.gitattributes

```
*.onnx filter=lfs diff=lfs merge=lfs -text
```

```
---
name: Bug report
about: Create a report to help us improve
title: "[BUG] "
labels: bug
assignees: ''
---
Please provide as much details as possible, this will help us to deliver a
fix as soon as possible.
Thank you!
**Describe the bug**
A clear and concise description of what the bug is.
**Log and Stack trace**
Please provide a log and a stack trace (with exception), if applicable.
**To Reproduce**
Please provide a relevant code snippets to reproduce this bug.
**Expected behavior**
A clear and concise description of what you expected to happen.
**Please complete the following information:**
- LangChain4j version: e.g. 0.23.0
- Java version: e.g. 11
- Spring Boot version (if applicable): e.g. 2.7.14
**Additional context**
Add any other context about the problem here.
```

.github\ISSUE_TEMPLATE\feature_request.md

```
---
name: Feature request
about: Suggest an idea for this project
title: "[FEATURE] "
labels: enhancement
assignees: ''
---
**Is your feature request related to a problem? Please describe.**
A clear and concise description of what the problem is. Ex. I'm always
frustrated when [...]
**Describe the solution you'd like**
A clear and concise description of what you want to happen.
**Describe alternatives you've considered**
A clear and concise description of any alternative solutions or features
you've considered.
**Additional context**
Add any other context or screenshots about the feature request here.
```

.github\workflows\main.yaml

```
name: Java CI
on: [pull_request]
jobs:
  build:
    runs-on: ubuntu-latest
    steps:
      - uses: actions/checkout@v3
      - name: Set up JDK
        uses: actions/setup-java@v3
        with:
          java-version: '11'
          distribution: 'adopt'
      - name: Test
        run: mvn --batch-mode test
  # For checking some compliance things (require a recent JDK due to plugins
so in a separate step)
  compliance:
    runs-on: ubuntu-latest
    steps:
      - uses: actions/checkout@v3
      - name: Set up JDK 17
        uses: actions/setup-java@v3
        with:
          java-version: '17'
          distribution: 'temurin'
        # Check we only rely on permissive licenses in the main parts of the
library:
      - name: License Compliance
        run: mvn -P compliance org.honton.chas:license-maven-plugin:compliance
# TODO's
#  - setup integration tests
#     - these require an openAI (and hugging face, etc) token
#     - do so that they always run for commits on main
#     - make the running be manually triggered for PRs (we don't want to burn
through credits)
```

.prettierrc

```
{
  "printWidth": 120
}
```

langchain4j\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j</artifactId>
    <packaging>jar</packaging>
    <name>langchain4j</name>
    <description>Java implementation of LangChain: Integrate your Java
application with countless AI tools and services
        smoothly
    </description>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>com.squareup.retrofit2</groupId>
            <artifactId>retrofit</artifactId>
        </dependency>
        <dependency>
            <groupId>com.squareup.okhttp3</groupId>
            <artifactId>okhttp</artifactId>
        </dependency>
        <dependency>
            <groupId>org.apache.opennlp</groupId>
            <artifactId>opennlp-tools</artifactId>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.apache.pdfbox</groupId>
            <artifactId>pdfbox</artifactId>
        </dependency>
        <dependency>
            <groupId>org.apache.poi</groupId>
            <artifactId>poi</artifactId>
            <version>5.2.3</version>
        </dependency>
        <dependency>
            <groupId>org.apache.poi</groupId>
            <artifactId>poi-ooxml</artifactId>
            <version>5.2.3</version>
        </dependency>
        <dependency>
            <groupId>org.apache.poi</groupId>
```

```
    <artifactId>poi-scratchpad</artifactId>
    <version>5.2.3</version>
</dependency>
<dependency>
    <groupId>org.jsoup</groupId>
    <artifactId>jsoup</artifactId>
</dependency>
<dependency>
    <groupId>org.slf4j</groupId>
    <artifactId>slf4j-api</artifactId>
</dependency>
<dependency>
    <groupId>dev.langchain4j</groupId>
    <artifactId>langchain4j-open-ai</artifactId>
    <version>${project.version}</version>
    <scope>test</scope>
</dependency>
<dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter-engine</artifactId>
    <scope>test</scope>
</dependency>
<dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter-params</artifactId>
    <scope>test</scope>
</dependency>
<dependency>
    <groupId>org.mockito</groupId>
    <artifactId>mockito-core</artifactId>
    <scope>test</scope>
</dependency>
<dependency>
    <groupId>org.mockito</groupId>
    <artifactId>mockito-junit-jupiter</artifactId>
    <scope>test</scope>
</dependency>
<dependency>
    <groupId>org.assertj</groupId>
    <artifactId>assertj-core</artifactId>
    <scope>test</scope>
</dependency>
<dependency>
    <groupId>org.tinylog</groupId>
    <artifactId>tinylog-impl</artifactId>
    <scope>test</scope>
</dependency>
<dependency>
    <groupId>org.tinylog</groupId>
    <artifactId>slf4j-tinylog</artifactId>
    <scope>test</scope>
</dependency>
<dependency>
    <groupId>dev.langchain4j</groupId>
    <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</artifactId>
    <scope>test</scope>
</dependency>
<dependency>
    <groupId>software.amazon.awssdk</groupId>
    <artifactId>s3</artifactId>
    <exclusions>
```

```
                <!-- Exclusion due to CWE-295 vulnerability -->
                <exclusion>
                    <groupId>io.netty</groupId>
                    <artifactId>netty-handler</artifactId>
                </exclusion>
                <!-- due to CVE-2023-44487 vulnerability -->
                <exclusion>
                    <groupId>io.netty</groupId>
                    <artifactId>netty-codec-http2</artifactId>
                </exclusion>
            </exclusions>
        </dependency>
        <dependency>
            <groupId>org.testcontainers</groupId>
            <artifactId>testcontainers</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.testcontainers</groupId>
            <artifactId>localstack</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j\src\main\java\dev\langchain4j\agent\tool\ToolExecutor.java

```
package dev.langchain4j.agent.tool;
import dev.langchain4j.internal.Json;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.lang.reflect.InvocationTargetException;
import java.lang.reflect.Method;
import java.lang.reflect.Parameter;
import java.math.BigDecimal;
import java.math.BigInteger;
import java.util.Map;
public class ToolExecutor {
    private static final Logger log =
LoggerFactory.getLogger(ToolExecutor.class);
    private final Object object;
    private final Method method;
    public ToolExecutor(Object object, Method method) {
        this.object = object;
        this.method = method;
    }
    public String execute(ToolExecutionRequest toolExecutionRequest) {
        log.debug("About to execute {}", toolExecutionRequest);
        // TODO ensure this method never throws exceptions
        Object[] arguments = prepareArguments(ToolExecutionRequestUtil.argumen
tsAsMap(toolExecutionRequest.arguments()));
        try {
            String result = execute(arguments);
            log.debug("Tool execution result: {}", result);
            return result;
        } catch (IllegalAccessException e) {
            try {
                method.setAccessible(true);
                String result = execute(arguments);
                log.debug("Tool execution result: {}", result);
                return result;
            } catch (IllegalAccessException e2) {
                throw new RuntimeException(e2);
            } catch (InvocationTargetException e2) {
                Throwable cause = e2.getCause();
                log.error("Error while executing tool", cause);
                return cause.getMessage();
            }
        } catch (InvocationTargetException e) {
            Throwable cause = e.getCause();
            log.error("Error while executing tool", cause);
            return cause.getMessage();
        }
    }
    private String execute(Object[] arguments) throws IllegalAccessException,
InvocationTargetException {
        Object result = method.invoke(object, arguments);
        if (method.getReturnType() == void.class) {
            return "Success";
        }
        return Json.toJson(result);
    }
    private Object[] prepareArguments(Map<String, Object> argumentsMap) {
        Parameter[] parameters = method.getParameters();
```

```
        Object[] arguments = new Object[parameters.length];
        for (int i = 0; i < parameters.length; i++) {
            String parameterName = parameters[i].getName();
            if (argumentsMap.containsKey(parameterName)) {
                Object argument = argumentsMap.get(parameterName);
                Class<?> parameterType = parameters[i].getType();
                // Gson always parses numbers into the Double type. If the
parameter type is not Double, a conversion attempt is made.
                if (argument instanceof Double && !(parameterType ==
Double.class || parameterType == double.class)) {
                    Double doubleValue = (Double) argument;
                    if (parameterType == Float.class || parameterType ==
float.class) {
                        if (doubleValue < -Float.MAX_VALUE || doubleValue >
Float.MAX_VALUE) {
                            throw new IllegalArgumentException("Double value
" + doubleValue + " is out of range for the float type");
                        }
                        argument = doubleValue.floatValue();
                    } else if (parameterType == BigDecimal.class) {
                        argument = BigDecimal.valueOf(doubleValue);
                    }
                    // Allow conversion to integer types only if double value
has no fractional part
                    if (hasNoFractionalPart(doubleValue)) {
                        if (parameterType == Integer.class || parameterType
== int.class) {
                            if (doubleValue < Integer.MIN_VALUE ||
doubleValue > Integer.MAX_VALUE) {
                                throw new IllegalArgumentException("Double
value " + doubleValue + " is out of range for the integer type");
                            }
                            argument = doubleValue.intValue();
                        } else if (parameterType == Long.class ||
parameterType == long.class) {
                            if (doubleValue < Long.MIN_VALUE || doubleValue >
Long.MAX_VALUE) {
                                throw new IllegalArgumentException("Double
value " + doubleValue + " is out of range for the long type");
                            }
                            argument = doubleValue.longValue();
                        } else if (parameterType == Short.class ||
parameterType == short.class) {
                            if (doubleValue < Short.MIN_VALUE || doubleValue
> Short.MAX_VALUE) {
                                throw new IllegalArgumentException("Double
value " + doubleValue + " is out of range for the short type");
                            }
                            argument = doubleValue.shortValue();
                        } else if (parameterType == Byte.class ||
parameterType == byte.class) {
                            if (doubleValue < Byte.MIN_VALUE || doubleValue >
Byte.MAX_VALUE) {
                                throw new IllegalArgumentException("Double
value " + doubleValue + " is out of range for the byte type");
                            }
                            argument = doubleValue.byteValue();
                        } else if (parameterType == BigInteger.class) {
                            argument =
BigDecimal.valueOf(doubleValue).toBigInteger();
                        }
```

```
                    }
                }
                arguments[i] = argument;
            }
        }
        return arguments;
    }
    private static boolean hasNoFractionalPart(Double doubleValue) {
        return doubleValue.equals(Math.floor(doubleValue));
    }
}
```

langchain4j\src\main\java\dev\langchain4j\chain\ConversationalChain.java

```
package dev.langchain4j.chain;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import lombok.Builder;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * A chain for interacting with a specified {@link ChatLanguageModel} while
maintaining a memory of the conversation.
 * Includes a default {@link ChatMemory} (a message window with maximum 10
messages), which can be overridden.
 */
public class ConversationalChain implements Chain<String, String> {
    private final ChatLanguageModel chatLanguageModel;
    private final ChatMemory chatMemory;
    @Builder
    private ConversationalChain(ChatLanguageModel chatLanguageModel,
ChatMemory chatMemory) {
        this.chatLanguageModel = ensureNotNull(chatLanguageModel,
"chatLanguageModel");
        this.chatMemory = chatMemory == null ?
MessageWindowChatMemory.withMaxMessages(10) : chatMemory;
    }
    @Override
    public String execute(String userMessage) {
        chatMemory.add(userMessage(ensureNotBlank(userMessage,
"userMessage")));
        AiMessage aiMessage =
chatLanguageModel.generate(chatMemory.messages()).content();
        chatMemory.add(aiMessage);
        return aiMessage.text();
    }
}
```

langchain4j\src\main\java\dev\langchain4j\chain\ConversationalRetrievalChain.java

```
package dev.langchain4j.chain;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.input.PromptTemplate;
import dev.langchain4j.retriever.Retriever;
import lombok.Builder;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
import static java.util.stream.Collectors.joining;
/**
 * A chain for interacting with a specified {@link ChatLanguageModel} based on the information provided by a specified {@link Retriever}.
 * Includes a default {@link PromptTemplate}, which can be overridden.
 * Includes a default {@link ChatMemory} (a message window with maximum 10 messages), which can be overridden.
 */
public class ConversationalRetrievalChain implements Chain<String, String> {
    private static final PromptTemplate DEFAULT_PROMPT_TEMPLATE = PromptTemplate.from(
            "Answer the following question to the best of your ability: {{question}}\n" +
                    "\n" +
                    "Base your answer on the following information:\n" +
                    "{{information}}");
    private final ChatLanguageModel chatLanguageModel;
    private final ChatMemory chatMemory;
    private final PromptTemplate promptTemplate;
    private final Retriever<TextSegment> retriever;
    @Builder
    public ConversationalRetrievalChain(ChatLanguageModel chatLanguageModel,
                                        ChatMemory chatMemory,
                                        PromptTemplate promptTemplate,
                                        Retriever<TextSegment> retriever) {
        this.chatLanguageModel = ensureNotNull(chatLanguageModel, "chatLanguageModel");
        this.chatMemory = chatMemory == null ? MessageWindowChatMemory.withMaxMessages(10) : chatMemory;
        this.promptTemplate = promptTemplate == null ? DEFAULT_PROMPT_TEMPLATE : promptTemplate;
        this.retriever = ensureNotNull(retriever, "retriever");
    }
    @Override
    public String execute(String question) {
        question = ensureNotBlank(question, "question");
        List<TextSegment> relevantSegments = retriever.findRelevant(question);
        Map<String, Object> variables = new HashMap<>();
        variables.put("question", question);
        variables.put("information", format(relevantSegments));
        UserMessage userMessage = promptTemplate.apply(variables).toUserMessage();
```

```
        chatMemory.add(userMessage);
        AiMessage aiMessage =
chatLanguageModel.generate(chatMemory.messages()).content();
        chatMemory.add(aiMessage);
        return aiMessage.text();
    }
    private static String format(List<TextSegment> relevantSegments) {
        return relevantSegments.stream()
                .map(TextSegment::text)
                .map(segment -> "..." + segment + "...")
                .collect(joining("\n\n"));
    }
}
```

langchain4j\src\main\java\dev\langchain4j\classification\EmbeddingModelTextClassifier.java

```
package dev.langchain4j.classification;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.RelevanceScore;
import java.util.ArrayList;
import java.util.Collection;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static dev.langchain4j.internal.ValidationUtils.ensureBetween;
import static dev.langchain4j.internal.ValidationUtils.ensureGreaterThanZero;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
import static java.util.Comparator.comparingDouble;
import static java.util.stream.Collectors.toList;
/**
 * A {@link TextClassifier} that uses an {@link EmbeddingModel} and predefined examples to perform classification.
 * Classification is done by comparing the embedding of the text being classified with the embeddings of predefined examples.
 * The classification quality improves with a greater number of examples for each label.
 * Examples can be easily generated by the LLM.
 * <p>
 * Example:
 * <pre>{@code
 * enum Sentiment {
 *     POSITIVE, NEUTRAL, NEGATIVE
 * }
 *
 *  Map<Sentiment, List<String>> examples = Map.of(
 *     POSITIVE, List.of("This is great!", "Wow, awesome!"),
 *     NEUTRAL,  List.of("Well, it's fine", "It's ok"),
 *     NEGATIVE, List.of("It is pretty bad", "Worst experience ever!")
 * );
 *
 * EmbeddingModel embeddingModel = new AllMiniLmL6V2QuantizedEmbeddingModel();
 *
 * TextClassifier<Sentiment> classifier = new EmbeddingModelTextClassifier<>(embeddingModel, examples);
 *
 * List<Sentiment> sentiments = classifier.classify("Awesome!");
 * System.out.println(sentiments); // [POSITIVE]
 * }</pre>
 *
 * @param <E> Enum that is the result of classification.
 */
public class EmbeddingModelTextClassifier<E extends Enum<E>> implements TextClassifier<E> {
    private final EmbeddingModel embeddingModel;
    private final Map<E, List<Embedding>> exampleEmbeddingsByLabel;
    private final int maxResults;
    private final double minScore;
    private final double meanToMaxScoreRatio;
    /**
     * Creates a classifier with the default values for {@link #maxResults} (1), {@link #minScore} (0)
```

```
     * and {@link #meanToMaxScoreRatio} (0.5).
     *
     * @param embeddingModel  The embedding model used for embedding both the
examples and the text to be classified.
     * @param examplesByLabel A map containing examples of texts for each
label.
     *                        The more examples, the better. Examples can be
easily generated by the LLM.
     */
    public EmbeddingModelTextClassifier(EmbeddingModel embeddingModel,
                                        Map<E, ? extends Collection<String>>
examplesByLabel) {
        this(embeddingModel, examplesByLabel, 1, 0, 0.5);
    }
    /**
     * Creates a classifier.
     *
     * @param embeddingModel      The embedding model used for embedding both
the examples and the text to be classified.
     * @param examplesByLabel     A map containing examples of texts for each
label.
     *                            The more examples, the better. Examples can
be easily generated by the LLM.
     * @param maxResults          The maximum number of labels to return for
each classification.
     * @param minScore            The minimum similarity score required for
classification, in the range [0..1].
     *                            Labels scoring lower than this value will
be discarded.
     * @param meanToMaxScoreRatio A ratio, in the range [0..1], between the
mean and max scores used for calculating
     *                            the final score.
     *                            During classification, the embeddings of
examples for each label are compared to
     *                            the embedding of the text being classified.
     *                            This results in two metrics: the mean and
max scores.
     *                            The mean score is the average similarity
score for all examples associated with a given label.
     *                            The max score is the highest similarity
score, corresponding to the example most
     *                            similar to the text being classified.
     *                            A value of 0 means that only the mean score
will be used for ranking labels.
     *                            A value of 0.5 means that both scores will
contribute equally to the final score.
     *                            A value of 1 means that only the max score
will be used for ranking labels.
     */
    public EmbeddingModelTextClassifier(EmbeddingModel embeddingModel,
                                        Map<E, ? extends Collection<String>>
examplesByLabel,
                                        int maxResults,
                                        double minScore,
                                        double meanToMaxScoreRatio) {
        this.embeddingModel = ensureNotNull(embeddingModel, "embeddingModel");
        ensureNotNull(examplesByLabel, "examplesByLabel");
        this.exampleEmbeddingsByLabel = new HashMap<>();
        examplesByLabel.forEach((label, examples) ->
                exampleEmbeddingsByLabel.put(label, examples.stream()
                        .map(example ->
```

```
embeddingModel.embed(example).content())
                        .collect(toList()))
        );
        this.maxResults = ensureGreaterThanZero(maxResults, "maxResults");
        this.minScore = ensureBetween(minScore, 0.0, 1.0, "minScore");
        this.meanToMaxScoreRatio = ensureBetween(meanToMaxScoreRatio, 0.0,
1.0, "meanToMaxScoreRatio");
    }
    @Override
    public List<E> classify(String text) {
        Embedding textEmbedding = embeddingModel.embed(text).content();
        List<LabelWithScore> labelsWithScores = new ArrayList<>();
        exampleEmbeddingsByLabel.forEach((label, exampleEmbeddings) -> {
            double meanScore = 0;
            double maxScore = 0;
            for (Embedding exampleEmbedding : exampleEmbeddings) {
                double cosineSimilarity =
CosineSimilarity.between(textEmbedding, exampleEmbedding);
                double score =
RelevanceScore.fromCosineSimilarity(cosineSimilarity);
                meanScore += score;
                maxScore = Math.max(score, maxScore);
            }
            meanScore /= exampleEmbeddings.size();
            labelsWithScores.add(new LabelWithScore(label,
aggregatedScore(meanScore, maxScore)));
        });
        return labelsWithScores.stream()
                .filter(it -> it.score >= minScore)
                // sorting in descending order to return highest score first
                .sorted(comparingDouble(labelWithScore -> 1 -
labelWithScore.score))
                .limit(maxResults)
                .map(it -> it.label)
                .collect(toList());
    }
    private double aggregatedScore(double meanScore, double maxScore) {
        return (meanToMaxScoreRatio * meanScore) + ((1 - meanToMaxScoreRatio)
* maxScore);
    }
    private class LabelWithScore {
        private final E label;
        private final double score;
        private LabelWithScore(E label, double score) {
            this.label = label;
            this.score = score;
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\code\JavaScriptCodeFixer.java

```
package dev.langchain4j.code;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
class JavaScriptCodeFixer {
    private static final Logger log =
LoggerFactory.getLogger(JavaScriptCodeFixer.class);
    static String fixIfNoLogToConsole(String code) {
        if (code.contains("\n")) {
            return fixIfNoLogToConsole(code, "\n");
        } else {
            return fixIfNoLogToConsole(code, " ");
        }
    }
    private static String fixIfNoLogToConsole(String code, String separator) {
        String[] parts = code.split(separator);
        String lastPart = parts[parts.length - 1];
        if (lastPart.startsWith("console.log")) {
            return code;
        }
        parts[parts.length - 1] = "console.log(" + lastPart.replace(";", "")
+ ");";
        String fixedCode = String.join(separator, parts);
        log.debug("The following code \"{}\" was fixed: \"{}\"", code,
fixedCode);
        return fixedCode;
    }
}
```

langchain4j\src\main\java\dev\langchain4j\code\Judge0JavaScriptEngine.java

```
package dev.langchain4j.code;
import dev.langchain4j.internal.Json;
import okhttp3.*;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.time.Duration;
import java.util.Base64;
import static dev.langchain4j.internal.Utils.isNullOrBlank;
class Judge0JavaScriptEngine implements CodeExecutionEngine {
    private static final Logger log =
LoggerFactory.getLogger(Judge0JavaScriptEngine.class);
    private static final MediaType MEDIA_TYPE = MediaType.parse("application/
json");
    private static final int ACCEPTED = 3;
    private final String apiKey;
    private final int languageId;
    private final OkHttpClient client;
    Judge0JavaScriptEngine(String apiKey, int languageId, Duration timeout) {
        this.apiKey = apiKey;
        this.languageId = languageId;
        this.client = new OkHttpClient.Builder()
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .callTimeout(timeout)
                .build();
    }
    @Override
    public String execute(String code) {
        String base64EncodedCode =
Base64.getEncoder().encodeToString(code.getBytes());
        Submission submission = new Submission(languageId, base64EncodedCode);
        RequestBody requestBody = RequestBody.create(Json.toJson(submission),
MEDIA_TYPE);
        Request request = new Request.Builder()
                .url("https://judge0-ce.p.rapidapi.com/submissions?
base64_encoded=true&wait=true&fields=*")
                .addHeader("X-RapidAPI-Key", apiKey)
                .post(requestBody)
                .build();
        try {
            Response response = client.newCall(request).execute();
            String responseBody = response.body().string();
            SubmissionResult result = Json.fromJson(responseBody,
SubmissionResult.class);
            if (result.status.id != ACCEPTED) {
                String error = result.status.description;
                if (!isNullOrBlank(result.compile_output)) {
                    error += "\n";
                    error += new
String(Base64.getMimeDecoder().decode(result.compile_output));
                }
                return error;
            }
            String base64EncodedStdout = result.stdout;
            if (base64EncodedStdout == null) {
                return "No result: nothing was printed out to the console";
            }
```

```
            return new
String(Base64.getMimeDecoder().decode(base64EncodedStdout.trim())).trim();
        } catch (Exception e) {
            log.warn("Error during code execution", e);
            return e.getMessage();
        }
    }
    private static class Submission {
        int language_id;
        String source_code;
        Submission(int languageId, String sourceCode) {
            this.language_id = languageId;
            this.source_code = sourceCode;
        }
    }
    private static class SubmissionResult {
        String stdout;
        Status status;
        String compile_output;
    }
    private static class Status {
        int id;
        String description;
    }
}
```

langchain4j\src\main\java\dev\langchain4j\code\Judge0JavaScriptExecutionTool.java

```
package dev.langchain4j.code;
import dev.langchain4j.agent.tool.P;
import dev.langchain4j.agent.tool.Tool;
import java.time.Duration;
import static dev.langchain4j.code.JavaScriptCodeFixer.fixIfNoLogToConsole;
import static dev.langchain4j.internal.Utils.isNullOrBlank;
/**
 * A tool that executes JS code using the Judge0 service, hosted by Rapid API.
 */
public class Judge0JavaScriptExecutionTool {
    private static final int JAVASCRIPT = 93;
    private final Judge0JavaScriptEngine engine;
    private final boolean fixCodeIfNeeded;
    /**
     * Constructs a new instance with the provided Rapid API key.
     * The code fixing feature is enabled by default.
     * Default timeout is 10 seconds.
     *
     * @param apiKey The Rapid API key. You can subscribe to the free plan
(Basic) here: https://rapidapi.com/judge0-official/api/judge0-ce/pricing
     */
    public Judge0JavaScriptExecutionTool(String apiKey) {
        this(apiKey, true, Duration.ofSeconds(10));
    }
    /**
     * Constructs a new instance with the provided Rapid API key, a flag to
control whether to fix the code, and a timeout.
     *
     * @param apiKey          Rapid API key. You can subscribe to the free
plan (Basic) here: https://rapidapi.com/judge0-official/api/judge0-ce/pricing
     * @param fixCodeIfNeeded Judge0 can return result of an execution if it
was printed to the console.
     *                        If provided JS code does not print result to
the console, attempt will be made to fix it.
     * @param timeout         Timeout for calling Judge0.
     */
    public Judge0JavaScriptExecutionTool(String apiKey, boolean
fixCodeIfNeeded, Duration timeout) {
        if (isNullOrBlank(apiKey)) {
            throw new IllegalArgumentException("Please provide a valid Rapid
API key");
        }
        this.engine = new Judge0JavaScriptEngine(apiKey, JAVASCRIPT, timeout);
        this.fixCodeIfNeeded = fixCodeIfNeeded;
    }
    @Tool("MUST be used for accurate calculations: math, sorting, filtering,
aggregating, string processing, etc")
    public String executeJavaScriptCode(
            @P("JavaScript code to execute, result MUST be printed to
console")
            String javaScriptCode
    ) {
        if (fixCodeIfNeeded) {
            javaScriptCode = fixIfNoLogToConsole(javaScriptCode);
        }
        return engine.execute(javaScriptCode);
    }
```

```
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\AbstractS3Loader.java

```
package dev.langchain4j.data.document;
import software.amazon.awssdk.auth.credentials.AwsBasicCredentials;
import software.amazon.awssdk.auth.credentials.AwsCredentialsProvider;
import software.amazon.awssdk.auth.credentials.AwsSessionCredentials;
import software.amazon.awssdk.auth.credentials.DefaultCredentialsProvider;
import software.amazon.awssdk.auth.credentials.ProfileCredentialsProvider;
import software.amazon.awssdk.auth.credentials.StaticCredentialsProvider;
import software.amazon.awssdk.regions.Region;
import software.amazon.awssdk.services.s3.S3Client;
import software.amazon.awssdk.services.s3.S3ClientBuilder;
import java.net.URI;
import java.net.URISyntaxException;
import static dev.langchain4j.internal.Utils.isNotNullOrBlank;
import static dev.langchain4j.internal.Utils.isNullOrBlank;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
public abstract class AbstractS3Loader<T> {
    protected final String bucket;
    protected final String region;
    protected final String endpointUrl;
    protected final String profile;
    protected final boolean forcePathStyle;
    protected final AwsCredentials awsCredentials;
    protected AbstractS3Loader(Builder builder) {
        this.bucket = ensureNotBlank(builder.bucket, "bucket");
        this.region = builder.region;
        this.endpointUrl = builder.endpointUrl;
        this.profile = builder.profile;
        this.forcePathStyle = builder.forcePathStyle;
        this.awsCredentials = builder.awsCredentials;
    }
    /**
     * Initiates the loading process by configuring the AWS credentials and
S3 client,
     * then loads either a document or a list of documents.
     *
     * @return A generic object of type T, which could be a Document or a
list of Documents
     * @throws RuntimeException if there are issues with AWS credentials or
S3 client configuration
     */
    public T load() {
        AwsCredentialsProvider awsCredentialsProvider =
configureCredentialsProvider();
        S3Client s3Client = configureS3Client(awsCredentialsProvider);
        return load(s3Client);
    }
    private static AwsSessionCredentials
toAwsSessionCredentials(AwsCredentials awsCredentials) {
        return AwsSessionCredentials.create(awsCredentials.accessKeyId(),
awsCredentials.secretAccessKey(), awsCredentials.sessionToken());
    }
    private static software.amazon.awssdk.auth.credentials.AwsCredentials
toAwsCredentials(AwsCredentials awsCredentials) {
        return AwsBasicCredentials.create(awsCredentials.accessKeyId(),
awsCredentials.secretAccessKey());
    }
    protected abstract T load(S3Client s3Client);
    private AwsCredentialsProvider configureCredentialsProvider() {
```

```
        AwsCredentialsProvider provider =
DefaultCredentialsProvider.builder().build();
        if (awsCredentials != null) {
            if (awsCredentials.hasAllCredentials()) {
                provider =
StaticCredentialsProvider.create(toAwsSessionCredentials(awsCredentials));
            }else if (awsCredentials.hasAccessKeyIdAndSecretKey()) {
                provider =
StaticCredentialsProvider.create(toAwsCredentials(awsCredentials));
            }
        }
        if( isNotNullOrBlank(profile) ) {
            provider = ProfileCredentialsProvider.create(profile);
        }
        return provider;
    }
    private S3Client configureS3Client(AwsCredentialsProvider provider) {
        S3ClientBuilder s3ClientBuilder = S3Client.builder()
                .region(Region.of(isNotNullOrBlank(region) ? region :
Region.US_EAST_1.id()))
                .forcePathStyle(forcePathStyle)
                .credentialsProvider(provider);
        if (!isNullOrBlank(endpointUrl)) {
            try {
                s3ClientBuilder.endpointOverride(new URI(endpointUrl));
            } catch (URISyntaxException e) {
                throw new IllegalArgumentException("Invalid URL: " +
endpointUrl, e);
            }
        }
        return s3ClientBuilder.build();
    }
    public static abstract class Builder<T extends Builder<T>> {
        private String bucket;
        private String region;
        private String endpointUrl;
        private String profile;
        private boolean forcePathStyle;
        private AwsCredentials awsCredentials;
        /**
         * Set the AWS bucket.
         *
         * @return The builder instance.
         */
        public T bucket(String bucket) {
            this.bucket = bucket;
            return self();
        }
        /**
         * Set the AWS region. Defaults to US_EAST_1
         *
         * @param region The AWS region.
         * @return The builder instance.
         */
        public T region(String region) {
            this.region = region;
            return self();
        }
        /**
         * Specifies a custom endpoint URL to override the default service
URL.
```

```
         *
         * @param endpointUrl The endpoint URL.
         * @return The builder instance.
         */
        public T endpointUrl(String endpointUrl) {
            this.endpointUrl = endpointUrl;
            return self();
        }
        /**
         * Set the profile defined in AWS credentials. If not set, it will
use the default profile.
         *
         * @param profile The profile defined in AWS credentials.
         * @return The builder instance.
         */
        public T profile(String profile) {
            this.profile = profile;
            return self();
        }
        /**
         * Set the forcePathStyle. When enabled, it will use the path-style
URL
         *
         * @param forcePathStyle The forcePathStyle.
         * @return The builder instance.
         */
        public T forcePathStyle(boolean forcePathStyle) {
            this.forcePathStyle = forcePathStyle;
            return self();
        }
        /**
         * Set the AWS credentials. If not set, it will use the default
credentials.
         *
         * @param awsCredentials The AWS credentials.
         * @return The builder instance.
         */
        public T awsCredentials(AwsCredentials awsCredentials) {
            this.awsCredentials = awsCredentials;
            return self();
        }
        public abstract AbstractS3Loader build();
        protected abstract T self();
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\AwsCredentials.java

```
package dev.langchain4j.data.document;
import static dev.langchain4j.internal.Utils.areNotNullOrBlank;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
/**
 * Represents an AWS credentials object, including access key ID, secret
access key, and optional session token.
 */
public class AwsCredentials {
    private final String accessKeyId;
    private final String secretAccessKey;
    private String sessionToken;
    public AwsCredentials(String accessKeyId, String secretAccessKey, String
sessionToken) {
        this.accessKeyId = ensureNotBlank(accessKeyId, "accessKeyId");
        this.secretAccessKey = ensureNotBlank(secretAccessKey,
"secretAccessKey");
        this.sessionToken = sessionToken;
    }
    public AwsCredentials(String accessKeyId, String secretAccessKey) {
        this(accessKeyId, secretAccessKey, null);
    }
    public String accessKeyId() {
        return accessKeyId;
    }
    public String secretAccessKey() {
        return secretAccessKey;
    }
    public String sessionToken() {
        return sessionToken;
    }
    public boolean hasAccessKeyIdAndSecretKey() {
        return areNotNullOrBlank(accessKeyId, secretAccessKey);
    }
    public boolean hasAllCredentials() {
        return areNotNullOrBlank(accessKeyId, secretAccessKey, sessionToken);
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\DocumentLoaderUtils.java

```
package dev.langchain4j.data.document;
import dev.langchain4j.data.document.parser.MsOfficeDocumentParser;
import dev.langchain4j.data.document.parser.PdfDocumentParser;
import dev.langchain4j.data.document.parser.TextDocumentParser;
import java.io.InputStream;
class DocumentLoaderUtils {
    static Document load(DocumentSource source, DocumentParser parser) {
        try (InputStream inputStream = source.inputStream()) {
            Document document = parser.parse(inputStream);
            source.metadata().asMap().forEach((key, value) ->
document.metadata().add(key, value));
            return document;
        } catch (Exception e) {
            throw new RuntimeException("Failed to load document", e);
        }
    }
    static DocumentParser parserFor(DocumentType type) {
        switch (type) {
            case TXT:
            case HTML:
            case UNKNOWN:
                return new TextDocumentParser(type);
            case PDF:
                return new PdfDocumentParser();
            case DOC:
            case XLS:
            case PPT:
                return new MsOfficeDocumentParser(type);
            default:
                throw new RuntimeException(String.format("Cannot find parser
for document type '%s'", type));
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\DocumentType.java

```
package dev.langchain4j.data.document;
import static java.util.Arrays.asList;
public enum DocumentType {
    TXT(".txt"),
    PDF(".pdf"),
    HTML(".html", ".htm", ".xhtml"),
    DOC(".doc", ".docx"),
    XLS(".xls", ".xlsx"),
    PPT(".ppt", ".pptx"),
    UNKNOWN;
    private final Iterable<String> supportedExtensions;
    DocumentType(String... supportedExtensions) {
        this.supportedExtensions = asList(supportedExtensions);
    }
    public static DocumentType of(String fileName) {
        for (DocumentType documentType : values()) {
            for (String supportedExtension :
documentType.supportedExtensions) {
                if (fileName.toLowerCase().endsWith(supportedExtension)) {
                    return documentType;
                }
            }
        }
        return UNKNOWN;
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\FileSystemDocumentLoader.java

```
package dev.langchain4j.data.document;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.io.IOException;
import java.nio.file.Files;
import java.nio.file.Path;
import java.nio.file.Paths;
import java.util.ArrayList;
import java.util.List;
import java.util.stream.Stream;
import static dev.langchain4j.data.document.DocumentLoaderUtils.parserFor;
import static dev.langchain4j.data.document.source.FileSystemSource.from;
import static dev.langchain4j.internal.Exceptions.illegalArgument;
import static java.nio.file.Files.isDirectory;
import static java.nio.file.Files.isRegularFile;
public class FileSystemDocumentLoader {
    private static final Logger log =
LoggerFactory.getLogger(FileSystemDocumentLoader.class);
    /**
     * Loads a document from the specified file, detecting document type
automatically.
     * See {@link DocumentType} for the list of supported document types.
     * If the document type is UNKNOWN, it is treated as TXT.
     *
     * @param filePath path to the file
     * @return document
     * @throws IllegalArgumentException if specified path is not a file
     */
    public static Document loadDocument(Path filePath) {
        return loadDocument(filePath, DocumentType.of(filePath.toString()));
    }
    /**
     * Loads a document from the specified file, detecting document type
automatically.
     * See {@link DocumentType} for the list of supported document types.
     * If the document type is UNKNOWN, it is treated as TXT.
     *
     * @param filePath path to the file
     * @return document
     * @throws IllegalArgumentException if specified path is not a file
     */
    public static Document loadDocument(String filePath) {
        return loadDocument(Paths.get(filePath));
    }
    /**
     * Loads a document from the specified file.
     *
     * @param filePath     path to the file
     * @param documentType type of the document
     * @return document
     * @throws IllegalArgumentException if specified path is not a file
     */
    public static Document loadDocument(Path filePath, DocumentType
documentType) {
        if (!isRegularFile(filePath)) {
            throw illegalArgument("%s is not a file", filePath);
        }
```

```
        return DocumentLoaderUtils.load(from(filePath),
parserFor(documentType));
    }
    /**
     * Loads a document from the specified file.
     *
     * @param filePath     path to the file
     * @param documentType type of the document
     * @return document
     * @throws IllegalArgumentException if specified path is not a file
     */
    public static Document loadDocument(String filePath, DocumentType
documentType) {
        return loadDocument(Paths.get(filePath), documentType);
    }
    /**
     * Loads documents from the specified directory. Does not use recursion.
     * Detects document types automatically.
     * See {@link DocumentType} for the list of supported document types.
     * If the document type is UNKNOWN, it is treated as TXT.
     *
     * @param directoryPath path to the directory with files
     * @return list of documents
     * @throws IllegalArgumentException if specified path is not a directory
     */
    public static List<Document> loadDocuments(Path directoryPath) {
        if (!isDirectory(directoryPath)) {
            throw illegalArgument("%s is not a directory", directoryPath);
        }
        List<Document> documents = new ArrayList<>();
        try (Stream<Path> paths = Files.list(directoryPath)) {
            paths.filter(Files::isRegularFile)
                    .forEach(filePath -> {
                        try {
                            Document document = loadDocument(filePath);
                            documents.add(document);
                        } catch (Exception e) {
                            log.warn("Failed to load document from " +
filePath, e);
                        }
                    });
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
        return documents;
    }
    /**
     * Loads documents from the specified directory. Does not use recursion.
     * Detects document types automatically.
     * See {@link DocumentType} for the list of supported document types.
     * If the document type is UNKNOWN, it is treated as TXT.
     *
     * @param directoryPath path to the directory with files
     * @return list of documents
     * @throws IllegalArgumentException if specified path is not a directory
     */
    public static List<Document> loadDocuments(String directoryPath) {
        return loadDocuments(Paths.get(directoryPath));
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\parser\MsOfficeDocumentParser.java

```
package dev.langchain4j.data.document.parser;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentParser;
import dev.langchain4j.data.document.DocumentType;
import dev.langchain4j.data.document.Metadata;
import org.apache.poi.extractor.ExtractorFactory;
import org.apache.poi.extractor.POITextExtractor;
import java.io.IOException;
import java.io.InputStream;
import static dev.langchain4j.data.document.Document.DOCUMENT_TYPE;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * Extracts text from a Microsoft Office document.
 * This parser supports various file formats, including ppt, pptx, doc, docx, xls, and xlsx.
 * For detailed information on supported formats, please refer to the <a href="https://poi.apache.org/">official Apache POI website</a>.
 */
public class MsOfficeDocumentParser implements DocumentParser {
    private final DocumentType documentType;
    public MsOfficeDocumentParser(DocumentType documentType) {
        this.documentType = ensureNotNull(documentType, "documentType");
    }
    @Override
    public Document parse(InputStream inputStream) {
        try (POITextExtractor extractor = ExtractorFactory.createExtractor(inputStream)) {
            return new Document(extractor.getText(), Metadata.from(DOCUMENT_TYPE, documentType));
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\parser\PdfDocumentParser.java

```
package dev.langchain4j.data.document.parser;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentParser;
import dev.langchain4j.data.document.Metadata;
import org.apache.pdfbox.pdmodel.PDDocument;
import org.apache.pdfbox.text.PDFTextStripper;
import java.io.IOException;
import java.io.InputStream;
import static dev.langchain4j.data.document.Document.DOCUMENT_TYPE;
import static dev.langchain4j.data.document.DocumentType.PDF;
public class PdfDocumentParser implements DocumentParser {
    @Override
    public Document parse(InputStream inputStream) {
        try {
            PDDocument pdfDocument = PDDocument.load(inputStream);
            PDFTextStripper stripper = new PDFTextStripper();
            String content = stripper.getText(pdfDocument);
            pdfDocument.close();
            return Document.from(content, Metadata.from(DOCUMENT_TYPE, PDF));
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\parser\TextDocumentParser.java

```
package dev.langchain4j.data.document.parser;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentParser;
import dev.langchain4j.data.document.DocumentType;
import dev.langchain4j.data.document.Metadata;
import java.io.ByteArrayOutputStream;
import java.io.InputStream;
import java.nio.charset.Charset;
import static dev.langchain4j.data.document.Document.DOCUMENT_TYPE;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
import static java.nio.charset.StandardCharsets.UTF_8;
public class TextDocumentParser implements DocumentParser {
    private final DocumentType documentType;
    private final Charset charset;
    public TextDocumentParser(DocumentType documentType) {
        this(documentType, UTF_8);
    }
    public TextDocumentParser(DocumentType documentType, Charset charset) {
        this.documentType = ensureNotNull(documentType, "documentType");
        this.charset = ensureNotNull(charset, "charset");
    }
    @Override
    public Document parse(InputStream inputStream) {
        try {
            ByteArrayOutputStream buffer = new ByteArrayOutputStream();
            int nRead;
            byte[] data = new byte[1024];
            while ((nRead = inputStream.read(data, 0, data.length)) != -1) {
                buffer.write(data, 0, nRead);
            }
            buffer.flush();
            String text = new String(buffer.toByteArray(), charset);
            return Document.from(text, Metadata.from(DOCUMENT_TYPE,
documentType.toString()));
        } catch (Exception e) {
            throw new RuntimeException(e);
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\S3DirectoryLoader.java

```
package dev.langchain4j.data.document;
import dev.langchain4j.data.document.source.S3Source;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import software.amazon.awssdk.core.ResponseInputStream;
import software.amazon.awssdk.services.s3.S3Client;
import software.amazon.awssdk.services.s3.model.*;
import java.util.ArrayList;
import java.util.List;
import java.util.stream.Collectors;
import static dev.langchain4j.data.document.DocumentLoaderUtils.parserFor;
/**
 * S3 Directory Loader Implementation
 */
public class S3DirectoryLoader extends AbstractS3Loader<List<Document>> {
    private static final Logger log =
LoggerFactory.getLogger(S3DirectoryLoader.class);
    private final String prefix;
    private S3DirectoryLoader(Builder builder) {
        super(builder);
        this.prefix = builder.prefix;
    }
    /**
     * Loads a list of documents from an S3 bucket, ignoring unsupported
document types.
     * If a prefix is specified, only objects with that prefix will be loaded.
     *
     * @param s3Client The S3 client used for the operation
     * @return A list of Document objects containing the content and metadata
of the S3 objects
     * @throws RuntimeException if an S3 exception occurs during the operation
     */
    @Override
    protected List<Document> load(S3Client s3Client) {
        List<Document> documents = new ArrayList<>();
        ListObjectsV2Request listObjectsV2Request =
ListObjectsV2Request.builder()
                .bucket(bucket)
                .prefix(prefix)
                .build();
        ListObjectsV2Response listObjectsV2Response =
s3Client.listObjectsV2(listObjectsV2Request);
        List<S3Object> filteredS3Objects =
listObjectsV2Response.contents().stream()
                .filter(s3Object -> !s3Object.key().endsWith("/") &&
s3Object.size() > 0)
                .collect(Collectors.toList());
        for (S3Object s3Object : filteredS3Objects) {
            String key = s3Object.key();
            GetObjectRequest getObjectRequest = GetObjectRequest.builder()
                    .bucket(bucket)
                    .key(key)
                    .build();
            ResponseInputStream<GetObjectResponse> inputStream =
s3Client.getObject(getObjectRequest);
            try {
                documents.add(DocumentLoaderUtils.load(new S3Source(bucket,
```

```
key, inputStream), parserFor(DocumentType.of(key))));
            } catch (Exception e) {
                log.warn("Failed to load document from S3", e);
            }
        }
        return documents;
    }
    public static Builder builder() {
        return new Builder();
    }
    public static final class Builder extends
AbstractS3Loader.Builder<Builder> {
        private String prefix = "";
        /**
         * Set the prefix.
         *
         * @param prefix Prefix.
         */
        public Builder prefix(String prefix) {
            this.prefix = prefix;
            return this;
        }
        @Override
        public S3DirectoryLoader build() {
            return new S3DirectoryLoader(this);
        }
        @Override
        protected Builder self() {
            return this;
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\S3FileLoader.java

```
package dev.langchain4j.data.document;
import dev.langchain4j.data.document.source.S3Source;
import software.amazon.awssdk.core.ResponseInputStream;
import software.amazon.awssdk.services.s3.S3Client;
import software.amazon.awssdk.services.s3.model.GetObjectRequest;
import software.amazon.awssdk.services.s3.model.GetObjectResponse;
import software.amazon.awssdk.services.s3.model.S3Exception;
import static dev.langchain4j.data.document.DocumentLoaderUtils.parserFor;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
/**
 * S3 File Loader Implementation
 */
public class S3FileLoader extends AbstractS3Loader<Document> {
    private final String key;
    private S3FileLoader(Builder builder) {
        super(builder);
        this.key = ensureNotBlank(builder.key, "key");
    }
    /**
     * Loads a document from an S3 bucket based on the specified key.
     *
     * @param s3Client The S3 client used for the operation
     * @return A Document object containing the content and metadata of the
S3 object
     * @throws RuntimeException if an S3 exception occurs during the operation
     */
    @Override
    protected Document load(S3Client s3Client) {
        try {
            GetObjectRequest objectRequest =
GetObjectRequest.builder().bucket(bucket).key(key).build();
            ResponseInputStream<GetObjectResponse> inputStream =
s3Client.getObject(objectRequest);
            return DocumentLoaderUtils.load(new S3Source(bucket, key,
inputStream), parserFor(DocumentType.of(key)));
        } catch (S3Exception e) {
            throw new RuntimeException("Failed to load document from s3", e);
        }
    }
    public static Builder builder() {
        return new Builder();
    }
    public static final class Builder extends
AbstractS3Loader.Builder<Builder> {
        private String key;
        /**
         * Set the object key.
         *
         * @param key Key.
         */
        public Builder key(String key) {
            this.key = key;
            return this;
        }
        @Override
        public S3FileLoader build() {
            return new S3FileLoader(this);
        }
```

```
        @Override
        protected Builder self() {
            return this;
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\source\FileSystemSource.java

```
package dev.langchain4j.data.document.source;
import dev.langchain4j.data.document.DocumentSource;
import dev.langchain4j.data.document.Metadata;
import java.io.File;
import java.io.IOException;
import java.io.InputStream;
import java.net.URI;
import java.nio.file.Files;
import java.nio.file.Path;
import java.nio.file.Paths;
import static dev.langchain4j.data.document.Document.ABSOLUTE_DIRECTORY_PATH;
import static dev.langchain4j.data.document.Document.FILE_NAME;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
public class FileSystemSource implements DocumentSource {
    public final Path path;
    public FileSystemSource(Path path) {
        this.path = ensureNotNull(path, "path");
    }
    @Override
    public InputStream inputStream() throws IOException {
        return Files.newInputStream(path);
    }
    @Override
    public Metadata metadata() {
        return new Metadata()
                .add(FILE_NAME, path.getFileName())
                .add(ABSOLUTE_DIRECTORY_PATH,
path.getParent().toAbsolutePath());
    }
    public static FileSystemSource from(Path filePath) {
        return new FileSystemSource(filePath);
    }
    public static FileSystemSource from(String filePath) {
        return new FileSystemSource(Paths.get(filePath));
    }
    public static FileSystemSource from(URI fileUri) {
        return new FileSystemSource(Paths.get(fileUri));
    }
    public static FileSystemSource from(File file) {
        return new FileSystemSource(file.toPath());
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\source\S3Source.java

```
package dev.langchain4j.data.document.source;
import dev.langchain4j.data.document.DocumentSource;
import dev.langchain4j.data.document.Metadata;
import java.io.IOException;
import java.io.InputStream;
public class S3Source implements DocumentSource {
    private static final String SOURCE = "source";
    private InputStream inputStream;
    private final String bucket;
    private final String key;
    public S3Source(String bucket, String key, InputStream inputStream) {
        this.inputStream = inputStream;
        this.bucket = bucket;
        this.key = key;
    }
    @Override
    public InputStream inputStream() throws IOException {
        return inputStream;
    }
    @Override
    public Metadata metadata() {
        return new Metadata()
                .add(SOURCE, String.format("s3://%s/%s", bucket, key));
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\source\UrlSource.java

```
package dev.langchain4j.data.document.source;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSource;
import dev.langchain4j.data.document.Metadata;
import java.io.IOException;
import java.io.InputStream;
import java.net.MalformedURLException;
import java.net.URI;
import java.net.URL;
import java.net.URLConnection;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
public class UrlSource implements DocumentSource {
    private final URL url;
    public UrlSource(URL url) {
        this.url = ensureNotNull(url, "url");
    }
    @Override
    public InputStream inputStream() throws IOException {
        URLConnection connection = url.openConnection();
        return connection.getInputStream();
    }
    @Override
    public Metadata metadata() {
        return Metadata.from(Document.URL, url);
    }
    public static UrlSource from(String url) {
        try {
            return new UrlSource(new URL(url));
        } catch (MalformedURLException e) {
            throw new RuntimeException(e);
        }
    }
    public static UrlSource from(URL url) {
        return new UrlSource(url);
    }
    public static UrlSource from(URI uri) {
        try {
            return new UrlSource(uri.toURL());
        } catch (MalformedURLException e) {
            throw new RuntimeException(e);
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\splitter\DocumentByCharacterSplitter.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
/**
 * Splits the provided {@link Document} into characters and attempts to fit as many characters as possible
 * into a single {@link TextSegment}, adhering to the limit set by {@code maxSegmentSize}.
 * <p>
 * The {@code maxSegmentSize} can be defined in terms of characters (default) or tokens.
 * For token-based limit, a {@link Tokenizer} must be provided.
 * <p>
 * If multiple characters fit within {@code maxSegmentSize}, they are joined together without delimiters.
 * <p>
 * Each {@link TextSegment} inherits all metadata from the {@link Document} and includes an "index" metadata key
 * representing its position within the document (starting from 0).
 */
public class DocumentByCharacterSplitter extends HierarchicalDocumentSplitter
{
    public DocumentByCharacterSplitter(int maxSegmentSizeInChars,
                                       int maxOverlapSizeInChars) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, null);
    }
    public DocumentByCharacterSplitter(int maxSegmentSizeInChars,
                                       int maxOverlapSizeInChars,
                                       DocumentSplitter subSplitter) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, subSplitter);
    }
    public DocumentByCharacterSplitter(int maxSegmentSizeInTokens,
                                       int maxOverlapSizeInTokens,
                                       Tokenizer tokenizer) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, null);
    }
    public DocumentByCharacterSplitter(int maxSegmentSizeInTokens,
                                       int maxOverlapSizeInTokens,
                                       Tokenizer tokenizer,
                                       DocumentSplitter subSplitter) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, subSplitter);
    }
    @Override
    public String[] split(String text) {
        return text.split("");
    }
    @Override
    public String joinDelimiter() {
        return "";
    }
    @Override
    protected DocumentSplitter defaultSubSplitter() {
```

```
            return null;
        }
    }
```

langchain4j\src\main\java\dev\langchain4j\data\document\splitter\DocumentByLineSplitter.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
/**
 * Splits the provided {@link Document} into lines and attempts to fit as many lines as possible
 * into a single {@link TextSegment}, adhering to the limit set by {@code maxSegmentSize}.
 * <p>
 * The {@code maxSegmentSize} can be defined in terms of characters (default) or tokens.
 * For token-based limit, a {@link Tokenizer} must be provided.
 * <p>
 * Line boundaries are detected by a minimum of one newline character ("\n").
 * Any additional whitespaces before or after are ignored.
 * So, the following examples are all valid line separators: "\n", "\n\n", " \n", "\n " and so on.
 * <p>
 * If multiple lines fit within {@code maxSegmentSize}, they are joined together using a newline ("\n").
 * <p>
 * If a single line is too long and exceeds {@code maxSegmentSize},
 * the {@code subSplitter} ({@link DocumentBySentenceSplitter} by default) is used to split it into smaller parts and
 * place them into multiple segments.
 * Such segments contain only the parts of the split long line.
 * <p>
 * Each {@link TextSegment} inherits all metadata from the {@link Document} and includes an "index" metadata key
 * representing its position within the document (starting from 0).
 */
public class DocumentByLineSplitter extends HierarchicalDocumentSplitter {
    public DocumentByLineSplitter(int maxSegmentSizeInChars,
                                  int maxOverlapSizeInChars) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, null);
    }
    public DocumentByLineSplitter(int maxSegmentSizeInChars,
                                  int maxOverlapSizeInChars,
                                  DocumentSplitter subSplitter) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, subSplitter);
    }
    public DocumentByLineSplitter(int maxSegmentSizeInTokens,
                                  int maxOverlapSizeInTokens,
                                  Tokenizer tokenizer) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, null);
    }
    public DocumentByLineSplitter(int maxSegmentSizeInTokens,
                                  int maxOverlapSizeInTokens,
                                  Tokenizer tokenizer,
                                  DocumentSplitter subSplitter) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, subSplitter);
    }
```

```
    @Override
    public String[] split(String text) {
        return text.split("\\s*\\R\\s*"); // additional whitespaces are
ignored
    }
    @Override
    public String joinDelimiter() {
        return "\n";
    }
    @Override
    protected DocumentSplitter defaultSubSplitter() {
        return new DocumentBySentenceSplitter(maxSegmentSize, maxOverlapSize,
tokenizer);
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\splitter\DocumentByParagraphSplitter.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
/**
 * Splits the provided {@link Document} into paragraphs and attempts to fit as many paragraphs as possible
 * into a single {@link TextSegment}, adhering to the limit set by {@code maxSegmentSize}.
 * <p>
 * The {@code maxSegmentSize} can be defined in terms of characters (default) or tokens.
 * For token-based limit, a {@link Tokenizer} must be provided.
 * <p>
 * Paragraph boundaries are detected by a minimum of two newline characters ("\n\n").
 * Any additional whitespaces before, between, or after are ignored.
 * So, the following examples are all valid paragraph separators: "\n\n", "\n\n\n", "\n \n", " \n \n ", and so on.
 * <p>
 * If multiple paragraphs fit within {@code maxSegmentSize}, they are joined together using a double newline ("\n\n").
 * <p>
 * If a single paragraph is too long and exceeds {@code maxSegmentSize},
 * the {@code subSplitter} ({@link DocumentBySentenceSplitter} by default) is used to split it into smaller parts and
 * place them into multiple segments.
 * Such segments contain only the parts of the split long paragraph.
 * <p>
 * Each {@link TextSegment} inherits all metadata from the {@link Document} and includes an "index" metadata key
 * representing its position within the document (starting from 0).
 */
public class DocumentByParagraphSplitter extends HierarchicalDocumentSplitter {
    public DocumentByParagraphSplitter(int maxSegmentSizeInChars,
                                       int maxOverlapSizeInChars) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, null);
    }
    public DocumentByParagraphSplitter(int maxSegmentSizeInChars,
                                       int maxOverlapSizeInChars,
                                       DocumentSplitter subSplitter) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, subSplitter);
    }
    public DocumentByParagraphSplitter(int maxSegmentSizeInTokens,
                                       int maxOverlapSizeInTokens,
                                       Tokenizer tokenizer) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, null);
    }
    public DocumentByParagraphSplitter(int maxSegmentSizeInTokens,
                                       int maxOverlapSizeInTokens,
                                       Tokenizer tokenizer,
                                       DocumentSplitter subSplitter) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer,
```

```
subSplitter);
    }
    @Override
    public String[] split(String text) {
        return text.split("\\s*\\R\\s*\\R\\s*"); // additional whitespaces
are ignored
    }
    @Override
    public String joinDelimiter() {
        return "\n\n";
    }
    @Override
    protected DocumentSplitter defaultSubSplitter() {
        return new DocumentBySentenceSplitter(maxSegmentSize, maxOverlapSize,
tokenizer);
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\splitter\DocumentByRegexSplitter.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * Splits the provided {@link Document} into parts using the provided {@code regex} and attempts to fit as many parts
 * as possible into a single {@link TextSegment}, adhering to the limit set by {@code maxSegmentSize}.
 * <p>
 * The {@code maxSegmentSize} can be defined in terms of characters (default) or tokens.
 * For token-based limit, a {@link Tokenizer} must be provided.
 * <p>
 * If multiple parts fit within {@code maxSegmentSize}, they are joined together using the provided {@code joinDelimiter}.
 * <p>
 * If a single part is too long and exceeds {@code maxSegmentSize}, the {@code subSplitter} (which should be provided)
 * is used to split it into sub-parts and place them into multiple segments.
 * Such segments contain only the sub-parts of the split long part.
 * <p>
 * Each {@link TextSegment} inherits all metadata from the {@link Document} and includes an "index" metadata key
 * representing its position within the document (starting from 0).
 */
public class DocumentByRegexSplitter extends HierarchicalDocumentSplitter {
    private final String regex;
    private final String joinDelimiter;
    public DocumentByRegexSplitter(String regex,
                                   String joinDelimiter,
                                   int maxSegmentSizeInChars,
                                   int maxOverlapSizeInChars) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, null);
        this.regex = ensureNotNull(regex, "regex");
        this.joinDelimiter = ensureNotNull(joinDelimiter, "joinDelimiter");
    }
    public DocumentByRegexSplitter(String regex,
                                   String joinDelimiter,
                                   int maxSegmentSizeInChars,
                                   int maxOverlapSizeInChars,
                                   DocumentSplitter subSplitter) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, subSplitter);
        this.regex = ensureNotNull(regex, "regex");
        this.joinDelimiter = ensureNotNull(joinDelimiter, "joinDelimiter");
    }
    public DocumentByRegexSplitter(String regex,
                                   String joinDelimiter,
                                   int maxSegmentSizeInTokens,
                                   int maxOverlapSizeInTokens,
                                   Tokenizer tokenizer) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, null);
        this.regex = ensureNotNull(regex, "regex");
```

```
        this.joinDelimiter = ensureNotNull(joinDelimiter, "joinDelimiter");
    }
    public DocumentByRegexSplitter(String regex,
                                   String joinDelimiter,
                                   int maxSegmentSizeInTokens,
                                   int maxOverlapSizeInTokens,
                                   Tokenizer tokenizer,
                                   DocumentSplitter subSplitter) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer,
subSplitter);
        this.regex = ensureNotNull(regex, "regex");
        this.joinDelimiter = ensureNotNull(joinDelimiter, "joinDelimiter");
    }
    @Override
    public String[] split(String text) {
        return text.split(regex);
    }
    @Override
    public String joinDelimiter() {
        return joinDelimiter;
    }
    @Override
    protected DocumentSplitter defaultSubSplitter() {
        return null;
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\splitter\DocumentBySentenceSplitter.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
import opennlp.tools.sentdetect.SentenceDetectorME;
import opennlp.tools.sentdetect.SentenceModel;
import java.io.InputStream;
/**
 * Splits the provided {@link Document} into sentences and attempts to fit as many sentences as possible
 * into a single {@link TextSegment}, adhering to the limit set by {@code maxSegmentSize}.
 * <p>
 * The {@code maxSegmentSize} can be defined in terms of characters (default) or tokens.
 * For token-based limit, a {@link Tokenizer} must be provided.
 * <p>
 * Sentence boundaries are detected using the Apache OpenNLP library with the English sentence model.
 * <p>
 * If multiple sentences fit within {@code maxSegmentSize}, they are joined together using a space (" ").
 * <p>
 * If a single sentence is too long and exceeds {@code maxSegmentSize},
 * the {@code subSplitter} ({@link DocumentByWordSplitter} by default) is used to split it into smaller parts and
 * place them into multiple segments.
 * Such segments contain only the parts of the split long sentence.
 * <p>
 * Each {@link TextSegment} inherits all metadata from the {@link Document} and includes an "index" metadata key
 * representing its position within the document (starting from 0).
 */
public class DocumentBySentenceSplitter extends HierarchicalDocumentSplitter {
    private final SentenceDetectorME sentenceDetector;
    public DocumentBySentenceSplitter(int maxSegmentSizeInChars,
                                      int maxOverlapSizeInChars) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, null);
        this.sentenceDetector = createSentenceDetector();
    }
    public DocumentBySentenceSplitter(int maxSegmentSizeInChars,
                                      int maxOverlapSizeInChars,
                                      DocumentSplitter subSplitter) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, subSplitter);
        this.sentenceDetector = createSentenceDetector();
    }
    public DocumentBySentenceSplitter(int maxSegmentSizeInTokens,
                                      int maxOverlapSizeInTokens,
                                      Tokenizer tokenizer) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, null);
        this.sentenceDetector = createSentenceDetector();
    }
    public DocumentBySentenceSplitter(int maxSegmentSizeInTokens,
                                      int maxOverlapSizeInTokens,
```

```
                                        Tokenizer tokenizer,
                                        DocumentSplitter subSplitter) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer,
subSplitter);
        this.sentenceDetector = createSentenceDetector();
    }
    private SentenceDetectorME createSentenceDetector() {
        String sentenceModelFilePath = "/opennlp/opennlp-en-ud-ewt-
sentence-1.0-1.9.3.bin";
        try (InputStream is =
getClass().getResourceAsStream(sentenceModelFilePath)) {
            return new SentenceDetectorME(new SentenceModel(is));
        } catch (Exception e) {
            throw new RuntimeException(e);
        }
    }
    @Override
    public String[] split(String text) {
        return sentenceDetector.sentDetect(text);
    }
    @Override
    public String joinDelimiter() {
        return " ";
    }
    @Override
    protected DocumentSplitter defaultSubSplitter() {
        return new DocumentByWordSplitter(maxSegmentSize, maxOverlapSize,
tokenizer);
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\splitter\DocumentByWordSplitter.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
/**
 * Splits the provided {@link Document} into words and attempts to fit as many words as possible
 * into a single {@link TextSegment}, adhering to the limit set by {@code maxSegmentSize}.
 * <p>
 * The {@code maxSegmentSize} can be defined in terms of characters (default) or tokens.
 * For token-based limit, a {@link Tokenizer} must be provided.
 * <p>
 * Word boundaries are detected by a minimum of one space (" ").
 * Any additional whitespaces before or after are ignored.
 * So, the following examples are all valid word separators: " ", "  ", "\n", and so on.
 * <p>
 * If multiple words fit within {@code maxSegmentSize}, they are joined together using a space (" ").
 * <p>
 * Although this should not happen, if a single word is too long and exceeds {@code maxSegmentSize},
 * the {@code subSplitter} ({@link DocumentByCharacterSplitter} by default) is used to split it into smaller parts and
 * place them into multiple segments.
 * Such segments contain only the parts of the split long word.
 * <p>
 * Each {@link TextSegment} inherits all metadata from the {@link Document} and includes an "index" metadata key
 * representing its position within the document (starting from 0).
 */
public class DocumentByWordSplitter extends HierarchicalDocumentSplitter {
    public DocumentByWordSplitter(int maxSegmentSizeInChars,
                                  int maxOverlapSizeInChars) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, null);
    }
    public DocumentByWordSplitter(int maxSegmentSizeInChars,
                                  int maxOverlapSizeInChars,
                                  DocumentSplitter subSplitter) {
        super(maxSegmentSizeInChars, maxOverlapSizeInChars, null, subSplitter);
    }
    public DocumentByWordSplitter(int maxSegmentSizeInTokens,
                                  int maxOverlapSizeInTokens,
                                  Tokenizer tokenizer) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, null);
    }
    public DocumentByWordSplitter(int maxSegmentSizeInTokens,
                                  int maxOverlapSizeInTokens,
                                  Tokenizer tokenizer,
                                  DocumentSplitter subSplitter) {
        super(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, subSplitter);
```

```
    }
    @Override
    public String[] split(String text) {
        return text.split("\\s+"); // additional whitespaces are ignored
    }
    @Override
    public String joinDelimiter() {
        return " ";
    }
    @Override
    protected DocumentSplitter defaultSubSplitter() {
        return new DocumentByCharacterSplitter(maxSegmentSize,
maxOverlapSize, tokenizer);
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\splitter\DocumentSplitters.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.model.Tokenizer;
public class DocumentSplitters {
    /**
     * This is a recommended {@link DocumentSplitter} for generic text.
     * It tries to split the document into paragraphs first and fits
     * as many paragraphs into a single {@link
dev.langchain4j.data.segment.TextSegment} as possible.
     * If some paragraphs are too long, they are recursively split into
lines, then sentences,
     * then words, and then characters until they fit into a segment.
     *
     * @param maxSegmentSizeInTokens The maximum size of the segment, defined
in tokens.
     * @param maxOverlapSizeInTokens The maximum size of the overlap, defined
in tokens.
     *                               Only full sentences are considered for
the overlap.
     * @param tokenizer              The tokenizer that is used to count
tokens in the text.
     * @return recursive document splitter
     */
    public static DocumentSplitter recursive(int maxSegmentSizeInTokens,
                                             int maxOverlapSizeInTokens,
                                             Tokenizer tokenizer) {
        return new DocumentByParagraphSplitter(maxSegmentSizeInTokens,
maxOverlapSizeInTokens, tokenizer,
                new DocumentByLineSplitter(maxSegmentSizeInTokens,
maxOverlapSizeInTokens, tokenizer,
                        new
DocumentBySentenceSplitter(maxSegmentSizeInTokens, maxOverlapSizeInTokens,
tokenizer,
                                new
DocumentByWordSplitter(maxSegmentSizeInTokens, maxOverlapSizeInTokens,
tokenizer)
                        )
                )
        );
    }
    /**
     * This is a recommended {@link DocumentSplitter} for generic text.
     * It tries to split the document into paragraphs first and fits
     * as many paragraphs into a single {@link
dev.langchain4j.data.segment.TextSegment} as possible.
     * If some paragraphs are too long, they are recursively split into
lines, then sentences,
     * then words, and then characters until they fit into a segment.
     *
     * @param maxSegmentSizeInChars  The maximum size of the segment, defined
in characters.
     * @param maxOverlapSizeInTokens The maximum size of the overlap, defined
in characters.
     *                               Only full sentences are considered for
the overlap.
     * @return recursive document splitter
     */
```

```
    public static DocumentSplitter recursive(int maxSegmentSizeInChars, int
maxOverlapSizeInTokens) {
        return recursive(maxSegmentSizeInChars, maxOverlapSizeInTokens, null);
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\splitter\HierarchicalDocumentSplitter.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
import java.util.ArrayList;
import java.util.List;
import java.util.concurrent.atomic.AtomicInteger;
import static dev.langchain4j.internal.Utils.firstChars;
import static dev.langchain4j.internal.ValidationUtils.*;
import static java.lang.String.format;
public abstract class HierarchicalDocumentSplitter implements
DocumentSplitter {
    private static final String INDEX = "index";
    protected final int maxSegmentSize;
    protected final int maxOverlapSize;
    protected final Tokenizer tokenizer;
    protected final DocumentSplitter subSplitter;
    protected HierarchicalDocumentSplitter(int maxSegmentSizeInChars, int
maxOverlapSizeInChars) {
        this(maxSegmentSizeInChars, maxOverlapSizeInChars, null, null);
    }
    protected HierarchicalDocumentSplitter(int maxSegmentSizeInChars,
                                           int maxOverlapSizeInChars,
                                           HierarchicalDocumentSplitter
subSplitter) {
        this(maxSegmentSizeInChars, maxOverlapSizeInChars, null, subSplitter);
    }
    protected HierarchicalDocumentSplitter(int maxSegmentSizeInTokens,
                                           int maxOverlapSizeInTokens,
                                           Tokenizer tokenizer) {
        this(maxSegmentSizeInTokens, maxOverlapSizeInTokens, tokenizer, null);
    }
    protected HierarchicalDocumentSplitter(int maxSegmentSizeInTokens,
                                           int maxOverlapSizeInTokens,
                                           Tokenizer tokenizer,
                                           DocumentSplitter subSplitter) {
        this.maxSegmentSize = ensureGreaterThanZero(maxSegmentSizeInTokens,
"maxSegmentSize");
        this.maxOverlapSize = ensureBetween(maxOverlapSizeInTokens, 0,
maxSegmentSize, "maxOverlapSize");
        this.tokenizer = tokenizer;
        this.subSplitter = subSplitter == null ? defaultSubSplitter() :
subSplitter;
    }
    protected abstract String[] split(String text);
    protected abstract String joinDelimiter();
    protected abstract DocumentSplitter defaultSubSplitter();
    @Override
    public List<TextSegment> split(Document document) {
        ensureNotNull(document, "document");
        List<TextSegment> segments = new ArrayList<>();
        SegmentBuilder segmentBuilder = new SegmentBuilder(maxSegmentSize,
this::sizeOf, joinDelimiter());
        AtomicInteger index = new AtomicInteger(0);
        String[] parts = split(document.text());
```

```
        String overlap = null;
        for (String part : parts) {
            if (segmentBuilder.hasSpaceFor(part)) {
                segmentBuilder.append(part);
            } else {
                if (segmentBuilder.isNotEmpty() && !
segmentBuilder.build().equals(overlap)) {
                    String segmentText = segmentBuilder.build();
                    segments.add(createSegment(segmentText, document,
index.getAndIncrement()));
                    segmentBuilder.reset();
                    overlap = overlapFrom(segmentText);
                    segmentBuilder.append(overlap);
                }
                if (segmentBuilder.hasSpaceFor(part)) {
                    segmentBuilder.append(part);
                } else {
                    if (subSplitter == null) {
                        throw new RuntimeException(format(
                                "The text \"%s...\" (%s %s long) doesn't fit
into the maximum segment size (%s %s), " +
                                        "and there is no subSplitter defined
to split it further.",
                                firstChars(part, 30),
                                sizeOf(part), tokenizer == null ?
"characters" : "tokens",
                                maxSegmentSize, tokenizer == null ?
"characters" : "tokens"
                        ));
                    }
                    segmentBuilder.append(part);
                    for (TextSegment segment :
subSplitter.split(Document.from(segmentBuilder.build()))) {
                        segments.add(createSegment(segment.text(), document,
index.getAndIncrement()));
                    }
                    segmentBuilder.reset();
                    TextSegment lastSegment = segments.get(segments.size() -
1);
                    overlap = overlapFrom(lastSegment.text());
                    segmentBuilder.append(overlap);
                }
            }
        }
        if (segmentBuilder.isNotEmpty() && !
segmentBuilder.build().equals(overlap)) {
            segments.add(createSegment(segmentBuilder.build(), document,
index.getAndIncrement()));
        }
        return segments;
    }
    private String overlapFrom(String segmentText) {
        if (maxOverlapSize == 0) {
            return "";
        }
        SegmentBuilder overlapBuilder = new SegmentBuilder(maxOverlapSize,
this::sizeOf, joinDelimiter());
        String[] sentences = new DocumentBySentenceSplitter(1, 0, null,
null).split(segmentText);
        for (int i = sentences.length - 1; i >= 0; i--) {
            String part = sentences[i];
```

```
            if (overlapBuilder.hasSpaceFor(part)) {
                overlapBuilder.prepend(part);
            } else {
                return overlapBuilder.build();
            }
        }
        return "";
    }
    private int sizeOf(String text) {
        if (tokenizer != null) {
            return tokenizer.estimateTokenCountInText(text);
        } else {
            return text.length();
        }
    }
    private static TextSegment createSegment(String text, Document document,
int index) {
        Metadata metadata = document.metadata().copy().add(INDEX, index);
        return TextSegment.from(text, metadata);
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\splitter\SegmentBuild
er.java

```
package dev.langchain4j.data.document.splitter;
import java.util.function.Function;
import static dev.langchain4j.internal.ValidationUtils.ensureGreaterThanZero;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
class SegmentBuilder {
    private StringBuilder segmentBuilder;
    private final int maxSegmentSize;
    private final Function<String, Integer> sizeFunction;
    private final String joinSeparator;
    SegmentBuilder(int maxSegmentSize, Function<String, Integer>
sizeFunction, String joinSeparator) {
        this.segmentBuilder = new StringBuilder();
        this.maxSegmentSize = ensureGreaterThanZero(maxSegmentSize,
"maxSegmentSize");
        this.sizeFunction = ensureNotNull(sizeFunction, "sizeFunction");
        this.joinSeparator = ensureNotNull(joinSeparator, "joinSeparator");
    }
    boolean hasSpaceFor(String text) {
        if (isNotEmpty()) {
            return sizeOf(segmentBuilder.toString()) + sizeOf(joinSeparator)
+ sizeOf(text) <= maxSegmentSize;
        } else {
            return sizeOf(text) <= maxSegmentSize;
        }
    }
    private int sizeOf(String text) {
        return sizeFunction.apply(text);
    }
    void append(String text) {
        if (isNotEmpty()) {
            segmentBuilder.append(joinSeparator);
        }
        segmentBuilder.append(text);
    }
    void prepend(String text) {
        if (isNotEmpty()) {
            segmentBuilder.insert(0, text + joinSeparator);
        } else {
            segmentBuilder.insert(0, text);
        }
    }
    boolean isNotEmpty() {
        return segmentBuilder.length() > 0;
    }
    String build() {
        return segmentBuilder.toString().trim();
    }
    void reset() {
        segmentBuilder = new StringBuilder();
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\transformer\HtmlTextExtractor.java

```
package dev.langchain4j.data.document.transformer;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentTransformer;
import dev.langchain4j.data.document.Metadata;
import org.jsoup.Jsoup;
import org.jsoup.nodes.Element;
import org.jsoup.nodes.Node;
import org.jsoup.nodes.TextNode;
import org.jsoup.select.NodeVisitor;
import java.util.Map;
import static java.lang.String.format;
import static java.util.stream.Collectors.joining;
import static org.jsoup.internal.StringUtil.in;
import static org.jsoup.select.NodeTraversor.traverse;
/**
 * Extracts text from a given HTML document.
 * A CSS selector can be specified to extract text only from desired element(s).
 * Also, multiple CSS selectors can be specified to extract metadata from desired elements.
 */
public class HtmlTextExtractor implements DocumentTransformer {
    private final String cssSelector;
    private final Map<String, String> metadataCssSelectors;
    private final boolean includeLinks;
    /**
     * Constructs an instance of HtmlToTextTransformer that extracts all text from a given Document containing HTML.
     */
    public HtmlTextExtractor() {
        this(null, null, false);
    }
    /**
     * Constructs an instance of HtmlToTextTransformer that extracts text from HTML elements matching the provided CSS selector.
     *
     * @param cssSelector          A CSS selector.
     *                             For example, "#page-content" will extract text from the HTML element with the id "page-content".
     * @param metadataCssSelectors A mapping from metadata keys to CSS selectors.
     *                             For example, Mep.of("title", "#page-title") will extract all text from the HTML element
     *                             with id "title" and store it in {@link Metadata} under the key "title".
     * @param includeLinks         Specifies whether links should be included in the extracted text.
     */
    public HtmlTextExtractor(String cssSelector, Map<String, String> metadataCssSelectors, boolean includeLinks) {
        this.cssSelector = cssSelector;
        this.metadataCssSelectors = metadataCssSelectors;
        this.includeLinks = includeLinks;
    }
    @Override
    public Document transform(Document document) {
        String html = document.text();
```

```
        org.jsoup.nodes.Document jsoupDocument = Jsoup.parse(html);
        String text;
        if (cssSelector != null) {
            text = extractText(jsoupDocument, cssSelector, includeLinks);
        } else {
            text = extractText(jsoupDocument, includeLinks);
        }
        Metadata metadata = document.metadata().copy();
        if (metadataCssSelectors != null) {
            metadataCssSelectors.forEach((metadataKey, cssSelector) ->
                    metadata.add(metadataKey,
jsoupDocument.select(cssSelector).text()));
        }
        return Document.from(text, metadata);
    }
    private static String extractText(org.jsoup.nodes.Document jsoupDocument,
String cssSelector, boolean includeLinks) {
        return jsoupDocument.select(cssSelector).stream()
                .map(element -> extractText(element, includeLinks))
                .collect(joining("\n\n"));
    }
    private static String extractText(Element element, boolean includeLinks) {
        NodeVisitor visitor = new TextExtractingVisitor(includeLinks);
        traverse(visitor, element);
        return visitor.toString().trim();
    }
    // taken from https://github.com/jhy/jsoup/blob/master/src/main/java/org/
jsoup/examples/HtmlToPlainText.java
    private static class TextExtractingVisitor implements NodeVisitor {
        private final StringBuilder textBuilder = new StringBuilder();
        private final boolean includeLinks;
        private TextExtractingVisitor(boolean includeLinks) {
            this.includeLinks = includeLinks;
        }
        @Override
        public void head(Node node, int depth) { // hit when the node is
first seen
            String name = node.nodeName();
            if (node instanceof TextNode)
                textBuilder.append(((TextNode) node).text());
            else if (name.equals("li"))
                textBuilder.append("\n * ");
            else if (name.equals("dt"))
                textBuilder.append("  ");
            else if (in(name, "p", "h1", "h2", "h3", "h4", "h5", "h6", "tr"))
                textBuilder.append("\n");
        }
        @Override
        public void tail(Node node, int depth) { // hit when all the node's
children (if any) have been visited
            String name = node.nodeName();
            if (in(name, "br", "dd", "dt", "p", "h1", "h2", "h3", "h4", "h5",
"h6"))
                textBuilder.append("\n");
            else if (includeLinks && name.equals("a"))
                textBuilder.append(format(" <%s>", node.absUrl("href")));
        }
        @Override
        public String toString() {
            return textBuilder.toString();
        }
```

```
    }
}
```

langchain4j\src\main\java\dev\langchain4j\data\document\UrlDocumentLoader.java

```
package dev.langchain4j.data.document;
import dev.langchain4j.data.document.source.UrlSource;
import java.net.MalformedURLException;
import java.net.URL;
import static dev.langchain4j.data.document.DocumentLoaderUtils.parserFor;
public class UrlDocumentLoader {
    /**
     * Loads a document from the specified URL, detecting the document type
automatically.
     * See {@link DocumentType} for the list of supported document types.
     * If the document type is UNKNOWN, it is treated as TXT.
     *
     * @param url URL of the file
     * @return document
     */
    public static Document load(URL url) {
        return load(url, DocumentType.of(url.toString()));
    }
    /**
     * Loads a document from the specified URL, detecting the document type
automatically.
     * See {@link DocumentType} for the list of supported document types.
     * If the document type is UNKNOWN, it is treated as TXT.
     *
     * @param url URL of the file
     * @return document
     * @throws RuntimeException if specified URL is malformed
     */
    public static Document load(String url) {
        try {
            return load(new URL(url));
        } catch (MalformedURLException e) {
            throw new RuntimeException(e);
        }
    }
    /**
     * Loads a document from the specified URL.
     *
     * @param url          URL of the file
     * @param documentType type of the document
     * @return document
     */
    public static Document load(URL url, DocumentType documentType) {
        return DocumentLoaderUtils.load(UrlSource.from(url),
parserFor(documentType));
    }
    /**
     * Loads a document from the specified URL.
     *
     * @param url          URL of the file
     * @param documentType type of the document
     * @return document
     * @throws RuntimeException if specified URL is malformed
     */
    public static Document load(String url, DocumentType documentType) {
        try {
            return load(new URL(url), documentType);
```

```
        } catch (MalformedURLException e) {
            throw new RuntimeException(e);
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\exception\IllegalConfigurationException.java

```
package dev.langchain4j.exception;
import static java.lang.String.format;
public class IllegalConfigurationException extends RuntimeException {
    public IllegalConfigurationException(String message) {
        super(message);
    }
    public static IllegalConfigurationException illegalConfiguration(String message) {
        return new IllegalConfigurationException(message);
    }
    public static IllegalConfigurationException illegalConfiguration(String format, Object... args) {
        return new IllegalConfigurationException(format(format, args));
    }
}
```

langchain4j\src\main\java\dev\langchain4j\memory\chat\ChatMemoryProvider.java

```
package dev.langchain4j.memory.chat;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.service.MemoryId;
/**
 * Provides instances of {@link ChatMemory}.
 * Intended to be used with {@link dev.langchain4j.service.AiServices}.
 */
@FunctionalInterface
public interface ChatMemoryProvider {
    /**
     * Provides an instance of {@link ChatMemory}.
     * This method is called each time an AI Service method (having a
parameter annotated with {@link MemoryId})
     * is called with a previously unseen memory ID.
     * Once the {@link ChatMemory} instance is returned, it's retained in
memory and managed by {@link dev.langchain4j.service.AiServices}.
     *
     * @param memoryId The ID of the chat memory.
     * @return A {@link ChatMemory} instance.
     * @see MemoryId
     */
    ChatMemory get(Object memoryId);
}
```

langchain4j\src\main\java\dev\langchain4j\memory\chat\MessageWindowChatMemory.java

```
package dev.langchain4j.memory.chat;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.SystemMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.store.memory.chat.ChatMemoryStore;
import dev.langchain4j.store.memory.chat.InMemoryChatMemoryStore;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.util.ArrayList;
import java.util.List;
import java.util.Optional;
import static dev.langchain4j.internal.ValidationUtils.ensureGreaterThanZero;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * This chat memory operates as a sliding window of {@link #maxMessages} messages.
 * It retains as many of the most recent messages as can fit into the window.
 * If there isn't enough space for a new message, the oldest one is discarded.
 * <p>
 * Once added, a {@link SystemMessage} is always retained.
 * Only one {@link SystemMessage} can be held at a time.
 * If a new {@link SystemMessage} with the same content is added, it is ignored.
 * If a new {@link SystemMessage} with different content is added, it replaces the previous one.
 * <p>
 * The state of chat memory is stored in {@link ChatMemoryStore}.
 */
public class MessageWindowChatMemory implements ChatMemory {
    private static final Logger log = LoggerFactory.getLogger(MessageWindowChatMemory.class);
    private final Object id;
    private final Integer maxMessages;
    private final ChatMemoryStore store;
    private MessageWindowChatMemory(Builder builder) {
        this.id = ensureNotNull(builder.id, "id");
        this.maxMessages = ensureGreaterThanZero(builder.maxMessages, "maxMessages");
        this.store = ensureNotNull(builder.store, "store");
    }
    @Override
    public Object id() {
        return id;
    }
    @Override
    public void add(ChatMessage message) {
        List<ChatMessage> messages = messages();
        if (message instanceof SystemMessage) {
            Optional<SystemMessage> systemMessage = findSystemMessage(messages);
            if (systemMessage.isPresent()) {
                if (systemMessage.get().equals(message)) {
                    return; // do not add the same system message
                } else {
                    messages.remove(systemMessage.get()); // need to replace existing system message
                }
```

```
            }
        }
        messages.add(message);
        ensureCapacity(messages, maxMessages);
        store.updateMessages(id, messages);
    }
    private static Optional<SystemMessage>
findSystemMessage(List<ChatMessage> messages) {
        return messages.stream()
                .filter(message -> message instanceof SystemMessage)
                .map(message -> (SystemMessage) message)
                .findAny();
    }
    @Override
    public List<ChatMessage> messages() {
        List<ChatMessage> messages = new ArrayList<>(store.getMessages(id));
        ensureCapacity(messages, maxMessages);
        return messages;
    }
    private static void ensureCapacity(List<ChatMessage> messages, int
maxMessages) {
        while (messages.size() > maxMessages) {
            int messageToRemove = 0;
            if (messages.get(0) instanceof SystemMessage) {
                messageToRemove = 1;
            }
            ChatMessage removedMessage = messages.remove(messageToRemove);
            log.trace("Removing the following message to comply with the
capacity requirements: {}", removedMessage);
        }
    }
    @Override
    public void clear() {
        store.deleteMessages(id);
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private Object id = "default";
        private Integer maxMessages;
        private ChatMemoryStore store = new InMemoryChatMemoryStore();
        /**
         * @param id The ID of the {@link ChatMemory}.
         *           If not provided, a "default" will be used.
         * @return builder
         */
        public Builder id(Object id) {
            this.id = id;
            return this;
        }
        /**
         * @param maxMessages The maximum number of messages to retain.
         * @return builder
         */
        public Builder maxMessages(Integer maxMessages) {
            this.maxMessages = maxMessages;
            return this;
        }
        /**
         * @param store The chat memory store responsible for storing the
```

```
chat memory state.
         *              If not provided, an {@link InMemoryChatMemoryStore}
will be used.
         * @return builder
         */
        public Builder chatMemoryStore(ChatMemoryStore store) {
            this.store = store;
            return this;
        }
        public MessageWindowChatMemory build() {
            return new MessageWindowChatMemory(this);
        }
    }
    public static MessageWindowChatMemory withMaxMessages(int maxMessages) {
        return builder().maxMessages(maxMessages).build();
    }
}
```

langchain4j\src\main\java\dev\langchain4j\memory\chat\TokenWindowChatMemory.java

```
package dev.langchain4j.memory.chat;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.SystemMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.store.memory.chat.ChatMemoryStore;
import dev.langchain4j.store.memory.chat.InMemoryChatMemoryStore;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.util.ArrayList;
import java.util.List;
import java.util.Optional;
import static dev.langchain4j.internal.ValidationUtils.ensureGreaterThanZero;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * This chat memory operates as a sliding window of {@link #maxTokens} tokens.
 * It retains as many of the most recent messages as can fit into the window.
 * If there isn't enough space for a new message, the oldest one (or
multiple) is discarded.
 * Messages are indivisible. If a message doesn't fit, it's discarded
completely.
 * <p>
 * Once added, a {@link SystemMessage} is always retained.
 * Only one {@link SystemMessage} can be held at a time.
 * If a new {@link SystemMessage} with the same content is added, it is
ignored.
 * If a new {@link SystemMessage} with different content is added, it
replaces the previous one.
 * <p>
 * The state of chat memory is stored in {@link ChatMemoryStore}.
 */
public class TokenWindowChatMemory implements ChatMemory {
    private static final Logger log =
LoggerFactory.getLogger(TokenWindowChatMemory.class);
    private final Object id;
    private final Integer maxTokens;
    private final Tokenizer tokenizer;
    private final ChatMemoryStore store;
    private TokenWindowChatMemory(Builder builder) {
        this.id = ensureNotNull(builder.id, "id");
        this.maxTokens = ensureGreaterThanZero(builder.maxTokens,
"maxTokens");
        this.tokenizer = ensureNotNull(builder.tokenizer, "tokenizer");
        this.store = ensureNotNull(builder.store, "store");
    }
    @Override
    public Object id() {
        return id;
    }
    @Override
    public void add(ChatMessage message) {
        List<ChatMessage> messages = messages();
        if (message instanceof SystemMessage) {
            Optional<SystemMessage> maybeSystemMessage =
findSystemMessage(messages);
            if (maybeSystemMessage.isPresent()) {
                if (maybeSystemMessage.get().equals(message)) {
```

```
                    return; // do not add the same system message
                } else {
                    messages.remove(maybeSystemMessage.get()); // need to
replace existing system message
                }
            }
        }
        messages.add(message);
        ensureCapacity(messages, maxTokens, tokenizer);
        store.updateMessages(id, messages);
    }
    private static Optional<SystemMessage>
findSystemMessage(List<ChatMessage> messages) {
        return messages.stream()
                .filter(message -> message instanceof SystemMessage)
                .map(message -> (SystemMessage) message)
                .findAny();
    }
    @Override
    public List<ChatMessage> messages() {
        List<ChatMessage> messages = new ArrayList<>(store.getMessages(id));
        ensureCapacity(messages, maxTokens, tokenizer);
        return messages;
    }
    private static void ensureCapacity(List<ChatMessage> messages, int
maxTokens, Tokenizer tokenizer) {
        int currentTokenCount =
tokenizer.estimateTokenCountInMessages(messages);
        while (currentTokenCount > maxTokens) {
            int messageToRemove = 0;
            if (messages.get(0) instanceof SystemMessage) {
                messageToRemove = 1;
            }
            ChatMessage removedMessage = messages.remove(messageToRemove);
            int tokenCountOfRemovedMessage =
tokenizer.estimateTokenCountInMessage(removedMessage);
            log.trace("Removing the following message ({} tokens) to comply
with the capacity requirements: {}",
                    tokenCountOfRemovedMessage, removedMessage);
            currentTokenCount -= tokenCountOfRemovedMessage;
        }
    }
    @Override
    public void clear() {
        store.deleteMessages(id);
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private Object id = "default";
        private Integer maxTokens;
        private Tokenizer tokenizer;
        private ChatMemoryStore store = new InMemoryChatMemoryStore();
        /**
         * @param id The ID of the {@link ChatMemory}.
         *           If not provided, a "default" will be used.
         * @return builder
         */
        public Builder id(Object id) {
            this.id = id;
```

```
            return this;
        }
        /**
         * @param maxTokens The maximum number of tokens to retain.
         *                  Chat memory will retain as many of the most
recent messages as can fit into {@code maxTokens}.
         *                  Messages are indivisible. If a message doesn't
fit, it's discarded completely.
         * @param tokenizer A {@link Tokenizer} responsible for counting
tokens in the messages.
         * @return builder
         */
        public Builder maxTokens(Integer maxTokens, Tokenizer tokenizer) {
            this.maxTokens = maxTokens;
            this.tokenizer = tokenizer;
            return this;
        }
        /**
         * @param store The chat memory store responsible for storing the
chat memory state.
         *              If not provided, an {@link InMemoryChatMemoryStore}
will be used.
         * @return builder
         */
        public Builder chatMemoryStore(ChatMemoryStore store) {
            this.store = store;
            return this;
        }
        public TokenWindowChatMemory build() {
            return new TokenWindowChatMemory(this);
        }
    }
    public static TokenWindowChatMemory withMaxTokens(int maxTokens,
Tokenizer tokenizer) {
        return builder().maxTokens(maxTokens, tokenizer).build();
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\BigDecimalOutputParser.java

```
package dev.langchain4j.model.output;
import java.math.BigDecimal;
public class BigDecimalOutputParser implements OutputParser<BigDecimal> {
    @Override
    public BigDecimal parse(String string) {
        return new BigDecimal(string);
    }
    @Override
    public String formatInstructions() {
        return "floating point number";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\BigIntegerOutputParser.java

```
package dev.langchain4j.model.output;
import java.math.BigInteger;
public class BigIntegerOutputParser implements OutputParser<BigInteger> {
    @Override
    public BigInteger parse(String string) {
        return new BigInteger(string);
    }
    @Override
    public String formatInstructions() {
        return "integer number";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\BooleanOutputParser.java

```
package dev.langchain4j.model.output;
public class BooleanOutputParser implements OutputParser<Boolean> {
    @Override
    public Boolean parse(String string) {
        return Boolean.parseBoolean(string);
    }
    @Override
    public String formatInstructions() {
        return "one of [true, false]";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\ByteOutputParser.java

```
package dev.langchain4j.model.output;
public class ByteOutputParser implements OutputParser<Byte> {
    @Override
    public Byte parse(String string) {
        return Byte.parseByte(string);
    }
    @Override
    public String formatInstructions() {
        return "integer number in range [-128, 127]";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\DateOutputParser.java

```
package dev.langchain4j.model.output;
import java.text.ParseException;
import java.text.SimpleDateFormat;
import java.util.Date;
public class DateOutputParser implements OutputParser<Date> {
    private static final String DATE_PATTERN = "yyyy-MM-dd";
    private static final SimpleDateFormat SIMPLE_DATE_FORMAT = new
SimpleDateFormat(DATE_PATTERN);
    @Override
    public Date parse(String string) {
        try {
            return SIMPLE_DATE_FORMAT.parse(string);
        } catch (ParseException e) {
            throw new RuntimeException(e);
        }
    }
    @Override
    public String formatInstructions() {
        return DATE_PATTERN;
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\DoubleOutputParser.java

```
package dev.langchain4j.model.output;
public class DoubleOutputParser implements OutputParser<Double> {
    @Override
    public Double parse(String string) {
        return Double.parseDouble(string);
    }
    @Override
    public String formatInstructions() {
        return "floating point number";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\EnumOutputParser.java

```
package dev.langchain4j.model.output;
import dev.langchain4j.internal.Json;
import java.util.Arrays;
public class EnumOutputParser implements OutputParser<Enum> {
    private final Class<? extends Enum> enumClass;
    public EnumOutputParser(Class<? extends Enum> enumClass) {
        this.enumClass = enumClass;
    }
    @Override
    public Enum parse(String string) {
        return Json.fromJson(string, enumClass);
    }
    @Override
    public String formatInstructions() {
        return "one of " + Arrays.toString(enumClass.getEnumConstants());
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\FloatOutputParser.java

```
package dev.langchain4j.model.output;
public class FloatOutputParser implements OutputParser<Float> {
    @Override
    public Float parse(String string) {
        return Float.parseFloat(string);
    }
    @Override
    public String formatInstructions() {
        return "floating point number";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\IntOutputParser.java

```
package dev.langchain4j.model.output;
public class IntOutputParser implements OutputParser<Integer> {
    @Override
    public Integer parse(String string) {
        return Integer.parseInt(string);
    }
    @Override
    public String formatInstructions() {
        return "integer number";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\LocalDateOutputParser.java

```
package dev.langchain4j.model.output;
import java.time.LocalDate;
import static java.time.format.DateTimeFormatter.ISO_LOCAL_DATE;
public class LocalDateOutputParser implements OutputParser<LocalDate> {
    @Override
    public LocalDate parse(String string) {
        return LocalDate.parse(string, ISO_LOCAL_DATE);
    }
    @Override
    public String formatInstructions() {
        return "2023-12-31";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\LocalDateTimeOutputParser.java

```
package dev.langchain4j.model.output;
import java.time.LocalDateTime;
import static java.time.format.DateTimeFormatter.ISO_LOCAL_DATE_TIME;
public class LocalDateTimeOutputParser implements OutputParser<LocalDateTime>
{
    @Override
    public LocalDateTime parse(String string) {
        return LocalDateTime.parse(string, ISO_LOCAL_DATE_TIME);
    }
    @Override
    public String formatInstructions() {
        return "2023-12-31T23:59:59";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\LocalTimeOutputParser.java

```
package dev.langchain4j.model.output;
import java.time.LocalTime;
import static java.time.format.DateTimeFormatter.ISO_LOCAL_TIME;
public class LocalTimeOutputParser implements OutputParser<LocalTime> {
    @Override
    public LocalTime parse(String string) {
        return LocalTime.parse(string, ISO_LOCAL_TIME);
    }
    @Override
    public String formatInstructions() {
        return "23:59:59";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\LongOutputParser.java

```
package dev.langchain4j.model.output;
public class LongOutputParser implements OutputParser<Long> {
    @Override
    public Long parse(String string) {
        return Long.parseLong(string);
    }
    @Override
    public String formatInstructions() {
        return "integer number";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\model\output\ShortOutputParser.java

```
package dev.langchain4j.model.output;
public class ShortOutputParser implements OutputParser<Short> {
    @Override
    public Short parse(String string) {
        return Short.parseShort(string);
    }
    @Override
    public String formatInstructions() {
        return "integer number in range [-32768, 32767]";
    }
}
```

langchain4j\src\main\java\dev\langchain4j\retriever\EmbeddingStoreRetriever.java

```
package dev.langchain4j.retriever;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import java.util.List;
import static java.util.stream.Collectors.toList;
public class EmbeddingStoreRetriever implements Retriever<TextSegment> {
    private final EmbeddingStore<TextSegment> embeddingStore;
    private final EmbeddingModel embeddingModel;
    private final int maxResults;
    private final Double minScore;
    public EmbeddingStoreRetriever(EmbeddingStore<TextSegment> embeddingStore,
                                   EmbeddingModel embeddingModel,
                                   int maxResults,
                                   Double minScore) {
        this.embeddingStore = embeddingStore;
        this.embeddingModel = embeddingModel;
        this.maxResults = maxResults;
        this.minScore = minScore;
    }
    @Override
    public List<TextSegment> findRelevant(String text) {
        Embedding embeddedText = embeddingModel.embed(text).content();
        List<EmbeddingMatch<TextSegment>> relevant;
        if (minScore == null) {
            relevant = embeddingStore.findRelevant(embeddedText, maxResults);
        } else {
            relevant = embeddingStore.findRelevant(embeddedText, maxResults,
minScore);
        }
        return relevant.stream()
                .map(EmbeddingMatch::embedded)
                .collect(toList());
    }
    public static EmbeddingStoreRetriever from(EmbeddingStore<TextSegment>
embeddingStore, EmbeddingModel embeddingModel) {
        return new EmbeddingStoreRetriever(embeddingStore, embeddingModel, 2,
null);
    }
    public static EmbeddingStoreRetriever from(EmbeddingStore<TextSegment>
embeddingStore, EmbeddingModel embeddingModel, int maxResults) {
        return new EmbeddingStoreRetriever(embeddingStore, embeddingModel,
maxResults, null);
    }
    public static EmbeddingStoreRetriever from(EmbeddingStore<TextSegment>
embeddingStore, EmbeddingModel embeddingModel, int maxResults, double
minScore) {
        return new EmbeddingStoreRetriever(embeddingStore, embeddingModel,
maxResults, minScore);
    }
}
```

langchain4j\src\main\java\dev\langchain4j\service\AiServiceContext.java

```
package dev.langchain4j.service;
import dev.langchain4j.agent.tool.ToolExecutor;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.ChatMemoryProvider;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.moderation.ModerationModel;
import dev.langchain4j.retriever.Retriever;
import java.util.List;
import java.util.Map;
class AiServiceContext {
    Class<?> aiServiceClass;
    ChatLanguageModel chatModel;
    StreamingChatLanguageModel streamingChatModel;
    Map</* id */ Object, ChatMemory> chatMemories;
    ChatMemoryProvider chatMemoryProvider;
    ModerationModel moderationModel;
    List<ToolSpecification> toolSpecifications;
    Map<String, ToolExecutor> toolExecutors;
    Retriever<TextSegment> retriever;
    boolean hasChatMemory() {
        return chatMemories != null;
    }
    ChatMemory chatMemory(Object memoryId) {
        return chatMemories.computeIfAbsent(memoryId, ignored ->
chatMemoryProvider.get(memoryId));
    }
}
```

langchain4j\src\main\java\dev\langchain4j\service\AiServices.java

```
package dev.langchain4j.service;
import dev.langchain4j.agent.tool.Tool;
import dev.langchain4j.agent.tool.ToolExecutionRequest;
import dev.langchain4j.agent.tool.ToolExecutor;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.ToolExecutionResultMessage;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.ChatMemoryProvider;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.input.PromptTemplate;
import dev.langchain4j.model.input.structured.StructuredPrompt;
import dev.langchain4j.model.input.structured.StructuredPromptProcessor;
import dev.langchain4j.model.moderation.Moderation;
import dev.langchain4j.model.moderation.ModerationModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.retriever.Retriever;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.lang.reflect.*;
import java.util.*;
import java.util.concurrent.*;
import static
dev.langchain4j.agent.tool.ToolSpecifications.toolSpecificationFrom;
import static dev.langchain4j.data.message.ToolExecutionResultMessage.toolExec
utionResultMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static
dev.langchain4j.exception.IllegalConfigurationException.illegalConfiguration;
import static dev.langchain4j.internal.Exceptions.illegalArgument;
import static
dev.langchain4j.service.ServiceOutputParser.outputFormatInstructions;
import static java.util.Collections.singletonMap;
import static java.util.stream.Collectors.joining;
import static java.util.stream.Collectors.toList;
/**
 * AI Services provide a simpler and more flexible alternative to chains.
 * You can define your own API (a Java interface with one or more methods),
 * and AiServices will provide an implementation for it (we call this "AI
Service").
 * <p>
 * Currently, AI Services support:
 * <pre>
 * - Prompt templates for user and system messages using {@link UserMessage}
and {@link SystemMessage}
 * - Structured prompts as method arguments (see {@link StructuredPrompt})
 * - Shared or per-user (see {@link MemoryId}) chat memory
 * - Retrievers
 * - Tools (see {@link Tool})
 * - Various return types (output parsers), see below
 * - Streaming (use {@link TokenStream} as a return type)
 * - Auto-moderation using {@link Moderate}
 * </pre>
 * <p>
```

```
 * Here is the simplest example of an AI Service:
 *
 * <pre>
 * interface Assistant {
 *
 *     String chat(String userMessage);
 * }
 *
 * Assistant assistant = AiServices.create(Assistant.class, model);
 *
 * String answer = assistant.chat("hello");
 * System.out.println(answer); // Hello, how can I help you today?
 * </pre>
 *
 * <pre>
 * The return type of methods in your AI Service can be any of the following:
 * - a {@code String} or an {@link AiMessage}, if you want to get the answer
from the LLM as-is
 * - a {@code List<String>} or {@code Set<String>}, if you want to receive
the answer as a collection of items or bullet points
 * - any {@code Enum} or a {@code boolean}, if you want to use the LLM for
classification
 * - a primitive or boxed Java type: {@code int}, {@code Double}, etc., if
you want to use the LLM for data extraction
 * - many default Java types: {@code Date}, {@code LocalDateTime}, {@code
BigDecimal}, etc., if you want to use the LLM for data extraction
 * - any custom POJO, if you want to use the LLM for data extraction
 * </pre>
 * <p>
 * Let's see how we can classify the sentiment of a text:
 * <pre>
 * enum Sentiment {
 *     POSITIVE, NEUTRAL, NEGATIVE
 * }
 *
 * interface SentimentAnalyzer {
 *
 *     {@code @UserMessage}("Analyze sentiment of {{it}}")
 *     Sentiment analyzeSentimentOf(String text);
 * }
 *
 * SentimentAnalyzer assistant = AiServices.create(SentimentAnalyzer.class,
model);
 *
 * Sentiment sentiment = analyzeSentimentOf.chat("I love you");
 * System.out.println(sentiment); // POSITIVE
 * </pre>
 * <p>
 * As demonstrated, you can put {@link UserMessage} and {@link SystemMessage}
annotations above a method to define
 * templates for user and system messages, respectively.
 * In this example, the special {@code {{it}}} prompt template variable is
used because there's only one method parameter.
 * However, you can use more parameters as demonstrated in the following
example:
 * <pre>
 * interface Translator {
 *
 *     {@code @SystemMessage}("You are a professional translator into
{{language}}")
 *     {@code @UserMessage}("Translate the following text: {{text}}")
```

```
 *     String translate(@V("text") String text, @V("language") String
language);
 * }
 * </pre>
 * <p>
 * See more examples <a href="https://github.com/langchain4j/langchain4j-
examples/tree/main/other-examples/src/main/java">here</a>.
 *
 * @param <T> The interface for which AiServices will provide an
implementation.
 */
public class AiServices<T> {
    private final Logger log = LoggerFactory.getLogger(AiServices.class);
    private static final String DEFAULT = "default";
    private final AiServiceContext context = new AiServiceContext();
    private AiServices(Class<T> aiServiceClass) {
        context.aiServiceClass = aiServiceClass;
    }
    /**
     * Creates an AI Service (an implementation of the provided interface),
that is backed by the provided chat model.
     * This convenience method can be used to create simple AI Services.
     * For more complex cases, please use {@link #builder}.
     *
     * @param aiService         The class of the interface to be implemented.
     * @param chatLanguageModel The chat model to be used under the hood.
     * @return An instance of the provided interface, implementing all its
defined methods.
     */
    public static <T> T create(Class<T> aiService, ChatLanguageModel
chatLanguageModel) {
        return builder(aiService)
                .chatLanguageModel(chatLanguageModel)
                .build();
    }
    /**
     * Creates an AI Service (an implementation of the provided interface),
that is backed by the provided streaming chat model.
     * This convenience method can be used to create simple AI Services.
     * For more complex cases, please use {@link #builder}.
     *
     * @param aiService                 The class of the interface to be
implemented.
     * @param streamingChatLanguageModel The streaming chat model to be used
under the hood.
     *                                  The return type of all methods
should be {@link TokenStream}.
     * @return An instance of the provided interface, implementing all its
defined methods.
     */
    public static <T> T create(Class<T> aiService, StreamingChatLanguageModel
streamingChatLanguageModel) {
        return builder(aiService)
                .streamingChatLanguageModel(streamingChatLanguageModel)
                .build();
    }
    /**
     * Begins the construction of an AI Service.
     *
     * @param aiService The class of the interface to be implemented.
     * @return builder
```

```
     */
    public static <T> AiServices<T> builder(Class<T> aiService) {
        return new AiServices<>(aiService);
    }
    /**
     * Configures chat model that will be used under the hood of the AI
Service.
     * <p>
     * Either {@link ChatLanguageModel} or {@link StreamingChatLanguageModel}
should be configured,
     * but not both at the same time.
     *
     * @param chatLanguageModel Chat model that will be used under the hood
of the AI Service.
     * @return builder
     */
    public AiServices<T> chatLanguageModel(ChatLanguageModel
chatLanguageModel) {
        context.chatModel = chatLanguageModel;
        return this;
    }
    /**
     * Configures streaming chat model that will be used under the hood of
the AI Service.
     * The methods of the AI Service must return a {@link TokenStream} type.
     * <p>
     * Either {@link ChatLanguageModel} or {@link StreamingChatLanguageModel}
should be configured,
     * but not both at the same time.
     *
     * @param streamingChatLanguageModel Streaming chat model that will be
used under the hood of the AI Service.
     * @return builder
     */
    public AiServices<T>
streamingChatLanguageModel(StreamingChatLanguageModel
streamingChatLanguageModel) {
        context.streamingChatModel = streamingChatLanguageModel;
        return this;
    }
    /**
     * Configures the chat memory that will be used to preserve conversation
history between method calls.
     * <p>
     * Unless a {@link ChatMemory} or {@link ChatMemoryProvider} is
configured, all method calls will be independent of each other.
     * In other words, the LLM will not remember the conversation from the
previous method calls.
     * <p>
     * The same {@link ChatMemory} instance will be used for every method
call.
     * <p>
     * If you want to have a separate {@link ChatMemory} for each user/
conversation, configure {@link #chatMemoryProvider} instead.
     * <p>
     * Either a {@link ChatMemory} or a {@link ChatMemoryProvider} can be
configured, but not both simultaneously.
     *
     * @param chatMemory An instance of chat memory to be used by the AI
Service.
     * @return builder
```

```
     */
    public AiServices<T> chatMemory(ChatMemory chatMemory) {
        context.chatMemories = new ConcurrentHashMap<>();
        context.chatMemories.put(DEFAULT, chatMemory);
        return this;
    }
    /**
     * Configures the chat memory provider, which provides a dedicated
instance of {@link ChatMemory} for each user/conversation.
     * To distinguish between users/conversations, one of the method's
arguments should be a memory ID (of any data type)
     * annotated with {@link MemoryId}.
     * For each new (previously unseen) memoryId, an instance of {@link
ChatMemory} will be automatically obtained
     * by invoking {@link ChatMemoryProvider#get(Object id)}.
     * Example:
     * <pre>
     * interface Assistant {
     *
     *     String chat(@MemoryId int memoryId, @UserMessage String message);
     * }
     * </pre>
     * If you prefer to use the same (shared) {@link ChatMemory} for all
users/conversations, configure a {@link #chatMemory} instead.
     * <p>
     * Either a {@link ChatMemory} or a {@link ChatMemoryProvider} can be
configured, but not both simultaneously.
     *
     * @param chatMemoryProvider The provider of a {@link ChatMemory} for
each new user/conversation.
     * @return builder
     */
    public AiServices<T> chatMemoryProvider(ChatMemoryProvider
chatMemoryProvider) {
        context.chatMemories = new ConcurrentHashMap<>();
        context.chatMemoryProvider = chatMemoryProvider;
        return this;
    }
    /**
     * Configures a moderation model to be used for automatic content
moderation.
     * If a method in the AI Service is annotated with {@link Moderate}, the
moderation model will be invoked
     * to check the user content for any inappropriate or harmful material.
     *
     * @param moderationModel The moderation model to be used for content
moderation.
     * @return builder
     * @see Moderate
     */
    public AiServices<T> moderationModel(ModerationModel moderationModel) {
        context.moderationModel = moderationModel;
        return this;
    }
    /**
     * Configures the tools that the LLM can use.
     * A {@link ChatMemory} that can hold at least 3 messages is required for
the tools to work properly.
     *
     * @param objectsWithTools One or more objects whose methods are
annotated with {@link Tool}.
```

```
     *                           All these tools (methods annotated with {@link
Tool}) will be accessible to the LLM.
     *                           Note that inherited methods are ignored.
     * @return builder
     * @see Tool
     */
    public AiServices<T> tools(Object... objectsWithTools) {
        return tools(Arrays.asList(objectsWithTools));
    }
    /**
     * Configures the tools that the LLM can use.
     * A {@link ChatMemory} that can hold at least 3 messages is required for
the tools to work properly.
     *
     * @param objectsWithTools A list of objects whose methods are annotated
with {@link Tool}.
     *                           All these tools (methods annotated with {@link
Tool}) are accessible to the LLM.
     *                           Note that inherited methods are ignored.
     * @return builder
     * @see Tool
     */
    public AiServices<T> tools(List<Object> objectsWithTools) {
        context.toolSpecifications = new ArrayList<>();
        context.toolExecutors = new HashMap<>();
        for (Object objectWithTool : objectsWithTools) {
            for (Method method :
objectWithTool.getClass().getDeclaredMethods()) {
                if (method.isAnnotationPresent(Tool.class)) {
                    ToolSpecification toolSpecification =
toolSpecificationFrom(method);
                    context.toolSpecifications.add(toolSpecification);
                    context.toolExecutors.put(toolSpecification.name(), new
ToolExecutor(objectWithTool, method));
                }
            }
        }
        return this;
    }
    // TODO separate retriever per user
    // TODO way to configure custom prompt with original message and context
    // TODO callback to transform/filter retrieved segments
    /**
     * Configures a retriever that will be invoked on every method call to
fetch relevant information
     * related to the current user message from an underlying source (e.g.,
embedding store).
     * This relevant information is automatically injected into the message
sent to the LLM.
     *
     * @param retriever The retriever to be used by the AI Service.
     * @return builder
     */
    public AiServices<T> retriever(Retriever<TextSegment> retriever) {
        context.retriever = retriever;
        return this;
    }
    /**
     * Constructs and returns the AI Service.
     *
     * @return An instance of the AI Service implementing the specified
```

```
interface.
     */
    public T build() {
        if (context.chatModel == null && context.streamingChatModel == null) {
            throw illegalConfiguration("Please specify either
chatLanguageModel or streamingChatLanguageModel");
        }
        for (Method method : context.aiServiceClass.getMethods()) {
            if (method.isAnnotationPresent(Moderate.class) &&
context.moderationModel == null) {
                throw illegalConfiguration("The @Moderate annotation is
present, but the moderationModel is not set up. " +
                        "Please ensure a valid moderationModel is configured
before using the @Moderate annotation.");
            }
        }
        if (context.toolSpecifications != null && !context.hasChatMemory()) {
            throw illegalConfiguration(
                    "Please set up chatMemory or chatMemoryProvider in order
to use tools. "
                            + "A ChatMemory that can hold at least 3 messages
is required for the tools to work properly. "
                            + "While the LLM can technically execute a tool
without chat memory, if it only receives the " +
                            "result of the tool's execution without the
initial message from the user, it won't interpret " +
                            "the result properly."
            );
        }
        Object proxyInstance = Proxy.newProxyInstance(
                context.aiServiceClass.getClassLoader(),
                new Class<?>[]{context.aiServiceClass},
                new InvocationHandler() {
                    private final ExecutorService executor =
Executors.newCachedThreadPool();
                    @Override
                    public Object invoke(Object proxy, Method method,
Object[] args) throws Exception {
                        if (method.getDeclaringClass() == Object.class) {
                            // methods like equals(), hashCode() and
toString() should not be handled by this proxy
                            return method.invoke(this, args);
                        }
                        validateParameters(method);
                        Optional<ChatMessage> systemMessage =
prepareSystemMessage(method, args);
                        ChatMessage userMessage = prepareUserMessage(method,
args);
                        if (context.retriever != null) { // TODO extract
method/class
                            List<TextSegment> relevant =
context.retriever.findRelevant(userMessage.text());
                            if (relevant == null || relevant.isEmpty()) {
                                log.debug("No relevant information was
found");
                            } else {
                                String relevantConcatenated =
relevant.stream()
                                        .map(TextSegment::text)
                                        .collect(joining("\n\n"));
                                log.debug("Retrieved relevant information:\n"
```

```
+ relevantConcatenated + "\n");
                                userMessage = userMessage(userMessage.text()
                                        + "\n\nHere is some information that
might be useful for answering:\n\n"
                                        + relevantConcatenated);
                            }
                        }
                        Object memoryId = memoryId(method,
args).orElse(DEFAULT);
                        if (context.hasChatMemory()) {
                            ChatMemory chatMemory =
context.chatMemory(memoryId);
                            systemMessage.ifPresent(chatMemory::add);
                            chatMemory.add(userMessage);
                        }
                        List<ChatMessage> messages;
                        if (context.hasChatMemory()) {
                            messages =
context.chatMemory(memoryId).messages();
                        } else {
                            messages = new ArrayList<>();
                            systemMessage.ifPresent(messages::add);
                            messages.add(userMessage);
                        }
                        Future<Moderation> moderationFuture =
triggerModerationIfNeeded(method, messages);
                        if (method.getReturnType() == TokenStream.class) {
                            return new AiServiceTokenStream(messages,
context, memoryId); // TODO moderation
                        }
                        Response<AiMessage> response =
context.toolSpecifications != null ?
                                context.chatModel.generate(messages,
context.toolSpecifications) :
                                context.chatModel.generate(messages);
                        verifyModerationIfNeeded(moderationFuture);
                        ToolExecutionRequest toolExecutionRequest;
                        while (true) { // TODO limit number of cycles
                            if (context.hasChatMemory()) {

context.chatMemory(memoryId).add(response.content());
                            }
                            toolExecutionRequest =
response.content().toolExecutionRequest();
                            if (toolExecutionRequest == null) {
                                break;
                            }
                            ToolExecutor toolExecutor =
context.toolExecutors.get(toolExecutionRequest.name());
                            String toolExecutionResult =
toolExecutor.execute(toolExecutionRequest);
                            ToolExecutionResultMessage
toolExecutionResultMessage
                                    =
toolExecutionResultMessage(toolExecutionRequest.name(), toolExecutionResult);
                            ChatMemory chatMemory =
context.chatMemory(memoryId);
                            chatMemory.add(toolExecutionResultMessage);
                            response =
context.chatModel.generate(chatMemory.messages(), context.toolSpecifications);
                        }
```

```
                        return ServiceOutputParser.parse(response,
method.getReturnType());
                    }
                    private Future<Moderation>
triggerModerationIfNeeded(Method method, List<ChatMessage> messages) {
                        if (method.isAnnotationPresent(Moderate.class)) {
                            return executor.submit(() -> {
                                List<ChatMessage> messagesToModerate =
removeToolMessages(messages);
                                return
context.moderationModel.moderate(messagesToModerate).content();
                            });
                        }
                        return null;
                    }
                    private List<ChatMessage>
removeToolMessages(List<ChatMessage> messages) {
                        return messages.stream()
                                .filter(it -> !(it instanceof
ToolExecutionResultMessage))
                                .filter(it -> !(it instanceof AiMessage &&
((AiMessage) it).toolExecutionRequest() != null))
                                .collect(toList());
                    }
                    private void verifyModerationIfNeeded(Future<Moderation>
moderationFuture) {
                        if (moderationFuture != null) {
                            try {
                                Moderation moderation =
moderationFuture.get();
                                if (moderation.flagged()) {
                                    throw new
ModerationException(String.format("Text \"%s\" violates content policy",
moderation.flaggedText()));
                                }
                            } catch (InterruptedException |
ExecutionException e) {
                                throw new RuntimeException(e);
                            }
                        }
                    }
                });
        return (T) proxyInstance;
    }
    private Optional<Object> memoryId(Method method, Object[] args) {
        Parameter[] parameters = method.getParameters();
        for (int i = 0; i < parameters.length; i++) {
            if (parameters[i].isAnnotationPresent(MemoryId.class)) {
                Object memoryId = args[i];
                if (memoryId == null) {
                    throw illegalArgument("The value of parameter %s
annotated with @MemoryId in method %s must not be null",
                            parameters[i].getName(), method.getName());
                }
                return Optional.of(memoryId);
            }
        }
        return Optional.empty();
    }
    private Optional<ChatMessage> prepareSystemMessage(Method method,
Object[] args) {
```

```
        Parameter[] parameters = method.getParameters();
        Map<String, Object> variables = getPromptTemplateVariables(args,
parameters);
        SystemMessage annotation = method.getAnnotation(SystemMessage.class);
        if (annotation != null) {
            String systemMessageTemplate =
String.join(annotation.delimiter(), annotation.value());
            if (systemMessageTemplate.isEmpty()) {
                throw illegalConfiguration("@SystemMessage's template cannot
be empty");
            }
            Prompt prompt =
PromptTemplate.from(systemMessageTemplate).apply(variables);
            return Optional.of(prompt.toSystemMessage());
        }
        return Optional.empty();
    }
    private static ChatMessage prepareUserMessage(Method method, Object[]
args) {
        Parameter[] parameters = method.getParameters();
        Map<String, Object> variables = getPromptTemplateVariables(args,
parameters);
        String outputFormatInstructions =
outputFormatInstructions(method.getReturnType());
        String userName = getUserName(parameters, args);
        UserMessage annotation = method.getAnnotation(UserMessage.class);
        if (annotation != null) {
            String userMessageTemplate = String.join(annotation.delimiter(),
annotation.value()) + outputFormatInstructions;
            if (userMessageTemplate.contains("{{it}}")) {
                if (parameters.length != 1) {
                    throw illegalConfiguration("Error: The {{it}} placeholder
is present but the method does not have exactly one parameter. " +
                            "Please ensure that methods using the {{it}}
placeholder have exactly one parameter.");
                }
                variables = singletonMap("it", toString(args[0]));
            }
            Prompt prompt =
PromptTemplate.from(userMessageTemplate).apply(variables);
            return userMessage(userName, prompt.text());
        }
        for (int i = 0; i < parameters.length; i++) {
            if (parameters[i].isAnnotationPresent(UserMessage.class)) {
                return userMessage(userName, toString(args[i]) +
outputFormatInstructions);
            }
        }
        if (args == null || args.length == 0) {
            throw illegalConfiguration("Method should have at least one
argument");
        }
        if (args.length == 1) {
            return userMessage(userName, toString(args[0]) +
outputFormatInstructions);
        }
        throw illegalConfiguration("For methods with multiple parameters,
each parameter must be annotated with @V, @UserMessage, @UserName or
@MemoryId");
    }
    private static String getUserName(Parameter[] parameters, Object[] args) {
```

```
        for (int i = 0; i < parameters.length; i++) {
            if (parameters[i].isAnnotationPresent(UserName.class)) {
                return args[i].toString();
            }
        }
        return null;
    }
    private static void validateParameters(Method method) {
        Parameter[] parameters = method.getParameters();
        if (parameters == null || parameters.length < 2) {
            return;
        }
        for (Parameter parameter : parameters) {
            V v = parameter.getAnnotation(V.class);
            UserMessage userMessage =
parameter.getAnnotation(UserMessage.class);
            MemoryId memoryId = parameter.getAnnotation(MemoryId.class);
            UserName userName = parameter.getAnnotation(UserName.class);
            if (v == null && userMessage == null && memoryId == null &&
userName == null) {
                throw illegalConfiguration(
                        "Parameter '%s' of method '%s' should be annotated
with @V or @UserMessage or @UserName or @MemoryId",
                        parameter.getName(), method.getName()
                );
            }
        }
    }
    private static Map<String, Object> getPromptTemplateVariables(Object[]
args, Parameter[] parameters) {
        Map<String, Object> variables = new HashMap<>();
        for (int i = 0; i < parameters.length; i++) {
            V varAnnotation = parameters[i].getAnnotation(V.class);
            if (varAnnotation != null) {
                String variableName = varAnnotation.value();
                Object variableValue = args[i];
                variables.put(variableName, variableValue);
            }
        }
        return variables;
    }
    private static Object toString(Object arg) {
        if (arg.getClass().isArray()) {
            return arrayToString(arg);
        } else if
(arg.getClass().isAnnotationPresent(StructuredPrompt.class)) {
            return StructuredPromptProcessor.toPrompt(arg).text();
        } else {
            return arg.toString();
        }
    }
    private static String arrayToString(Object arg) {
        StringBuilder sb = new StringBuilder("[");
        int length = Array.getLength(arg);
        for (int i = 0; i < length; i++) {
            sb.append(toString(Array.get(arg, i)));
            if (i < length - 1) {
                sb.append(", ");
            }
        }
        sb.append("]");
```

```
        return sb.toString();
    }
}
```

langchain4j\src\main\java\dev\langchain4j\service\AiServiceStreamingResponseHandler.java

```
package dev.langchain4j.service;
import dev.langchain4j.agent.tool.ToolExecutionRequest;
import dev.langchain4j.agent.tool.ToolExecutor;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ToolExecutionResultMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.util.function.Consumer;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * Handles response from a language model for AI Service that is streamed token-by-token.
 * Handles both regular (text) responses and responses with the request to execute a tool.
 */
class AiServiceStreamingResponseHandler implements StreamingResponseHandler<AiMessage> {
    private final Logger log = LoggerFactory.getLogger(AiServiceStreamingResponseHandler.class);
    private final AiServiceContext context;
    private final Object memoryId;
    private final Consumer<String> tokenHandler;
    private final Consumer<Response<AiMessage>> completionHandler;
    private final Consumer<Throwable> errorHandler;
    private final TokenUsage tokenUsage;
    AiServiceStreamingResponseHandler(AiServiceContext context,
                                      Object memoryId,
                                      Consumer<String> tokenHandler,
                                      Consumer<Response<AiMessage>> completionHandler,
                                      Consumer<Throwable> errorHandler,
                                      TokenUsage tokenUsage) {
        this.context = ensureNotNull(context, "context");
        this.memoryId = ensureNotNull(memoryId, "memoryId");
        this.tokenHandler = ensureNotNull(tokenHandler, "tokenHandler");
        this.completionHandler = completionHandler;
        this.errorHandler = errorHandler;
        this.tokenUsage = ensureNotNull(tokenUsage, "tokenUsage");
    }
    @Override
    public void onNext(String token) {
        tokenHandler.accept(token);
    }
    @Override
    public void onComplete(Response<AiMessage> response) {
        if (context.hasChatMemory()) {
            context.chatMemory(memoryId).add(response.content());
        }
        ToolExecutionRequest toolExecutionRequest = response.content().toolExecutionRequest();
        if (toolExecutionRequest != null) {
            ToolExecutor toolExecutor = context.toolExecutors.get(toolExecutionRequest.name());
            String toolExecutionResult =
```

```
toolExecutor.execute(toolExecutionRequest);
            ToolExecutionResultMessage toolExecutionResultMessage =
ToolExecutionResultMessage.from(
                    toolExecutionRequest.name(),
                    toolExecutionResult
            );
            context.chatMemory(memoryId).add(toolExecutionResultMessage);
            context.streamingChatModel.generate(
                    context.chatMemory(memoryId).messages(),
                    context.toolSpecifications,
                    new AiServiceStreamingResponseHandler(
                            context,
                            memoryId,
                            tokenHandler,
                            completionHandler,
                            errorHandler,
                            tokenUsage.add(response.tokenUsage())
                    )
            );
        } else {
            if (completionHandler != null) {
                completionHandler.accept(Response.from(
                        response.content(),
                        tokenUsage.add(response.tokenUsage()),
                        response.finishReason())
                );
            }
        }
    }
    @Override
    public void onError(Throwable error) {
        if (errorHandler != null) {
            try {
                errorHandler.accept(error);
            } catch (Exception e) {
                log.error("While handling the following error...", error);
                log.error("...the following error happened", e);
            }
        } else {
            log.warn("Ignored error", error);
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\service\AiServiceTokenStream.java

```
package dev.langchain4j.service;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import java.util.List;
import java.util.function.Consumer;
import static dev.langchain4j.internal.ValidationUtils.ensureNotEmpty;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
class AiServiceTokenStream implements TokenStream {
    private final List<ChatMessage> messagesToSend;
    private final AiServiceContext context;
    private final Object memoryId;
    AiServiceTokenStream(List<ChatMessage> messagesToSend, AiServiceContext
context, Object memoryId) {
        this.messagesToSend = ensureNotEmpty(messagesToSend,
"messagesToSend");
        this.context = ensureNotNull(context, "context");
        this.memoryId = ensureNotNull(memoryId, "memoryId");
        ensureNotNull(context.streamingChatModel, "streamingChatModel");
    }
    @Override
    public OnCompleteOrOnError onNext(Consumer<String> tokenHandler) {
        return new OnCompleteOrOnError() {
            @Override
            public OnError onComplete(Consumer<Response<AiMessage>>
completionHandler) {
                return new OnError() {
                    @Override
                    public OnStart onError(Consumer<Throwable> errorHandler) {
                        return new AiServiceOnStart(tokenHandler,
completionHandler, errorHandler);
                    }
                    @Override
                    public OnStart ignoreErrors() {
                        return new AiServiceOnStart(tokenHandler,
completionHandler, null);
                    }
                };
            }
            @Override
            public OnStart onError(Consumer<Throwable> errorHandler) {
                return new AiServiceOnStart(tokenHandler, null, errorHandler);
            }
            @Override
            public OnStart ignoreErrors() {
                return new AiServiceOnStart(tokenHandler, null, null);
            }
        };
    }
    private class AiServiceOnStart implements OnStart {
        private final Consumer<String> tokenHandler;
        private final Consumer<Response<AiMessage>> completionHandler;
        private final Consumer<Throwable> errorHandler;
        private AiServiceOnStart(Consumer<String> tokenHandler,
                                 Consumer<Response<AiMessage>>
completionHandler,
                                 Consumer<Throwable> errorHandler) {
```

```
            this.tokenHandler = ensureNotNull(tokenHandler, "tokenHandler");
            this.completionHandler = completionHandler;
            this.errorHandler = errorHandler;
        }
        @Override
        public void start() {
            context.streamingChatModel.generate(
                    messagesToSend,
                    context.toolSpecifications,
                    new AiServiceStreamingResponseHandler(
                            context,
                            memoryId,
                            tokenHandler,
                            completionHandler,
                            errorHandler,
                            new TokenUsage()
                    )
            );
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\service\MemoryId.java

```
package dev.langchain4j.service;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.PARAMETER;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
/**
 * The value of a method parameter annotated with @MemoryId will be used to
find the memory belonging to that user/conversation.
 * A parameter annotated with @MemoryId can be of any type, provided it has
properly implemented equals() and hashCode() methods.
 */
@Retention(RUNTIME)
@Target(PARAMETER)
public @interface MemoryId {
}
```

langchain4j\src\main\java\dev\langchain4j\service\Moderate.java

```
package dev.langchain4j.service;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.METHOD;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
/**
 * When a method in the AI Service is annotated with @Moderate, each
invocation of this method will call not only the LLM,
 * but also the moderation model (which must be provided during the
construction of the AI Service) in parallel.
 * This ensures that no malicious content is supplied by the user.
 * Before the method returns an answer from the LLM, it will wait until the
moderation model returns a result.
 * If the moderation model flags the content, a ModerationException will be
thrown.
 * There is also an option to moderate user input *before* sending it to the
LLM. If you require this functionality,
 * please open an issue.
 */
@Target(METHOD)
@Retention(RUNTIME)
public @interface Moderate {
}
```

langchain4j\src\main\java\dev\langchain4j\service\ModerationException.java

```
package dev.langchain4j.service;
/**
 * Thrown when content moderation fails, i.e., when content is flagged by the
moderation model.
 *
 * @see Moderate
 * @see dev.langchain4j.model.moderation.ModerationModel
 */
public class ModerationException extends RuntimeException {
    public ModerationException(String message) {
        super(message);
    }
}
```

langchain4j\src\main\java\dev\langchain4j\service\OnCompleteOrOnError.java

```
package dev.langchain4j.service;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.output.Response;
import java.util.function.Consumer;
public interface OnCompleteOrOnError {
    /**
     * The provided consumer will be invoked when a language model finishes
streaming a response.
     *
     * @param completionHandler lambda that will be invoked when language
model finishes streaming
     * @return the next step of the step-builder
     */
    OnError onComplete(Consumer<Response<AiMessage>> completionHandler);
    /**
     * The provided consumer will be invoked when an error occurs during
streaming.
     *
     * @param errorHandler lambda that will be invoked when an error occurs
     * @return the next step of the step-builder
     */
    OnStart onError(Consumer<Throwable> errorHandler);
    /**
     * All errors during streaming will be ignored (but will be logged with a
WARN log level).
     *
     * @return the next step of the step-builder
     */
    OnStart ignoreErrors();
}
```

langchain4j\src\main\java\dev\langchain4j\service\OnError.java

```
package dev.langchain4j.service;
import java.util.function.Consumer;
public interface OnError {
    /**
     * The provided Consumer will be invoked when an error occurs during
streaming.
     *
     * @param errorHandler lambda that will be invoked when an error occurs
     * @return the next step of the step-builder
     */
    OnStart onError(Consumer<Throwable> errorHandler);
    /**
     * All errors during streaming will be ignored (but will be logged with a
WARN log level).
     *
     * @return the next step of the step-builder
     */
    OnStart ignoreErrors();
}
```

langchain4j\src\main\java\dev\langchain4j\service\OnStart.java

```
package dev.langchain4j.service;
public interface OnStart {
    /**
     * Invoke this method to send a request to LLM and start response
streaming.
     */
    void start();
}
```

langchain4j\src\main\java\dev\langchain4j\service\ServiceOutputParser.java

```
package dev.langchain4j.service;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.internal.Json;
import dev.langchain4j.model.output.*;
import dev.langchain4j.model.output.structured.Description;
import java.lang.reflect.Field;
import java.lang.reflect.ParameterizedType;
import java.lang.reflect.Type;
import java.math.BigDecimal;
import java.math.BigInteger;
import java.time.LocalDate;
import java.time.LocalDateTime;
import java.time.LocalTime;
import java.util.*;
import static
dev.langchain4j.exception.IllegalConfigurationException.illegalConfiguration;
import static java.lang.String.format;
import static java.util.Arrays.asList;
class ServiceOutputParser {
    private static final Map<Class<?>, OutputParser<?>> OUTPUT_PARSERS = new
HashMap<>();
    static {
        OUTPUT_PARSERS.put(boolean.class, new BooleanOutputParser());
        OUTPUT_PARSERS.put(Boolean.class, new BooleanOutputParser());
        OUTPUT_PARSERS.put(byte.class, new ByteOutputParser());
        OUTPUT_PARSERS.put(Byte.class, new ByteOutputParser());
        OUTPUT_PARSERS.put(short.class, new ShortOutputParser());
        OUTPUT_PARSERS.put(Short.class, new ShortOutputParser());
        OUTPUT_PARSERS.put(int.class, new IntOutputParser());
        OUTPUT_PARSERS.put(Integer.class, new IntOutputParser());
        OUTPUT_PARSERS.put(long.class, new LongOutputParser());
        OUTPUT_PARSERS.put(Long.class, new LongOutputParser());
        OUTPUT_PARSERS.put(BigInteger.class, new BigIntegerOutputParser());
        OUTPUT_PARSERS.put(float.class, new FloatOutputParser());
        OUTPUT_PARSERS.put(Float.class, new FloatOutputParser());
        OUTPUT_PARSERS.put(double.class, new DoubleOutputParser());
        OUTPUT_PARSERS.put(Double.class, new DoubleOutputParser());
        OUTPUT_PARSERS.put(BigDecimal.class, new BigDecimalOutputParser());
        OUTPUT_PARSERS.put(Date.class, new DateOutputParser());
        OUTPUT_PARSERS.put(LocalDate.class, new LocalDateOutputParser());
        OUTPUT_PARSERS.put(LocalTime.class, new LocalTimeOutputParser());
        OUTPUT_PARSERS.put(LocalDateTime.class, new
LocalDateTimeOutputParser());
    }
    static Object parse(Response<AiMessage> response, Class<?> returnType) {
        if (returnType == Response.class) {
            return response;
        }
        AiMessage aiMessage = response.content();
        if (returnType == AiMessage.class) {
            return aiMessage;
        }
        String text = aiMessage.text();
        if (returnType == String.class) {
            return text;
        }
        OutputParser<?> outputParser = OUTPUT_PARSERS.get(returnType);
        if (outputParser != null) {
```

```
            return outputParser.parse(text);
        }
        if (returnType == List.class) {
            return asList(text.split("\n"));
        }
        if (returnType == Set.class) {
            return new HashSet<>(asList(text.split("\n")));
        }
        return Json.fromJson(text, returnType);
    }
    static String outputFormatInstructions(Class<?> returnType) {
        if (returnType == String.class
                || returnType == AiMessage.class
                || returnType == TokenStream.class
                || returnType == Response.class) {
            return "";
        }
        if (returnType == void.class) {
            throw illegalConfiguration("Return type of method '%s' cannot be
void");
        }
        if (returnType.isEnum()) {
            String formatInstructions = new
EnumOutputParser(returnType.asSubclass(Enum.class)).formatInstructions();
            return "\nYou must answer strictly in the following format: " +
formatInstructions;
        }
        OutputParser<?> outputParser = OUTPUT_PARSERS.get(returnType);
        if (outputParser != null) {
            String formatInstructions = outputParser.formatInstructions();
            return "\nYou must answer strictly in the following format: " +
formatInstructions;
        }
        if (returnType == List.class || returnType == Set.class) {
            return "\nYou must put every item on a separate line.";
        }
        return "\nYou must answer strictly in the following JSON format: " +
jsonStructure(returnType);
    }
    private static String jsonStructure(Class<?> structured) {
        StringBuilder jsonSchema = new StringBuilder();
        jsonSchema.append("{\n");
        for (Field field : structured.getDeclaredFields()) {
            jsonSchema.append(format("\"%s\": (%s),\n", field.getName(),
descriptionFor(field)));
        }
        jsonSchema.append("}");
        return jsonSchema.toString();
    }
    private static String descriptionFor(Field field) {
        Description fieldDescription = field.getAnnotation(Description.class);
        if (fieldDescription == null) {
            return "type: " + typeOf(field);
        }
        return String.join(" ", fieldDescription.value()) + "; type: " +
typeOf(field);
    }
    private static String typeOf(Field field) {
        Type type = field.getGenericType();
        if (type instanceof ParameterizedType) {
            ParameterizedType parameterizedType = (ParameterizedType) type;
```

```
            Type[] typeArguments = parameterizedType.getActualTypeArguments();
            if (parameterizedType.getRawType().equals(List.class)
                    || parameterizedType.getRawType().equals(Set.class)) {
                return format("array of %s",
simpleTypeName(typeArguments[0]));
            }
        } else if (field.getType().isArray()) {
            return format("array of %s",
simpleTypeName(field.getType().getComponentType()));
        } else if (((Class<?>) type).isEnum()) {
            return "enum, must be one of " + Arrays.toString(((Class<?>)
type).getEnumConstants());
        }
        return simpleTypeName(type);
    }
    private static String simpleTypeName(Type type) {
        switch (type.getTypeName()) {
            case "java.lang.String":
                return "string";
            case "java.lang.Integer":
            case "int":
                return "integer";
            case "java.lang.Boolean":
            case "boolean":
                return "boolean";
            case "java.lang.Float":
            case "float":
                return "float";
            case "java.lang.Double":
            case "double":
                return "double";
            case "java.util.Date":
            case "java.time.LocalDate":
                return "date string (2023-12-31)";
            case "java.time.LocalTime":
                return "time string (23:59:59)";
            case "java.time.LocalDateTime":
                return "date-time string (2023-12-31T23:59:59)";
            default:
                return type.getTypeName();
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\service\SystemMessage.java

```
package dev.langchain4j.service;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.METHOD;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
@Target(METHOD)
@Retention(RUNTIME)
public @interface SystemMessage {
    /**
     * Prompt template can be defined in one line or multiple lines.
     * If the template is defined in multiple lines, the lines will be joined
with a delimiter defined below.
     */
    String[] value();
    String delimiter() default "\n";
}
```

langchain4j\src\main\java\dev\langchain4j\service\TokenStream.java

```
package dev.langchain4j.service;
import java.util.function.Consumer;
/**
 * Represents a token stream from language model to which you can subscribe
and receive updates
 * when a new token is available, when language model finishes streaming, or
when an error occurs during streaming.
 * It is intended to be used as a return type in AI Service.
 */
public interface TokenStream {
    /**
     * The provided consumer will be invoked every time a new token from a
language model is available.
     *
     * @param tokenHandler lambda that consumes tokens of the response
     * @return the next step of a step-builder
     */
    OnCompleteOrOnError onNext(Consumer<String> tokenHandler);
}
```

langchain4j\src\main\java\dev\langchain4j\service\UserMessage.java

```
package dev.langchain4j.service;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.METHOD;
import static java.lang.annotation.ElementType.PARAMETER;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
@Retention(RUNTIME)
@Target({METHOD, PARAMETER})
public @interface UserMessage {
    /**
     * Prompt template can be defined in one line or multiple lines.
     * If the template is defined in multiple lines, the lines will be joined
with a delimiter defined below.
     */
    String[] value() default "";
    String delimiter() default "\n";
}
```

langchain4j\src\main\java\dev\langchain4j\service\UserName.java

```
package dev.langchain4j.service;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.PARAMETER;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
/**
 * The value of a method parameter annotated with @UserName will be injected
into the field 'name' of a UserMessage.
 */
@Retention(RUNTIME)
@Target(PARAMETER)
public @interface UserName {
}
```

langchain4j\src\main\java\dev\langchain4j\service\V.java

```
package dev.langchain4j.service;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.PARAMETER;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
/**
 * The values of method parameters annotated with @V, together with prompt
templates defined by @UserMessage
 * and @SystemMessage, are used to produce a message that will be sent to the
LLM.
 * Variables (placeholders), like {{xxx}} in prompt templates, are filled
with the corresponding values
 * of parameters annotated with @V("xxx").
 * <p>
 * Example:
 * <pre>
 * {@code @UserMessage("Hello, my name is {{name}}. I am {{age}} years old.")}
 * String chat(@V("name") String name, @V("age") int age);
 * </pre>
 * <p>
 * This annotation is necessary only when the "-parameters" option is *not*
enabled during Java compilation.
 * If the "-parameters" option is enabled, parameter names can directly serve
as identifiers, eliminating
 * the need to define a value of @V annotation.
 * Example:
 * <pre>
 * {@code @UserMessage("Hello, my name is {{name}}. I am {{age}} years old.")}
 * String chat(@V String name, @V int age);
 * </pre>
 * <p>
 * When using Spring Boot, defining the value of this annotation is not
required.
 *
 * @see UserMessage
 * @see SystemMessage
 * @see dev.langchain4j.model.input.PromptTemplate
 */
@Target(PARAMETER)
@Retention(RUNTIME)
public @interface V {
    /**
     * Name of a variable (placeholder) in a prompt template.
     */
    String value();
}
```

langchain4j\src\main\java\dev\langchain4j\store\embedding\EmbeddingStoreIngestor.java

```
package dev.langchain4j.store.embedding;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.document.DocumentTransformer;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.data.segment.TextSegmentTransformer;
import dev.langchain4j.model.embedding.EmbeddingModel;
import java.util.List;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
import static java.util.Arrays.asList;
import static java.util.Collections.singletonList;
/**
 * EmbeddingStoreIngestor is responsible for the ingestion of documents into an embedding store.
 * It manages the entire pipeline process, from splitting the documents into text segments,
 * generating embeddings for these segments using a provided embedding model, to finally
 * storing these embeddings into an embedding store.
 * Optionally, it can also transform documents before splitting them, which can be useful if you want
 * to clean your data, format it differently, etc.
 * Additionally, it can optionally transform segments after they have been split.
 */
public class EmbeddingStoreIngestor {
    private final DocumentTransformer documentTransformer;
    private final DocumentSplitter documentSplitter;
    private final TextSegmentTransformer textSegmentTransformer;
    private final EmbeddingModel embeddingModel;
    private final EmbeddingStore<TextSegment> embeddingStore;
    public EmbeddingStoreIngestor(DocumentTransformer documentTransformer,
                                  DocumentSplitter documentSplitter,
                                  TextSegmentTransformer textSegmentTransformer,
                                  EmbeddingModel embeddingModel,
                                  EmbeddingStore<TextSegment> embeddingStore) {
        this.documentTransformer = documentTransformer;
        this.documentSplitter = ensureNotNull(documentSplitter, "documentSplitter");
        this.textSegmentTransformer = textSegmentTransformer;
        this.embeddingModel = ensureNotNull(embeddingModel, "embeddingModel");
        this.embeddingStore = ensureNotNull(embeddingStore, "embeddingStore");
    }
    public void ingest(Document document) {
        ingest(singletonList(document));
    }
    public void ingest(Document... documents) {
        ingest(asList(documents));
    }
    public void ingest(List<Document> documents) {
        if (documentTransformer != null) {
            documents = documentTransformer.transformAll(documents);
        }
        List<TextSegment> segments = documentSplitter.splitAll(documents);
```

```
        if (textSegmentTransformer != null) {
            segments = textSegmentTransformer.transformAll(segments);
        }
        List<Embedding> embeddings =
embeddingModel.embedAll(segments).content();
        embeddingStore.addAll(embeddings, segments);
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private DocumentTransformer documentTransformer;
        private DocumentSplitter documentSplitter;
        private TextSegmentTransformer textSegmentTransformer;
        private EmbeddingModel embeddingModel;
        private EmbeddingStore<TextSegment> embeddingStore;
        public Builder documentTransformer(DocumentTransformer
documentTransformer) {
            this.documentTransformer = documentTransformer;
            return this;
        }
        public Builder documentSplitter(DocumentSplitter documentSplitter) {
            this.documentSplitter = documentSplitter;
            return this;
        }
        public Builder textSegmentTransformer(TextSegmentTransformer
textSegmentTransformer) {
            this.textSegmentTransformer = textSegmentTransformer;
            return this;
        }
        public Builder embeddingModel(EmbeddingModel embeddingModel) {
            this.embeddingModel = embeddingModel;
            return this;
        }
        public Builder embeddingStore(EmbeddingStore<TextSegment>
embeddingStore) {
            this.embeddingStore = embeddingStore;
            return this;
        }
        public EmbeddingStoreIngestor build() {
            return new EmbeddingStoreIngestor(
                    documentTransformer,
                    documentSplitter,
                    textSegmentTransformer,
                    embeddingModel,
                    embeddingStore
            );
        }
    }
}
```

langchain4j\src\main\java\dev\langchain4j\store\embedding\inmemory\InMemoryEmbeddingStore.java

```
package dev.langchain4j.store.embedding.inmemory;
import com.google.gson.Gson;
import com.google.gson.reflect.TypeToken;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import java.io.IOException;
import java.lang.reflect.Type;
import java.nio.file.Files;
import java.nio.file.Path;
import java.nio.file.Paths;
import java.util.ArrayList;
import java.util.Collections;
import java.util.Comparator;
import java.util.List;
import java.util.Objects;
import java.util.PriorityQueue;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.nio.file.StandardOpenOption.CREATE;
import static java.nio.file.StandardOpenOption.TRUNCATE_EXISTING;
import static java.util.Comparator.comparingDouble;
/**
 * An {@link EmbeddingStore} that stores embeddings in memory.
 * <p>
 * Uses a brute force approach by iterating over all embeddings to find the
best matches.
 * <p>
 * This store can be persisted using the {@link #serializeToJson()} and
{@link #serializeToFile(Path)} methods.
 * <p>
 * It can also be recreated from JSON or a file using the {@link
#fromJson(String)} and {@link #fromFile(Path)} methods.
 *
 * @param <Embedded> The class of the object that has been embedded.
 *                   Typically, it is {@link
dev.langchain4j.data.segment.TextSegment}.
 */
public class InMemoryEmbeddingStore<Embedded> implements
EmbeddingStore<Embedded> {
    private static class Entry<Embedded> {
        String id;
        Embedding embedding;
        Embedded embedded;
        Entry(String id, Embedding embedding, Embedded embedded) {
            this.id = id;
            this.embedding = embedding;
            this.embedded = embedded;
        }
        @Override
        public boolean equals(Object o) {
            if (this == o) return true;
            if (o == null || getClass() != o.getClass()) return false;
            Entry<?> that = (Entry<?>) o;
            return Objects.equals(this.id, that.id)
```

```
                    && Objects.equals(this.embedding, that.embedding)
                    && Objects.equals(this.embedded, that.embedded);
        }
        @Override
        public int hashCode() {
            return Objects.hash(id, embedding, embedded);
        }
    }
    private final List<Entry<Embedded>> entries = new ArrayList<>();
    @Override
    public String add(Embedding embedding) {
        String id = randomUUID();
        add(id, embedding);
        return id;
    }
    @Override
    public void add(String id, Embedding embedding) {
        add(id, embedding, null);
    }
    @Override
    public String add(Embedding embedding, Embedded embedded) {
        String id = randomUUID();
        add(id, embedding, embedded);
        return id;
    }
    private void add(String id, Embedding embedding, Embedded embedded) {
        entries.add(new Entry<>(id, embedding, embedded));
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings) {
        List<String> ids = new ArrayList<>();
        for (Embedding embedding : embeddings) {
            ids.add(add(embedding));
        }
        return ids;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings, List<Embedded>
embedded) {
        if (embeddings.size() != embedded.size()) {
            throw new IllegalArgumentException("The list of embeddings and
embedded must have the same size");
        }
        List<String> ids = new ArrayList<>();
        for (int i = 0; i < embeddings.size(); i++) {
            ids.add(add(embeddings.get(i), embedded.get(i)));
        }
        return ids;
    }
    @Override
    public List<EmbeddingMatch<Embedded>> findRelevant(Embedding
referenceEmbedding, int maxResults, double minScore) {
        Comparator<EmbeddingMatch<Embedded>> comparator =
comparingDouble(EmbeddingMatch::score);
        PriorityQueue<EmbeddingMatch<Embedded>> matches = new
PriorityQueue<>(comparator);
        for (Entry<Embedded> entry : entries) {
            double cosineSimilarity =
CosineSimilarity.between(entry.embedding, referenceEmbedding);
            double score =
RelevanceScore.fromCosineSimilarity(cosineSimilarity);
```

```
            if (score >= minScore) {
                matches.add(new EmbeddingMatch<>(score, entry.id,
entry.embedding, entry.embedded));
                if (matches.size() > maxResults) {
                    matches.poll();
                }
            }
        }
        List<EmbeddingMatch<Embedded>> result = new ArrayList<>(matches);
        result.sort(comparator);
        Collections.reverse(result);
        return result;
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        InMemoryEmbeddingStore<?> that = (InMemoryEmbeddingStore<?>) o;
        return Objects.equals(this.entries, that.entries);
    }
    @Override
    public int hashCode() {
        return Objects.hash(entries);
    }
    public String serializeToJson() {
        return new Gson().toJson(this);
    }
    public void serializeToFile(Path filePath) {
        try {
            String json = serializeToJson();
            Files.write(filePath, json.getBytes(), CREATE, TRUNCATE_EXISTING);
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
    public void serializeToFile(String filePath) {
        serializeToFile(Paths.get(filePath));
    }
    public static InMemoryEmbeddingStore<TextSegment> fromJson(String json) {
        Type type = new TypeToken<InMemoryEmbeddingStore<TextSegment>>() {
        }.getType();
        return new Gson().fromJson(json, type);
    }
    public static InMemoryEmbeddingStore<TextSegment> fromFile(Path filePath)
{
        try {
            String json = new String(Files.readAllBytes(filePath));
            return fromJson(json);
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
    public static InMemoryEmbeddingStore<TextSegment> fromFile(String
filePath) {
        return fromFile(Paths.get(filePath));
    }
}
```

langchain4j\src\main\resources\opennlp\opennlp-en-ud-ewt-sentence-1.0-1.9.3.bin

BASE64:

UEsDBBQACAgIAIJOiFEAAAAAAAAAAAAAAATAAAAbWFuaWZlc3QucHJvcGVydGllc11Ou2rDMBTd9R
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YD20wbq7tgsS3RYerL157pFChwHbwM8RIrW4f1Dr3p8BhtbvRnCRofOaX17emHEwETpzX1A3PzHHDk
DDCgNqJPYRF06Hz/Qr+idLOuM1l+wINPXowx9ZPIsmGtJHywh+1AXWpYTiir2CXmWyq6SQUvZVCdeq
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EAAFBLAwQUAAgICACCTohRAAAAAAAAAAAAAAAACgAAAHNlbnQubW9kZWxUegVYVM/3/
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kHL29KjtSPyMpxJr/XcYS+LHm+rr0dS5Gvu9ZNgM+JZRazfVjKeEO8sxB/HeCly/
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Z5wOPgIMI3cHC508NyXaixsF2ogTlCEV4UL7VDgrWHA8mG7c5EHjGZG01GfF1bN+JeNK3xacibCdk7
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```
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AAAAAAAAAAAAAAACcBAABzZW50Lm1vZGVsUEsFBgAAAAACAAIAeQAAAM5OAAAAAA==

langchain4j\src\test\java\dev\langchain4j\agent\tool\ToolExecutorTest.java

```
package dev.langchain4j.agent.tool;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.ValueSource;
import java.math.BigDecimal;
import java.math.BigInteger;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.api.Assertions.assertThatThrownBy;
class ToolExecutorTest {
    TestTool testTool = new TestTool();
    private static class TestTool {
        @Tool
        double doubles(double arg0, Double arg1) {
            return arg0 + arg1;
        }
        @Tool
        float floats(float arg0, Float arg1) {
            return arg0 + arg1;
        }
        @Tool
        BigDecimal bigDecimals(BigDecimal arg0, BigDecimal arg1) {
            return arg0.add(arg1);
        }
        @Tool
        long longs(long arg0, Long arg1) {
            return arg0 + arg1;
        }
        @Tool
        int ints(int arg0, Integer arg1) {
            return arg0 + arg1;
        }
        @Tool
        short shorts(short arg0, Short arg1) {
            return (short) (arg0 + arg1);
        }
        @Tool
        byte bytes(byte arg0, Byte arg1) {
            return (byte) (arg0 + arg1);
        }
        @Tool
        BigInteger bigIntegers(BigInteger arg0, BigInteger arg1) {
            return arg0.add(arg1);
        }
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2}",
            "{\"arg0\": 2.0, \"arg1\": 2.0}",
            "{\"arg0\": 1.9, \"arg1\": 2.1}",
    })
    void should_execute_tool_with_parameters_of_type_double(String arguments)
throws NoSuchMethodException {
        executeAndAssert(arguments, "doubles", double.class, Double.class,
"4.0");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2}",
            "{\"arg0\": 2.0, \"arg1\": 2.0}",
```

```
            "{\"arg0\": 1.9, \"arg1\": 2.1}",
    })
    void should_execute_tool_with_parameters_of_type_float(String arguments)
throws NoSuchMethodException {
        executeAndAssert(arguments, "floats", float.class, Float.class,
"4.0");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": " + Float.MAX_VALUE + "}",
            "{\"arg0\": 2, \"arg1\": " + -Double.MAX_VALUE + "}"
    })
    void should_fail_when_argument_does_not_fit_into_float_type(String
arguments) throws NoSuchMethodException {
        executeAndExpectFailure(arguments, "floats", float.class,
Float.class, "is out of range for the float type");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2}",
            "{\"arg0\": 2.0, \"arg1\": 2.0}",
            "{\"arg0\": 1.9, \"arg1\": 2.1}",
    })
    void should_execute_tool_with_parameters_of_type_BigDecimal(String
arguments) throws NoSuchMethodException {
        executeAndAssert(arguments, "bigDecimals", BigDecimal.class,
BigDecimal.class, "4.0");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2}",
            "{\"arg0\": 2.0, \"arg1\": 2.0}"
    })
    void should_execute_tool_with_parameters_of_type_long(String arguments)
throws NoSuchMethodException {
        executeAndAssert(arguments, "longs", long.class, Long.class, "4");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2.1}",
            "{\"arg0\": 2.1, \"arg1\": 2}"
    })
    void should_fail_when_argument_is_fractional_number_for_parameter_of_type_
long(String arguments) throws NoSuchMethodException {
        executeAndExpectFailure(arguments, "longs", long.class, Long.class,
"argument type mismatch");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": " + Double.MAX_VALUE + "}",
            "{\"arg0\": 2, \"arg1\": " + -Double.MAX_VALUE + "}"
    })
    void should_fail_when_argument_does_not_fit_into_long_type(String
arguments) throws NoSuchMethodException {
        executeAndExpectFailure(arguments, "longs", long.class, Long.class,
"is out of range for the long type");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2}",
            "{\"arg0\": 2.0, \"arg1\": 2.0}"
```

```
    })
    void should_execute_tool_with_parameters_of_type_int(String arguments)
throws NoSuchMethodException {
        executeAndAssert(arguments, "ints", int.class, Integer.class, "4");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2.1}",
            "{\"arg0\": 2.1, \"arg1\": 2}"
    })
    void should_fail_when_argument_is_fractional_number_for_parameter_of_type_
int(String arguments) throws NoSuchMethodException {
        executeAndExpectFailure(arguments, "ints", int.class, Integer.class,
"argument type mismatch");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": " + Double.MAX_VALUE + "}",
            "{\"arg0\": 2, \"arg1\": " + -Double.MAX_VALUE + "}"
    })
    void should_fail_when_argument_does_not_fit_into_int_type(String
arguments) throws NoSuchMethodException {
        executeAndExpectFailure(arguments, "ints", int.class, Integer.class,
"is out of range for the integer type");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2}",
            "{\"arg0\": 2.0, \"arg1\": 2.0}"
    })
    void should_execute_tool_with_parameters_of_type_short(String arguments)
throws NoSuchMethodException {
        executeAndAssert(arguments, "shorts", short.class, Short.class, "4");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2.1}",
            "{\"arg0\": 2.1, \"arg1\": 2}"
    })
    void should_fail_when_argument_is_fractional_number_for_parameter_of_type_
short(String arguments) throws NoSuchMethodException {
        executeAndExpectFailure(arguments, "shorts", short.class,
Short.class, "argument type mismatch");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": " + Double.MAX_VALUE + "}",
            "{\"arg0\": 2, \"arg1\": " + -Double.MAX_VALUE + "}"
    })
    void should_fail_when_argument_does_not_fit_into_short_type(String
arguments) throws NoSuchMethodException {
        executeAndExpectFailure(arguments, "shorts", short.class,
Short.class, "is out of range for the short type");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2}",
            "{\"arg0\": 2.0, \"arg1\": 2.0}"
    })
    void should_execute_tool_with_parameters_of_type_byte(String arguments)
throws NoSuchMethodException {
```

```
        executeAndAssert(arguments, "bytes", byte.class, Byte.class, "4");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2.1}",
            "{\"arg0\": 2.1, \"arg1\": 2}"
    })
    void should_fail_when_argument_is_fractional_number_for_parameter_of_type_
byte(String arguments) throws NoSuchMethodException {
        executeAndExpectFailure(arguments, "bytes", byte.class, Byte.class,
"argument type mismatch");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": " + Double.MAX_VALUE + "}",
            "{\"arg0\": 2, \"arg1\": " + -Double.MAX_VALUE + "}"
    })
    void should_fail_when_argument_does_not_fit_into_byte_type(String
arguments) throws NoSuchMethodException {
        executeAndExpectFailure(arguments, "bytes", byte.class, Byte.class,
"is out of range for the byte type");
    }
    @ParameterizedTest
    @ValueSource(strings = {
            "{\"arg0\": 2, \"arg1\": 2}",
            "{\"arg0\": 2.0, \"arg1\": 2.0}"
    })
    void should_execute_tool_with_parameters_of_type_BigInteger(String
arguments) throws NoSuchMethodException {
        executeAndAssert(arguments, "bigIntegers", BigInteger.class,
BigInteger.class, "4");
    }
    private void executeAndAssert(String arguments, String methodName, Class<?
> arg0Type, Class<?> arg1Type, String expectedResult) throws
NoSuchMethodException {
        ToolExecutionRequest request = ToolExecutionRequest.builder()
                .arguments(arguments)
                .build();
        ToolExecutor toolExecutor = new ToolExecutor(testTool,
TestTool.class.getDeclaredMethod(methodName, arg0Type, arg1Type));
        String result = toolExecutor.execute(request);
        assertThat(result).isEqualTo(expectedResult);
    }
    private void executeAndExpectFailure(String arguments, String methodName,
Class<?> arg0Type, Class<?> arg1Type, String expectedError) throws
NoSuchMethodException {
        ToolExecutionRequest request = ToolExecutionRequest.builder()
                .arguments(arguments)
                .build();
        ToolExecutor toolExecutor = new ToolExecutor(testTool,
TestTool.class.getDeclaredMethod(methodName, arg0Type, arg1Type));
        assertThatThrownBy(() -> toolExecutor.execute(request))
                .isExactlyInstanceOf(IllegalArgumentException.class)
                .hasMessageContaining(expectedError);
    }
}
```

langchain4j\src\test\java\dev\langchain4j\chain\ConversationalChainTest.java

```
package dev.langchain4j.chain;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.NullSource;
import org.junit.jupiter.params.provider.ValueSource;
import static dev.langchain4j.data.message.AiMessage.aiMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static java.util.Collections.singletonList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.api.Assertions.assertThatThrownBy;
import static org.mockito.Mockito.*;
public class ConversationalChainTest {
    @Test
    public void should_store_user_and_ai_messages_in_chat_memory() {
        // Given
        ChatLanguageModel chatLanguageModel = mock(ChatLanguageModel.class);
        String aiMessage = "Hi there";
        when(chatLanguageModel.generate(anyList())).thenReturn(Response.from(a
iMessage(aiMessage)));
        ChatMemory chatMemory =
spy(MessageWindowChatMemory.withMaxMessages(10));
        ConversationalChain chain = ConversationalChain.builder()
                .chatLanguageModel(chatLanguageModel)
                .chatMemory(chatMemory)
                .build();
        String userMessage = "Hello";
        // When
        String response = chain.execute(userMessage);
        // Then
        assertThat(response).isEqualTo(aiMessage);
        verify(chatMemory).add(userMessage(userMessage));
        verify(chatMemory, times(3)).messages();

verify(chatLanguageModel).generate(singletonList(userMessage(userMessage)));
        verify(chatMemory).add(aiMessage(aiMessage));
        verifyNoMoreInteractions(chatMemory);
        verifyNoMoreInteractions(chatLanguageModel);
    }
    @ParameterizedTest
    @NullSource
    @ValueSource(strings = {"", " "})
    public void should_fail_when_user_message_is_null_or_blank(String
userMessage) {
        // Given
        ChatLanguageModel chatLanguageModel = mock(ChatLanguageModel.class);
        ChatMemory chatMemory = mock(ChatMemory.class);
        ConversationalChain chain = ConversationalChain.builder()
                .chatLanguageModel(chatLanguageModel)
                .chatMemory(chatMemory)
                .build();
        // When & Then
        assertThatThrownBy(() -> chain.execute(userMessage))
                .isExactlyInstanceOf(IllegalArgumentException.class)
                .hasMessage("userMessage cannot be null or blank");
```

```
    }
}
```

langchain4j\src\test\java\dev\langchain4j\classification\EmbeddingModelTextClassifierTest.java

```
package dev.langchain4j.classification;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static dev.langchain4j.classification.EmbeddingModelTextClassifierTest.CustomerServiceCategory.*;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
class EmbeddingModelTextClassifierTest {
    enum CustomerServiceCategory {
        BILLING_AND_PAYMENTS,
        TECHNICAL_SUPPORT,
        ACCOUNT_MANAGEMENT,
        PRODUCT_INFORMATION,
        ORDER_STATUS,
        RETURNS_AND_EXCHANGES,
        FEEDBACK_AND_COMPLAINTS
    }
    private final Map<CustomerServiceCategory, List<String>> examples = new HashMap<>();
    {
        examples.put(BILLING_AND_PAYMENTS, asList(
                "Can I pay using PayPal?",
                "Do you accept Bitcoin?",
                "Is it possible to pay via wire transfer?",
                "I keep getting an error message when I try to pay.",
                "My card was charged twice, can you help?",
                "Why was my payment declined?",
                "How can I request a refund?",
                "When will I get my refund?",
                "Can I get a refund if I cancel my subscription?",
                "Can you send me an invoice for my last order?",
                "I didn't receive a receipt for my purchase.",
                "Is the invoice sent to my email automatically?",
                "How do I upgrade my subscription?",
                "What are the differences between the Basic and Premium plans?",
                "How do I cancel my subscription?",
                "Can I switch to a monthly plan from an annual one?",
                "I want to downgrade my subscription, how do I go about it?",
                "Is there a penalty for downgrading my plan?"
        ));
        examples.put(TECHNICAL_SUPPORT, asList(
                "The app keeps crashing whenever I open it.",
                "I can't save changes in the settings.",
                "Why is the search function not working?",
                "The installer is stuck at 50%.",
                "I keep getting an ‘Installation Failed' message.",
                "How do I install this on a Mac?",
                "I can't connect to the server.",
                "Why am I constantly getting disconnected?",
                "My Wi-Fi works, but your app says no internet connection.",
                "Why is the app so slow?",
                "I'm experiencing lag during video calls.",
```

```
        "The website keeps freezing on my browser.",
        "I get a ‘404 Not Found' error.",
        "What does the ‘Permission Denied' error mean?",
        "Why am I seeing an ‘Insufficient Storage' warning?",
        "Is this compatible with Windows 11?",
        "The app doesn't work on my Android phone.",
        "Do you have a browser extension for Safari?"
));
examples.put(ACCOUNT_MANAGEMENT, asList(
        "I forgot my password, how can I reset it?",
        "I didn't receive a password reset email.",
        "Is there a way to change my password from within the app?",
        "How do I set up two-factor authentication?",
        "I lost my phone, how can I log in now?",
        "Why am I not getting the 2FA code?",
        "My account has been locked, what do I do?",
        "Is there a limit on login attempts?",
        "I've been locked out for no reason, can you help?",
        "How do I change my email address?",
        "Can I update my profile picture?",
        "How do I edit my shipping address?",
        "Can I share my account with family?",
        "How do I give admin access to my team member?",
        "Is there a guest access feature?",
        "How do I delete my account?",
        "What happens to my data if I deactivate my account?",
        "Can I reactivate my account later?"
));
examples.put(PRODUCT_INFORMATION, asList(
        "What does the ‘Sync' feature do?",
        "How does the privacy mode work?",
        "Can you explain the real-time tracking feature?",
        "When will the new model be in stock?",
        "Do you have this item in a size medium?",
        "Are you restocking the sold-out items soon?",
        "What's the difference between version 1.0 and 2.0?",
        "Is the Pro version worth the extra cost?",
        "Do older versions support the new update?",
        "Is this product compatible with iOS?",
        "Will this work with a 220V power supply?",
        "Do you have options for USB-C?",
        "Are there any accessories included?",
        "Do you sell protective cases for this model?",
        "What add-ons would you recommend?",
        "What does the warranty cover?",
        "How do I claim the warranty?",
        "Is the warranty international?"
));
examples.put(ORDER_STATUS, asList(
        "Where is my order right now?",
        "Can you give me a tracking number?",
        "How do I know my order has been shipped?",
        "Can I change the shipping method?",
        "Do you offer overnight shipping?",
        "Is pickup from the store an option?",
        "When will my order arrive?",
        "Why is my delivery delayed?",
        "Can I specify a delivery date?",
        "It's past the delivery date, where is my order?",
        "Will I be notified if there's a delay?",
        "How long will the weather delay my shipment?",
```

```
                "I received my order, but an item is missing.",
                "The package was empty when it arrived.",
                "I got the wrong item, what should I do?",
                "Will all my items arrive at the same time?",
                "Why did I receive only part of my order?",
                "Is it possible to get the remaining items faster?"
        ));
        examples.put(RETURNS_AND_EXCHANGES, asList(
                "What's your return policy?",
                "Is the return shipping free?",
                "Do I need the original packaging to return?",
                "How do I get a return label?",
                "Do I need to call customer service for a return?",
                "Is an RMA number required?",
                "I need to exchange for a different size.",
                "Can I exchange a gift?",
                "How long does the exchange process take?",
                "My item arrived damaged, what do I do?",
                "The product doesn't work as described.",
                "There's a part missing, can you send it?",
                "I received the wrong item, how can I get it corrected?",
                "I didn't order this, why did I receive it?",
                "You sent me two of the same item by mistake.",
                "Is there a restocking fee for returns?",
                "Will I get a full refund?",
                "How much will be deducted for restocking?"
        ));
        examples.put(FEEDBACK_AND_COMPLAINTS, asList(
                "The material quality is not as advertised.",
                "The product broke after a week of use.",
                "The colors faded after the first wash.",
                "The representative was rude to me.",
                "I was on hold for 30 minutes, this is unacceptable.",
                "Your customer service resolved my issue quickly, thank you!",
                "Your website is hard to navigate.",
                "The app keeps crashing, it's frustrating.",
                "The checkout process is confusing.",
                "You should offer a chat feature for quicker help.",
                "Can you add a wishlist feature?",
                "Please make a mobile-friendly version of the website.",
                "I found a bug in your software.",
                "There's a typo on your homepage.",
                "The payment page has a glitch.",
                "Can you start offering this in a gluten-free option?",
                "Please add support for Linux.",
                "I wish you had more colors to choose from."
        ));
    }
    @Test
    @Disabled
    void should_return_one_category_by_default() {
        TextClassifier<CustomerServiceCategory> classifier = new
EmbeddingModelTextClassifier<>(
                new AllMiniLmL6V2QuantizedEmbeddingModel(),
                examples
        );
        List<CustomerServiceCategory> categories = classifier.classify("Yo
where is my order?");
        assertThat(categories).containsExactly(ORDER_STATUS);
    }
    @Test
```

```
    @Disabled
    void should_return_multiple_categories() {
        TextClassifier<CustomerServiceCategory> classifier = new
EmbeddingModelTextClassifier<>(
                new AllMiniLmL6V2QuantizedEmbeddingModel(),
                examples,
                2,
                0,
                0.5
        );
        List<CustomerServiceCategory> categories = classifier.classify("Bro,
this product is crap");
        assertThat(categories).containsExactly(RETURNS_AND_EXCHANGES,
FEEDBACK_AND_COMPLAINTS);
    }
    @Test
    @Disabled
    void should_classify_respecting_minScore() {
        TextClassifier<CustomerServiceCategory> classifier = new
EmbeddingModelTextClassifier<>(
                new AllMiniLmL6V2QuantizedEmbeddingModel(),
                examples,
                2,
                0.64,
                0.5
        );
        List<CustomerServiceCategory> categories = classifier.classify("Bro,
this product is crap");
        assertThat(categories).containsExactly(RETURNS_AND_EXCHANGES);
    }
    @Test
    @Disabled
    void should_classify_respecting_meanToMaxScoreRatio_1() {
        TextClassifier<CustomerServiceCategory> classifier = new
EmbeddingModelTextClassifier<>(
                new AllMiniLmL6V2QuantizedEmbeddingModel(),
                examples,
                1,
                0,
                1
        );
        List<CustomerServiceCategory> categories = classifier.classify("Bro,
this product is crap");
        assertThat(categories).containsExactly(FEEDBACK_AND_COMPLAINTS);
    }
    @Test
    @Disabled
    void should_classify_respecting_meanToMaxScoreRatio_0() {
        TextClassifier<CustomerServiceCategory> classifier = new
EmbeddingModelTextClassifier<>(
                new AllMiniLmL6V2QuantizedEmbeddingModel(),
                examples,
                1,
                0,
                0
        );
        List<CustomerServiceCategory> categories = classifier.classify("Bro,
this product is crap");
        assertThat(categories).containsExactly(RETURNS_AND_EXCHANGES);
    }
}
```

langchain4j\src\test\java\dev\langchain4j\code\JavaScriptCodeFixerTest.java

```
package dev.langchain4j.code;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class JavaScriptCodeFixerTest {
    @Test
    void should_fix_multi_line_code_when_result_is_not_logged_to_console() {
        String code = "const startDate = new Date('Feb 21, 1988 17:00:00');
\nconst endDate = new Date('Apr 12, 2014 04:00:00');\nconst diff = endDate -
startDate;\nconst result = diff / (1000*60*60);\n;const startDate = new
Date('Feb 21, 1988 17:00:00');\nconst endDate = new Date('Apr 12, 2014
04:00:00');\nconst diff = endDate - startDate;\nconst result = diff /
(1000*60*60);\n";
        String result = JavaScriptCodeFixer.fixIfNoLogToConsole(code +
"result");
        assertThat(result).isEqualTo(code + "console.log(result);");
    }
    @Test
    void should_not_fix_multi_line_code_when_result_is_logged_to_console() {
        String code = "const startDate = new Date('Feb 21, 1988 17:00:00');
\nconst endDate = new Date('Apr 12, 2014 04:00:00');\nconst diff = endDate -
startDate;\nconst result = diff / (1000*60*60);\nconsole.log(result);";
        String result = JavaScriptCodeFixer.fixIfNoLogToConsole(code);
        assertThat(result).isEqualTo(code);
    }
    @Test
    void should_fix_one_line_code_when_result_is_not_logged_to_console() {
        String code = "const start = new Date('1988-02-21T17:00:00'); const
end = new Date('2014-04-12T04:00:00'); const hours = (end - start) / (1000 *
60 * 60); ";
        String result = JavaScriptCodeFixer.fixIfNoLogToConsole(code +
"hours");
        assertThat(result).isEqualTo(code + "console.log(hours);");
    }
    @Test
    void should_not_fix_one_line_code_when_result_is_logged_to_console() {
        String code = "const start = new Date('1988-02-21T17:00:00'); const
end = new Date('2014-04-12T04:00:00'); const hours = (end - start) / (1000 *
60 * 60); console.log(hours);";
        String result = JavaScriptCodeFixer.fixIfNoLogToConsole(code);
        assertThat(result).isEqualTo(code);
    }
    @Test
    void should_fix_one_statement_when_result_is_not_logged_to_console() {
        String code = "Math.sqrt(49506838032859)";
        String result = JavaScriptCodeFixer.fixIfNoLogToConsole(code);

assertThat(result).isEqualTo("console.log(Math.sqrt(49506838032859));");
    }
    @Test
    void should_not_fix_one_statement_when_result_is_logged_to_console() {
        String code = "console.log(Math.sqrt(49506838032859));";
        String result = JavaScriptCodeFixer.fixIfNoLogToConsole(code);
        assertThat(result).isEqualTo(code);
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\FileSystemDocumentLoaderTest.java

```
package dev.langchain4j.data.document;
import org.junit.jupiter.api.Test;
import java.net.URISyntaxException;
import java.nio.file.Files;
import java.nio.file.Path;
import java.nio.file.Paths;
import java.util.List;
import static dev.langchain4j.data.document.Document.DOCUMENT_TYPE;
import static dev.langchain4j.data.document.Document.FILE_NAME;
import static dev.langchain4j.data.document.DocumentType.UNKNOWN;
import static
dev.langchain4j.data.document.FileSystemDocumentLoader.loadDocument;
import static
dev.langchain4j.data.document.FileSystemDocumentLoader.loadDocuments;
import static java.util.stream.Collectors.toList;
import static org.assertj.core.api.Assertions.assertThat;
class FileSystemDocumentLoaderTest {
    @Test
    void should_load_text_document() {
        Document document = loadDocument(toPath("test-file-utf8.txt"));
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        Metadata metadata = document.metadata();
        assertThat(metadata.get("file_name")).isEqualTo("test-file-utf8.txt");

assertThat(Paths.get(metadata.get("absolute_directory_path"))).isAbsolute();
    }
    @Test
    void should_load_pdf_document() {
        Document document = loadDocument(toPath("test-file.pdf"));
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        Metadata metadata = document.metadata();
        assertThat(metadata.get("file_name")).isEqualTo("test-file.pdf");

assertThat(Paths.get(metadata.get("absolute_directory_path"))).isAbsolute();
    }
    @Test
    void should_load_ppt_document() {
        Document document = loadDocument(toPath("test-file.ppt"));
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        Metadata metadata = document.metadata();
        assertThat(metadata.get("file_name")).isEqualTo("test-file.ppt");

assertThat(Paths.get(metadata.get("absolute_directory_path"))).isAbsolute();
    }
    @Test
    void should_load_pptx_document() {
        Document document = loadDocument(toPath("test-file.pptx"));
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        Metadata metadata = document.metadata();
        assertThat(metadata.get("file_name")).isEqualTo("test-file.pptx");

assertThat(Paths.get(metadata.get("absolute_directory_path"))).isAbsolute();
    }
```

```
    @Test
    void should_load_doc_document() {
        Document document = loadDocument(toPath("test-file.doc"));
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        Metadata metadata = document.metadata();
        assertThat(metadata.get("file_name")).isEqualTo("test-file.doc");

assertThat(Paths.get(metadata.get("absolute_directory_path"))).isAbsolute();
    }
    @Test
    void should_load_docx_document() {
        Document document = loadDocument(toPath("test-file.docx"));
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        Metadata metadata = document.metadata();
        assertThat(metadata.get("file_name")).isEqualTo("test-file.docx");

assertThat(Paths.get(metadata.get("absolute_directory_path"))).isAbsolute();
    }
    @Test
    void should_load_xls_document() {
        Document document = loadDocument(toPath("test-file.xls"));
        assertThat(document.text()).isEqualToIgnoringWhitespace("Sheet1\ntest
content\nSheet2\ntest content");
        Metadata metadata = document.metadata();
        assertThat(metadata.get("file_name")).isEqualTo("test-file.xls");

assertThat(Paths.get(metadata.get("absolute_directory_path"))).isAbsolute();
    }
    @Test
    void should_load_xlsx_document() {
        Document document = loadDocument(toPath("test-file.xlsx"));
        assertThat(document.text()).isEqualToIgnoringWhitespace("Sheet1\ntest
content\nSheet2\ntest content");
        Metadata metadata = document.metadata();
        assertThat(metadata.get("file_name")).isEqualTo("test-file.xlsx");

assertThat(Paths.get(metadata.get("absolute_directory_path"))).isAbsolute();
    }
    @Test
    void
should_load_documents_from_directory_including_unknown_document_types() {
        String userDir = System.getProperty("user.dir");
        Path resourceDirectory = Paths.get(userDir, "langchain4j/src/test/
resources");
        if (!Files.exists(resourceDirectory)) {
            resourceDirectory = Paths.get(userDir, "src/test/resources");
        }
        List<Document> documents = loadDocuments(resourceDirectory);
        assertThat(documents).hasSize(10);
        List<Document> documentsWithUnknownType = documents.stream()
                .filter(document ->
document.metadata(DOCUMENT_TYPE).equals(UNKNOWN.toString()))
                .collect(toList());
        assertThat(documentsWithUnknownType).hasSize(1);
        assertThat(documentsWithUnknownType.get(0).metadata(FILE_NAME)).isEqua
lTo("test-file.banana");
    }
    private Path toPath(String fileName) {
        try {
```

```
            return
Paths.get(getClass().getClassLoader().getResource(fileName).toURI());
        } catch (URISyntaxException e) {
            throw new RuntimeException(e);
        }
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\parser\MsOfficeDocumentParserTest.java

```
package dev.langchain4j.data.document.parser;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentParser;
import org.junit.jupiter.api.Test;
import java.io.InputStream;
import static dev.langchain4j.data.document.DocumentType.*;
import static org.assertj.core.api.Assertions.assertThat;
public class MsOfficeDocumentParserTest {
    @Test
    void should_parse_ppt_file() {
        DocumentParser parser = new MsOfficeDocumentParser(PPT);
        InputStream inputStream =
getClass().getClassLoader().getResourceAsStream("test-file.ppt");
        Document document = parser.parse(inputStream);
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        assertThat(document.metadata("document_type")).isEqualTo("PPT");
    }
    @Test
    void should_parse_pptx_file() {
        DocumentParser parser = new MsOfficeDocumentParser(PPT);
        InputStream inputStream =
getClass().getClassLoader().getResourceAsStream("test-file.pptx");
        Document document = parser.parse(inputStream);
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        assertThat(document.metadata("document_type")).isEqualTo("PPT");
    }
    @Test
    void should_parse_doc_file() {
        DocumentParser parser = new MsOfficeDocumentParser(DOC);
        InputStream inputStream =
getClass().getClassLoader().getResourceAsStream("test-file.doc");
        Document document = parser.parse(inputStream);
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        assertThat(document.metadata("document_type")).isEqualTo("DOC");
    }
    @Test
    void should_parse_docx_file() {
        DocumentParser parser = new MsOfficeDocumentParser(DOC);
        InputStream inputStream =
getClass().getClassLoader().getResourceAsStream("test-file.docx");
        Document document = parser.parse(inputStream);
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        assertThat(document.metadata("document_type")).isEqualTo("DOC");
    }
    @Test
    void should_parse_xls_file() {
        DocumentParser parser = new MsOfficeDocumentParser(XLS);
        InputStream inputStream =
getClass().getClassLoader().getResourceAsStream("test-file.xls");
        Document document = parser.parse(inputStream);
        assertThat(document.text()).isEqualToIgnoringWhitespace("Sheet1\ntest
content\nSheet2\ntest content");
        assertThat(document.metadata("document_type")).isEqualTo("XLS");
```

```
    }
    @Test
    void should_parse_xlsx_file() {
        DocumentParser parser = new MsOfficeDocumentParser(XLS);
        InputStream inputStream =
getClass().getClassLoader().getResourceAsStream("test-file.xlsx");
        Document document = parser.parse(inputStream);
        assertThat(document.text()).isEqualToIgnoringWhitespace("Sheet1\ntest
content\nSheet2\ntest content");
        assertThat(document.metadata("document_type")).isEqualTo("XLS");
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\parser\TextDocumentParserTest.java

```
package dev.langchain4j.data.document.parser;
import dev.langchain4j.data.document.Document;
import org.junit.jupiter.api.Test;
import java.io.InputStream;
import static dev.langchain4j.data.document.DocumentType.TXT;
import static java.nio.charset.StandardCharsets.ISO_8859_1;
import static org.assertj.core.api.Assertions.assertThat;
class TextDocumentParserTest {
    @Test
    void should_parse_with_utf8_charset_by_default() {
        TextDocumentParser parser = new TextDocumentParser(TXT);
        InputStream inputStream =
getClass().getClassLoader().getResourceAsStream("test-file-utf8.txt");
        Document document = parser.parse(inputStream);
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        assertThat(document.metadata("document_type")).isEqualTo("TXT");
    }
    @Test
    void should_parse_with_specified_charset() {
        TextDocumentParser parser = new TextDocumentParser(TXT, ISO_8859_1);
        InputStream inputStream =
getClass().getClassLoader().getResourceAsStream("test-file-iso-8859-1.txt");
        Document document = parser.parse(inputStream);
        assertThat(document.text()).isEqualToIgnoringWhitespace("test
content");
        assertThat(document.metadata("document_type")).isEqualTo("TXT");
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\S3DirectoryLoaderIT.java

```
package dev.langchain4j.data.document;
import org.junit.jupiter.api.AfterAll;
import org.junit.jupiter.api.AfterEach;
import org.junit.jupiter.api.BeforeAll;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import org.testcontainers.containers.localstack.LocalStackContainer;
import org.testcontainers.utility.DockerImageName;
import software.amazon.awssdk.services.s3.S3Client;
import software.amazon.awssdk.services.s3.model.CreateBucketRequest;
import software.amazon.awssdk.services.s3.model.PutObjectRequest;
import software.amazon.awssdk.core.sync.RequestBody;
import java.util.List;
import static org.junit.jupiter.api.Assertions.assertEquals;
import static org.junit.jupiter.api.Assertions.assertTrue;
import static
org.testcontainers.containers.localstack.LocalStackContainer.Service.S3;
@Disabled("To run this test, you need a Docker-API compatible container
runtime, such as using Testcontainers Cloud or installing Docker locally.")
public class S3DirectoryLoaderIT {
    private LocalStackContainer s3Container;
    private S3Client s3Client;
    @BeforeAll
    public static void setUpClass() {
        System.setProperty("aws.region", "us-east-1");
    }
    @BeforeEach
    public void setUp() {
        s3Container = new
LocalStackContainer(DockerImageName.parse("localstack/localstack:2.0"))
                .withServices(S3)
                .withEnv("DEFAULT_REGION", "us-east-1");
        s3Container.start();
        s3Client = S3Client.builder()
                .endpointOverride(s3Container.getEndpointOverride(S3))
                .build();
        s3Client.createBucket(CreateBucketRequest.builder().bucket("test-
bucket").build());
    }
    @Test
    public void should_load_empty_list() {
        S3DirectoryLoader s3DirectoryLoader = S3DirectoryLoader.builder()
                .bucket("test-bucket")
                .endpointUrl(s3Container.getEndpointOverride(S3).toString())
                .build();
        List<Document> documents = s3DirectoryLoader.load();
        assertTrue(documents.isEmpty());
    }
    @Test
    public void should_load_multiple_files_without_prefix() {
        s3Client.putObject(PutObjectRequest.builder().bucket("test-
bucket").key("file1.txt").build(),
                RequestBody.fromString("Hello, World!"));
        s3Client.putObject(PutObjectRequest.builder().bucket("test-
bucket").key("directory/file2.txt").build(),
                RequestBody.fromString("Hello, again!"));
```

```
        S3DirectoryLoader s3DirectoryLoader = S3DirectoryLoader.builder()
                .bucket("test-bucket")
                .endpointUrl(s3Container.getEndpointOverride(S3).toString())
                .build();
        List<Document> documents = s3DirectoryLoader.load();
        assertEquals(2, documents.size());
        assertEquals("Hello, again!", documents.get(0).text());
        assertEquals("s3://test-bucket/directory/file2.txt",
documents.get(0).metadata("source"));
        assertEquals("Hello, World!", documents.get(1).text());
        assertEquals("s3://test-bucket/file1.txt",
documents.get(1).metadata("source"));
    }
    @Test
    public void should_load_multiple_files_with_prefix() {
        s3Client.putObject(PutObjectRequest.builder().bucket("test-
bucket").key("other_directory/file1.txt").build(),
                RequestBody.fromString("You cannot load me!"));
        s3Client.putObject(PutObjectRequest.builder().bucket("test-
bucket").key("directory/file2.txt").build(),
                RequestBody.fromString("Hello, World!"));
        s3Client.putObject(PutObjectRequest.builder().bucket("test-
bucket").key("directory/file3.txt").build(),
                RequestBody.fromString("Hello, again!"));
        S3DirectoryLoader s3DirectoryLoader = S3DirectoryLoader.builder()
                .bucket("test-bucket")
                .prefix("directory")
                .endpointUrl(s3Container.getEndpointOverride(S3).toString())
                .build();
        List<Document> documents = s3DirectoryLoader.load();
        assertEquals(2, documents.size());
        assertEquals("Hello, World!", documents.get(0).text());
        assertEquals("s3://test-bucket/directory/file2.txt",
documents.get(0).metadata("source"));
        assertEquals("Hello, again!", documents.get(1).text());
        assertEquals("s3://test-bucket/directory/file3.txt",
documents.get(1).metadata("source"));
    }
    @Test
    public void should_load_accepting_unknown_types() {
        s3Client.putObject(PutObjectRequest.builder().bucket("test-
bucket").key("directory/file2.unknown").build(),
                RequestBody.fromString("I am unknown."));
        s3Client.putObject(PutObjectRequest.builder().bucket("test-
bucket").key("directory/file3.txt").build(),
                RequestBody.fromString("Hello, World!"));
        S3DirectoryLoader s3DirectoryLoader = S3DirectoryLoader.builder()
                .bucket("test-bucket")
                .prefix("directory")
                .endpointUrl(s3Container.getEndpointOverride(S3).toString())
                .build();
        List<Document> documents = s3DirectoryLoader.load();
        assertEquals(2, documents.size());
        assertEquals("I am unknown.", documents.get(0).text());
        assertEquals("s3://test-bucket/directory/file2.unknown",
documents.get(0).metadata("source"));
        assertEquals("Hello, World!", documents.get(1).text());
        assertEquals("s3://test-bucket/directory/file3.txt",
documents.get(1).metadata("source"));
    }
    @AfterEach
```

```
    public void tearDown() {
        s3Container.stop();
    }
    @AfterAll
    public static void tearDownClass() {
        System.clearProperty("aws.region");
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\S3DirectoryLoaderTest.java

```
package dev.langchain4j.data.document;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;
import software.amazon.awssdk.core.ResponseInputStream;
import software.amazon.awssdk.services.s3.S3Client;
import software.amazon.awssdk.services.s3.model.GetObjectRequest;
import software.amazon.awssdk.services.s3.model.GetObjectResponse;
import software.amazon.awssdk.services.s3.model.ListObjectsV2Request;
import software.amazon.awssdk.services.s3.model.ListObjectsV2Response;
import software.amazon.awssdk.services.s3.model.S3Exception;
import software.amazon.awssdk.services.s3.model.S3Object;
import java.io.ByteArrayInputStream;
import java.util.Arrays;
import java.util.List;
import static org.junit.jupiter.api.Assertions.assertEquals;
import static org.junit.jupiter.api.Assertions.assertThrows;
import static org.junit.jupiter.api.Assertions.assertTrue;
import static org.mockito.ArgumentMatchers.any;
import static org.mockito.Mockito.when;
@ExtendWith(MockitoExtension.class)
public class S3DirectoryLoaderTest {
    @Mock
    private S3Client s3Client;
    @Mock
    private ListObjectsV2Response listObjectsV2Response;
    @Mock
    private GetObjectResponse getObjectResponse;
    private S3DirectoryLoader s3DirectoryLoader;
    @BeforeEach
    public void setUp() {
        s3DirectoryLoader = S3DirectoryLoader.builder()
                .bucket("langchain4j")
                .prefix("testPrefix")
                .build();
    }
    @Test
    public void should_load_documents_from_directory() {
        S3Object s3Object1 = S3Object.builder().key("testPrefix/
testKey1.txt").size(10L).build();
        S3Object s3Object2 = S3Object.builder().key("testPrefix/
testKey2.txt").size(20L).build();

when(listObjectsV2Response.contents()).thenReturn(Arrays.asList(s3Object1,
s3Object2));
        when(s3Client.listObjectsV2(any(ListObjectsV2Request.class))).thenRetu
rn(listObjectsV2Response);
        ResponseInputStream<GetObjectResponse> responseInputStream1 = new
ResponseInputStream<>(getObjectResponse, new
ByteArrayInputStream("test1".getBytes()));
        ResponseInputStream<GetObjectResponse> responseInputStream2 = new
ResponseInputStream<>(getObjectResponse, new
ByteArrayInputStream("test2".getBytes()));
        when(s3Client.getObject(any(GetObjectRequest.class))).thenReturn(respo
nseInputStream1).thenReturn(responseInputStream2);
```

```
        List<Document> documents = s3DirectoryLoader.load(s3Client);
        assertEquals(2, documents.size());
        assertEquals("test1", documents.get(0).text());
        assertEquals("test2", documents.get(1).text());
        assertEquals("s3://langchain4j/testPrefix/testKey1.txt",
documents.get(0).metadata("source"));
        assertEquals("s3://langchain4j/testPrefix/testKey2.txt",
documents.get(1).metadata("source"));
    }
    @Test
    public void
should_load_documents_from_directory_accepting_unknown_types() {
        S3Object s3Object1 = S3Object.builder().key("testPrefix/
testKey1.txt").size(10L).build();
        S3Object s3Object2 = S3Object.builder().key("testPrefix/
testKey2.txt").size(20L).build();
        S3Object s3Object3 = S3Object.builder().key("testPrefix/
testKey3.unknown").size(30L).build();

when(listObjectsV2Response.contents()).thenReturn(Arrays.asList(s3Object1,
s3Object2, s3Object3));
        when(s3Client.listObjectsV2(any(ListObjectsV2Request.class))).thenRetu
rn(listObjectsV2Response);
        ResponseInputStream<GetObjectResponse> responseInputStream1 = new
ResponseInputStream<>(getObjectResponse, new
ByteArrayInputStream("test1".getBytes()));
        ResponseInputStream<GetObjectResponse> responseInputStream2 = new
ResponseInputStream<>(getObjectResponse, new
ByteArrayInputStream("test2".getBytes()));
        ResponseInputStream<GetObjectResponse> responseInputStream3 = new
ResponseInputStream<>(getObjectResponse, new
ByteArrayInputStream("unknown".getBytes()));
        when(s3Client.getObject(any(GetObjectRequest.class))).thenReturn(respo
nseInputStream1).thenReturn(responseInputStream2).thenReturn(responseInputStre
am3);
        List<Document> documents = s3DirectoryLoader.load(s3Client);
        assertEquals(3, documents.size());
        assertEquals("test1", documents.get(0).text());
        assertEquals("test2", documents.get(1).text());
        assertEquals("unknown", documents.get(2).text());
        assertEquals("s3://langchain4j/testPrefix/testKey1.txt",
documents.get(0).metadata("source"));
        assertEquals("s3://langchain4j/testPrefix/testKey2.txt",
documents.get(1).metadata("source"));
        assertEquals("s3://langchain4j/testPrefix/testKey3.unknown",
documents.get(2).metadata("source"));
    }
    @Test
    public void should_return_empty_list_when_no_objects() {
        when(listObjectsV2Response.contents()).thenReturn(Arrays.asList());
        when(s3Client.listObjectsV2(any(ListObjectsV2Request.class))).thenRetu
rn(listObjectsV2Response);
        List<Document> documents = s3DirectoryLoader.load(s3Client);
        assertTrue(documents.isEmpty());
    }
    @Test
    public void should_throw_s3_exception() {
        when(s3Client.listObjectsV2(any(ListObjectsV2Request.class))).thenThro
w(S3Exception.builder().message("S3 error").build());
        assertThrows(RuntimeException.class, () ->
s3DirectoryLoader.load(s3Client));
```

```
    }
    @Test
    public void should_throw_invalid_bucket() {
        assertThrows(IllegalArgumentException.class, () ->
S3DirectoryLoader.builder()
                .prefix("testPrefix")
                .build());
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\S3FileLoaderIT.java

```
package dev.langchain4j.data.document;
import org.junit.jupiter.api.AfterAll;
import org.junit.jupiter.api.AfterEach;
import org.junit.jupiter.api.BeforeAll;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import org.testcontainers.containers.localstack.LocalStackContainer;
import org.testcontainers.utility.DockerImageName;
import software.amazon.awssdk.services.s3.S3Client;
import software.amazon.awssdk.services.s3.model.CreateBucketRequest;
import software.amazon.awssdk.services.s3.model.PutObjectRequest;
import software.amazon.awssdk.core.sync.RequestBody;
import static
org.testcontainers.containers.localstack.LocalStackContainer.Service.S3;
import static org.junit.jupiter.api.Assertions.*;
@Disabled("To run this test, you need a Docker-API compatible container
runtime, such as using Testcontainers Cloud or installing Docker locally.")
public class S3FileLoaderIT {
    private LocalStackContainer s3Container;
    private S3Client s3Client;
    private static final DockerImageName localstackImage =
DockerImageName.parse("localstack/localstack:2.0");
    @BeforeAll
    public static void setUpClass() {
        System.setProperty("aws.region", "us-east-1");
    }
    @BeforeEach
    public void setUp() {
        s3Container = new LocalStackContainer(localstackImage)
                .withServices(S3)
                .withEnv("DEFAULT_REGION", "us-east-1");
        s3Container.start();
        s3Client = S3Client.builder()
                .endpointOverride(s3Container.getEndpointOverride(LocalStackCo
ntainer.Service.S3))
                .build();
        s3Client.createBucket(CreateBucketRequest.builder().bucket("test-
bucket").build());
        s3Client.putObject(PutObjectRequest.builder().bucket("test-
bucket").key("test-file.txt").build(),
                RequestBody.fromString("Hello, World!"));
    }
    @Test
    public void should_load_document() {
        S3FileLoader s3FileLoader = S3FileLoader.builder()
                .bucket("test-bucket")
                .key("test-file.txt")
                .endpointUrl(s3Container.getEndpointOverride(LocalStackContain
er.Service.S3).toString())
                .build();
        Document document = s3FileLoader.load();
        assertNotNull(document);
        assertEquals("Hello, World!", document.text());
        assertEquals("s3://test-bucket/test-file.txt",
document.metadata("source"));
    }
    @Test
```

```
    public void should_load_document_unknown_type() {
        S3Client s3Client = S3Client.builder()
                .endpointOverride(s3Container.getEndpointOverride(LocalStackCo
ntainer.Service.S3))
                .build();
        s3Client.createBucket(CreateBucketRequest.builder().bucket("test-
bucket").build());
        s3Client.putObject(PutObjectRequest.builder().bucket("test-
bucket").key("unknown-test-file.unknown").build(),
                RequestBody.fromString("Hello, World! I am Unknown"));
        S3FileLoader s3FileLoader = S3FileLoader.builder()
                .bucket("test-bucket")
                .key("unknown-test-file.unknown")
                .endpointUrl(s3Container.getEndpointOverride(LocalStackContain
er.Service.S3).toString())
                .build();
        Document document = s3FileLoader.load();
        assertNotNull(document);
        assertEquals("Hello, World! I am Unknown", document.text());
        assertEquals("s3://test-bucket/unknown-test-file.unknown",
document.metadata("source"));
    }
    @AfterEach
    public void tearDown() {
        s3Container.stop();
    }
    @AfterAll
    public static void tearDownClass() {
        System.clearProperty("aws.region");
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\S3FileLoaderTest.java

```
package dev.langchain4j.data.document;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;
import software.amazon.awssdk.core.ResponseInputStream;
import software.amazon.awssdk.services.s3.S3Client;
import software.amazon.awssdk.services.s3.model.GetObjectRequest;
import software.amazon.awssdk.services.s3.model.GetObjectResponse;
import software.amazon.awssdk.services.s3.model.S3Exception;
import java.io.ByteArrayInputStream;
import static org.junit.jupiter.api.Assertions.assertEquals;
import static org.junit.jupiter.api.Assertions.assertNotNull;
import static org.junit.jupiter.api.Assertions.assertThrows;
import static org.mockito.ArgumentMatchers.any;
import static org.mockito.Mockito.when;
@ExtendWith(MockitoExtension.class)
public class S3FileLoaderTest {
    @Mock
    private S3Client s3Client;
    @Mock
    private GetObjectResponse getObjectResponse;
    private S3FileLoader s3FileLoader;
    @BeforeEach
    public void setUp() {
        s3FileLoader = S3FileLoader.builder()
                .bucket("langchain4j")
                .key("key.txt")
                .build();
    }
    @Test
    public void should_load_document() {
        ResponseInputStream<GetObjectResponse> responseInputStream = new
ResponseInputStream<>(getObjectResponse, new
ByteArrayInputStream("test".getBytes()));
        when(s3Client.getObject(any(GetObjectRequest.class))).thenReturn(respo
nseInputStream);
        Document result = s3FileLoader.load(s3Client);
        assertNotNull(result);
        assertEquals("test", result.text());
        assertEquals("s3://langchain4j/key.txt", result.metadata("source"));
    }
    @Test
    public void should_throw_s3_exception() {
        when(s3Client.getObject(any(GetObjectRequest.class))).thenThrow(S3Exce
ption.builder().message("S3 error").build());
        assertThrows(RuntimeException.class, () ->
s3FileLoader.load(s3Client));
    }
    @Test
    public void should_throw_invalid_key() {
        assertThrows(IllegalArgumentException.class, () ->
S3FileLoader.builder()
                .bucket("testBucket")
                .build());
    }
    @Test
```

```
    public void should_throw_invalid_bucket() {
        assertThrows(IllegalArgumentException.class, () ->
S3FileLoader.builder()
                .key("testKey")
                .build());
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\splitter\DocumentByParagraphSplitterTest.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import org.junit.jupiter.api.Test;
import java.util.List;
import static dev.langchain4j.data.document.Metadata.metadata;
import static dev.langchain4j.data.segment.TextSegment.textSegment;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static java.lang.String.format;
import static org.assertj.core.api.Assertions.assertThat;
class DocumentByParagraphSplitterTest {
    @Test
    void should_split_into_segments_with_one_paragraph_per_segment() {
        int maxSegmentSize = 30;
        String firstParagraph = "This is a first paragraph.";
        assertThat(firstParagraph).hasSizeLessThan(maxSegmentSize);
        String secondParagraph = "This is a second paragraph.";
        assertThat(secondParagraph).hasSizeLessThan(maxSegmentSize);
        assertThat(firstParagraph + "\n \n" +
secondParagraph).hasSizeGreaterThan(maxSegmentSize);
        Document document = Document.from(
                format(" %s \n \n %s ", firstParagraph, secondParagraph),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
DocumentByParagraphSplitter(maxSegmentSize, 0);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->

assertThat(segment.text().length()).isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment(firstParagraph, metadata("index",
"0").add("document", "0")),
                textSegment(secondParagraph, metadata("index",
"1").add("document", "0"))
        );
    }
    @Test
    void should_split_into_segments_with_multiple_paragraphs_per_segment() {
        int maxSegmentSize = 60;
        String firstParagraph = "This is a first paragraph.";
        String secondParagraph = "This is a second paragraph.";
        assertThat(firstParagraph +
secondParagraph).hasSizeLessThan(maxSegmentSize);
        String thirdParagraph = "This is a third paragraph.";
        assertThat(thirdParagraph).hasSizeLessThan(maxSegmentSize);
        assertThat(firstParagraph + secondParagraph + thirdParagraph)
                .hasSizeGreaterThan(maxSegmentSize);
        Document document = Document.from(
                format(" %s \n \n %s \n \n %s ", firstParagraph,
secondParagraph, thirdParagraph),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
```

```
DocumentByParagraphSplitter(maxSegmentSize, 0);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->

assertThat(segment.text().length()).isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment(firstParagraph + "\n\n" + secondParagraph,
metadata("index", "0").add("document", "0")),
                textSegment(thirdParagraph, metadata("index",
"1").add("document", "0"))
        );
    }
    @Test
    void
should_split_paragraph_into_sentences_if_it_does_not_fit_into_segment() {
        int maxSegmentSize = 50;
        String firstParagraph = "This is a first paragraph.";
        assertThat(firstParagraph).hasSizeLessThan(maxSegmentSize);
        String firstSentenceOfSecondParagraph = "This is a fist sentence of a
second paragraph.";

assertThat(firstSentenceOfSecondParagraph).hasSizeLessThan(maxSegmentSize);
        String secondSentenceOfSecondParagraph = "This is a second sentence
of a second paragraph.";

assertThat(secondSentenceOfSecondParagraph).hasSizeLessThan(maxSegmentSize);
        String secondParagraph = firstSentenceOfSecondParagraph + " " +
secondSentenceOfSecondParagraph;
        assertThat(secondParagraph).hasSizeGreaterThan(maxSegmentSize);
        String thirdParagraph = "This is a third paragraph.";
        assertThat(thirdParagraph).hasSizeLessThan(maxSegmentSize);
        Document document = Document.from(
                format(" %s \n \n %s \n \n %s ", firstParagraph,
secondParagraph, thirdParagraph),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
DocumentByParagraphSplitter(maxSegmentSize, 0);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->

assertThat(segment.text().length()).isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment(firstParagraph, metadata("index",
"0").add("document", "0")),
                textSegment(firstSentenceOfSecondParagraph, metadata("index",
"1").add("document", "0")),
                textSegment(secondSentenceOfSecondParagraph,
metadata("index", "2").add("document", "0")),
                textSegment(thirdParagraph, metadata("index",
"3").add("document", "0"))
        );
    }
    @Test
    void should_split_sample_text_containing_multiple_paragraphs() {
        int maxSegmentSize = 65;
        Tokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        String p1 = "In a small town nestled between two vast mountains,
there was a shop unlike any other. " +
                "A unique haven. " +
                "Visitors would often comment on its peculiar charm, always
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```
slightly different from what they " +
                "remembered on their previous visits. " +
                "The store stood as a testament to the passage of time and
the ever-changing landscape of tales.";
        assertThat(tokenizer.estimateTokenCountInText(p1)).isEqualTo(62);
        String p2p1 = "Upon entering, the first thing to strike you was the
enormity of it all. " +
                "Every inch of space was occupied with books. " +
                "Some stood tall and regal on the highest shelves, looking as
if they had witnessed epochs come and go. " +
                "They were leather-bound, with pages yellowed by age.";
        assertThat(tokenizer.estimateTokenCountInText(p2p1)).isEqualTo(60);
        String p2p2 = "Others, smaller and brightly adorned, were reminiscent
of summer days and childhood laughter. " +
                "But these physical objects were mere vessels. " +
                "It was the stories inside that held power.";
        assertThat(tokenizer.estimateTokenCountInText(p2p2)).isEqualTo(33);
        String p3 = "Mrs. Jenkins ran the shop. " +
                "A mystery in her own right. " +
                "Her silver hair cascaded like a waterfall, and her eyes
seemed to see more than most. " +
                "With just a glance, she'd find the perfect story for you.";
        assertThat(tokenizer.estimateTokenCountInText(p3)).isEqualTo(47);
        String p4p1 = "One wet afternoon, Eli entered. " +
                "He was just a boy, lost in the vastness of the store. " +
                "Between the aisles, his small fingers danced on the spines
of books, feeling the heartbeat of " +
                "countless tales. " +
                "Then, a simple brown-covered book whispered to him.";
        assertThat(tokenizer.estimateTokenCountInText(p4p1)).isEqualTo(56);
        String p4p2 = "Without grandeur or pretense, it beckoned. " +
                "And he listened.";
        assertThat(tokenizer.estimateTokenCountInText(p4p2)).isEqualTo(15);
        String p5 = "He read. " +
                "And read. " +
                "The world around him melted.";
        assertThat(tokenizer.estimateTokenCountInText(p5)).isEqualTo(12);
        String p6 = "When Mrs. Jenkins approached, night had fallen. " +
                "She gently remarked, \"Books have a way of finding their
reader.\" " +
                "Eli simply nodded, understanding the profound truth in her
words.";
        assertThat(tokenizer.estimateTokenCountInText(p6)).isEqualTo(36);
        String p7 = "Some places and stories remain etched in our souls,
offering lessons and moments of sheer wonder. " +
                "They defy definition.";
        assertThat(tokenizer.estimateTokenCountInText(p7)).isEqualTo(23);
        Document document = Document.from(
                format("%s\n\n%s %s\n\n%s\n\n%s %s\n\n%s\n\n%s\n\n%s", p1,
p2p1, p2p2, p3, p4p1, p4p2, p5, p6, p7),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
DocumentByParagraphSplitter(maxSegmentSize, 0, tokenizer);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->
                assertThat(tokenizer.estimateTokenCountInText(segment.text()))
.isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment(p1, metadata("index", "0").add("document", "0")),
                textSegment(p2p1, metadata("index", "1").add("document",
```

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"0")),
                textSegment(p2p2, metadata("index", "2").add("document",
"0")),
                textSegment(p3, metadata("index", "3").add("document", "0")),
                textSegment(p4p1, metadata("index", "4").add("document",
"0")),
                textSegment(p4p2, metadata("index", "5").add("document",
"0")),
                textSegment(p5 + "\n\n" + p6, metadata("index",
"6").add("document", "0")),
                textSegment(p7, metadata("index", "7").add("document", "0"))
        );
    }
    @Test
    void
should_split_sample_text_containing_multiple_paragraphs_with_overlap() {
        int maxSegmentSize = 65;
        int maxOverlapSize = 15;
        Tokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        String s1 = "In a small town nestled between two vast mountains,
there was a shop unlike any other.";
        String s2 = "A unique haven.";
        String s3 = "Visitors would often comment on its peculiar charm,
always slightly different from what they remembered on their previous
visits.";
        String s4 = "The store stood as a testament to the passage of time
and the ever-changing landscape of tales.";
        String s5 = "Upon entering, the first thing to strike you was the
enormity of it all.";
        String s6 = "Every inch of space was occupied with books.";
        String s7 = "Some stood tall and regal on the highest shelves,
looking as if they had witnessed epochs come and go.";
        String s8 = "They were leather-bound, with pages yellowed by age.";
        String s9 = "Others, smaller and brightly adorned, were reminiscent
of summer days and childhood laughter.";
        String s10 = "But these physical objects were mere vessels.";
        String s11 = "It was the stories inside that held power.";
        String s12 = "Mrs. Jenkins ran the shop.";
        String s13 = "A mystery in her own right.";
        String s14 = "Her silver hair cascaded like a waterfall, and her eyes
seemed to see more than most.";
        String s15 = "With just a glance, she'd find the perfect story for
you.";
        String s16 = "One wet afternoon, Eli entered.";
        String s17 = "He was just a boy, lost in the vastness of the store.";
        String s18 = "Between the aisles, his small fingers danced on the
spines of books, feeling the heartbeat of countless tales.";
        String s19 = "Then, a simple brown-covered book whispered to him.";
        String s20 = "Without grandeur or pretense, it beckoned.";
        String s21 = "And he listened.";
        String s22 = "He read.";
        String s23 = "And read.";
        String s24 = "The world around him melted.";
        String s25 = "When Mrs. Jenkins approached, night had fallen.";
        String s26 = "She gently remarked, \"Books have a way of finding
their reader.\"";
        String s27 = "Eli simply nodded, understanding the profound truth in
her words.";
        String s28 = "Some places and stories remain etched in our souls,
offering lessons and moments of sheer wonder.";
        String s29 = "They defy definition.";
```

```
        Document document = Document.from(
                format("%s %s %s %s\n\n%s %s %s %s %s %s %s\n\n%s %s %s
%s\n\n%s %s %s %s %s %s %s %s\n\n%s %s %s %s %s",
                        s1, s2, s3, s4,
                        s5, s6, s7, s8, s9, s10, s11,
                        s12, s13, s14, s15,
                        s16, s17, s18, s19, s20, s21, s22, s23, s24,
                        s25, s26, s27, s28, s29
                ),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
DocumentByParagraphSplitter(maxSegmentSize, maxOverlapSize, tokenizer);
        List<TextSegment> segments = splitter.split(document);
        assertThat(segments).containsExactly(
                textSegment(format("%s %s %s %s", s1, s2, s3, s4),
metadata("index", "0").add("document", "0")),
                textSegment(format("%s %s %s %s", s5, s6, s7, s8),
metadata("index", "1").add("document", "0")),
                textSegment(format("%s %s %s %s", s8, s9, s10, s11),
metadata("index", "2").add("document", "0")),
                textSegment(format("%s\n\n%s %s %s %s", s11, s12, s13, s14,
s15), metadata("index", "3").add("document", "0")),
                textSegment(format("%s %s %s %s", s15, s16, s17, s18),
metadata("index", "4").add("document", "0")),
                textSegment(format("%s %s %s %s %s %s", s19, s20, s21, s22,
s23, s24), metadata("index", "5").add("document", "0")),
                textSegment(format("%s %s %s %s %s %s", s22, s23, s24, s25,
s26, s27), metadata("index", "6").add("document", "0")),
                textSegment(format("%s %s %s", s27, s28, s29),
metadata("index", "7").add("document", "0"))
        );
    }
    @Test
    void should_split_sample_text_without_paragraphs() {
        int maxSegmentSize = 100;
        Tokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        String segment1 = "In a small town nestled between two vast
mountains, there was a shop unlike any other. " +
                "A unique haven. " +
                "Visitors would often comment on its peculiar charm, always
slightly different from what they " +
                "remembered on their previous visits. " +
                "The store stood as a testament to the passage of time and
the ever-changing landscape of tales. " +
                "Upon entering, the first thing to strike you was the
enormity of it all. " +
                "Every inch of space was occupied with books.";
        String segment2 = "Some stood tall and regal on the highest shelves,
" +
                "looking as if they had witnessed epochs come and go. " +
                "They were leather-bound, with pages yellowed by age. " +
                "Others, smaller and brightly adorned, were reminiscent of
summer days and childhood laughter. " +
                "But these physical objects were mere vessels. " +
                "It was the stories inside that held power. " +
                "Mrs. Jenkins ran the shop. " +
                "A mystery in her own right.";
        String segment3 = "Her silver hair cascaded like a waterfall, and her
eyes seemed to see more than most. " +
                "With just a glance, she'd find the perfect story for you. " +
```

```
                "One wet afternoon, Eli entered. " +
                "He was just a boy, lost in the vastness of the store. " +
                "Between the aisles, his small fingers danced on the spines
of books, feeling the heartbeat of " +
                "countless tales. " +
                "Then, a simple brown-covered book whispered to him.";
        String segment4 = "Without grandeur or pretense, it beckoned. " +
                "And he listened. " +
                "He read. " +
                "And read. " +
                "The world around him melted. " +
                "When Mrs. Jenkins approached, night had fallen. " +
                "She gently remarked, \"Books have a way of finding their
reader.\" " +
                "Eli simply nodded, understanding the profound truth in her
words. " +
                "Some places and stories remain etched in our souls, offering
lessons and moments of sheer wonder. " +
                "They defy definition.";
        Document document = Document.from(
                format("%s %s %s %s", segment1, segment2, segment3, segment4),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
DocumentByParagraphSplitter(maxSegmentSize, 0, tokenizer);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->
                assertThat(tokenizer.estimateTokenCountInText(segment.text()))
.isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment(segment1, metadata("index", "0").add("document",
"0")),
                textSegment(segment2, metadata("index", "1").add("document",
"0")),
                textSegment(segment3, metadata("index", "2").add("document",
"0")),
                textSegment(segment4, metadata("index", "3").add("document",
"0"))
        );
    }
    @Test
    void should_split_sample_text_without_paragraphs_with_overlap() {
        int maxSegmentSize = 100;
        int maxOverlapSize = 25;
        Tokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        String s1 = "In a small town nestled between two vast mountains,
there was a shop unlike any other.";
        String s2 = "A unique haven.";
        String s3 = "Visitors would often comment on its peculiar charm,
always slightly different from what they remembered on their previous
visits.";
        String s4 = "The store stood as a testament to the passage of time
and the ever-changing landscape of tales.";
        String s5 = "Upon entering, the first thing to strike you was the
enormity of it all.";
        String s6 = "Every inch of space was occupied with books.";
        String s7 = "Some stood tall and regal on the highest shelves,
looking as if they had witnessed epochs come and go.";
        String s8 = "They were leather-bound, with pages yellowed by age.";
        String s9 = "Others, smaller and brightly adorned, were reminiscent
of summer days and childhood laughter.";
```

```
        String s10 = "But these physical objects were mere vessels.";
        String s11 = "It was the stories inside that held power.";
        String s12 = "Mrs. Jenkins ran the shop.";
        String s13 = "A mystery in her own right.";
        String s14 = "Her silver hair cascaded like a waterfall, and her eyes
seemed to see more than most.";
        String s15 = "With just a glance, she'd find the perfect story for
you.";
        String s16 = "One wet afternoon, Eli entered.";
        String s17 = "He was just a boy, lost in the vastness of the store.";
        String s18 = "Between the aisles, his small fingers danced on the
spines of books, feeling the heartbeat of countless tales.";
        String s19 = "Then, a simple brown-covered book whispered to him.";
        String s20 = "Without grandeur or pretense, it beckoned.";
        String s21 = "And he listened.";
        String s22 = "He read.";
        String s23 = "And read.";
        String s24 = "The world around him melted.";
        String s25 = "When Mrs. Jenkins approached, night had fallen.";
        String s26 = "She gently remarked, \"Books have a way of finding
their reader.\"";
        String s27 = "Eli simply nodded, understanding the profound truth in
her words.";
        String s28 = "Some places and stories remain etched in our souls,
offering lessons and moments of sheer wonder.";
        String s29 = "They defy definition.";
        Document document = Document.from(
                format("%s %s %s %s %s %s %s %s %s %s %s %s %s %s %s %s %s
%s %s %s %s %s %s %s %s %s %s %s",
                        s1, s2, s3, s4, s5, s6, s7, s8, s9, s10, s11, s12,
s13, s14, s15, s16, s17, s18, s19, s20,
                        s21, s22, s23, s24, s25, s26, s27, s28, s29),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
DocumentByParagraphSplitter(maxSegmentSize, maxOverlapSize, tokenizer);
        List<TextSegment> segments = splitter.split(document);
        assertThat(segments).containsExactly(
                textSegment(format("%s %s %s %s %s %s", s1, s2, s3, s4, s5,
s6), metadata("index", "0").add("document", "0")),
                textSegment(format("%s %s %s %s %s %s %s %s", s6, s7, s8, s9,
s10, s11, s12, s13), metadata("index", "1").add("document", "0")),
                textSegment(format("%s %s %s %s %s %s %s", s11, s12, s13,
s14, s15, s16, s17), metadata("index", "2").add("document", "0")),
                textSegment(format("%s %s %s %s %s %s %s %s %s %s", s16, s17,
s18, s19, s20, s21, s22, s23, s24, s25), metadata("index",
"3").add("document", "0")),
                textSegment(format("%s %s %s %s %s %s %s %s", s22, s23, s24,
s25, s26, s27, s28, s29), metadata("index", "4").add("document", "0"))
        );
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\splitter\DocumentByRegexSplitterTest.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.segment.TextSegment;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.ValueSource;
import java.util.List;
import static dev.langchain4j.data.document.Metadata.metadata;
import static dev.langchain4j.data.segment.TextSegment.textSegment;
import static java.lang.String.format;
import static org.assertj.core.api.Assertions.assertThat;
class DocumentByRegexSplitterTest {
    @ParameterizedTest
    @ValueSource(strings = {" ", ",", "\n", "\n\n"})
    void should_split_by(String separator) {
        String text = format("one%stwo%sthree", separator, separator);
        Document document = Document.from(text, metadata("document", "0"));
        int maxSegmentSize = 5;
        DocumentSplitter splitter = new DocumentByRegexSplitter(separator,
separator, maxSegmentSize, 0);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->

assertThat(segment.text().length()).isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment("one", metadata("index", "0").add("document",
"0")),
                textSegment("two", metadata("index", "1").add("document",
"0")),
                textSegment("three", metadata("index", "2").add("document",
"0"))
        );
    }
    @Test
    void should_fit_multiple_parts_into_the_same_segment() {
        Document document = Document.from("one two three",
metadata("document", "0"));
        int maxSegmentSize = 10;
        DocumentSplitter splitter = new DocumentByRegexSplitter(" ", "\n",
maxSegmentSize, 0);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->

assertThat(segment.text().length()).isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment("one\ntwo", metadata("index",
"0").add("document", "0")),
                textSegment("three", metadata("index", "1").add("document",
"0"))
        );
    }
    @Test
    void should_split_part_into_sub_parts_if_it_does_not_fit_into_segment() {
        Document document = Document.from(
                "This is a first line.\nThis is a second line.\n\nThis is a
third line.",
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                metadata("document", "0")
        );
        int maxSegmentSize = 15;
        DocumentSplitter subSplitter = new
DocumentByWordSplitter(maxSegmentSize, 0);
        DocumentSplitter splitter = new DocumentByRegexSplitter("\n", "\n",
maxSegmentSize, 0, subSplitter);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->

assertThat(segment.text().length()).isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment("This is a first", metadata("index",
"0").add("document", "0")),
                textSegment("line.", metadata("index", "1").add("document",
"0")),
                textSegment("This is a", metadata("index",
"2").add("document", "0")),
                textSegment("second line.", metadata("index",
"3").add("document", "0")),
                textSegment("This is a third", metadata("index",
"4").add("document", "0")),
                textSegment("line.", metadata("index", "5").add("document",
"0"))
        );
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\splitter\DocumentBySentenceSplitterTest.java

```
package dev.langchain4j.data.document.splitter;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import org.junit.jupiter.api.Test;
import java.util.List;
import static dev.langchain4j.data.document.Metadata.metadata;
import static dev.langchain4j.data.segment.TextSegment.textSegment;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static java.lang.String.format;
import static org.assertj.core.api.Assertions.assertThat;
class DocumentBySentenceSplitterTest {
    @Test
    void should_split_into_segments_with_one_sentence_per_segment() {
        int maxSegmentSize = 30;
        String firstSentence = "This is a first sentence.";
        assertThat(firstSentence).hasSizeLessThan(maxSegmentSize);
        String secondSentence = "This is a second sentence.";
        assertThat(secondSentence).hasSizeLessThan(maxSegmentSize);
        assertThat(firstSentence + " " +
secondSentence).hasSizeGreaterThan(maxSegmentSize);
        Document document = Document.from(
                format(" %s  %s ", firstSentence, secondSentence),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
DocumentBySentenceSplitter(maxSegmentSize, 0);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->

assertThat(segment.text().length()).isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment(firstSentence, metadata("index",
"0").add("document", "0")),
                textSegment(secondSentence, metadata("index",
"1").add("document", "0"))
        );
    }
    @Test
    void should_split_into_segments_with_multiple_sentences_per_segment() {
        int maxSegmentSize = 60;
        String firstSentence = "This is a first sentence.";
        String secondSentence = "This is a second sentence.";
        assertThat(firstSentence + " " +
secondSentence).hasSizeLessThan(maxSegmentSize);
        String thirdSentence = "This is a third sentence.";
        assertThat(firstSentence + " " + secondSentence + " " + thirdSentence)
                .hasSizeGreaterThan(maxSegmentSize);
        Document document = Document.from(
                format(" %s  %s  %s ", firstSentence, secondSentence,
thirdSentence),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
DocumentBySentenceSplitter(maxSegmentSize, 0);
        List<TextSegment> segments = splitter.split(document);
```

```
        segments.forEach(segment ->

assertThat(segment.text().length()).isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment(firstSentence + " " + secondSentence,
metadata("index", "0").add("document", "0")),
                textSegment(thirdSentence, metadata("index",
"1").add("document", "0"))
        );
    }
    @Test
    void should_split_sentence_if_it_does_not_fit_into_segment() {
        int maxSegmentSize = 40;
        String firstSentence = "This is a short sentence.";
        assertThat(firstSentence).hasSizeLessThan(maxSegmentSize);
        String secondSentence = "This is a very long sentence that does not
fit into segment.";
        assertThat(secondSentence).hasSizeGreaterThan(maxSegmentSize);
        String thirdSentence = "This is another short sentence.";
        assertThat(thirdSentence).hasSizeLessThan(maxSegmentSize);
        Document document = Document.from(
                format(" %s  %s  %s ", firstSentence, secondSentence,
thirdSentence),
                metadata("document", "0")
        );
        DocumentSplitter splitter = new
DocumentBySentenceSplitter(maxSegmentSize, 0);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->

assertThat(segment.text().length()).isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment(firstSentence, metadata("index",
"0").add("document", "0")),
                textSegment("This is a very long sentence that does",
metadata("index", "1").add("document", "0")),
                textSegment("not fit into segment.", metadata("index",
"2").add("document", "0")),
                textSegment(thirdSentence, metadata("index",
"3").add("document", "0"))
        );
    }
    @Test
    void should_split_sample_text() {
        String s1 = "In a sleepy hamlet, where the trees towered high, there
lived a young boy named Elias.";
        String s2 = "He loved exploring.";
        String s3 = "Fields of gold stretched as far as the eye could see,
punctuated by tiny blossoms.";
        String s4 = "The wind whispered.";
        String s5p1 = "Sometimes, it would carry fragrances from the
neighboring towns, which included chocolate, " +
                "freshly baked bread, and the salty tang of";
        String s5p2 = "the sea.";
        String s6 = "In the middle of the town, a single lamppost stood.";
        String s7 = "Cats lounged beneath it, stretching languidly in the
dappled sunlight.";
        String s8 = "Elias had a dream: to build a flying machine.";
        String s9 = "Some days, it felt impossible.";
        String s10 = "Yet, every evening, he would pull out his sketches,
tinkering and toiling away.";
```

```
        String s11 = "There was a resilience in his spirit.";
        String s12 = "Birds often stopped to watch.";
        String s13 = "Curiosity is the spark of invention.";
        String s14 = "He believed.";
        String s15 = "And one day, with the town gathered around him, Elias
soared.";
        String s16 = "The horizon awaited.";
        String s17 = "Life is full of surprises.";
        String s18 = "Embrace them.";
        Document document = Document.from(
                format(
                        "%s %s %s %s %s %s %s %s %s %s %s %s %s %s %s %s %s
%s %s",
                        s1, s2, s3, s4, s5p1, s5p2, s6, s7, s8, s9, s10, s11,
s12, s13, s14, s15, s16, s17, s18
                ),
                metadata("document", "0")
        );
        int maxSegmentSize = 26;
        OpenAiTokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        DocumentSplitter splitter = new
DocumentBySentenceSplitter(maxSegmentSize, 0, tokenizer);
        List<TextSegment> segments = splitter.split(document);
        segments.forEach(segment ->
                assertThat(tokenizer.estimateTokenCountInText(segment.text()))
.isLessThanOrEqualTo(maxSegmentSize));
        assertThat(segments).containsExactly(
                textSegment(s1 + " " + s2, metadata("index",
0).add("document", "0")),
                textSegment(s3 + " " + s4, metadata("index",
1).add("document", "0")),
                textSegment(s5p1, metadata("index", 2).add("document", "0")),
                textSegment(s5p2, metadata("index", 3).add("document", "0")),
                textSegment(s6, metadata("index", 4).add("document", "0")),
                textSegment(s7, metadata("index", 5).add("document", "0")),
                textSegment(s8 + " " + s9, metadata("index",
6).add("document", "0")),
                textSegment(s10, metadata("index", 7).add("document", "0")),
                textSegment(s11 + " " + s12 + " " + s13 + " " + s14,
metadata("index", 8).add("document", "0")),
                textSegment(s15 + " " + s16 + " " + s17, metadata("index",
9).add("document", "0")),
                textSegment(s18, metadata("index", 10).add("document", "0"))
        );
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\transformer\HtmlTextExtractorTest.java

```
package dev.langchain4j.data.document.transformer;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.Metadata;
import org.junit.jupiter.api.Test;
import java.util.HashMap;
import java.util.Map;
import static dev.langchain4j.data.document.Document.DOCUMENT_TYPE;
import static dev.langchain4j.data.document.DocumentType.HTML;
import static org.assertj.core.api.Assertions.assertThat;
class HtmlTextExtractorTest {
    private static final String SAMPLE_HTML = "<html>" +
            "<body>" +
            "<h1 id=\"title\">Title</h1>" +
            "<p id=\"p1\">Paragraph 1<br>Something</p>" +
            "<p id=\"p2\">Paragraph 2</p>" +
            "<p id=\"p3\">More details <a href=\"http://example.org\">here</
a>.</p>" +
            "List:<ul><li>Item one</li><li>Item two</li></ul>" +
            "</body>" +
            "</html>";
    @Test
    void should_extract_all_text_from_html() {
        HtmlTextExtractor transformer = new HtmlTextExtractor();
        Document htmlDocument = Document.from(SAMPLE_HTML,
Metadata.from(DOCUMENT_TYPE, HTML));
        Document transformedDocument = transformer.transform(htmlDocument);
        assertThat(transformedDocument.text()).isEqualTo(
                "Title\n" +
                        "\n" +
                        "Paragraph 1\n" +
                        "Something\n" +
                        "\n" +
                        "Paragraph 2\n" +
                        "\n" +
                        "More details here.\n" +
                        "List:\n" +
                        " * Item one\n" +
                        " * Item two"
        );
    }
    @Test
    void should_extract_text_from_html_by_css_selector() {
        HtmlTextExtractor transformer = new HtmlTextExtractor("#p1", null,
false);
        Document htmlDocument = Document.from(SAMPLE_HTML,
Metadata.from(DOCUMENT_TYPE, HTML));
        Document transformedDocument = transformer.transform(htmlDocument);
        assertThat(transformedDocument.text()).isEqualTo("Paragraph
1\nSomething");
        assertThat(transformedDocument.metadata(DOCUMENT_TYPE)).isEqualTo(HTML
.toString());
    }
    @Test
    void should_extract_text_and_metadata_from_html_by_css_selectors() {
        Map<String, String> metadataCssSelectors = new HashMap<>();
        metadataCssSelectors.put("title", "#title");
        HtmlTextExtractor transformer = new HtmlTextExtractor("#p1",
```

```
metadataCssSelectors, false);
        Document htmlDocument = Document.from(SAMPLE_HTML,
Metadata.from(DOCUMENT_TYPE, HTML));
        Document transformedDocument = transformer.transform(htmlDocument);
        assertThat(transformedDocument.text()).isEqualTo("Paragraph
1\nSomething");
        assertThat(transformedDocument.metadata().asMap()).hasSize(2);
        assertThat(transformedDocument.metadata(DOCUMENT_TYPE)).isEqualTo(HTML
.toString());
        assertThat(transformedDocument.metadata("title")).isEqualTo("Title");
    }
    @Test
    void should_extract_text_with_links_from_html() {
        HtmlTextExtractor transformer = new HtmlTextExtractor(null, null,
true);
        Document htmlDocument = Document.from(SAMPLE_HTML,
Metadata.from(DOCUMENT_TYPE, HTML));
        Document transformedDocument = transformer.transform(htmlDocument);
        assertThat(transformedDocument.text()).isEqualTo(
                "Title\n" +
                        "\n" +
                        "Paragraph 1\n" +
                        "Something\n" +
                        "\n" +
                        "Paragraph 2\n" +
                        "\n" +
                        "More details here <http://example.org>.\n" +
                        "List:\n" +
                        " * Item one\n" +
                        " * Item two"
        );
        assertThat(transformedDocument.metadata(DOCUMENT_TYPE)).isEqualTo(HTML
.toString());
    }
}
```

langchain4j\src\test\java\dev\langchain4j\data\document\UrlDocumentLoaderTest.java

```
package dev.langchain4j.data.document;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class UrlDocumentLoaderTest {
    @Test
    void should_load_text_document() {
        String url = "https://raw.githubusercontent.com/langchain4j/
langchain4j/main/langchain4j/src/test/resources/test-file-utf8.txt";
        Document document = UrlDocumentLoader.load(url);
        assertThat(document.text()).isEqualTo("test\ncontent");
        Metadata metadata = document.metadata();
        assertThat(metadata.get("url")).isEqualTo(url);
    }
}
```

langchain4j\src\test\java\dev\langchain4j\internal\RetryUtilsTest.java

```
package dev.langchain4j.internal;
import org.junit.jupiter.api.Test;
import java.util.concurrent.Callable;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.api.Assertions.assertThatThrownBy;
import static org.mockito.Mockito.*;
class RetryUtilsTest {
    @Test
    void testSuccessfulCall() throws Exception {
        Callable<String> mockAction = mock(Callable.class);
        when(mockAction.call()).thenReturn("Success");
        String result = withRetry(mockAction, 3);
        assertThat(result).isEqualTo("Success");
        verify(mockAction).call();
        verifyNoMoreInteractions(mockAction);
    }
    @Test
    void testRetryThenSuccess() throws Exception {
        Callable<String> mockAction = mock(Callable.class);
        when(mockAction.call())
                .thenThrow(new RuntimeException())
                .thenReturn("Success");
        long startTime = System.currentTimeMillis();
        String result = withRetry(mockAction, 3);
        long endTime = System.currentTimeMillis();
        long duration = endTime - startTime;
        assertThat(result).isEqualTo("Success");
        verify(mockAction, times(2)).call();
        verifyNoMoreInteractions(mockAction);
        assertThat(duration).isGreaterThanOrEqualTo(1000);
    }
    @Test
    void testMaxAttemptsReached() throws Exception {
        Callable<String> mockAction = mock(Callable.class);
        when(mockAction.call()).thenThrow(new RuntimeException());
        assertThatThrownBy(() -> withRetry(mockAction, 3))
                .isInstanceOf(RuntimeException.class);
        verify(mockAction, times(3)).call();
        verifyNoMoreInteractions(mockAction);
    }
}
```

langchain4j\src\test\java\dev\langchain4j\internal\TestUtils.java

```
package dev.langchain4j.internal;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.SystemMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import lombok.val;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.ValueSource;
import java.util.ArrayList;
import java.util.List;
import static dev.langchain4j.data.message.AiMessage.aiMessage;
import static dev.langchain4j.data.message.SystemMessage.systemMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static org.assertj.core.api.Assertions.assertThat;
public class TestUtils {
    private static final int EXTRA_TOKENS_PER_EACH_MESSAGE =
            3 /* extra tokens for each message */ + 1 /* extra token for
'role' */;
    private static final OpenAiTokenizer TOKENIZER = new
OpenAiTokenizer(GPT_3_5_TURBO);
    @ParameterizedTest
    @ValueSource(ints = {5, 10, 25, 50, 100, 250, 500, 1000})
    void should_create_system_message_with_tokens(int numberOfTokens) {
        SystemMessage systemMessage = systemMessageWithTokens(numberOfTokens);
        assertThat(TOKENIZER.estimateTokenCountInMessage(systemMessage)).isEqu
alTo(numberOfTokens);
    }
    public static SystemMessage systemMessageWithTokens(int numberOfTokens) {
        return systemMessage(textWithTokens(numberOfTokens -
EXTRA_TOKENS_PER_EACH_MESSAGE));
    }
    @ParameterizedTest
    @ValueSource(ints = {5, 10, 25, 50, 100, 250, 500, 1000})
    void should_create_user_message_with_tokens(int numberOfTokens) {
        UserMessage userMessage = userMessageWithTokens(numberOfTokens);
        assertThat(TOKENIZER.estimateTokenCountInMessage(userMessage)).isEqual
To(numberOfTokens);
    }
    public static UserMessage userMessageWithTokens(int numberOfTokens) {
        return userMessage(textWithTokens(numberOfTokens -
EXTRA_TOKENS_PER_EACH_MESSAGE));
    }
    @ParameterizedTest
    @ValueSource(ints = {5, 10, 25, 50, 100, 250, 500, 1000})
    void should_create_ai_message_with_tokens(int numberOfTokens) {
        AiMessage aiMessage = aiMessageWithTokens(numberOfTokens);
        assertThat(TOKENIZER.estimateTokenCountInMessage(aiMessage)).isEqualTo
(numberOfTokens);
    }
    public static AiMessage aiMessageWithTokens(int numberOfTokens) {
        return aiMessage(textWithTokens(numberOfTokens -
EXTRA_TOKENS_PER_EACH_MESSAGE));
    }
    @ParameterizedTest
    @ValueSource(ints = {1, 2, 5, 10, 25, 50, 100, 250, 500, 1000})
    void should_generate_tokens(int numberOfTokens) {
```

```
        String text = textWithTokens(numberOfTokens);
        assertThat(TOKENIZER.estimateTokenCountInText(text)).isEqualTo(numberO
fTokens);
    }
    private static String textWithTokens(int n) {
        String text = String.join(" ", repeat("one two", n));
        return TOKENIZER.decode(TOKENIZER.encode(text, n));
    }
    @Test
    void should_repeat_n_times() {
        assertThat(repeat("word", 1))
                .hasSize(1)
                .containsExactly("word");
        assertThat(repeat("word", 2))
                .hasSize(2)
                .containsExactly("word", "word");
        assertThat(repeat("word", 3))
                .hasSize(3)
                .containsExactly("word", "word", "word");
    }
    public static List<String> repeat(String s, int n) {
        val result = new ArrayList<String>();
        for (int i = 0; i < n; i++) {
            result.add(s);
        }
        return result;
    }
}
```

langchain4j\src\test\java\dev\langchain4j\memory\chat\MessageWindowChatMemoryTest.java

```
package dev.langchain4j.memory.chat;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.SystemMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.memory.ChatMemory;
import org.junit.jupiter.api.Test;
import static dev.langchain4j.data.message.AiMessage.aiMessage;
import static dev.langchain4j.data.message.SystemMessage.systemMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static org.assertj.core.api.Assertions.assertThat;
class MessageWindowChatMemoryTest {
    @Test
    void should_keep_specified_number_of_messages_in_chat_memory() {
        ChatMemory chatMemory = MessageWindowChatMemory.withMaxMessages(3);
        UserMessage firstUserMessage = userMessage("hello");
        chatMemory.add(firstUserMessage);
        assertThat(chatMemory.messages())
                .hasSize(1)
                .containsExactly(firstUserMessage);
        AiMessage firstAiMessage = aiMessage("hi");
        chatMemory.add(firstAiMessage);
        assertThat(chatMemory.messages())
                .hasSize(2)
                .containsExactly(firstUserMessage, firstAiMessage);
        UserMessage secondUserMessage = userMessage("sup");
        chatMemory.add(secondUserMessage);
        assertThat(chatMemory.messages())
                .hasSize(3)
                .containsExactly(
                        firstUserMessage,
                        firstAiMessage,
                        secondUserMessage
                );
        AiMessage secondAiMessage = aiMessage("not much");
        chatMemory.add(secondAiMessage);
        assertThat(chatMemory.messages())
                .hasSize(3)
                .containsExactly(
                        // firstUserMessage was removed
                        firstAiMessage,
                        secondUserMessage,
                        secondAiMessage
                );
    }
    @Test
    void should_not_remove_system_message_from_chat_memory() {
        ChatMemory chatMemory = MessageWindowChatMemory.withMaxMessages(3);
        SystemMessage systemMessage = systemMessage("You are a helpful
assistant");
        chatMemory.add(systemMessage);
        UserMessage firstUserMessage = userMessage("Hello");
        chatMemory.add(firstUserMessage);
        AiMessage firstAiMessage = aiMessage("Hi, how can I help you?");
        chatMemory.add(firstAiMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                firstUserMessage,
```

```
                firstAiMessage
        );
        UserMessage secondUserMessage = userMessage("Tell me a joke");
        chatMemory.add(secondUserMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                // firstUserMessage was removed
                firstAiMessage,
                secondUserMessage
        );
        AiMessage secondAiMessage = aiMessage("Why did the Java developer
wear glasses? Because they didn't see sharp!");
        chatMemory.add(secondAiMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                // firstAiMessage was removed
                secondUserMessage,
                secondAiMessage
        );
    }
    @Test
    void should_keep_only_the_latest_system_message_in_chat_memory() {
        ChatMemory chatMemory = MessageWindowChatMemory.withMaxMessages(3);
        SystemMessage firstSystemMessage = systemMessage("You are a helpful
assistant");
        chatMemory.add(firstSystemMessage);
        UserMessage firstUserMessage = userMessage("Hello");
        chatMemory.add(firstUserMessage);
        AiMessage firstAiMessage = aiMessage("Hi, how can I help you?");
        chatMemory.add(firstAiMessage);
        assertThat(chatMemory.messages()).containsExactly(
                firstSystemMessage,
                firstUserMessage,
                firstAiMessage
        );
        SystemMessage secondSystemMessage = systemMessage("You are an
unhelpful assistant");
        chatMemory.add(secondSystemMessage);
        assertThat(chatMemory.messages()).containsExactly(
                // firstSystemMessage was removed
                firstUserMessage,
                firstAiMessage,
                secondSystemMessage
        );
    }
    @Test
    void should_not_add_the_same_system_message_to_chat_memory_if_it_is_alread
y_there() {
        ChatMemory chatMemory = MessageWindowChatMemory.withMaxMessages(3);
        SystemMessage systemMessage = systemMessage("You are a helpful
assistant");
        chatMemory.add(systemMessage);
        UserMessage userMessage = userMessage("Hello");
        chatMemory.add(userMessage);
        AiMessage aiMessage = aiMessage("Hi, how can I help you?");
        chatMemory.add(aiMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                userMessage,
                aiMessage
        );
```

```
        chatMemory.add(systemMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                userMessage,
                aiMessage
        );
    }
}
```

langchain4j\src\test\java\dev\langchain4j\memory\chat\TokenWindowChatMemoryTest.java

```
package dev.langchain4j.memory.chat;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.SystemMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import org.junit.jupiter.api.Test;
import static dev.langchain4j.data.message.SystemMessage.systemMessage;
import static dev.langchain4j.internal.TestUtils.*;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static org.assertj.core.api.Assertions.assertThat;
class TokenWindowChatMemoryTest {
    @Test
    void should_keep_specified_number_of_tokens_in_chat_memory() {
        OpenAiTokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        ChatMemory chatMemory = TokenWindowChatMemory.withMaxTokens(33,
tokenizer);
        UserMessage firstUserMessage = userMessageWithTokens(10);
        chatMemory.add(firstUserMessage);
        assertThat(chatMemory.messages()).containsExactly(firstUserMessage);
        // @formatter:off
        assertThat(tokenizer.estimateTokenCountInMessages(chatMemory.messages(
))).isEqualTo(
                  10 // firstUserMessage
                + 3  // overhead
        );
        // @formatter:on
        AiMessage firstAiMessage = aiMessageWithTokens(10);
        chatMemory.add(firstAiMessage);
        assertThat(chatMemory.messages()).containsExactly(firstUserMessage,
firstAiMessage);
        // @formatter:off
        assertThat(tokenizer.estimateTokenCountInMessages(chatMemory.messages(
))).isEqualTo(
                  10 // firstUserMessage
                + 10 // firstAiMessage
                + 3  // overhead
        );
        // @formatter:on
        UserMessage secondUserMessage = userMessageWithTokens(10);
        chatMemory.add(secondUserMessage);
        assertThat(chatMemory.messages()).containsExactly(
                firstUserMessage,
                firstAiMessage,
                secondUserMessage
        );
        // @formatter:off
        assertThat(tokenizer.estimateTokenCountInMessages(chatMemory.messages(
))).isEqualTo(
                  10 // firstUserMessage
                + 10 // firstAiMessage
                + 10 // secondUserMessage
                + 3  // overhead
        );
        // @formatter:on
        AiMessage secondAiMessage = aiMessageWithTokens(10);
        chatMemory.add(secondAiMessage);
```

```
        assertThat(chatMemory.messages()).containsExactly(
                // firstUserMessage was removed
                firstAiMessage,
                secondUserMessage,
                secondAiMessage
        );
        // @formatter:off
        assertThat(tokenizer.estimateTokenCountInMessages(chatMemory.messages(
))).isEqualTo(
                 10 // firstAiMessage
               + 10 // secondUserMessage
               + 10 // secondAiMessage
               + 3  // overhead
        );
        // @formatter:on
    }
    @Test
    void should_not_remove_system_message_from_chat_memory() {
        OpenAiTokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        ChatMemory chatMemory = TokenWindowChatMemory.withMaxTokens(33,
tokenizer);
        SystemMessage systemMessage = systemMessageWithTokens(10);
        chatMemory.add(systemMessage);
        UserMessage firstUserMessage = userMessageWithTokens(10);
        chatMemory.add(firstUserMessage);
        AiMessage firstAiMessage = aiMessageWithTokens(10);
        chatMemory.add(firstAiMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                firstUserMessage,
                firstAiMessage
        );
        UserMessage secondUserMessage = userMessageWithTokens(10);
        chatMemory.add(secondUserMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                // firstUserMessage was removed
                firstAiMessage,
                secondUserMessage
        );
        AiMessage secondAiMessage = aiMessageWithTokens(10);
        chatMemory.add(secondAiMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                // firstAiMessage was removed
                secondUserMessage,
                secondAiMessage
        );
    }
    @Test
    void should_keep_only_the_latest_system_message_in_chat_memory() {
        OpenAiTokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        ChatMemory chatMemory = TokenWindowChatMemory.withMaxTokens(40,
tokenizer);
        SystemMessage firstSystemMessage = systemMessage("You are a helpful
assistant");
        chatMemory.add(firstSystemMessage);
        UserMessage firstUserMessage = userMessageWithTokens(10);
        chatMemory.add(firstUserMessage);
        AiMessage firstAiMessage = aiMessageWithTokens(10);
        chatMemory.add(firstAiMessage);
```

```
        assertThat(chatMemory.messages()).containsExactly(
                firstSystemMessage,
                firstUserMessage,
                firstAiMessage
        );
        SystemMessage secondSystemMessage = systemMessage("You are an
unhelpful assistant");
        chatMemory.add(secondSystemMessage);
        assertThat(chatMemory.messages()).containsExactly(
                // firstSystemMessage was removed
                firstUserMessage,
                firstAiMessage,
                secondSystemMessage
        );
    }
    @Test
    void should_not_add_the_same_system_message_to_chat_memory_if_it_is_alread
y_there() {
        OpenAiTokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        ChatMemory chatMemory = TokenWindowChatMemory.withMaxTokens(33,
tokenizer);
        SystemMessage systemMessage = systemMessageWithTokens(10);
        chatMemory.add(systemMessage);
        UserMessage userMessage = userMessageWithTokens(10);
        chatMemory.add(userMessage);
        AiMessage aiMessage = aiMessageWithTokens(10);
        chatMemory.add(aiMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                userMessage,
                aiMessage
        );
        chatMemory.add(systemMessage);
        assertThat(chatMemory.messages()).containsExactly(
                systemMessage,
                userMessage,
                aiMessage
        );
    }
}
```

langchain4j\src\test\java\dev\langchain4j\service\AiServicesIT.java

```
package dev.langchain4j.service;
import dev.langchain4j.agent.tool.JsonSchemaProperty;
import dev.langchain4j.agent.tool.P;
import dev.langchain4j.agent.tool.Tool;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.ToolExecutionResultMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.ChatMemoryProvider;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.input.structured.StructuredPrompt;
import dev.langchain4j.model.moderation.ModerationModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.model.openai.OpenAiModerationModel;
import dev.langchain4j.model.output.structured.Description;
import dev.langchain4j.store.memory.chat.ChatMemoryStore;
import lombok.Builder;
import lombok.ToString;
import org.junit.jupiter.api.AfterEach;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.mockito.Spy;
import org.mockito.junit.jupiter.MockitoExtension;
import java.time.LocalDate;
import java.time.LocalDateTime;
import java.time.LocalTime;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static dev.langchain4j.agent.tool.JsonSchemaProperty.NUMBER;
import static dev.langchain4j.data.message.AiMessage.aiMessage;
import static
dev.langchain4j.data.message.ChatMessageDeserializer.messagesFromJson;
import static
dev.langchain4j.data.message.ChatMessageSerializer.messagesToJson;
import static dev.langchain4j.data.message.SystemMessage.systemMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.service.AiServicesIT.Sentiment.POSITIVE;
import static java.time.Month.JULY;
import static java.util.Arrays.asList;
import static java.util.Collections.singletonList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.api.Assertions.assertThatThrownBy;
import static org.mockito.Mockito.*;
@ExtendWith(MockitoExtension.class)
public class AiServicesIT {
    @Spy
    ChatLanguageModel chatLanguageModel = OpenAiChatModel.builder()
            .apiKey(System.getenv("OPENAI_API_KEY"))
            .temperature(0.0)
            .logRequests(true)
            .logResponses(true)
            .build();
    @Spy
    ChatMemory chatMemory = MessageWindowChatMemory.withMaxMessages(10);
    @Spy
```

```
    ModerationModel moderationModel = OpenAiModerationModel.builder()
            .apiKey(System.getenv("OPENAI_API_KEY"))
            .build();
    @AfterEach
    void afterEach() {
        verifyNoMoreInteractions(chatLanguageModel);
        verifyNoMoreInteractions(chatMemory);
        verifyNoMoreInteractions(moderationModel);
    }
    interface Humorist {
        @UserMessage("Tell me a joke about {{it}}")
        String joke(String topic);
    }
    @Test
    void test_simple_instruction_with_single_argument() {
        Humorist humorist = AiServices.create(Humorist.class,
chatLanguageModel);
        String joke = humorist.joke("AI");
        assertThat(joke).isNotBlank();
        System.out.println(joke);
        verify(chatLanguageModel).generate(singletonList(userMessage("Tell me
a joke about AI")));
    }
    interface DateTimeExtractor {
        @UserMessage("Extract date from {{it}}")
        LocalDate extractDateFrom(String text);
        @UserMessage("Extract time from {{it}}")
        LocalTime extractTimeFrom(String text);
        @UserMessage("Extract date and time from {{it}}")
        LocalDateTime extractDateTimeFrom(String text);
    }
    @Test
    void test_extract_date() {
        DateTimeExtractor dateTimeExtractor =
AiServices.create(DateTimeExtractor.class, chatLanguageModel);
        String text = "The tranquility pervaded the evening of 1968, just
fifteen minutes shy of midnight, following the celebrations of Independence
Day.";
        LocalDate date = dateTimeExtractor.extractDateFrom(text);
        assertThat(date).isEqualTo(LocalDate.of(1968, JULY, 4));
        verify(chatLanguageModel).generate(singletonList(userMessage(
                "Extract date from " + text + "\n" +
                        "You must answer strictly in the following format:
2023-12-31")));
    }
    @Test
    void test_extract_time() {
        DateTimeExtractor dateTimeExtractor =
AiServices.create(DateTimeExtractor.class, chatLanguageModel);
        String text = "The tranquility pervaded the evening of 1968, just
fifteen minutes shy of midnight, following the celebrations of Independence
Day.";
        LocalTime time = dateTimeExtractor.extractTimeFrom(text);
        assertThat(time).isEqualTo(LocalTime.of(23, 45, 0));
        verify(chatLanguageModel).generate(singletonList(userMessage(
                "Extract time from " + text + "\n" +
                        "You must answer strictly in the following format:
23:59:59")));
    }
    @Test
    void test_extract_date_time() {
```

```
        DateTimeExtractor dateTimeExtractor =
AiServices.create(DateTimeExtractor.class, chatLanguageModel);
        String text = "The tranquility pervaded the evening of 1968, just
fifteen minutes shy of midnight, following the celebrations of Independence
Day.";
        LocalDateTime dateTime = dateTimeExtractor.extractDateTimeFrom(text);
        assertThat(dateTime).isEqualTo(LocalDateTime.of(1968, JULY, 4, 23,
45, 0));
        verify(chatLanguageModel).generate(singletonList(userMessage(
                "Extract date and time from " + text + "\n" +
                        "You must answer strictly in the following format:
2023-12-31T23:59:59")));
    }
    enum Sentiment {
        POSITIVE, NEUTRAL, NEGATIVE
    }
    interface SentimentAnalyzer {
        @UserMessage("Analyze sentiment of {{it}}")
        Sentiment analyzeSentimentOf(String text);
    }
    @Test
    void test_extract_enum() {
        SentimentAnalyzer sentimentAnalyzer =
AiServices.create(SentimentAnalyzer.class, chatLanguageModel);
        String customerReview = "This LaptopPro X15 is wicked fast and that
4K screen is a dream.";
        Sentiment sentiment =
sentimentAnalyzer.analyzeSentimentOf(customerReview);
        assertThat(sentiment).isEqualTo(POSITIVE);
        verify(chatLanguageModel).generate(singletonList(userMessage(
                "Analyze sentiment of " + customerReview + "\n" +
                        "You must answer strictly in the following format:
one of [POSITIVE, NEUTRAL, NEGATIVE]")));
    }
    static class Person {
        private String firstName;
        private String lastName;
        private LocalDate birthDate;
    }
    interface PersonExtractor {
        @UserMessage("Extract information about a person from {{it}}")
        Person extractPersonFrom(String text);
    }
    @Test
    void test_extract_custom_POJO() {
        PersonExtractor personExtractor =
AiServices.create(PersonExtractor.class, chatLanguageModel);
        String text = "In 1968, amidst the fading echoes of Independence Day,
"
                + "a child named John arrived under the calm evening sky. "
                + "This newborn, bearing the surname Doe, marked the start of
a new journey.";
        Person person = personExtractor.extractPersonFrom(text);
        assertThat(person.firstName).isEqualTo("John");
        assertThat(person.lastName).isEqualTo("Doe");
        assertThat(person.birthDate).isEqualTo(LocalDate.of(1968, JULY, 4));
        verify(chatLanguageModel).generate(singletonList(userMessage(
                "Extract information about a person from " + text + "\n" +
                        "You must answer strictly in the following JSON
format: {\n" +
                        "\"firstName\": (type: string),\n" +
```

```
                        "\"lastName\": (type: string),\n" +
                        "\"birthDate\": (type: date string (2023-12-31)),\n" +
                        "}")));
    }
    @ToString
    static class Recipe {
        private String title;
        private String description;
        @Description("each step should be described in 4 words, steps should
rhyme")
        private String[] steps;
        private Integer preparationTimeMinutes;
    }
    interface Chef {
        @UserMessage("Create recipe using only {{it}}")
        Recipe createRecipeFrom(String... ingredients);
        Recipe createRecipeFrom(CreateRecipePrompt prompt);
        @SystemMessage("You are very {{character}} chef")
        Recipe createRecipeFrom(@UserMessage CreateRecipePrompt prompt,
@V("character") String character);
    }
    @Test
    void test_create_recipe_from_list_of_ingredients() {
        Chef chef = AiServices.create(Chef.class, chatLanguageModel);
        Recipe recipe = chef.createRecipeFrom("cucumber", "tomato", "feta",
"onion", "olives");
        assertThat(recipe.title).isNotBlank();
        assertThat(recipe.description).isNotBlank();
        assertThat(recipe.steps).isNotEmpty();
        assertThat(recipe.preparationTimeMinutes).isPositive();
        System.out.println(recipe);
        verify(chatLanguageModel).generate(singletonList(userMessage(
                "Create recipe using only [cucumber, tomato, feta, onion,
olives]\n" +
                        "You must answer strictly in the following JSON
format: {\n" +
                        "\"title\": (type: string),\n" +
                        "\"description\": (type: string),\n" +
                        "\"steps\": (each step should be described in 4
words, steps should rhyme; type: array of string),\n" +
                        "\"preparationTimeMinutes\": (type: integer),\n" +
                        "}")));
    }
    @Builder
    @StructuredPrompt("Create a recipe of a {{dish}} that can be prepared
using only {{ingredients}}")
    static class CreateRecipePrompt {
        private String dish;
        private List<String> ingredients;
    }
    @Test
    void test_create_recipe_using_structured_prompt() {
        Chef chef = AiServices.create(Chef.class, chatLanguageModel);
        CreateRecipePrompt prompt = CreateRecipePrompt.builder()
                .dish("salad")
                .ingredients(asList("cucumber", "tomato", "feta", "onion",
"olives"))
                .build();
        Recipe recipe = chef.createRecipeFrom(prompt);
        assertThat(recipe.title).isNotBlank();
        assertThat(recipe.description).isNotBlank();
```

```
        assertThat(recipe.steps).isNotEmpty();
        assertThat(recipe.preparationTimeMinutes).isPositive();
        System.out.println(recipe);
        verify(chatLanguageModel).generate(singletonList(userMessage(
                "Create a recipe of a salad that can be prepared using only
[cucumber, tomato, feta, onion, olives]\n" +
                        "You must answer strictly in the following JSON
format: {\n" +
                        "\"title\": (type: string),\n" +
                        "\"description\": (type: string),\n" +
                        "\"steps\": (each step should be described in 4
words, steps should rhyme; type: array of string),\n" +
                        "\"preparationTimeMinutes\": (type: integer),\n" +
                        "}")));
    }
    @Test
    void test_create_recipe_using_structured_prompt_and_system_message() {
        Chef chef = AiServices.create(Chef.class, chatLanguageModel);
        CreateRecipePrompt prompt = CreateRecipePrompt
                .builder()
                .dish("salad")
                .ingredients(asList("cucumber", "tomato", "feta", "onion",
"olives"))
                .build();
        Recipe recipe = chef.createRecipeFrom(prompt, "funny");
        assertThat(recipe.title).isNotBlank();
        assertThat(recipe.description).isNotBlank();
        assertThat(recipe.steps).isNotEmpty();
        assertThat(recipe.preparationTimeMinutes).isPositive();
        System.out.println(recipe);
        verify(chatLanguageModel).generate(asList(
                systemMessage("You are very funny chef"),
                userMessage("Create a recipe of a salad that can be prepared
using only [cucumber, tomato, feta, onion, olives]\n" +
                        "You must answer strictly in the following JSON
format: {\n" +
                        "\"title\": (type: string),\n" +
                        "\"description\": (type: string),\n" +
                        "\"steps\": (each step should be described in 4
words, steps should rhyme; type: array of string),\n" +
                        "\"preparationTimeMinutes\": (type: integer),\n" +
                        "}")
        ));
    }
    interface ProfessionalChef {
        @SystemMessage("You are a professional chef. You are friendly, polite
and concise.")
        String answer(String question);
    }
    @Test
    void test_with_system_message() {
        ProfessionalChef chef = AiServices.create(ProfessionalChef.class,
chatLanguageModel);
        String question = "How long should I grill chicken?";
        String answer = chef.answer(question);
        assertThat(answer).isNotBlank();
        System.out.println(answer);
        verify(chatLanguageModel).generate(asList(
                systemMessage("You are a professional chef. You are friendly,
polite and concise."),
                userMessage(question)
```

```
        ));
    }
    interface Translator {
        @SystemMessage("You are a professional translator into {{language}}")
        @UserMessage("Translate the following text: {{text}}")
        String translate(@V("text") String text, @V("language") String
language);
    }
    @Test
    void test_with_system_and_user_messages() {
        Translator translator = AiServices.create(Translator.class,
chatLanguageModel);
        String text = "Hello, how are you?";
        String translation = translator.translate(text, "german");
        assertThat(translation).isEqualTo("Hallo, wie geht es dir?");
        verify(chatLanguageModel).generate(asList(
                systemMessage("You are a professional translator into
german"),
                userMessage("Translate the following text: Hello, how are
you?")
        ));
    }
    interface Summarizer {
        @SystemMessage("Summarize every message from user in {{n}} bullet
points. Provide only bullet points.")
        List<String> summarize(@UserMessage String text, @V("n") int n);
    }
    @Test
    void test_with_system_message_and_user_message_as_argument() {
        Summarizer summarizer = AiServices.create(Summarizer.class,
chatLanguageModel);
        String text = "AI, or artificial intelligence, is a branch of
computer science that aims to create " +
                "machines that mimic human intelligence. This can range from
simple tasks such as recognizing " +
                "patterns or speech to more complex tasks like making
decisions or predictions.";
        List<String> bulletPoints = summarizer.summarize(text, 3);
        assertThat(bulletPoints).hasSize(3);
        System.out.println(bulletPoints);
        verify(chatLanguageModel).generate(asList(
                systemMessage("Summarize every message from user in 3 bullet
points. Provide only bullet points."),
                userMessage(text + "\nYou must put every item on a separate
line.")
        ));
    }
    interface ChatWithModeration {
        @Moderate
        String chat(String message);
    }
    @Test
    void should_throw_when_text_is_flagged() {
        ChatWithModeration chatWithModeration =
AiServices.builder(ChatWithModeration.class)
                .chatLanguageModel(chatLanguageModel)
                .moderationModel(moderationModel)
                .build();
        String message = "I WILL KILL YOU!!!";
        assertThatThrownBy(() -> chatWithModeration.chat(message))
                .isExactlyInstanceOf(ModerationException.class)
```

```
                .hasMessage("Text \"" + message + "\" violates content
policy");

verify(chatLanguageModel).generate(singletonList(userMessage(message)));
        verify(moderationModel).moderate(singletonList(userMessage(message)));
    }
    @Test
    void should_not_throw_when_text_is_not_flagged() {
        ChatWithModeration chatWithModeration =
AiServices.builder(ChatWithModeration.class)
                .chatLanguageModel(chatLanguageModel)
                .moderationModel(moderationModel)
                .build();
        String message = "I will hug them!";
        String response = chatWithModeration.chat(message);
        assertThat(response).isNotBlank();

verify(chatLanguageModel).generate(singletonList(userMessage(message)));
        verify(moderationModel).moderate(singletonList(userMessage(message)));
    }
    interface ChatWithMemory {
        String chatWithoutSystemMessage(String userMessage);
        @SystemMessage("You are helpful assistant")
        String chatWithSystemMessage(String userMessage);
        @SystemMessage("You are funny assistant")
        String chatWithAnotherSystemMessage(String userMessage);
    }
    @Test
    void should_keep_chat_memory() {
        ChatWithMemory chatWithMemory =
AiServices.builder(ChatWithMemory.class)
                .chatLanguageModel(chatLanguageModel)
                .chatMemory(chatMemory)
                .build();
        String firstUserMessage = "Hello, my name is Klaus";
        String firstAiMessage =
chatWithMemory.chatWithoutSystemMessage(firstUserMessage);
        verify(chatMemory).add(userMessage(firstUserMessage));
        verify(chatLanguageModel).generate(singletonList(userMessage(firstUser
Message)));
        verify(chatMemory).add(aiMessage(firstAiMessage));
        String secondUserMessage = "What is my name?";
        String secondAiMessage =
chatWithMemory.chatWithoutSystemMessage(secondUserMessage);
        assertThat(secondAiMessage).contains("Klaus");
        verify(chatMemory).add(userMessage(secondUserMessage));
        verify(chatLanguageModel).generate(asList(
                userMessage(firstUserMessage),
                aiMessage(firstAiMessage),
                userMessage(secondUserMessage)
        ));
        verify(chatMemory).add(aiMessage(secondAiMessage));
        verify(chatMemory, times(6)).messages();
    }
    @Test
    void should_keep_chat_memory_and_not_duplicate_system_message() {
        ChatWithMemory chatWithMemory =
AiServices.builder(ChatWithMemory.class)
                .chatLanguageModel(chatLanguageModel)
                .chatMemory(chatMemory)
                .build();
```

```
        String systemMessage = "You are helpful assistant";
        String firstUserMessage = "Hello, my name is Klaus";
        String firstAiMessage =
chatWithMemory.chatWithSystemMessage(firstUserMessage);
        verify(chatLanguageModel).generate(asList(
                systemMessage(systemMessage),
                userMessage(firstUserMessage)
        ));
        String secondUserMessage = "What is my name?";
        String secondAiMessage =
chatWithMemory.chatWithSystemMessage(secondUserMessage);
        assertThat(secondAiMessage).contains("Klaus");
        verify(chatLanguageModel).generate(asList(
                systemMessage(systemMessage),
                userMessage(firstUserMessage),
                aiMessage(firstAiMessage),
                userMessage(secondUserMessage)
        ));
        verify(chatMemory, times(2)).add(systemMessage(systemMessage));
        verify(chatMemory).add(userMessage(firstUserMessage));
        verify(chatMemory).add(aiMessage(firstAiMessage));
        verify(chatMemory).add(userMessage(secondUserMessage));
        verify(chatMemory).add(aiMessage(secondAiMessage));
        verify(chatMemory, times(8)).messages();
    }
    @Test
    void should_keep_chat_memory_and_add_new_system_message() {
        ChatWithMemory chatWithMemory =
AiServices.builder(ChatWithMemory.class)
                .chatLanguageModel(chatLanguageModel)
                .chatMemory(chatMemory)
                .build();
        String firstSystemMessage = "You are helpful assistant";
        String firstUserMessage = "Hello, my name is Klaus";
        String firstAiMessage =
chatWithMemory.chatWithSystemMessage(firstUserMessage);
        verify(chatLanguageModel).generate(asList(
                systemMessage(firstSystemMessage),
                userMessage(firstUserMessage)
        ));
        String secondSystemMessage = "You are funny assistant";
        String secondUserMessage = "What is my name?";
        String secondAiMessage =
chatWithMemory.chatWithAnotherSystemMessage(secondUserMessage);
        assertThat(secondAiMessage).contains("Klaus");
        verify(chatLanguageModel).generate(asList(
                userMessage(firstUserMessage),
                aiMessage(firstAiMessage),
                systemMessage(secondSystemMessage),
                userMessage(secondUserMessage)
        ));
        verify(chatMemory).add(systemMessage(firstSystemMessage));
        verify(chatMemory).add(userMessage(firstUserMessage));
        verify(chatMemory).add(aiMessage(firstAiMessage));
        verify(chatMemory).add(aiMessage(secondAiMessage));
        verify(chatMemory).add(systemMessage(secondSystemMessage));
        verify(chatMemory).add(userMessage(secondUserMessage));
        verify(chatMemory, times(8)).messages();
    }
    interface ChatWithSeparateMemoryForEachUser {
        String chat(@MemoryId int memoryId, @UserMessage String userMessage);
```

```
    }
    @Test
    void should_keep_separate_chat_memory_for_each_user_in_store() {
        // emulating persistent storage
        Map</* memoryId */ Object, String> persistentStorage = new
HashMap<>();
        ChatMemoryStore store = new ChatMemoryStore() {
            @Override
            public List<ChatMessage> getMessages(Object memoryId) {
                return messagesFromJson(persistentStorage.get(memoryId));
            }
            @Override
            public void updateMessages(Object memoryId, List<ChatMessage>
messages) {
                persistentStorage.put(memoryId, messagesToJson(messages));
            }
            @Override
            public void deleteMessages(Object memoryId) {
                persistentStorage.remove(memoryId);
            }
        };
        ChatMemoryProvider chatMemoryProvider = memoryId ->
MessageWindowChatMemory.builder()
                .id(memoryId)
                .maxMessages(10)
                .chatMemoryStore(store)
                .build();
        int firstMemoryId = 1;
        int secondMemoryId = 2;
        ChatWithSeparateMemoryForEachUser chatWithMemory =
AiServices.builder(ChatWithSeparateMemoryForEachUser.class)
                .chatLanguageModel(chatLanguageModel)
                .chatMemoryProvider(chatMemoryProvider)
                .build();
        String firstMessageFromFirstUser = "Hello, my name is Klaus";
        String firstAiResponseToFirstUser =
chatWithMemory.chat(firstMemoryId, firstMessageFromFirstUser);
        verify(chatLanguageModel).generate(singletonList(userMessage(firstMess
ageFromFirstUser)));
        String firstMessageFromSecondUser = "Hello, my name is Francine";
        String firstAiResponseToSecondUser =
chatWithMemory.chat(secondMemoryId, firstMessageFromSecondUser);
        verify(chatLanguageModel).generate(singletonList(userMessage(firstMess
ageFromSecondUser)));
        String secondMessageFromFirstUser = "What is my name?";
        String secondAiResponseToFirstUser =
chatWithMemory.chat(firstMemoryId, secondMessageFromFirstUser);
        assertThat(secondAiResponseToFirstUser).contains("Klaus");
        verify(chatLanguageModel).generate(asList(
                userMessage(firstMessageFromFirstUser),
                aiMessage(firstAiResponseToFirstUser),
                userMessage(secondMessageFromFirstUser)
        ));
        String secondMessageFromSecondUser = "What is my name?";
        String secondAiResponseToSecondUser =
chatWithMemory.chat(secondMemoryId, secondMessageFromSecondUser);
        assertThat(secondAiResponseToSecondUser).contains("Francine");
        verify(chatLanguageModel).generate(asList(
                userMessage(firstMessageFromSecondUser),
                aiMessage(firstAiResponseToSecondUser),
                userMessage(secondMessageFromSecondUser)
```

```
        ));
        assertThat(persistentStorage).containsOnlyKeys(firstMemoryId,
secondMemoryId);
        List<ChatMessage> persistedMessagesOfFirstUser =
messagesFromJson(persistentStorage.get(firstMemoryId));
        assertThat(persistedMessagesOfFirstUser).containsExactly(
                userMessage(firstMessageFromFirstUser),
                aiMessage(firstAiResponseToFirstUser),
                userMessage(secondMessageFromFirstUser),
                aiMessage(secondAiResponseToFirstUser)
        );
        List<ChatMessage> persistedMessagesOfSecondUser =
messagesFromJson(persistentStorage.get(secondMemoryId));
        assertThat(persistedMessagesOfSecondUser).containsExactly(
                userMessage(firstMessageFromSecondUser),
                aiMessage(firstAiResponseToSecondUser),
                userMessage(secondMessageFromSecondUser),
                aiMessage(secondAiResponseToSecondUser)
        );
    }
    interface Assistant {
        String chat(String userMessage);
    }
    static class Calculator {
        @Tool("calculates the square root of the provided number")
        double squareRoot(@P("number to operate on") double number) {
            return Math.sqrt(number);
        }
    }
    @Test
    void should_execute_tool_then_answer() {
        Calculator calculator = spy(new Calculator());
        ChatMemory chatMemory = MessageWindowChatMemory.withMaxMessages(10);
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(chatLanguageModel)
                .chatMemory(chatMemory)
                .tools(calculator)
                .build();
        String userMessage = "What is the square root of 485906798473894056
in scientific notation?";
        String answer = assistant.chat(userMessage);
        assertThat(answer).contains("6.97");
        verify(calculator).squareRoot(485906798473894056.0);
        verifyNoMoreInteractions(calculator);
        List<ChatMessage> messages = chatMemory.messages();
        assertThat(messages).hasSize(4);
        assertThat(messages.get(0)).isInstanceOf(dev.langchain4j.data.message.
UserMessage.class);
        assertThat(messages.get(0).text()).isEqualTo(userMessage);
        assertThat(messages.get(1)).isInstanceOf(AiMessage.class);
        AiMessage aiMessage = (AiMessage) messages.get(1);

assertThat(aiMessage.toolExecutionRequest().name()).isEqualTo("squareRoot");
        assertThat(aiMessage.toolExecutionRequest().arguments())
                .isEqualToIgnoringWhitespace("{\"arg0\":
485906798473894056}");
        assertThat(messages.get(1).text()).isNull();

assertThat(messages.get(2)).isInstanceOf(ToolExecutionResultMessage.class);
        assertThat(messages.get(2).text()).isEqualTo("6.97070153193991E8");
        assertThat(messages.get(3)).isInstanceOf(AiMessage.class);
```

```
        assertThat(messages.get(3).text()).contains("6.97");
        verify(chatLanguageModel).generate(
                singletonList(messages.get(0)),
                singletonList(ToolSpecification.builder()
                        .name("squareRoot")
                        .description("calculates the square root of the
provided number")
                        .addParameter("arg0", NUMBER,
JsonSchemaProperty.description("number to operate on"))
                        .build())
        );
        verify(chatLanguageModel).generate(
                asList(messages.get(0), messages.get(1), messages.get(2)),
                singletonList(ToolSpecification.builder()
                        .name("squareRoot")
                        .description("calculates the square root of the
provided number")
                        .addParameter("arg0", NUMBER,
JsonSchemaProperty.description("number to operate on"))
                        .build())
        );
    }
}
```

langchain4j\src\test\java\dev\langchain4j\service\StreamingAiServicesIT.java

```
package dev.langchain4j.service;
import dev.langchain4j.agent.tool.Tool;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.ToolExecutionResultMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiStreamingChatModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.api.Test;
import java.util.List;
import java.util.concurrent.CompletableFuture;
import static dev.langchain4j.model.output.FinishReason.STOP;
import static java.time.Duration.ofSeconds;
import static java.util.concurrent.TimeUnit.SECONDS;
import static org.assertj.core.api.Assertions.assertThat;
import static org.mockito.Mockito.*;
public class StreamingAiServicesIT {
    StreamingChatLanguageModel streamingChatModel =
OpenAiStreamingChatModel.builder()
            .apiKey(System.getenv("OPENAI_API_KEY"))
            .timeout(ofSeconds(30))
            .logRequests(true)
            .logResponses(true)
            .build();
    interface Assistant {
        TokenStream chat(String userMessage);
    }
    @Test
    void should_stream_answer() throws Exception {
        Assistant assistant = AiServices.create(Assistant.class,
streamingChatModel);
        StringBuilder answerBuilder = new StringBuilder();
        CompletableFuture<String> futureAnswer = new CompletableFuture<>();
        CompletableFuture<Response<AiMessage>> futureResponse = new
CompletableFuture<>();
        assistant.chat("What is the capital of Germany?")
                .onNext(answerBuilder::append)
                .onComplete(response -> {
                    futureAnswer.complete(answerBuilder.toString());
                    futureResponse.complete(response);
                })
                .onError(futureAnswer::completeExceptionally)
                .start();
        String answer = futureAnswer.get(30, SECONDS);
        Response<AiMessage> response = futureResponse.get(30, SECONDS);
        assertThat(answer).contains("Berlin");
        assertThat(response.content().text()).isEqualTo(answer);
        assertThat(response.tokenUsage().inputTokenCount()).isEqualTo(14);
        assertThat(response.tokenUsage().outputTokenCount()).isGreaterThan(1);
        assertThat(response.tokenUsage().totalTokenCount()).isGreaterThan(15);
        assertThat(response.finishReason()).isEqualTo(STOP);
    }
    @Test
    void should_stream_answers_with_memory() throws Exception {
        ChatMemory chatMemory = MessageWindowChatMemory.withMaxMessages(10);
```

```
        Assistant assistant = AiServices.builder(Assistant.class)
                .streamingChatLanguageModel(streamingChatModel)
                .chatMemory(chatMemory)
                .build();
        String firstUserMessage = "Hi, my name is Klaus";
        CompletableFuture<Response<AiMessage>> firstResultFuture = new
CompletableFuture<>();
        assistant.chat(firstUserMessage)
                .onNext(System.out::println)
                .onComplete(firstResultFuture::complete)
                .onError(firstResultFuture::completeExceptionally)
                .start();
        Response<AiMessage> firstResponse = firstResultFuture.get(30,
SECONDS);
        assertThat(firstResponse.content().text()).contains("Klaus");
        String secondUserMessage = "What is my name?";
        CompletableFuture<Response<AiMessage>> secondResultFuture = new
CompletableFuture<>();
        assistant.chat(secondUserMessage)
                .onNext(System.out::println)
                .onComplete(secondResultFuture::complete)
                .onError(secondResultFuture::completeExceptionally)
                .start();
        Response<AiMessage> secondResponse = secondResultFuture.get(30,
SECONDS);
        assertThat(secondResponse.content().text()).contains("Klaus");
        List<ChatMessage> messages = chatMemory.messages();
        assertThat(messages).hasSize(4);
        assertThat(messages.get(0)).isInstanceOf(UserMessage.class);
        assertThat(messages.get(0).text()).isEqualTo(firstUserMessage);
        assertThat(messages.get(1)).isInstanceOf(AiMessage.class);
        assertThat(messages.get(1)).isEqualTo(firstResponse.content());
        assertThat(messages.get(2)).isInstanceOf(UserMessage.class);
        assertThat(messages.get(2).text()).isEqualTo(secondUserMessage);
        assertThat(messages.get(3)).isInstanceOf(AiMessage.class);
        assertThat(messages.get(3)).isEqualTo(secondResponse.content());
    }
    static class Calculator {
        @Tool
        double squareRoot(double number) {
            return Math.sqrt(number);
        }
    }
    @Test
    void should_execute_tool_then_stream_answer() throws Exception {
        Calculator calculator = spy(new Calculator());
        ChatMemory chatMemory = MessageWindowChatMemory.withMaxMessages(10);
        Assistant assistant = AiServices.builder(Assistant.class)
                .streamingChatLanguageModel(streamingChatModel)
                .chatMemory(chatMemory)
                .tools(calculator)
                .build();
        StringBuilder answerBuilder = new StringBuilder();
        CompletableFuture<String> futureAnswer = new CompletableFuture<>();
        CompletableFuture<Response<AiMessage>> futureResponse = new
CompletableFuture<>();
        String userMessage = "What is the square root of 485906798473894056
in scientific notation?";
        assistant.chat(userMessage)
                .onNext(answerBuilder::append)
                .onComplete(response -> {
```

```
                    futureAnswer.complete(answerBuilder.toString());
                    futureResponse.complete(response);
                })
                .onError(futureAnswer::completeExceptionally)
                .start();
        String answer = futureAnswer.get(30, SECONDS);
        Response<AiMessage> response = futureResponse.get(30, SECONDS);
        assertThat(answer).contains("6.97");
        assertThat(response.content().text()).isEqualTo(answer);
        // tool arguments provided by the model (which contribute to the
input token count)
        // can have different formatting (extra spaces) which results in one
extra/missing token
        assertThat(response.tokenUsage().inputTokenCount()).isBetween(146,
147);
        assertThat(response.tokenUsage().outputTokenCount()).isGreaterThan(1);

assertThat(response.tokenUsage().totalTokenCount()).isGreaterThan(148);
        assertThat(response.finishReason()).isEqualTo(STOP);
        verify(calculator).squareRoot(485906798473894056.0);
        verifyNoMoreInteractions(calculator);
        List<ChatMessage> messages = chatMemory.messages();
        assertThat(messages).hasSize(4);
        assertThat(messages.get(0)).isInstanceOf(UserMessage.class);
        assertThat(messages.get(0).text()).isEqualTo(userMessage);
        assertThat(messages.get(1)).isInstanceOf(AiMessage.class);
        AiMessage aiMessage = (AiMessage) messages.get(1);

assertThat(aiMessage.toolExecutionRequest().name()).isEqualTo("squareRoot");
        assertThat(aiMessage.toolExecutionRequest().arguments())
                .isEqualToIgnoringWhitespace("{\"arg0\":
485906798473894056}");
        assertThat(messages.get(1).text()).isNull();

assertThat(messages.get(2)).isInstanceOf(ToolExecutionResultMessage.class);
        assertThat(messages.get(2).text()).isEqualTo("6.97070153193991E8");
        assertThat(messages.get(3)).isInstanceOf(AiMessage.class);
        assertThat(messages.get(3).text()).contains("6.97");
    }
}
```

langchain4j\src\test\java\dev\langchain4j\store\embedding\EmbeddingStoreIngestorTest.java

```
package dev.langchain4j.store.embedding;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.document.DocumentTransformer;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.data.segment.TextSegmentTransformer;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.api.Test;
import java.util.List;
import static dev.langchain4j.data.segment.TextSegment.textSegment;
import static java.util.Arrays.asList;
import static org.mockito.Mockito.*;
class EmbeddingStoreIngestorTest {
    @Test
    public void should_extract_text_then_split_into_segments_then_embed_them_a
nd_store_in_embedding_store() {
        Document firstDocument = Document.from("First sentence.");
        Document secondDocument = Document.from("Second sentence. Third
sentence.");
        List<Document> documents = asList(firstDocument, secondDocument);
        DocumentTransformer documentTransformer =
mock(DocumentTransformer.class);

when(documentTransformer.transformAll(documents)).thenReturn(documents);
        DocumentSplitter documentSplitter = mock(DocumentSplitter.class);
        List<TextSegment> segments = asList(
                textSegment("First sentence."),
                textSegment("Second sentence."),
                textSegment("Third sentence.")
        );
        when(documentSplitter.splitAll(documents)).thenReturn(segments);
        TextSegmentTransformer textSegmentTransformer =
mock(TextSegmentTransformer.class);
        List<TextSegment> transformedSegments = asList(
                textSegment("Transformed first sentence."),
                textSegment("Transformed second sentence."),
                textSegment("Transformed third sentence.")
        );
        when(textSegmentTransformer.transformAll(segments)).thenReturn(transfo
rmedSegments);
        EmbeddingModel embeddingModel = mock(EmbeddingModel.class);
        List<Embedding> embeddings = asList(
                Embedding.from(new float[]{1}),
                Embedding.from(new float[]{2}),
                Embedding.from(new float[]{3})
        );
        when(embeddingModel.embedAll(transformedSegments)).thenReturn(Response
.from(embeddings));
        EmbeddingStore<TextSegment> embeddingStore =
mock(EmbeddingStore.class);
        EmbeddingStoreIngestor ingestor = EmbeddingStoreIngestor.builder()
                .documentTransformer(documentTransformer)
                .documentSplitter(documentSplitter)
                .textSegmentTransformer(textSegmentTransformer)
                .embeddingModel(embeddingModel)
```

```
                .embeddingStore(embeddingStore)
                .build();
        ingestor.ingest(documents);
        verify(documentTransformer).transformAll(documents);
        verifyNoMoreInteractions(documentTransformer);
        verify(documentSplitter).splitAll(documents);
        verifyNoMoreInteractions(documentSplitter);
        verify(textSegmentTransformer).transformAll(segments);
        verifyNoMoreInteractions(textSegmentTransformer);
        verify(embeddingModel).embedAll(transformedSegments);
        verifyNoMoreInteractions(embeddingModel);
        verify(embeddingStore).addAll(embeddings, transformedSegments);
        verifyNoMoreInteractions(embeddingStore);
    }
}
```

langchain4j\src\test\java\dev\langchain4j\store\embedding\inmemory\InMemoryEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.inmemory;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.io.TempDir;
import java.nio.file.Path;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
class InMemoryEmbeddingStoreTest {
    @TempDir
    Path temporaryDirectory;
    private final EmbeddingStore<TextSegment> embeddingStore = new
InMemoryEmbeddingStore<>();
    private final EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    @Test
    void should_add_embedding() {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() {
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
```

```
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_embedding_with_segment_with_metadata() {
        TextSegment segment = TextSegment.from(randomUUID(),
Metadata.from("test-key", "test-value"));
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids = embeddingStore.addAll(
                asList(firstEmbedding, secondEmbedding),
                asList(firstSegment, secondSegment)
```

```
        );
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() - 0.01
        );
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score()
        );
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() + 0.01
        );
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
```

```
    }
    @Test
    void should_return_correct_score() {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(

RelevanceScore.fromCosineSimilarity(CosineSimilarity.between(embedding,
referenceEmbedding)),
                withPercentage(1)
        );
    }
    @Test
    void should_serialize_to_and_deserialize_from_json() {
        InMemoryEmbeddingStore<TextSegment> originalEmbeddingStore =
createEmbeddingStore();
        String json = originalEmbeddingStore.serializeToJson();
        InMemoryEmbeddingStore<TextSegment> deserializedEmbeddingStore =
InMemoryEmbeddingStore.fromJson(json);

assertThat(deserializedEmbeddingStore).isEqualTo(originalEmbeddingStore);
    }
    @Test
    void should_serialize_to_and_deserialize_from_file() {
        InMemoryEmbeddingStore<TextSegment> originalEmbeddingStore =
createEmbeddingStore();
        Path filePath = temporaryDirectory.resolve("embedding-store.json");
        originalEmbeddingStore.serializeToFile(filePath);
        InMemoryEmbeddingStore<TextSegment> deserializedEmbeddingStore =
InMemoryEmbeddingStore.fromFile(filePath);

assertThat(deserializedEmbeddingStore).isEqualTo(originalEmbeddingStore);
    }
    private InMemoryEmbeddingStore<TextSegment> createEmbeddingStore() {
        InMemoryEmbeddingStore<TextSegment> embeddingStore = new
InMemoryEmbeddingStore<>();
        TextSegment segment = TextSegment.from("first");
        Embedding embedding = embeddingModel.embed(segment).content();
        embeddingStore.add(embedding, segment);
        TextSegment segmentWithMetadata = TextSegment.from("second",
Metadata.from("key", "value"));
        Embedding embedding2 =
embeddingModel.embed(segmentWithMetadata).content();
        embeddingStore.add(embedding2, segmentWithMetadata);
        return embeddingStore;
    }
}
```

```
 langchain4j\src\test\resources\mockito-
extensions\org.mockito.plugins.MockMaker

mock-maker-inline
```

langchain4j\src\test\resources\test-file-iso-8859-1.txt

test
content

langchain4j\src\test\resources\test-file-utf8.txt

```
test
content
```

langchain4j\src\test\resources\test-file.banana

this document type is unknown

langchain4j\src\test\resources\test-file.doc

BASE64:

0M8R4KGxGuEAAAAAAAAAAAAAAAAAAAAAPgADAP7/
CQAGAAAAAAAAAAAAAAAABAAAAJwAAAAAAAAAAAEAAAKQAAAAEAAAD+////AAAAACYAAAD//////////
//
//
//
//
//
//
//
///////////////////spcEAiwQJBAAA8BK/AAAAAAABEAAAAAAACAAADQgAAA4AYmpiakIUQhQAAA
AAAAAAAAAAAAAAAAAAAAJBBYALg4AACB+rF8gfqxfDQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAD//w8AAAAAAAAAAAAD//w8AAAAAAAAAAAAD//w8AAAAAAAAAAAAAAAAAAAAAAALcAAAAAAEQHAA
AAAAAARAcAANYUAAAAAAAAA1hQAAAAAAADWFAAAAAAAANYUAAAAAAAA1hQAABQAAAAAAAAAAAAAAP//
//8AAAAA6hQAAAAAAAADqFAAAAAAAAOoUAAAAAAAAA6hQAAAwAAAD2FAAADAAAAOoUAAAAAAAAA/RUAAM
QBAAACFQAAAAAAAAIVAAAAAAAAAhUAAAAAAAACFQAAAAAAAAIVAAAAAAAAAhUAAAAAAAACFQAAAAAA
AAIVAAAAAAAAfBUAAAIAAAB+FQAAAAAAAH4VAAAAAAAAfhUAAAAAAAB+FQAAAAAAAH4VAAAAAAAAfh
UAACQAAADBFwAAtgIAAHcaAAA2AAAAohUAABUAAAAAAAAAAAAAAAAAAAAAAAAAAAA1hQAAAAAAAACFQAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAACFQAAAAAAAAIVAAAAAAAAAhUAAAAAAAACFQAAAAAAAKIVAAAAAA
AAAAAAAAAAAADWFAAAAAAAANYUAAAAAAAAAhUAAAAAAAAAAAAAAAAAAAAAAIVAAAAAAAAAtxUAABYAAAA8
FQAAAAAAADwVAAAAAAAAPBUAAAAAAAACFQAAEAAAANYUAAAAAAAAAhUAAAAAAAADWFAAAAAAAAAIVAA
AAAAAAfBUAAAAAAAAAAAAAAAAAAADwVAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAhUAAAAAAAB8FQAAAAAAAAAAAAAAAAAAAAAPBUAAAAAAAAAAAAAAAAAAAD
wVAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAPBUAAAAAAAAAAAAAAAAAAP////8AAAAAQFVzKArG2QEAAAAAAA
AAAP////8AAAAAEhUAAAoAAAA8FQAAAAAAAAAAAAAAAAAAAAAAaBUAABQAAADNFQAAMAAAAAP0VAAAAAAAA
PBUAAAAAAACtGgAAAAAAABwVAAAQAAAArRoAAAAAAAAA8FQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAK0aAAAA
AAAAAAAAAAAAAADWFAAAAAAAADwVAAAsAAAAAhUAAAAAAAACFQAAAAAAAADwVAAAAAAAAAhUAAAAAAAA
ACFQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAhUAAAAAAAACFQAAAAAAAAIV
AAAAAAAAohUAAAAAAACiFQAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAALBUAAB
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAIVAAAAAAAAAhUAAAAAAAACFQAAAAAA
AP0VAAAAAAAAAhUAAAAAAAACFQAAAAAAAAIVAAAAAAAAAhUAAAAAAAAAAAAAAAAAAP////8AAAAA//
///wAAAAD/////AAAAAAAAAAAAAAAAA/////wAAAAD/////AAAAAP////8AAAAA/////wAAAAD/////
AAAAAP////8AAAAA/////wAAAAD/////AAAAAP////8AAAAA/////wAAAAD/////
AAAAAP////8AAAAA/////wAAAAD/////AAAAAK0aAAAAAAAAAhUAAAAAAAACFQAAAAAAAAIVAAAAAA
AAAhUAAAAAAAACFQAAAAAAAAIVAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAACFQAAAAAAAAIVAAAAAAAAAhUAAAAAAABEBwAAWAwAAJwTAA
A6AQAABQASAQAAAAwSBAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
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AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHRlc3QgY29udGVudA0AAAAAAAAAAAAAAAAAAAAAAAAAAA
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AAAAAAAAAAAAAAAAAgAAAEIAAAFCAAADAgAAA0IAAD4+PjtAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
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AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAFBVogkWSABZoAFAzAG1ICQRzSAkEAA4WaIJFkgBtSAkEc0gJBAQACAAA
DQgAAP0AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
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AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAABAAAAASwAMZBoAR+w0C8gsOA9IbCgBS
KwoAUjkKAFJJCgBSWwAAAXsMQCGLDEAgyQxAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHgYPABIAAQB4AQ8ABwADAAQAAwAAAAQACAAAAJgAAACe
AAAAngAAAJ4AAACeAAAAngAAAJ4AAACeAAAAngAAADYGAAA2BgAANgYAADYGAAA2BgAANgYAADYGAA
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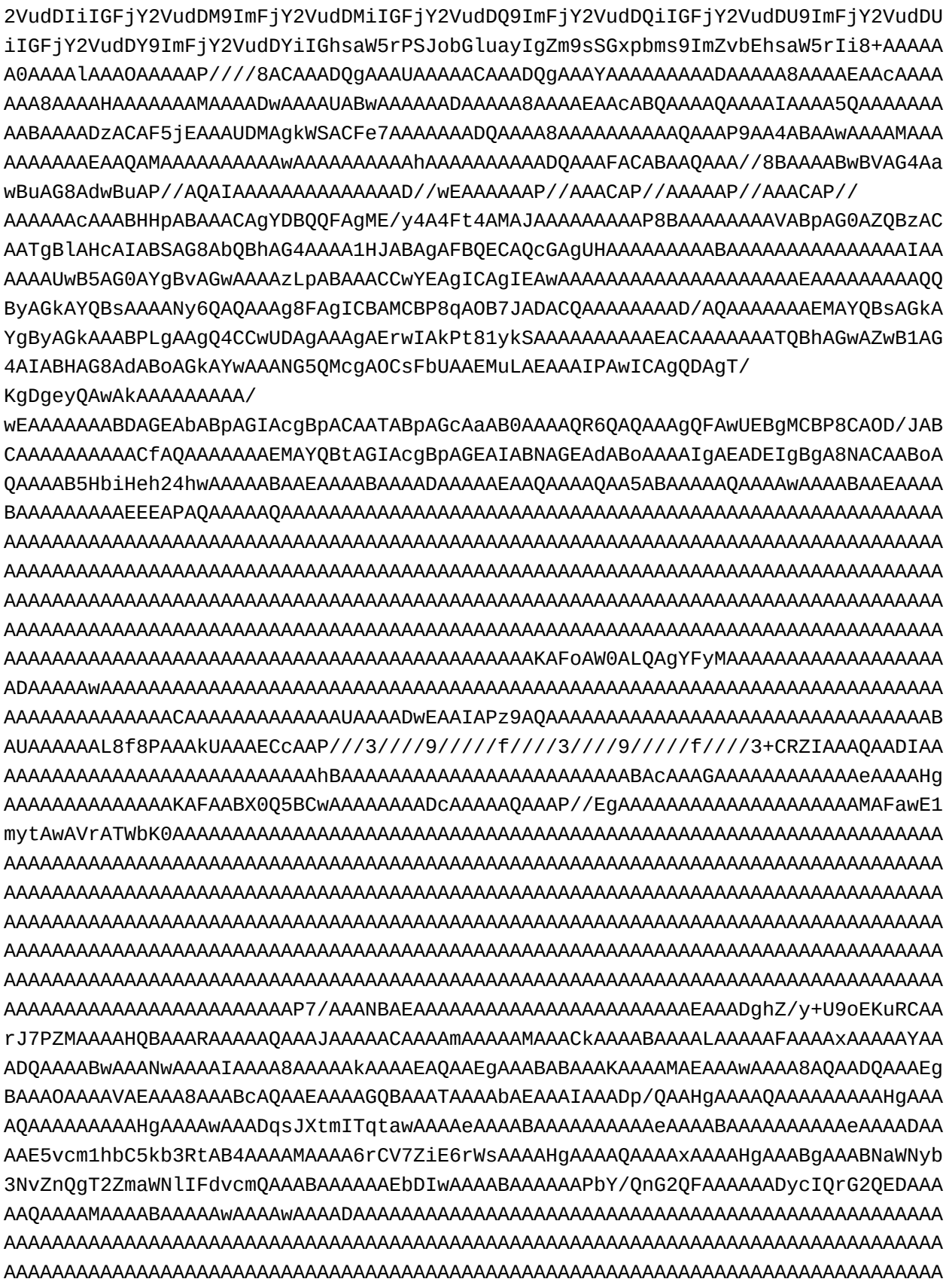

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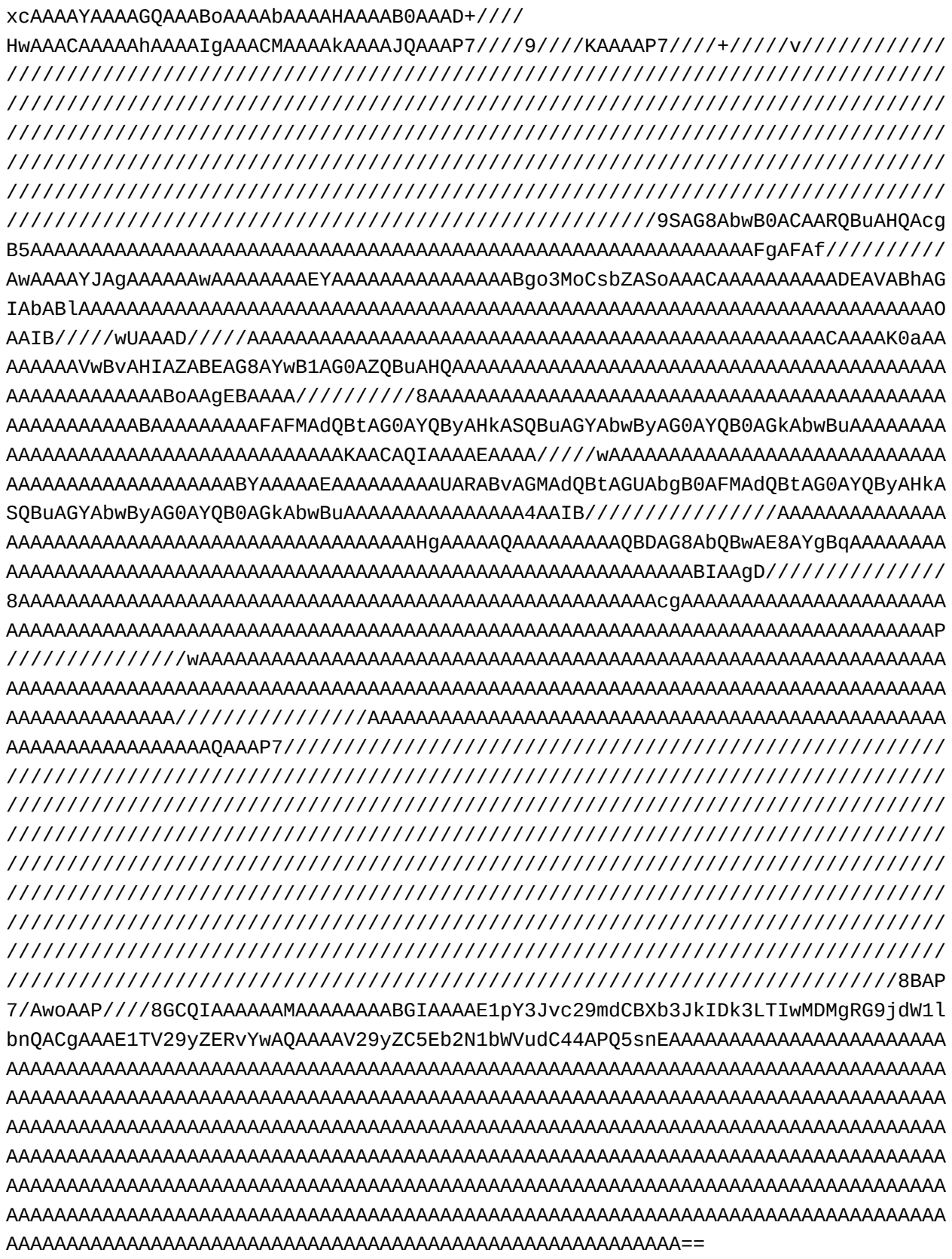

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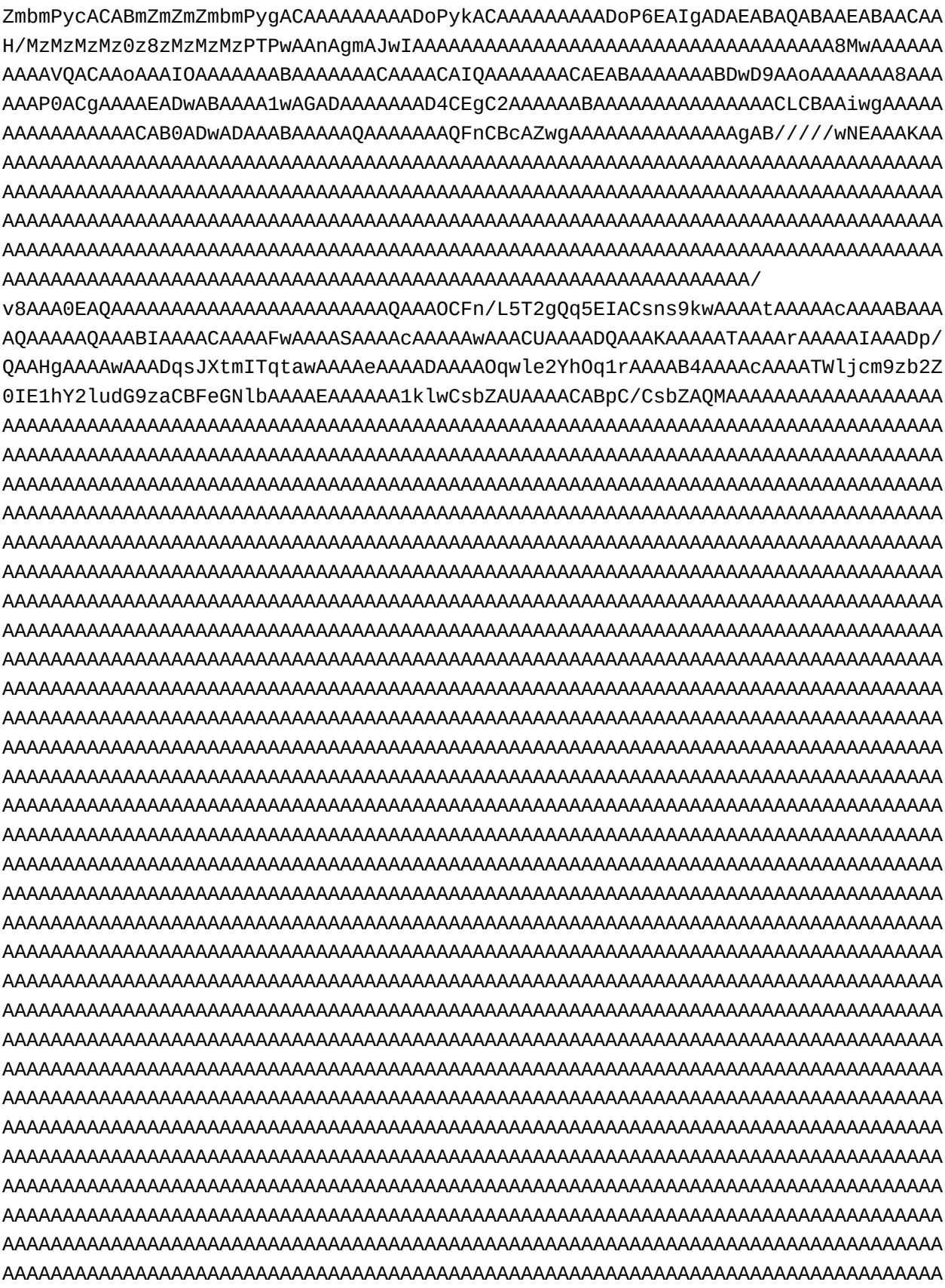

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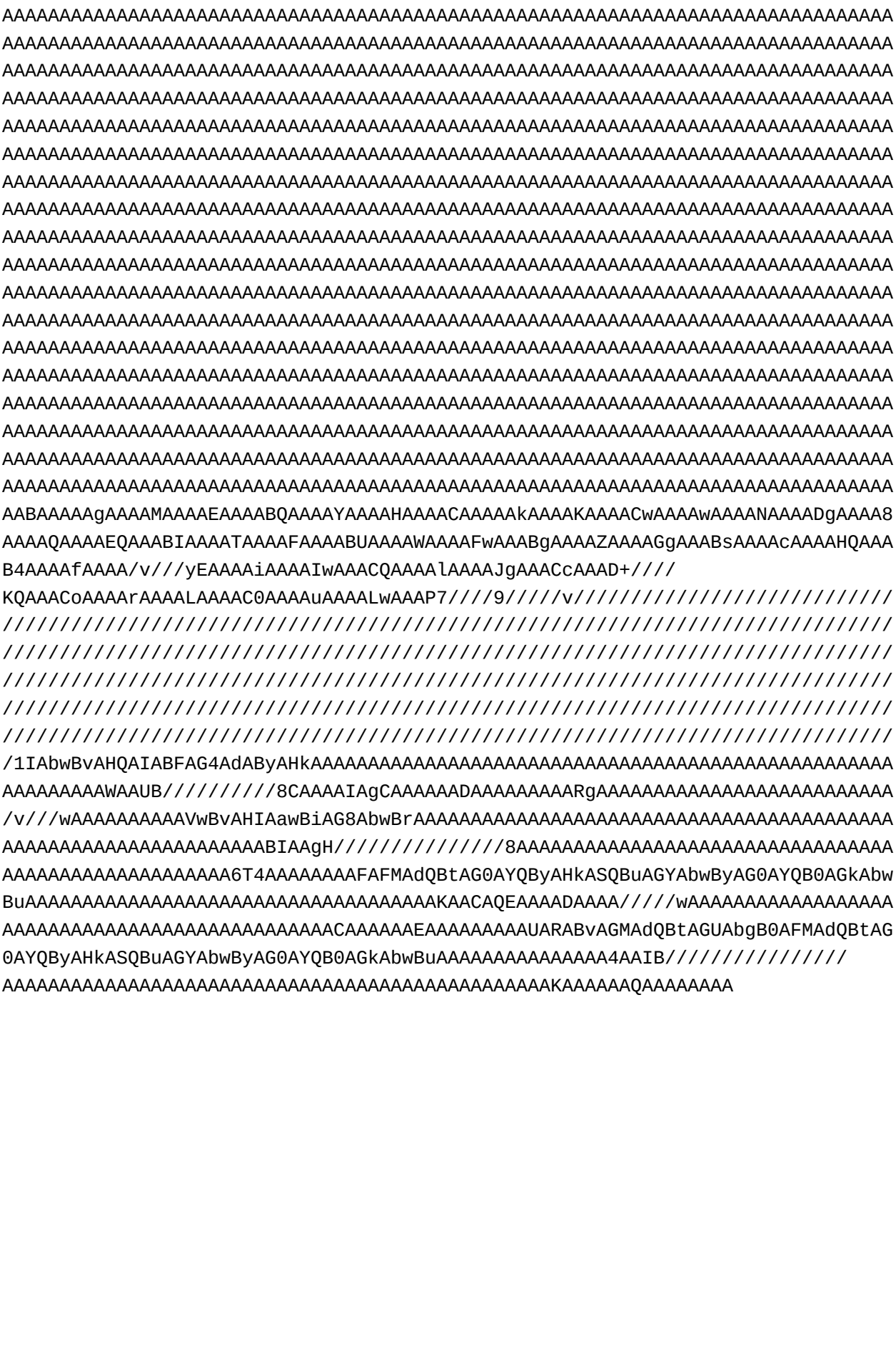

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AAAAAAAAAAAAAAAAAJ0DAABfcmVscy8ucmVsc1BLAQItABQABgAIAAAAIQBKqaZh+gAAAEcDAAAaAA
AAAAAAAAAAAAAAAMIGAAB4bC9fcmVscy93b3JrYm9vay54bWwucmVsc1BLAQItABQABgAIAAAAIQDZ
wZXLfQMAAPAIAAAPAAAAAAAAAAAAAAAAAPwIAAB4bC93b3JrYm9vay54bWxQSwECLQAUAAYACAAAAC
EA8AhY9KUCAABSBgAADQAAAAAAAAAAAAAAAACmDAAAeGwvc3R5bGVzLnhtbFBLAQItABQABgAIAAAA
IQDBFxC+TgcAAMYgAAATAAAAAAAAAAAAAAAAAHYPAAB4bC90aGVtZS90aGVtZTEueG1sUEsBAi0AFA
AGAAgAAAAhAA8SL8xvAgAAYgQAABgAAAAAAAAAAAAAAAAA9RYAAHhsL3dvcmtzaGVldHMvc2hlZXQx
LnhtbFBLAQItABQABgAIAAAAIQARBX48pAAAAMsAAAAUAAAAAAAAAAAAAAAAAJoZAAB4bC9zaGFyZW
RTdHJpbmdzLnhtbFBLAQItABQABgAIAAAAIQCLquW5YgIAAFAEAAAYAAAAAAAAAAAAAAAAAHAaAAB4
bC93b3Jrc2hlZXRzL3NoZWV0Mi54bWxQSwECLQAUAAYACAAAACEA/3lsfk4BAABjAgAAEQAAAAAAAAA
AAAAAAAAAIHQAAZG9jUHJvcHMvY29yZS54bWxQSwECLQAUAAYACAAAACEAtphM8ZUBAAA2AwAAEAAA

AAAAAAAAAAAAAACNHwAAZG9jUHJvcHMvYXBwLnhtbFBLBQYAAAAACwALAMYCAABYIgAAAAA=

langchain4j-azure-open-ai\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-azure-open-ai</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with Azure OpenAI</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-open-ai</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-params</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-azure-open-ai\src\main\java\dev\langchain4j\model\azure\AzureOpenAiChatModel.java

```
package dev.langchain4j.model.azure;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.chat.ChatCompletionRequest;
import dev.ai4j.openai4j.chat.ChatCompletionResponse;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.chat.TokenCountEstimator;
import dev.langchain4j.model.output.Response;
import java.net.Proxy;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.*;
import static java.time.Duration.ofSeconds;
import static java.util.Collections.singletonList;
/**
 * Represents an OpenAI language model, hosted on Azure, that has a chat
completion interface, such as gpt-3.5-turbo.
 * <p>
 * Mandatory parameters for initialization are: baseUrl, apiVersion and
apiKey.
 * <p>
 * There are two primary authentication methods to access Azure OpenAI:
 * <p>
 * 1. API Key Authentication: For this type of authentication, HTTP requests
must include the
 * API Key in the "api-key" HTTP header.
 * <p>
 * 2. Azure Active Directory Authentication: For this type of authentication,
HTTP requests must include the
 * authentication/access token in the "Authorization" HTTP header.
 * <p>
 * <a href="https://learn.microsoft.com/en-us/azure/ai-services/openai/
reference">More information</a>
 * <p>
 * Please note, that currently, only API Key authentication is supported by
this class,
 * second authentication option will be supported later.
 */
public class AzureOpenAiChatModel implements ChatLanguageModel,
TokenCountEstimator {
    private final OpenAiClient client;
    private final Double temperature;
    private final Double topP;
    private final Integer maxTokens;
    private final Double presencePenalty;
    private final Double frequencyPenalty;
    private final Integer maxRetries;
    private final Tokenizer tokenizer;
    public AzureOpenAiChatModel(String baseUrl,
                                String apiVersion,
                                String apiKey,
```

```
                                Tokenizer tokenizer,
                                Double temperature,
                                Double topP,
                                Integer maxTokens,
                                Double presencePenalty,
                                Double frequencyPenalty,
                                Duration timeout,
                                Integer maxRetries,
                                Proxy proxy,
                                Boolean logRequests,
                                Boolean logResponses) {
        timeout = getOrDefault(timeout, ofSeconds(60));
        this.client = OpenAiClient.builder()
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .azureApiKey(apiKey)
                .apiVersion(apiVersion)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.temperature = getOrDefault(temperature, 0.7);
        this.topP = topP;
        this.maxTokens = maxTokens;
        this.presencePenalty = presencePenalty;
        this.frequencyPenalty = frequencyPenalty;
        this.maxRetries = getOrDefault(maxRetries, 3);
        this.tokenizer = tokenizer;
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages) {
        return generate(messages, null, null);
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
List<ToolSpecification> toolSpecifications) {
        return generate(messages, toolSpecifications, null);
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
ToolSpecification toolSpecification) {
        return generate(messages, singletonList(toolSpecification),
toolSpecification);
    }
    private Response<AiMessage> generate(List<ChatMessage> messages,
                                         List<ToolSpecification>
toolSpecifications,
                                         ToolSpecification
toolThatMustBeExecuted
    ) {
        ChatCompletionRequest.Builder requestBuilder =
ChatCompletionRequest.builder()
                .messages(toOpenAiMessages(messages))
                .temperature(temperature)
                .topP(topP)
                .maxTokens(maxTokens)
                .presencePenalty(presencePenalty)
                .frequencyPenalty(frequencyPenalty);
```

```
        if (toolSpecifications != null && !toolSpecifications.isEmpty()) {
            requestBuilder.functions(toFunctions(toolSpecifications));
        }
        if (toolThatMustBeExecuted != null) {
            requestBuilder.functionCall(toolThatMustBeExecuted.name());
        }
        ChatCompletionRequest request = requestBuilder.build();
        ChatCompletionResponse response = withRetry(() ->
client.chatCompletion(request).execute(), maxRetries);
        return Response.from(
                aiMessageFrom(response),
                tokenUsageFrom(response.usage()),
                finishReasonFrom(response.choices().get(0).finishReason())
        );
    }
    @Override
    public int estimateTokenCount(List<ChatMessage> messages) {
        return tokenizer.estimateTokenCountInMessages(messages);
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String baseUrl;
        private String apiVersion;
        private String apiKey;
        private Tokenizer tokenizer;
        private Double temperature;
        private Double topP;
        private Integer maxTokens;
        private Double presencePenalty;
        private Double frequencyPenalty;
        private Duration timeout;
        private Integer maxRetries;
        private Proxy proxy;
        private Boolean logRequests;
        private Boolean logResponses;
        /**
         * Sets the Azure OpenAI base URL. This is a mandatory parameter.
         *
         * @param baseUrl The Azure OpenAI base URL in the format: https://
{resource}.openai.azure.com/openai/deployments/{deployment}
         * @return builder
         */
        public Builder baseUrl(String baseUrl) {
            this.baseUrl = baseUrl;
            return this;
        }
        /**
         * Sets the Azure OpenAI API version. This is a mandatory parameter.
         *
         * @param apiVersion The Azure OpenAI api version in the format:
2023-05-15
         * @return builder
         */
        public Builder apiVersion(String apiVersion) {
            this.apiVersion = apiVersion;
            return this;
        }
        /**
         * Sets the Azure OpenAI API key. This is a mandatory parameter.
```

```
     *
     * @param apiKey The Azure OpenAI API key.
     * @return builder
     */
    public Builder apiKey(String apiKey) {
        this.apiKey = apiKey;
        return this;
    }
    public Builder tokenizer(Tokenizer tokenizer) {
        this.tokenizer = tokenizer;
        return this;
    }
    public Builder temperature(Double temperature) {
        this.temperature = temperature;
        return this;
    }
    public Builder topP(Double topP) {
        this.topP = topP;
        return this;
    }
    public Builder maxTokens(Integer maxTokens) {
        this.maxTokens = maxTokens;
        return this;
    }
    public Builder presencePenalty(Double presencePenalty) {
        this.presencePenalty = presencePenalty;
        return this;
    }
    public Builder frequencyPenalty(Double frequencyPenalty) {
        this.frequencyPenalty = frequencyPenalty;
        return this;
    }
    public Builder timeout(Duration timeout) {
        this.timeout = timeout;
        return this;
    }
    public Builder maxRetries(Integer maxRetries) {
        this.maxRetries = maxRetries;
        return this;
    }
    public Builder proxy(Proxy proxy) {
        this.proxy = proxy;
        return this;
    }
    public Builder logRequests(Boolean logRequests) {
        this.logRequests = logRequests;
        return this;
    }
    public Builder logResponses(Boolean logResponses) {
        this.logResponses = logResponses;
        return this;
    }
    public AzureOpenAiChatModel build() {
        return new AzureOpenAiChatModel(
                baseUrl,
                apiVersion,
                apiKey,
                tokenizer,
                temperature,
                topP,
                maxTokens,
```

```
                    presencePenalty,
                    frequencyPenalty,
                    timeout,
                    maxRetries,
                    proxy,
                    logRequests,
                    logResponses
                );
            }
        }
    }
```

langchain4j-azure-open-ai\src\main\java\dev\langchain4j\model\azure\AzureOpenAiEmbeddingModel.java

```
package dev.langchain4j.model.azure;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.embedding.EmbeddingRequest;
import dev.ai4j.openai4j.embedding.EmbeddingResponse;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.embedding.TokenCountEstimator;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import java.net.Proxy;
import java.time.Duration;
import java.util.ArrayList;
import java.util.List;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static java.time.Duration.ofSeconds;
import static java.util.stream.Collectors.toList;
/**
 * Represents an OpenAI embedding model, hosted on Azure, such as text-embedding-ada-002.
 * <p>
 * Mandatory parameters for initialization are: baseUrl, apiVersion and apiKey.
 * <p>
 * There are two primary authentication methods to access Azure OpenAI:
 * <p>
 * 1. API Key Authentication: For this type of authentication, HTTP requests must include the
 * API Key in the "api-key" HTTP header.
 * <p>
 * 2. Azure Active Directory Authentication: For this type of authentication, HTTP requests must include the
 * authentication/access token in the "Authorization" HTTP header.
 * <p>
 * <a href="https://learn.microsoft.com/en-us/azure/ai-services/openai/reference">More information</a>
 * <p>
 */
public class AzureOpenAiEmbeddingModel implements EmbeddingModel, TokenCountEstimator {
    private static final int BATCH_SIZE = 16;
    private final OpenAiClient client;
    private final Integer maxRetries;
    private final Tokenizer tokenizer;
    public AzureOpenAiEmbeddingModel(String baseUrl,
                                     String apiVersion,
                                     String apiKey,
                                     Tokenizer tokenizer,
                                     Duration timeout,
                                     Integer maxRetries,
                                     Proxy proxy,
                                     Boolean logRequests,
                                     Boolean logResponses) {
        timeout = getOrDefault(timeout, ofSeconds(60));
```

```
        this.client = OpenAiClient.builder()
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .azureApiKey(apiKey)
                .apiVersion(apiVersion)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.maxRetries = getOrDefault(maxRetries, 3);
        this.tokenizer = tokenizer;
    }
    /**
     * Embeds the provided text segments, processing a maximum of 16 segments
at a time.
     * For more information, refer to the documentation <a href="https://
learn.microsoft.com/en-us/azure/ai-services/openai/faq#i-am-trying-to-use-
embeddings-and-received-the-error--invalidrequesterror--too-many-inputs--the-
max-number-of-inputs-is-1---how-do-i-fix-this-">here</a>.
     *
     * @param textSegments A list of text segments.
     * @return A list of corresponding embeddings.
     */
    @Override
    public Response<List<Embedding>> embedAll(List<TextSegment> textSegments)
{
        List<String> texts = textSegments.stream()
                .map(TextSegment::text)
                .collect(toList());
        return embedTexts(texts);
    }
    private Response<List<Embedding>> embedTexts(List<String> texts) {
        List<Embedding> embeddings = new ArrayList<>();
        int inputTokenCount = 0;
        for (int i = 0; i < texts.size(); i += BATCH_SIZE) {
            List<String> batch = texts.subList(i, Math.min(i + BATCH_SIZE,
texts.size()));
            EmbeddingRequest request = EmbeddingRequest.builder()
                    .input(batch)
                    .build();
            EmbeddingResponse response = withRetry(() ->
client.embedding(request).execute(), maxRetries);
            embeddings.addAll(response.data().stream()
                    .map(openAiEmbedding ->
Embedding.from(openAiEmbedding.embedding()))
                    .collect(toList()));
            inputTokenCount += response.usage().promptTokens();
        }
        return Response.from(
                embeddings,
                new TokenUsage(inputTokenCount)
        );
    }
    @Override
    public int estimateTokenCount(String text) {
        return tokenizer.estimateTokenCountInText(text);
    }
    public static Builder builder() {
```

```
        return new Builder();
    }
    public static class Builder {
        private String baseUrl;
        private String apiVersion;
        private String apiKey;
        private Tokenizer tokenizer;
        private Duration timeout;
        private Integer maxRetries;
        private Proxy proxy;
        private Boolean logRequests;
        private Boolean logResponses;
        /**
         * Sets the Azure OpenAI base URL. This is a mandatory parameter.
         *
         * @param baseUrl The Azure OpenAI base URL in the format: https://
{resource}.openai.azure.com/openai/deployments/{deployment}
         * @return builder
         */
        public Builder baseUrl(String baseUrl) {
            this.baseUrl = baseUrl;
            return this;
        }
        /**
         * Sets the Azure OpenAI API version. This is a mandatory parameter.
         *
         * @param apiVersion The Azure OpenAI api version in the format:
2023-05-15
         * @return builder
         */
        public Builder apiVersion(String apiVersion) {
            this.apiVersion = apiVersion;
            return this;
        }
        /**
         * Sets the Azure OpenAI API key. This is a mandatory parameter.
         *
         * @param apiKey The Azure OpenAI API key.
         * @return builder
         */
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
        }
        public Builder tokenizer(Tokenizer tokenizer) {
            this.tokenizer = tokenizer;
            return this;
        }
        public Builder timeout(Duration timeout) {
            this.timeout = timeout;
            return this;
        }
        public Builder maxRetries(Integer maxRetries) {
            this.maxRetries = maxRetries;
            return this;
        }
        public Builder proxy(Proxy proxy) {
            this.proxy = proxy;
            return this;
        }
        public Builder logRequests(Boolean logRequests) {
```

```
            this.logRequests = logRequests;
            return this;
        }
        public Builder logResponses(Boolean logResponses) {
            this.logResponses = logResponses;
            return this;
        }
        public AzureOpenAiEmbeddingModel build() {
            return new AzureOpenAiEmbeddingModel(
                    baseUrl,
                    apiVersion,
                    apiKey,
                    tokenizer,
                    timeout,
                    maxRetries,
                    proxy,
                    logRequests,
                    logResponses
            );
        }
    }
}
```

langchain4j-azure-open-ai\src\main\java\dev\langchain4j\model\azure\AzureOpenAiLanguageModel.java

```
package dev.langchain4j.model.azure;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.completion.CompletionChoice;
import dev.ai4j.openai4j.completion.CompletionRequest;
import dev.ai4j.openai4j.completion.CompletionResponse;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.language.LanguageModel;
import dev.langchain4j.model.language.TokenCountEstimator;
import dev.langchain4j.model.output.Response;
import java.net.Proxy;
import java.time.Duration;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static
dev.langchain4j.model.openai.InternalOpenAiHelper.finishReasonFrom;
import static
dev.langchain4j.model.openai.InternalOpenAiHelper.tokenUsageFrom;
import static java.time.Duration.ofSeconds;
/**
 * Represents an OpenAI language model, hosted on Azure, such as text-
davinci-003.
 * However, it's recommended to use {@link AzureOpenAiChatModel} instead,
 * as it offers more advanced features like function calling, multi-turn
conversations, etc.
 * <p>
 * Mandatory parameters for initialization are: baseUrl, apiVersion and
apiKey.
 * <p>
 * There are two primary authentication methods to access Azure OpenAI:
 * <p>
 * 1. API Key Authentication: For this type of authentication, HTTP requests
must include the
 * API Key in the "api-key" HTTP header.
 * <p>
 * 2. Azure Active Directory Authentication: For this type of authentication,
HTTP requests must include the
 * authentication/access token in the "Authorization" HTTP header.
 * <p>
 * <a href="https://learn.microsoft.com/en-us/azure/ai-services/openai/
reference">More information</a>
 * <p>
 * Please note, that currently, only API Key authentication is supported by
this class,
 * second authentication option will be supported later.
 */
public class AzureOpenAiLanguageModel implements LanguageModel,
TokenCountEstimator {
    private final OpenAiClient client;
    private final Double temperature;
    private final Integer maxRetries;
    private final Tokenizer tokenizer;
    public AzureOpenAiLanguageModel(String baseUrl,
                                    String apiVersion,
                                    String apiKey,
                                    Tokenizer tokenizer,
                                    Double temperature,
```

```
                                    Duration timeout,
                                    Integer maxRetries,
                                    Proxy proxy,
                                    Boolean logRequests,
                                    Boolean logResponses) {
        timeout = timeout == null ? ofSeconds(60) : timeout;
        this.client = OpenAiClient.builder()
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .azureApiKey(apiKey)
                .apiVersion(apiVersion)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.temperature = getOrDefault(temperature, 0.7);
        this.maxRetries = getOrDefault(maxRetries, 3);
        this.tokenizer = tokenizer;
    }
    @Override
    public Response<String> generate(String prompt) {
        CompletionRequest request = CompletionRequest.builder()
                .prompt(prompt)
                .temperature(temperature)
                .build();
        CompletionResponse response = withRetry(() ->
client.completion(request).execute(), maxRetries);
        CompletionChoice completionChoice = response.choices().get(0);
        return Response.from(
                completionChoice.text(),
                tokenUsageFrom(response.usage()),
                finishReasonFrom(completionChoice.finishReason())
        );
    }
    @Override
    public int estimateTokenCount(String prompt) {
        return tokenizer.estimateTokenCountInText(prompt);
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String baseUrl;
        private String apiVersion;
        private String apiKey;
        private Tokenizer tokenizer;
        private Double temperature;
        private Duration timeout;
        private Integer maxRetries;
        private Proxy proxy;
        private Boolean logRequests;
        private Boolean logResponses;
        /**
         * Sets the Azure OpenAI base URL. This is a mandatory parameter.
         *
         * @param baseUrl The Azure OpenAI base URL in the format: https://
{resource}.openai.azure.com/openai/deployments/{deployment}
         * @return builder
```

```
         */
        public Builder baseUrl(String baseUrl) {
            this.baseUrl = baseUrl;
            return this;
        }
        /**
         * Sets the Azure OpenAI API version. This is a mandatory parameter.
         *
         * @param apiVersion The Azure OpenAI api version in the format:
2023-05-15
         * @return builder
         */
        public Builder apiVersion(String apiVersion) {
            this.apiVersion = apiVersion;
            return this;
        }
        /**
         * Sets the Azure OpenAI API key. This is a mandatory parameter.
         *
         * @param apiKey The Azure OpenAI API key.
         * @return builder
         */
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
        }
        public Builder tokenizer(Tokenizer tokenizer) {
            this.tokenizer = tokenizer;
            return this;
        }
        public Builder temperature(Double temperature) {
            this.temperature = temperature;
            return this;
        }
        public Builder timeout(Duration timeout) {
            this.timeout = timeout;
            return this;
        }
        public Builder maxRetries(Integer maxRetries) {
            this.maxRetries = maxRetries;
            return this;
        }
        public Builder proxy(Proxy proxy) {
            this.proxy = proxy;
            return this;
        }
        public Builder logRequests(Boolean logRequests) {
            this.logRequests = logRequests;
            return this;
        }
        public Builder logResponses(Boolean logResponses) {
            this.logResponses = logResponses;
            return this;
        }
        public AzureOpenAiLanguageModel build() {
            return new AzureOpenAiLanguageModel(
                    baseUrl,
                    apiVersion,
                    apiKey,
                    tokenizer,
                    temperature,
```

```
                    timeout,
                    maxRetries,
                    proxy,
                    logRequests,
                    logResponses
                );
            }
        }
    }
```

langchain4j-azure-open-ai\src\main\java\dev\langchain4j\model\azure\AzureOpenAiStreamingChatModel.java

```
package dev.langchain4j.model.azure;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.chat.ChatCompletionChoice;
import dev.ai4j.openai4j.chat.ChatCompletionRequest;
import dev.ai4j.openai4j.chat.ChatCompletionResponse;
import dev.ai4j.openai4j.chat.Delta;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.chat.TokenCountEstimator;
import dev.langchain4j.model.openai.OpenAiStreamingResponseBuilder;
import dev.langchain4j.model.output.Response;
import java.net.Proxy;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.toFunctions;
import static
dev.langchain4j.model.openai.InternalOpenAiHelper.toOpenAiMessages;
import static java.time.Duration.ofSeconds;
import static java.util.Collections.singletonList;
/**
 * Represents an OpenAI language model, hosted on Azure, that has a chat
completion interface, such as gpt-3.5-turbo.
 * The model's response is streamed token by token and should be handled with
{@link StreamingResponseHandler}.
 * <p>
 * Mandatory parameters for initialization are: baseUrl, apiVersion and
apiKey.
 * <p>
 * There are two primary authentication methods to access Azure OpenAI:
 * <p>
 * 1. API Key Authentication: For this type of authentication, HTTP requests
must include the
 * API Key in the "api-key" HTTP header.
 * <p>
 * 2. Azure Active Directory Authentication: For this type of authentication,
HTTP requests must include the
 * authentication/access token in the "Authorization" HTTP header.
 * <p>
 * <a href="https://learn.microsoft.com/en-us/azure/ai-services/openai/
reference">More information</a>
 * <p>
 * Please note, that currently, only API Key authentication is supported by
this class,
 * second authentication option will be supported later.
 */
public class AzureOpenAiStreamingChatModel implements
StreamingChatLanguageModel, TokenCountEstimator {
    private final OpenAiClient client;
    private final Double temperature;
    private final Double topP;
    private final Integer maxTokens;
```

```
    private final Double presencePenalty;
    private final Double frequencyPenalty;
    private final Tokenizer tokenizer;
    public AzureOpenAiStreamingChatModel(String baseUrl,
                                         String apiVersion,
                                         String apiKey,
                                         Tokenizer tokenizer,
                                         Double temperature,
                                         Double topP,
                                         Integer maxTokens,
                                         Double presencePenalty,
                                         Double frequencyPenalty,
                                         Duration timeout,
                                         Proxy proxy,
                                         Boolean logRequests,
                                         Boolean logResponses) {
        timeout = getOrDefault(timeout, ofSeconds(60));
        this.client = OpenAiClient.builder()
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .azureApiKey(apiKey)
                .apiVersion(apiVersion)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logStreamingResponses(logResponses)
                .build();
        this.temperature = getOrDefault(temperature, 0.7);
        this.topP = topP;
        this.maxTokens = maxTokens;
        this.presencePenalty = presencePenalty;
        this.frequencyPenalty = frequencyPenalty;
        this.tokenizer = tokenizer;
    }
    @Override
    public void generate(List<ChatMessage> messages,
StreamingResponseHandler<AiMessage> handler) {
        generate(messages, null, null, handler);
    }
    @Override
    public void generate(List<ChatMessage> messages, List<ToolSpecification>
toolSpecifications, StreamingResponseHandler<AiMessage> handler) {
        generate(messages, toolSpecifications, null, handler);
    }
    @Override
    public void generate(List<ChatMessage> messages, ToolSpecification
toolSpecification, StreamingResponseHandler<AiMessage> handler) {
        generate(messages, singletonList(toolSpecification),
toolSpecification, handler);
    }
    private void generate(List<ChatMessage> messages,
                          List<ToolSpecification> toolSpecifications,
                          ToolSpecification toolThatMustBeExecuted,
                          StreamingResponseHandler<AiMessage> handler
    ) {
        ChatCompletionRequest.Builder requestBuilder =
ChatCompletionRequest.builder()
                .stream(true)
                .messages(toOpenAiMessages(messages))
```

```
                .temperature(temperature)
                .topP(topP)
                .maxTokens(maxTokens)
                .presencePenalty(presencePenalty)
                .frequencyPenalty(frequencyPenalty);
        Integer inputTokenCount = tokenizer == null ? null :
tokenizer.estimateTokenCountInMessages(messages);
        if (toolSpecifications != null && !toolSpecifications.isEmpty()) {
            requestBuilder.functions(toFunctions(toolSpecifications));
            if (tokenizer != null) {
                inputTokenCount +=
tokenizer.estimateTokenCountInToolSpecifications(toolSpecifications);
            }
        }
        if (toolThatMustBeExecuted != null) {
            requestBuilder.functionCall(toolThatMustBeExecuted.name());
            if (tokenizer != null) {
                inputTokenCount +=
tokenizer.estimateTokenCountInToolSpecification(toolThatMustBeExecuted);
            }
        }
        ChatCompletionRequest request = requestBuilder.build();
        OpenAiStreamingResponseBuilder responseBuilder = new
OpenAiStreamingResponseBuilder(inputTokenCount);
        client.chatCompletion(request)
                .onPartialResponse(partialResponse -> {
                    responseBuilder.append(partialResponse);
                    handle(partialResponse, handler);
                })
                .onComplete(() -> {
                    Response<AiMessage> response = responseBuilder.build();
                    handler.onComplete(response);
                })
                .onError(handler::onError)
                .execute();
    }
    private static void handle(ChatCompletionResponse partialResponse,
                               StreamingResponseHandler<AiMessage> handler) {
        List<ChatCompletionChoice> choices = partialResponse.choices();
        if (choices == null || choices.isEmpty()) {
            return;
        }
        Delta delta = choices.get(0).delta();
        String content = delta.content();
        if (content != null) {
            handler.onNext(content);
        }
    }
    @Override
    public int estimateTokenCount(List<ChatMessage> messages) {
        return tokenizer.estimateTokenCountInMessages(messages);
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String baseUrl;
        private String apiVersion;
        private String apiKey;
        private Tokenizer tokenizer;
        private Double temperature;
```

```
        private Double topP;
        private Integer maxTokens;
        private Double presencePenalty;
        private Double frequencyPenalty;
        private Duration timeout;
        private Proxy proxy;
        private Boolean logRequests;
        private Boolean logResponses;
        /**
         * Sets the Azure OpenAI base URL. This is a mandatory parameter.
         *
         * @param baseUrl The Azure OpenAI base URL in the format: https://
{resource}.openai.azure.com/openai/deployments/{deployment}
         * @return builder
         */
        public Builder baseUrl(String baseUrl) {
            this.baseUrl = baseUrl;
            return this;
        }
        /**
         * Sets the Azure OpenAI API version. This is a mandatory parameter.
         *
         * @param apiVersion The Azure OpenAI api version in the format:
2023-05-15
         * @return builder
         */
        public Builder apiVersion(String apiVersion) {
            this.apiVersion = apiVersion;
            return this;
        }
        /**
         * Sets the Azure OpenAI API key. This is a mandatory parameter.
         *
         * @param apiKey The Azure OpenAI API key.
         * @return builder
         */
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
        }
        public Builder tokenizer(Tokenizer tokenizer) {
            this.tokenizer = tokenizer;
            return this;
        }
        public Builder temperature(Double temperature) {
            this.temperature = temperature;
            return this;
        }
        public Builder topP(Double topP) {
            this.topP = topP;
            return this;
        }
        public Builder maxTokens(Integer maxTokens) {
            this.maxTokens = maxTokens;
            return this;
        }
        public Builder presencePenalty(Double presencePenalty) {
            this.presencePenalty = presencePenalty;
            return this;
        }
        public Builder frequencyPenalty(Double frequencyPenalty) {
```

```
            this.frequencyPenalty = frequencyPenalty;
            return this;
        }
        public Builder timeout(Duration timeout) {
            this.timeout = timeout;
            return this;
        }
        public Builder proxy(Proxy proxy) {
            this.proxy = proxy;
            return this;
        }
        public Builder logRequests(Boolean logRequests) {
            this.logRequests = logRequests;
            return this;
        }
        public Builder logResponses(Boolean logResponses) {
            this.logResponses = logResponses;
            return this;
        }
        public AzureOpenAiStreamingChatModel build() {
            return new AzureOpenAiStreamingChatModel(
                    baseUrl,
                    apiVersion,
                    apiKey,
                    tokenizer,
                    temperature,
                    topP,
                    maxTokens,
                    presencePenalty,
                    frequencyPenalty,
                    timeout,
                    proxy,
                    logRequests,
                    logResponses
            );
        }
    }
}
```

langchain4j-azure-open-ai\src\main\java\dev\langchain4j\model\azure\AzureOpenAiStreamingLanguageModel.java

```
package dev.langchain4j.model.azure;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.completion.CompletionRequest;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.language.StreamingLanguageModel;
import dev.langchain4j.model.language.TokenCountEstimator;
import dev.langchain4j.model.openai.OpenAiStreamingChatModel;
import dev.langchain4j.model.openai.OpenAiStreamingResponseBuilder;
import dev.langchain4j.model.output.Response;
import java.net.Proxy;
import java.time.Duration;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static java.time.Duration.ofSeconds;
/**
 * Represents an OpenAI language model, hosted on Azure, such as text-davinci-003.
 * The LLM's response is streamed token by token and should be handled with {@link StreamingResponseHandler}.
 * However, it's recommended to use {@link OpenAiStreamingChatModel} instead,
 * as it offers more advanced features like function calling, multi-turn conversations, etc.
 * <p>
 * Mandatory parameters for initialization are: baseUrl, apiVersion and apiKey.
 * <p>
 * There are two primary authentication methods to access Azure OpenAI:
 * <p>
 * 1. API Key Authentication: For this type of authentication, HTTP requests must include the
 * API Key in the "api-key" HTTP header.
 * <p>
 * 2. Azure Active Directory Authentication: For this type of authentication, HTTP requests must include the
 * authentication/access token in the "Authorization" HTTP header.
 * <p>
 * <a href="https://learn.microsoft.com/en-us/azure/ai-services/openai/reference">More information</a>
 * <p>
 * Please note, that currently, only API Key authentication is supported by this class,
 * second authentication option will be supported later.
 */
public class AzureOpenAiStreamingLanguageModel implements StreamingLanguageModel, TokenCountEstimator {
    private final OpenAiClient client;
    private final Double temperature;
    private final Tokenizer tokenizer;
    public AzureOpenAiStreamingLanguageModel(String baseUrl,
                                             String apiVersion,
                                             String apiKey,
                                             Tokenizer tokenizer,
                                             Double temperature,
                                             Duration timeout,
                                             Proxy proxy,
```

```
                                            Boolean logRequests,
                                            Boolean logResponses) {
        timeout = getOrDefault(timeout, ofSeconds(60));
        this.client = OpenAiClient.builder()
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .azureApiKey(apiKey)
                .apiVersion(apiVersion)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logStreamingResponses(logResponses)
                .build();
        this.temperature = getOrDefault(temperature, 0.7);
        this.tokenizer = tokenizer;
    }
    @Override
    public void generate(String prompt, StreamingResponseHandler<String>
handler) {
        CompletionRequest request = CompletionRequest.builder()
                .prompt(prompt)
                .temperature(temperature)
                .build();
        Integer inputTokenCount = tokenizer == null ? null :
tokenizer.estimateTokenCountInText(prompt);
        OpenAiStreamingResponseBuilder responseBuilder = new
OpenAiStreamingResponseBuilder(inputTokenCount);
        client.completion(request)
                .onPartialResponse(partialResponse -> {
                    responseBuilder.append(partialResponse);
                    String token = partialResponse.text();
                    if (token != null) {
                        handler.onNext(token);
                    }
                })
                .onComplete(() -> {
                    Response<AiMessage> response = responseBuilder.build();
                    handler.onComplete(Response.from(
                            response.content().text(),
                            response.tokenUsage(),
                            response.finishReason()
                    ));
                })
                .onError(handler::onError)
                .execute();
    }
    @Override
    public int estimateTokenCount(String prompt) {
        return tokenizer.estimateTokenCountInText(prompt);
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String baseUrl;
        private String apiVersion;
        private String apiKey;
        private Tokenizer tokenizer;
        private Double temperature;
```

```
        private Duration timeout;
        private Proxy proxy;
        private Boolean logRequests;
        private Boolean logResponses;
        /**
         * Sets the Azure OpenAI base URL. This is a mandatory parameter.
         *
         * @param baseUrl The Azure OpenAI base URL in the format: https://
{resource}.openai.azure.com/openai/deployments/{deployment}
         * @return builder
         */
        public Builder baseUrl(String baseUrl) {
            this.baseUrl = baseUrl;
            return this;
        }
        /**
         * Sets the Azure OpenAI API version. This is a mandatory parameter.
         *
         * @param apiVersion The Azure OpenAI api version in the format:
2023-05-15
         * @return builder
         */
        public Builder apiVersion(String apiVersion) {
            this.apiVersion = apiVersion;
            return this;
        }
        /**
         * Sets the Azure OpenAI API key. This is a mandatory parameter.
         *
         * @param apiKey The Azure OpenAI API key.
         * @return builder
         */
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
        }
        public Builder tokenizer(Tokenizer tokenizer) {
            this.tokenizer = tokenizer;
            return this;
        }
        public Builder temperature(Double temperature) {
            this.temperature = temperature;
            return this;
        }
        public Builder timeout(Duration timeout) {
            this.timeout = timeout;
            return this;
        }
        public Builder proxy(Proxy proxy) {
            this.proxy = proxy;
            return this;
        }
        public Builder logRequests(Boolean logRequests) {
            this.logRequests = logRequests;
            return this;
        }
        public Builder logResponses(Boolean logResponses) {
            this.logResponses = logResponses;
            return this;
        }
        public AzureOpenAiStreamingLanguageModel build() {
```

```
            return new AzureOpenAiStreamingLanguageModel(
                    baseUrl,
                    apiVersion,
                    apiKey,
                    tokenizer,
                    temperature,
                    timeout,
                    proxy,
                    logRequests,
                    logResponses
            );
        }
    }
}
```

langchain4j-bom\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-bom</artifactId>
    <packaging>pom</packaging>
    <name>LangChain4j BOM</name>
    <description>Bill of Materials pom for getting full, complete set of
compatible versions
        of LangChain4j components
    </description>
    <dependencyManagement>
        <dependencies>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-core</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-spring-boot-starter</artifactId>
                <version>${project.version}</version>
            </dependency>
            <!-- model providers -->
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-open-ai</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-azure-open-ai</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-hugging-face</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-local-ai</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
```

```
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-vertex-ai</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-dashscope</artifactId>
                <version>${project.version}</version>
            </dependency>
            <!-- embedding stores -->
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-cassandra</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-chroma</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-elasticsearch</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-milvus</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-opensearch</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-pinecone</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-redis</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-vespa</artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-weaviate</artifactId>
                <version>${project.version}</version>
            </dependency>
        </dependencies>
    </dependencyManagement>
</project>
```

langchain4j-cassandra\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <artifactId>langchain4j-cassandra</artifactId>
    <name>LangChain4j integration with Cassandra and AstraDb</name>
    <description>Some dependencies have a "Public Domain" license</
description>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <properties>
        <astra-sdk.version>0.6.11</astra-sdk.version>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j</artifactId>
            <version>${parent.version}</version>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.slf4j</groupId>
            <artifactId>slf4j-api</artifactId>
        </dependency>
        <dependency>
            <groupId>com.datastax.astra</groupId>
            <artifactId>astra-sdk-vector</artifactId>
            <version>${astra-sdk.version}</version>
            <exclusions>
                <exclusion>
                    <groupId>ch.qos.logback</groupId>
                    <artifactId>logback-classic</artifactId>
                </exclusion>
            </exclusions>
        </dependency>
        <!-- removing cve -->
        <dependency>
            <groupId>org.json</groupId>
            <artifactId>json</artifactId>
            <version>20230618</version>
        </dependency>
        <dependency>
            <groupId>commons-beanutils</groupId>
            <artifactId>commons-beanutils</artifactId>
            <version>1.9.4</version>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
```

```
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <version>${assertj.version}</version>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-open-ai</artifactId>
            <version>${parent.version}</version>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <build>
        <plugins>
            <plugin>
                <groupId>org.honton.chas</groupId>
                <artifactId>license-maven-plugin</artifactId>
                <configuration>
                    <!-- org.json:json has a "Public Domain" license -->
                    <skipCompliance>true</skipCompliance>
                </configuration>
            </plugin>
        </plugins>
    </build>
</project>
```

langchain4j-cassandra\src\main\java\dev\langchain4j\store\embedding\cassandra\AstraDbEmbeddingConfiguration.java

```
package dev.langchain4j.store.embedding.cassandra;
import lombok.Builder;
import lombok.Getter;
import lombok.NonNull;
/**
 * Plain old Java Object (POJO) to hold the configuration for the CassandraEmbeddingStore.
 * Wrapping all arguments needed to initialize a store in a single object makes it easier to pass them around.
 * It also makes it easier to add new arguments in the future, without having to change the constructor of the store.
 * This is especially useful when the store is used in a pipeline, where the arguments are passed around multiple times.
 *
 * @see CassandraEmbeddingStore
 */
@Getter
@Builder
public class AstraDbEmbeddingConfiguration {
    /**
     * Represents the Api Key to interact with Astra DB
     *
     * @see <a href="https://docs.datastax.com/en/astra/docs/manage-application-tokens.html">Astra DB Api Key</a>
     */
    @NonNull
    private String token;
    /**
     * Represents the unique identifier for your database.
     */
    @NonNull
    private String databaseId;
    /**
     * Represents the region where your database is hosted. A database can be deployed
     * in multiple regions at the same time, and you can choose the region that is closest to your users.
     * If a database has a single region, it will be picked for you.
     */
    private String databaseRegion;
    /**
     * Represents the workspace name where you create your tables. One database can hold multiple keyspaces.
     * Best practice is to provide a keyspace for each application.
     */
    @NonNull
    protected String keyspace;
    /**
     * Represents the name of the table.
     */
    @NonNull
    protected String table;
    /**
     * Represents the dimension of the vector used to save the embeddings.
     */
    @NonNull
    protected Integer dimension;
```

```
    /**
     * Initialize the builder.
     *
     * @return cassandra embedding configuration builder
     */
    public static
AstraDbEmbeddingConfiguration.AstraDbEmbeddingConfigurationBuilder builder() {
        return new
AstraDbEmbeddingConfiguration.AstraDbEmbeddingConfigurationBuilder();
    }
    /**
     * Signature for the builder.
     */
    public static class AstraDbEmbeddingConfigurationBuilder {
    }
}
```

langchain4j-cassandra\src\main\java\dev\langchain4j\store\embedding\cassandra\AstraDbEmbeddingStore.java

```
package dev.langchain4j.store.embedding.cassandra;
import com.datastax.astra.sdk.AstraClient;
import com.datastax.oss.driver.api.core.CqlSession;
import com.dtsx.astra.sdk.cassio.MetadataVectorCassandraTable;
import dev.langchain4j.store.embedding.EmbeddingStore;
/**
 * Implementation of {@link EmbeddingStore} using Cassandra AstraDB.
 *
 * @see EmbeddingStore
 * @see MetadataVectorCassandraTable
 */
public class AstraDbEmbeddingStore extends CassandraEmbeddingStoreSupport {
    /**
     * Build the store from the configuration.
     *
     * @param config configuration
     */
    public AstraDbEmbeddingStore(AstraDbEmbeddingConfiguration config) {
        CqlSession cqlSession = AstraClient.builder()
                .withToken(config.getToken())
                .withCqlKeyspace(config.getKeyspace())
                .withDatabaseId(config.getDatabaseId())
                .withDatabaseRegion(config.getDatabaseRegion())
                .enableCql()
                .enableDownloadSecureConnectBundle()
                .build().cqlSession();
        embeddingTable = new MetadataVectorCassandraTable(cqlSession,
config.getKeyspace(), config.getTable(), config.getDimension());
    }
    public static Builder builder() {
        return new Builder();
    }
    /**
     * Syntax Sugar Builder.
     */
    public static class Builder {
        /**
         * Configuration built with the builder
         */
        private final
AstraDbEmbeddingConfiguration.AstraDbEmbeddingConfigurationBuilder conf;
        /**
         * Initialization
         */
        public Builder() {
            conf = AstraDbEmbeddingConfiguration.builder();
        }
        /**
         * Populating token.
         *
         * @param token token
         * @return current reference
         */
        public Builder token(String token) {
            conf.token(token);
            return this;
        }
```

```
        /**
         * Populating token.
         *
         * @param databaseId     database Identifier
         * @param databaseRegion database region
         * @return current reference
         */
        public Builder database(String databaseId, String databaseRegion) {
            conf.databaseId(databaseId);
            conf.databaseRegion(databaseRegion);
            return this;
        }
        /**
         * Populating model dimension.
         *
         * @param dimension model dimension
         * @return current reference
         */
        public Builder vectorDimension(int dimension) {
            conf.dimension(dimension);
            return this;
        }
        /**
         * Populating table name.
         *
         * @param keyspace keyspace name
         * @param table    table name
         * @return current reference
         */
        public Builder table(String keyspace, String table) {
            conf.keyspace(keyspace);
            conf.table(table);
            return this;
        }
        /**
         * Building the Store.
         *
         * @return store for Astra.
         */
        public AstraDbEmbeddingStore build() {
            return new AstraDbEmbeddingStore(conf.build());
        }
    }
}
```

langchain4j-cassandra\src\main\java\dev\langchain4j\store\embedding\cassandra\CassandraEmbeddingConfiguration.java

```
package dev.langchain4j.store.embedding.cassandra;
import lombok.Builder;
import lombok.Getter;
import lombok.NonNull;
import java.util.List;
/**
 * Plain old Java Object (POJO) to hold the configuration for the CassandraEmbeddingStore.
 * Wrapping all arguments needed to initialize a store in a single object makes it easier to pass them around.
 * It also makes it easier to add new arguments in the future, without having to change the constructor of the store.
 * This is especially useful when the store is used in a pipeline, where the arguments are passed around multiple times.
 *
 * @see CassandraEmbeddingStore
 */
@Getter
@Builder
public class CassandraEmbeddingConfiguration {
    /**
     * Default Cassandra Port.
     */
    public static Integer DEFAULT_PORT = 9042;
    // --- Connectivity Parameters ---
    /**
     * Represents the cassandra Contact points.
     */
    @NonNull
    private List<String> contactPoints;
    /**
     * Represent the local data center.
     */
    @NonNull
    private String localDataCenter;
    /**
     * Connection Port
     */
    @NonNull
    private Integer port;
    /**
     * (Optional) Represents the username to connect to the database.
     */
    private String userName;
    /**
     * (Optional) Represents the password to connect to the database.
     */
    private String password;
    /**
     * Represents the workspace name where you create your tables. One database can hold multiple keyspaces.
     * Best practice is to provide a keyspace for each application.
     */
    @NonNull
    protected String keyspace;
    /**
     * Represents the name of the table.
```

```
     */
    @NonNull
    protected String table;
    /**
     * Represents the dimension of the model use to create the embeddings.
The vector holding the embeddings
     * is a fixed size. The dimension of the vector is the dimension of the
model used to create the embeddings.
     */
    @NonNull
    protected Integer dimension;
    /**
     * Initialize the builder.
     *
     * @return cassandra embedding configuration buildesr
     */
    public static CassandraEmbeddingConfigurationBuilder builder() {
        return new CassandraEmbeddingConfigurationBuilder();
    }
    /**
     * Signature for the builder.
     */
    public static class CassandraEmbeddingConfigurationBuilder {
    }
}
```

langchain4j-cassandra\src\main\java\dev\langchain4j\store\embedding\cassandra\CassandraEmbeddingStore.java

```
package dev.langchain4j.store.embedding.cassandra;
import com.datastax.oss.driver.api.core.CqlSession;
import com.datastax.oss.driver.api.core.CqlSessionBuilder;
import com.datastax.oss.driver.api.querybuilder.SchemaBuilder;
import com.dtsx.astra.sdk.cassio.MetadataVectorCassandraTable;
import com.dtsx.astra.sdk.cassio.SimilarityMetric;
import dev.langchain4j.store.embedding.EmbeddingStore;
import java.net.InetSocketAddress;
import java.util.Arrays;
/**
 * Implementation of {@link EmbeddingStore} using Cassandra AstraDB.
 *
 * @see EmbeddingStore
 * @see MetadataVectorCassandraTable
 */
public class CassandraEmbeddingStore extends CassandraEmbeddingStoreSupport {
    /**
     * Build the store from the configuration.
     *
     * @param config configuration
     */
    public CassandraEmbeddingStore(CassandraEmbeddingConfiguration config) {
        CqlSessionBuilder sessionBuilder = createCqlSessionBuilder(config);
        createKeyspaceIfNotExist(sessionBuilder, config.getKeyspace());
        sessionBuilder.withKeyspace(config.getKeyspace());
        this.embeddingTable = new
MetadataVectorCassandraTable(sessionBuilder.build(),
                config.getKeyspace(), config.getTable(),
config.getDimension(), SimilarityMetric.COS);
    }
    /**
     * Build the cassandra session from the config. At the difference of
adminSession there
     * a keyspace attached to it.
     *
     * @param config current configuration
     * @return cassandra session
     */
    private CqlSessionBuilder
createCqlSessionBuilder(CassandraEmbeddingConfiguration config) {
        CqlSessionBuilder cqlSessionBuilder = CqlSession.builder();
        cqlSessionBuilder.withLocalDatacenter(config.getLocalDataCenter());
        if (config.getUserName() != null && config.getPassword() != null) {
            cqlSessionBuilder.withAuthCredentials(config.getUserName(),
config.getPassword());
        }
        config.getContactPoints().forEach(cp ->
                cqlSessionBuilder.addContactPoint(new InetSocketAddress(cp,
config.getPort())));
        return cqlSessionBuilder;
    }
    /**
     * Create the keyspace in cassandra Destination if not exist.
     */
    private void createKeyspaceIfNotExist(CqlSessionBuilder
cqlSessionBuilder, String keyspace) {
        try (CqlSession adminSession = cqlSessionBuilder.build()) {
```

```
            adminSession.execute(SchemaBuilder.createKeyspace(keyspace)
                    .ifNotExists()
                    .withSimpleStrategy(1)
                    .withDurableWrites(true)
                    .build());
        }
    }
    public static Builder builder() {
        return new Builder();
    }
    /**
     * Syntax Sugar Builder.
     */
    public static class Builder {
        /**
         * Configuration built with the builder
         */
        private final
CassandraEmbeddingConfiguration.CassandraEmbeddingConfigurationBuilder conf;
        /**
         * Initialization
         */
        public Builder() {
            conf = CassandraEmbeddingConfiguration.builder();
        }
        /**
         * Populating cassandra port.
         *
         * @param port port
         * @return current reference
         */
        public CassandraEmbeddingStore.Builder port(int port) {
            conf.port(port);
            return this;
        }
        /**
         * Populating cassandra contact points.
         *
         * @param hosts port
         * @return current reference
         */
        public CassandraEmbeddingStore.Builder contactPoints(String... hosts)
{
            conf.contactPoints(Arrays.asList(hosts));
            return this;
        }
        /**
         * Populating model dimension.
         *
         * @param dimension model dimension
         * @return current reference
         */
        public CassandraEmbeddingStore.Builder vectorDimension(int dimension)
{
            conf.dimension(dimension);
            return this;
        }
        /**
         * Populating datacenter.
         *
         * @param dc datacenter
```

```
         * @return current reference
         */
        public CassandraEmbeddingStore.Builder localDataCenter(String dc) {
            conf.localDataCenter(dc);
            return this;
        }
        /**
         * Populating table name.
         *
         * @param keyspace keyspace name
         * @param table    table name
         * @return current reference
         */
        public CassandraEmbeddingStore.Builder table(String keyspace, String
table) {
            conf.keyspace(keyspace);
            conf.table(table);
            return this;
        }
        /**
         * Building the Store.
         *
         * @return store for Astra.
         */
        public CassandraEmbeddingStore build() {
            return new CassandraEmbeddingStore(conf.build());
        }
    }
}
```

langchain4j-cassandra\src\main\java\dev\langchain4j\store\embedding\cassandra\CassandraEmbeddingStoreSupport.java

```
package dev.langchain4j.store.embedding.cassandra;
import com.dtsx.astra.sdk.cassio.MetadataVectorCassandraTable;
import com.dtsx.astra.sdk.cassio.SimilarityMetric;
import com.dtsx.astra.sdk.cassio.SimilaritySearchQuery;
import
com.dtsx.astra.sdk.cassio.SimilaritySearchQuery.SimilaritySearchQueryBuilder;
import com.dtsx.astra.sdk.cassio.SimilaritySearchResult;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import lombok.Getter;
import lombok.NonNull;
import java.util.ArrayList;
import java.util.List;
import static dev.langchain4j.internal.ValidationUtils.ensureBetween;
import static dev.langchain4j.internal.ValidationUtils.ensureGreaterThanZero;
import static java.util.stream.Collectors.toList;
/**
 * Support for CassandraEmbeddingStore with and Without Astra.
 */
@Getter
abstract class CassandraEmbeddingStoreSupport implements
EmbeddingStore<TextSegment> {
    /**
     * Represents an embedding table in Cassandra, it is a table with a
vector column.
     */
    protected MetadataVectorCassandraTable embeddingTable;
    /**
     * Add a new embedding to the store.
     * - the row id is generated
     * - text and metadata are not stored
     *
     * @param embedding representation of the list of floats
     * @return newly created row id
     */
    @Override
    public String add(@NonNull Embedding embedding) {
        return add(embedding, null);
    }
    /**
     * Add a new embedding to the store.
     * - the row id is generated
     * - text and metadata coming from the text Segment
     *
     * @param embedding   representation of the list of floats
     * @param textSegment text content and metadata
     * @return newly created row id
     */
    @Override
    public String add(@NonNull Embedding embedding, TextSegment textSegment) {
        MetadataVectorCassandraTable.Record record = new
MetadataVectorCassandraTable.Record(embedding.vectorAsList());
```

```
        if (textSegment != null) {
            record.setBody(textSegment.text());
            record.setMetadata(textSegment.metadata().asMap());
        }
        embeddingTable.put(record);
        return record.getRowId();
    }
    /**
     * Add a new embedding to the store.
     *
     * @param rowId     the row id
     * @param embedding representation of the list of floats
     */
    @Override
    public void add(@NonNull String rowId, @NonNull Embedding embedding) {
        embeddingTable.put(new MetadataVectorCassandraTable.Record(rowId,
embedding.vectorAsList()));
    }
    /**
     * Add multiple embeddings as a single action.
     *
     * @param embeddingList embeddings list
     * @return list of new row if (same order as the input)
     */
    @Override
    public List<String> addAll(List<Embedding> embeddingList) {
        return embeddingList.stream()
                .map(Embedding::vectorAsList)
                .map(MetadataVectorCassandraTable.Record::new)
                .peek(embeddingTable::putAsync)
                .map(MetadataVectorCassandraTable.Record::getRowId)
                .collect(toList());
    }
    /**
     * Add multiple embeddings as a single action.
     *
     * @param embeddingList   embeddings
     * @param textSegmentList text segments
     * @return list of new row if (same order as the input)
     */
    @Override
    public List<String> addAll(List<Embedding> embeddingList,
List<TextSegment> textSegmentList) {
        if (embeddingList == null || textSegmentList == null ||
embeddingList.size() != textSegmentList.size()) {
            throw new IllegalArgumentException("embeddingList and
textSegmentList must not be null and have the same size");
        }
        // Looping on both list with an index
        List<String> ids = new ArrayList<>();
        for (int i = 0; i < embeddingList.size(); i++) {
            ids.add(add(embeddingList.get(i), textSegmentList.get(i)));
        }
        return ids;
    }
    /**
     * Search for relevant.
     *
     * @param embedding  current embeddings
     * @param maxResults max number of result
     * @param minScore   threshold
```

```
     * @return list of matching elements
     */
    @Override
    public List<EmbeddingMatch<TextSegment>> findRelevant(Embedding
embedding, int maxResults, double minScore) {
        return embeddingTable
                .similaritySearch(SimilaritySearchQuery.builder()
                        .embeddings(embedding.vectorAsList())
                        .recordCount(ensureGreaterThanZero(maxResults,
"maxResults"))
                        .threshold(CosineSimilarity.fromRelevanceScore(ensureB
etween(minScore, 0, 1, "minScore")))
                        .distance(SimilarityMetric.COS)
                        .build())
                .stream()
                .map(CassandraEmbeddingStoreSupport::mapSearchResult)
                .collect(toList());
    }
    /**
     * Map Search result coming from Astra.
     *
     * @param record current record
     * @return search result
     */
    private static EmbeddingMatch<TextSegment>
mapSearchResult(SimilaritySearchResult<MetadataVectorCassandraTable.Record>
record) {
        return new EmbeddingMatch<>(
                // Score
                RelevanceScore.fromCosineSimilarity(record.getSimilarity()),
                // EmbeddingId : unique identifier
                record.getEmbedded().getRowId(),
                // Embeddings vector
                Embedding.from(record.getEmbedded().getVector()),
                // Text segment and metadata
                TextSegment.from(record.getEmbedded().getBody(), new
Metadata(record.getEmbedded().getMetadata())));
    }
    /**
     * Similarity Search ANN based on the embedding.
     *
     * @param embedding  vector
     * @param maxResults max number of results
     * @param minScore   score minScore
     * @param metadata   map key-value to build a metadata filter
     * @return list of matching results
     */
    public List<EmbeddingMatch<TextSegment>> findRelevant(Embedding
embedding, int maxResults, double minScore, Metadata metadata) {
        SimilaritySearchQueryBuilder builder = SimilaritySearchQuery.builder()
                .embeddings(embedding.vectorAsList())
                .recordCount(ensureGreaterThanZero(maxResults, "maxResults"))
                .threshold(CosineSimilarity.fromRelevanceScore(ensureBetween(m
inScore, 0, 1, "minScore")));
        if (metadata != null) {
            builder.metaData(metadata.asMap());
        }
        return embeddingTable
                .similaritySearch(builder.build())
                .stream()
                .map(CassandraEmbeddingStoreSupport::mapSearchResult)
```

```
                .collect(toList());
    }
}
```

langchain4j-cassandra\src\main\java\dev\langchain4j\store\memory\chat\cassandra\AstraDbChatMemoryStore.java

```
package dev.langchain4j.store.memory.chat.cassandra;
import com.datastax.astra.sdk.AstraClient;
/**
 * AstraDb is a version of Cassandra running in Saas Mode.
 * <p>
 * The initialization of the CQLSession will be done through an AstraClient
 */
public class AstraDbChatMemoryStore extends CassandraChatMemoryStore {
    /**
     * Constructor with default table name.
     *
     * @param token        token
     * @param dbId         database identifier
     * @param dbRegion     database region
     * @param keyspaceName keyspace name
     */
    public AstraDbChatMemoryStore(String token, String dbId, String dbRegion,
String keyspaceName) {
        this(token, dbId, dbRegion, keyspaceName, DEFAULT_TABLE_NAME);
    }
    /**
     * Constructor with explicit table name.
     *
     * @param token        token
     * @param dbId         database identifier
     * @param dbRegion     database region
     * @param keyspaceName keyspace name
     * @param tableName    table name
     */
    public AstraDbChatMemoryStore(String token, String dbId, String dbRegion,
String keyspaceName, String tableName) {
        super(AstraClient.builder()
                .withToken(token)
                .withCqlKeyspace(keyspaceName)
                .withDatabaseId(dbId)
                .withDatabaseRegion(dbRegion)
                .enableCql()
                .enableDownloadSecureConnectBundle()
                .build().cqlSession(), keyspaceName, tableName);
    }
}
```

langchain4j-cassandra\src\main\java\dev\langchain4j\store\memory\chat\cassandra\CassandraChatMemoryStore.java

```
package dev.langchain4j.store.memory.chat.cassandra;
import com.datastax.oss.driver.api.core.CqlSession;
import com.datastax.oss.driver.api.core.uuid.Uuids;
import com.dtsx.astra.sdk.cassio.ClusteredCassandraTable;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.ChatMessageDeserializer;
import dev.langchain4j.data.message.ChatMessageSerializer;
import dev.langchain4j.store.memory.chat.ChatMemoryStore;
import lombok.NonNull;
import lombok.extern.slf4j.Slf4j;
import java.util.Collection;
import java.util.Collections;
import java.util.List;
import static com.dtsx.astra.sdk.cassio.ClusteredCassandraTable.Record;
import static java.util.stream.Collectors.toList;
/**
 * Implementation of {@link ChatMemoryStore} using Astra DB Vector Search.
 * Table contains all chats. (default name is message_store). Each chat with multiple messages
 * is a partition.Message id is a time uuid.
 *
 * @see <a href="https://docs.datastax.com/en/astra-serverless/docs/vector-search/overview.html">Astra Vector Store Documentation</a>
 */
@Slf4j
public class CassandraChatMemoryStore implements ChatMemoryStore {
    /**
     * Default message store.
     */
    public static final String DEFAULT_TABLE_NAME = "message_store";
    /**
     * Message Table.
     */
    private final ClusteredCassandraTable messageTable;
    /**
     * Constructor for message store
     *
     * @param session      cassandra session
     * @param keyspaceName keyspace name
     * @param tableName    table name
     */
    public CassandraChatMemoryStore(CqlSession session, String keyspaceName, String tableName) {
        messageTable = new ClusteredCassandraTable(session, keyspaceName, tableName);
    }
    /**
     * Constructor for message store
     *
     * @param session      cassandra session
     * @param keyspaceName keyspace name
     */
    public CassandraChatMemoryStore(CqlSession session, String keyspaceName) {
        messageTable = new ClusteredCassandraTable(session, keyspaceName, DEFAULT_TABLE_NAME);
    }
    /**
```

```
     * {@inheritDoc}
     */
    @Override
    public List<ChatMessage> getMessages(@NonNull Object memoryId) {
        /*
         * RATIONAL:
         * In the cassandra table the order is explicitly put to DESC with
         * latest to come first (for long conversation for instance). Here we
ask
         * for the full history. Instead of changing the multi purpose table
         * we reverse the list.
         */
        List<ChatMessage> latestFirstList = messageTable
                .findPartition(getMemoryId(memoryId))
                .stream()
                .map(this::toChatMessage)
                .collect(toList());
        Collections.reverse(latestFirstList);
        return latestFirstList;
    }
    /**
     * {@inheritDoc}
     */
    @Override
    public void updateMessages(@NonNull Object memoryId, @NonNull
List<ChatMessage> messages) {
        deleteMessages(memoryId);
        messageTable.upsertPartition(messages.stream()
                .map(record -> fromChatMessage(getMemoryId(memoryId), record))
                .collect(toList()));
    }
    /**
     * {@inheritDoc}
     */
    @Override
    public void deleteMessages(@NonNull Object memoryId) {
        messageTable.deletePartition(getMemoryId(memoryId));
    }
    /**
     * Unmarshalling Cassandra row as a Message with proper sub-type.
     *
     * @param record cassandra record
     * @return chat message
     */
    private ChatMessage toChatMessage(@NonNull Record record) {
        try {
            return ChatMessageDeserializer.messageFromJson(record.getBody());
        } catch (Exception e) {
            log.error("Unable to parse message body", e);
            throw new IllegalArgumentException("Unable to parse message
body");
        }
    }
    /**
     * Serialize the {@link ChatMessage} as a Cassandra Row.
     *
     * @param memoryId    chat session identifier
     * @param chatMessage chat message
     * @return cassandra row.
     */
    private Record fromChatMessage(@NonNull String memoryId, @NonNull
```

```
ChatMessage chatMessage) {
        try {
            Record record = new Record();
            record.setRowId(Uuids.timeBased());
            record.setPartitionId(memoryId);
            record.setBody(ChatMessageSerializer.messageToJson(chatMessage));
            return record;
        } catch (Exception e) {
            log.error("Unable to parse message body", e);
            throw new IllegalArgumentException("Unable to parse message
body", e);
        }
    }
    private String getMemoryId(Object memoryId) {
        if (!(memoryId instanceof String)) {
            throw new IllegalArgumentException("memoryId must be a String");
        }
        return (String) memoryId;
    }
}
```

langchain4j-cassandra\src\test\java\dev\langchain4j\store\embedding\cassandra\AstraDbEmbeddingConfigurationTest.java

```
package dev.langchain4j.store.embedding.cassandra;
import org.junit.jupiter.api.Test;
import static org.junit.jupiter.api.Assertions.*;
/**
 * The configuration objects include a few validation rules.
 */
public class AstraDbEmbeddingConfigurationTest {
    @Test
    public void should_build_configuration_test() {
        AstraDbEmbeddingConfiguration config =
AstraDbEmbeddingConfiguration.builder()
                .token("token")
                .databaseId("dbId")
                .databaseRegion("dbRegion")
                .keyspace("ks")
                .dimension(20)
                .table("table")
                .build();
        assertNotNull(config);
        assertNotNull(config.getToken());
        assertNotNull(config.getDatabaseId());
        assertNotNull(config.getDatabaseRegion());
    }
    @Test
    public void should_error_if_no_table_test() {
        // Table is required
        NullPointerException exception =
assertThrows(NullPointerException.class,
                () -> AstraDbEmbeddingConfiguration.builder()
                        .token("token")
                        .databaseId("dbId")
                        .databaseRegion("dbRegion")
                        .keyspace("ks")
                        .dimension(20)
                        .build());
        assertEquals("table is marked non-null but is null",
exception.getMessage());
    }
    @Test
    public void should_error_if_no_keyspace_test() {
        // Table is required
        NullPointerException exception =
assertThrows(NullPointerException.class,
                () -> AstraDbEmbeddingConfiguration.builder()
                        .token("token")
                        .databaseId("dbId")
                        .databaseRegion("dbRegion")
                        .table("ks")
                        .dimension(20)
                        .build());
        assertEquals("keyspace is marked non-null but is null",
exception.getMessage());
    }
    @Test
    public void should_error_if_no_dimension_test() {
        // Table is required
        NullPointerException exception =
```

```
assertThrows(NullPointerException.class,
                () -> AstraDbEmbeddingConfiguration.builder()
                        .token("token")
                        .databaseId("dbId")
                        .databaseRegion("dbRegion")
                        .table("ks")
                        .keyspace("ks")
                        .build());
        assertEquals("dimension is marked non-null but is null",
exception.getMessage());
    }
    @Test
    public void should_error_if_no_token_test() {
        // Table is required
        NullPointerException exception =
assertThrows(NullPointerException.class,
                () -> AstraDbEmbeddingConfiguration.builder()
                        .databaseId("dbId")
                        .databaseRegion("dbRegion")
                        .table("ks")
                        .keyspace("ks")
                        .dimension(20)
                        .build());
        assertEquals("token is marked non-null but is null",
exception.getMessage());
    }
    @Test
    public void should_error_if_no_database_test() {
        // Table is required
        NullPointerException exception =
assertThrows(NullPointerException.class,
                () -> AstraDbEmbeddingConfiguration.builder()
                        .token("token")
                        .table("ks")
                        .keyspace("ks")
                        .dimension(20)
                        .build());
        assertEquals("databaseId is marked non-null but is null",
exception.getMessage());
    }
}
```

langchain4j-cassandra\src\test\java\dev\langchain4j\store\embedding\cassandra\AstraDbEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.cassandra;
import com.datastax.astra.sdk.AstraClient;
import com.datastax.oss.driver.api.core.CqlSession;
import com.dtsx.astra.sdk.utils.TestUtils;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.condition.EnabledIfEnvironmentVariable;
import java.util.List;
import static com.dtsx.astra.sdk.utils.TestUtils.getAstraToken;
import static com.dtsx.astra.sdk.utils.TestUtils.setupDatabase;
import static org.assertj.core.api.Assertions.assertThat;
import static org.junit.jupiter.api.Assertions.assertEquals;
import static org.junit.jupiter.api.Assertions.assertTrue;
/**
 * Testing implementation of Embedding Store using AstraDB.
 */
class AstraDbEmbeddingStoreTest {
    private static final String TEST_KEYSPACE = "langchain4j";
    private static final String TEST_INDEX = "test_embedding_store";
    /**
     * We want to trigger the test only if the expected variable
     * is present.
     */
    @Test
    @EnabledIfEnvironmentVariable(named = "ASTRA_DB_APPLICATION_TOKEN",
matches = "Astra.*")
    void testAddEmbeddingAndFindRelevant() {
        String astraToken = getAstraToken();
        String databaseId = setupDatabase("langchain4j", TEST_KEYSPACE);
        // Flush Table for test to be idempotent
        truncateTable(databaseId, TEST_KEYSPACE, TEST_INDEX);
        // Create the Store with the builder
        AstraDbEmbeddingStore astraDbEmbeddingStore = new
AstraDbEmbeddingStore(AstraDbEmbeddingConfiguration
                .builder()
                .token(astraToken)
                .databaseId(databaseId)
                .databaseRegion(TestUtils.TEST_REGION)
                .keyspace(TEST_KEYSPACE)
                .table(TEST_INDEX)
                .dimension(11)
                .build());
        Embedding embedding = Embedding.from(new float[]{9.9F, 4.5F, 3.5F,
1.3F, 1.7F, 5.7F, 6.4F, 5.5F, 8.2F, 9.3F, 1.5F});
        TextSegment textSegment = TextSegment.from("Text",
Metadata.from("Key", "Value"));
        String id = astraDbEmbeddingStore.add(embedding, textSegment);
        assertTrue(id != null && !id.isEmpty());
        Embedding refereceEmbedding = Embedding.from(new float[]{8.7F, 4.5F,
3.4F, 1.2F, 5.5F, 5.6F, 6.4F, 5.5F, 8.1F, 9.1F, 1.1F});
        List<EmbeddingMatch<TextSegment>> embeddingMatches =
astraDbEmbeddingStore.findRelevant(refereceEmbedding, 10);
        assertEquals(1, embeddingMatches.size());
```

```
        EmbeddingMatch<TextSegment> embeddingMatch = embeddingMatches.get(0);
        assertThat(embeddingMatch.score()).isBetween(0d, 1d);
        assertThat(embeddingMatch.embeddingId()).isEqualTo(id);
        assertThat(embeddingMatch.embedding()).isEqualTo(embedding);
        assertThat(embeddingMatch.embedded()).isEqualTo(textSegment);
    }
    private void truncateTable(String databaseId, String keyspace, String
table) {
        try (AstraClient astraClient = AstraClient.builder()
                    .withToken(getAstraToken())
                    .withCqlKeyspace(keyspace)
                    .withDatabaseId(databaseId)
                    .withDatabaseRegion(TestUtils.TEST_REGION)
                    .enableCql()
                    .enableDownloadSecureConnectBundle()
                    .build()) {
            astraClient.cqlSession()
                       .execute("TRUNCATE TABLE " + table);
        }
    }
}
```

langchain4j-cassandra\src\test\java\dev\langchain4j\store\embedding\cassandra\CassandraEmbeddingConfigurationTest.java

```
package dev.langchain4j.store.embedding.cassandra;
import org.junit.jupiter.api.Test;
import static dev.langchain4j.store.embedding.cassandra.CassandraEmbeddingConfiguration.DEFAULT_PORT;
import static java.util.Collections.singletonList;
import static org.junit.jupiter.api.Assertions.*;
public class CassandraEmbeddingConfigurationTest {
    @Test
    public void should_build_configuration_test() {
        CassandraEmbeddingConfiguration config = CassandraEmbeddingConfiguration.builder()
                .contactPoints(singletonList("localhost"))
                .port(DEFAULT_PORT)
                .keyspace("ks")
                .dimension(20)
                .table("table")
                .localDataCenter("dc1")
                .build();
        assertNotNull(config);
    }
    @Test
    public void should_error_if_no_datacenter_test() {
        // Table is required
        NullPointerException exception = assertThrows(NullPointerException.class,
                () -> CassandraEmbeddingConfiguration.builder()
                        .contactPoints(singletonList("localhost"))
                        .port(DEFAULT_PORT)
                        .keyspace("ks")
                        .dimension(20)
                        .table("table")
                        .build());
        assertEquals("localDataCenter is marked non-null but is null", exception.getMessage());
    }
    @Test
    public void should_error_if_no_table_test() {
        // Table is required
        NullPointerException exception = assertThrows(NullPointerException.class,
                () -> CassandraEmbeddingConfiguration.builder()
                        .contactPoints(singletonList("localhost"))
                        .port(DEFAULT_PORT)
                        .keyspace("ks")
                        .dimension(20)
                        .localDataCenter("dc1")
                        .build());
        assertEquals("table is marked non-null but is null", exception.getMessage());
    }
    @Test
    public void should_error_if_no_keyspace_test() {
        // Table is required
        NullPointerException exception = assertThrows(NullPointerException.class,
                () -> CassandraEmbeddingConfiguration.builder()
                        .contactPoints(singletonList("localhost"))
```

```
                        .port(DEFAULT_PORT)
                        .table("ks")
                        .dimension(20)
                        .localDataCenter("dc1")
                        .build());
        assertEquals("keyspace is marked non-null but is null",
exception.getMessage());
    }
    @Test
    public void should_error_if_no_dimension_test() {
        // Table is required
        NullPointerException exception =
assertThrows(NullPointerException.class,
                () -> CassandraEmbeddingConfiguration.builder()
                        .contactPoints(singletonList("localhost"))
                        .port(DEFAULT_PORT)
                        .table("ks")
                        .keyspace("ks")
                        .localDataCenter("dc1")
                        .build());
        assertEquals("dimension is marked non-null but is null",
exception.getMessage());
    }
    @Test
    public void should_error_if_no_contact_points_test() {
        // Table is required
        NullPointerException exception =
assertThrows(NullPointerException.class,
                () -> CassandraEmbeddingConfiguration.builder()
                        .port(DEFAULT_PORT)
                        .table("ks")
                        .keyspace("ks")
                        .dimension(20)
                        .localDataCenter("dc1")
                        .build());
        assertEquals("contactPoints is marked non-null but is null",
exception.getMessage());
    }
}
```

langchain4j-cassandra\src\test\java\dev\langchain4j\store\embedding\cassandra\CassandraEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.cassandra;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static org.assertj.core.api.Assertions.assertThat;
import static org.junit.jupiter.api.Assertions.assertEquals;
import static org.junit.jupiter.api.Assertions.assertTrue;
/**
 * Work with Cassandra Embedding Store.
 */
class CassandraEmbeddingStoreTest {
    @Test
    @Disabled("To run this test, you must have a local Cassandra instance, a docker-compose is provided")
    public void testAddEmbeddingAndFindRelevant() {
        CassandraEmbeddingStore cassandraEmbeddingStore = initStore();
        Embedding embedding = Embedding.from(new float[]{9.9F, 4.5F, 3.5F, 1.3F, 1.7F, 5.7F, 6.4F, 5.5F, 8.2F, 9.3F, 1.5F});
        TextSegment textSegment = TextSegment.from("Text", Metadata.from("Key", "Value"));
        String id = cassandraEmbeddingStore.add(embedding, textSegment);
        assertTrue(id != null && !id.isEmpty());
        Embedding refereceEmbedding = Embedding.from(new float[]{8.7F, 4.5F, 3.4F, 1.2F, 5.5F, 5.6F, 6.4F, 5.5F, 8.1F, 9.1F, 1.1F});
        List<EmbeddingMatch<TextSegment>> embeddingMatches = cassandraEmbeddingStore.findRelevant(refereceEmbedding, 1);
        assertEquals(1, embeddingMatches.size());
        EmbeddingMatch<TextSegment> embeddingMatch = embeddingMatches.get(0);
        assertThat(embeddingMatch.score()).isBetween(0d, 1d);
        assertThat(embeddingMatch.embeddingId()).isEqualTo(id);
        assertThat(embeddingMatch.embedding()).isEqualTo(embedding);
        assertThat(embeddingMatch.embedded()).isEqualTo(textSegment);
    }
    private CassandraEmbeddingStore initStore() {
        return CassandraEmbeddingStore.builder()
                .contactPoints("127.0.0.1")
                .port(9042)
                .localDataCenter("datacenter1")
                .table("langchain4j", "table_" + randomUUID().replace("-", ""))
                .vectorDimension(11)
                .build();
    }
}
```

langchain4j-cassandra\src\test\java\dev\langchain4j\store\embedding\cassandra\SampleDocumentLoaderAndRagWithAstraTest.java

```
package dev.langchain4j.store.embedding.cassandra;
import com.dtsx.astra.sdk.utils.TestUtils;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.document.DocumentType;
import dev.langchain4j.data.document.FileSystemDocumentLoader;
import dev.langchain4j.data.document.splitter.DocumentSplitters;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.input.PromptTemplate;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.model.openai.OpenAiEmbeddingModel;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.EmbeddingStoreIngestor;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.condition.EnabledIfEnvironmentVariable;
import java.io.File;
import java.nio.file.Path;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static com.dtsx.astra.sdk.utils.TestUtils.getAstraToken;
import static com.dtsx.astra.sdk.utils.TestUtils.setupDatabase;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static
dev.langchain4j.model.openai.OpenAiModelName.TEXT_EMBEDDING_ADA_002;
import static java.time.Duration.ofSeconds;
import static java.util.stream.Collectors.joining;
import static org.junit.jupiter.api.Assertions.assertNotNull;
class SampleDocumentLoaderAndRagWithAstraTest {
    @Test
    @EnabledIfEnvironmentVariable(named = "ASTRA_DB_APPLICATION_TOKEN",
matches = "Astra.*")
    @EnabledIfEnvironmentVariable(named = "OPENAI_API_KEY", matches = "sk.*")
    void shouldRagWithOpenAiAndAstra() {
        // Initialization
        String astraToken = getAstraToken();
        String databaseId = setupDatabase("langchain4j", "langchain4j");
        String openAIKey = System.getenv("OPENAI_API_KEY");
        // Given
        assertNotNull(openAIKey);
        assertNotNull(databaseId);
        assertNotNull(astraToken);
        // --- Ingesting documents ---
        // Parsing input file
        Path path = new File(getClass().getResource("/story-about-happy-
carrot.txt").getFile()).toPath();
        Document document = FileSystemDocumentLoader.loadDocument(path,
DocumentType.TXT);
        DocumentSplitter splitter = DocumentSplitters
```

```
                .recursive(100, 10, new OpenAiTokenizer(GPT_3_5_TURBO));
        // Embedding model (OpenAI)
        EmbeddingModel embeddingModel = OpenAiEmbeddingModel.builder()
                .apiKey(openAIKey)
                .modelName(TEXT_EMBEDDING_ADA_002)
                .timeout(ofSeconds(15))
                .logRequests(true)
                .logResponses(true)
                .build();
        // Embed the document and it in the store
        EmbeddingStore<TextSegment> embeddingStore =
AstraDbEmbeddingStore.builder()
                .token(astraToken)
                .database(databaseId, TestUtils.TEST_REGION)
                .table("langchain4j", "table_story")
                .vectorDimension(1536)
                .build();
        // Ingest method 2
        EmbeddingStoreIngestor ingestor = EmbeddingStoreIngestor.builder()
                .documentSplitter(splitter)
                .embeddingModel(embeddingModel)
                .embeddingStore(embeddingStore)
                .build();
        ingestor.ingest(document);
        // --------- RAG -------------
        // Specify the question you want to ask the model
        String question = "Who is Charlie?";
        // Embed the question
        Response<Embedding> questionEmbedding =
embeddingModel.embed(question);
        // Find relevant embeddings in embedding store by semantic similarity
        // You can play with parameters below to find a sweet spot for your
specific use case
        int maxResults = 3;
        double minScore = 0.8;
        List<EmbeddingMatch<TextSegment>> relevantEmbeddings =
                embeddingStore.findRelevant(questionEmbedding.content(),
maxResults, minScore);
        // --------- Chat Template -------------
        // Create a prompt for the model that includes question and relevant
embeddings
        PromptTemplate promptTemplate = PromptTemplate.from(
                "Answer the following question to the best of your ability:\n"
                        + "\n"
                        + "Question:\n"
                        + "{{question}}\n"
                        + "\n"
                        + "Base your answer on the following information:\n"
                        + "{{information}}");
        String information = relevantEmbeddings.stream()
                .map(match -> match.embedded().text())
                .collect(joining("\n\n"));
        Map<String, Object> variables = new HashMap<>();
        variables.put("question", question);
        variables.put("information", information);
        Prompt prompt = promptTemplate.apply(variables);
        // Send the prompt to the OpenAI chat model
        ChatLanguageModel chatModel = OpenAiChatModel.builder()
                .apiKey(openAIKey)
                .modelName(GPT_3_5_TURBO)
                .temperature(0.7)
```

```
                .timeout(ofSeconds(15))
                .maxRetries(3)
                .logResponses(true)
                .logRequests(true)
                .build();
        Response<AiMessage> aiMessage =
chatModel.generate(prompt.toUserMessage());
        // See an answer from the model
        String answer = aiMessage.content().text();
        System.out.println(answer);
    }
}
```

langchain4j-cassandra\src\test\java\dev\langchain4j\store\memory\chat\cassandra\ChatMemoryStoreAstraTest.java

```
package dev.langchain4j.store.memory.chat.cassandra;
import com.datastax.astra.sdk.AstraClient;
import com.dtsx.astra.sdk.utils.TestUtils;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.TokenWindowChatMemory;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import dev.langchain4j.store.memory.chat.ChatMemoryStore;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.condition.EnabledIfEnvironmentVariable;
import java.util.UUID;
import static com.dtsx.astra.sdk.utils.TestUtils.*;
import static dev.langchain4j.data.message.AiMessage.aiMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static org.assertj.core.api.Assertions.assertThat;
import static org.junit.jupiter.api.Assertions.assertNotNull;
/**
 * Test Cassandra Chat Memory Store with a Saas DB.
 */
public class ChatMemoryStoreAstraTest {
    private static final String TEST_DATABASE = "langchain4j";
    private static final String TEST_KEYSPACE = "langchain4j";
    @Test
    @EnabledIfEnvironmentVariable(named = "ASTRA_DB_APPLICATION_TOKEN",
matches = "Astra.*")
    @EnabledIfEnvironmentVariable(named = "OPENAI_API_KEY", matches = "sk.*")
    void chatMemoryAstraTest() {
        // Initialization
        String astraToken = getAstraToken();
        String databaseId = setupDatabase(TEST_DATABASE, TEST_KEYSPACE);
        // Given
        assertNotNull(databaseId);
        assertNotNull(astraToken);
        // Flush Table before test
        truncateTable(databaseId, TEST_KEYSPACE,
CassandraChatMemoryStore.DEFAULT_TABLE_NAME);
        // When
        ChatMemoryStore chatMemoryStore =
                new AstraDbChatMemoryStore(astraToken, databaseId,
TEST_REGION, "langchain4j");
        // When
        String chatSessionId = "chat-" + UUID.randomUUID();
        ChatMemory chatMemory = TokenWindowChatMemory.builder()
                .chatMemoryStore(chatMemoryStore)
                .id(chatSessionId)
                .maxTokens(300, new OpenAiTokenizer(GPT_3_5_TURBO))
                .build();
        // When
        UserMessage userMessage = userMessage("I will ask you a few question
about ff4j.");
        chatMemory.add(userMessage);
        AiMessage aiMessage = aiMessage("Sure, go ahead!");
        chatMemory.add(aiMessage);
        // Then
```

```
        assertThat(chatMemory.messages()).containsExactly(userMessage,
aiMessage);
    }
    private void truncateTable(String databaseId, String keyspace, String
table) {
        try (AstraClient astraClient = AstraClient.builder()
                .withToken(getAstraToken())
                .withCqlKeyspace(keyspace)
                .withDatabaseId(databaseId)
                .withDatabaseRegion(TestUtils.TEST_REGION)
                .enableCql()
                .enableDownloadSecureConnectBundle()
                .build()) {
            astraClient.cqlSession()
                    .execute("TRUNCATE TABLE " + table);
        }
    }
}
```

langchain4j-cassandra\src\test\resources\story-about-happy-carrot.txt

Once upon a time in the town of VeggieVille, there lived a cheerful carrot named Charlie.
Charlie was a radiant carrot, always beaming with joy and positivity.
His vibrant orange skin and lush green top were a sight to behold, but it was his infectious laughter and warm personality that really set him apart.
Charlie had a diverse group of friends, each a vegetable with their own unique characteristics.
There was Bella the blushing beetroot, always ready with a riddle or two; Timmy the timid tomato, a gentle soul with a heart of gold; and Percy the prankster potato, whose jokes always brought a smile to everyone's faces.
Despite their differences, they shared a close bond, their friendship as robust as their natural goodness.
Their lives were filled with delightful adventures, from playing hide-and-seek amidst the leafy lettuce to swimming in the dewy droplets that pooled on the cabbage leaves.
Their favorite place, though, was the sunlit corner of the vegetable patch, where they would bask in the warmth of the sun, share stories, and have hearty laughs.
One day, a bunch of pesky caterpillars invaded VeggieVille.
The vegetables were terrified, fearing they would be nibbled to nothingness.
But Charlie, with his usual sunny disposition, had an idea.
He proposed they host a grand feast for the caterpillars, with the juiciest leaves from the outskirts of the town.
Charlie's optimism was contagious, and his friends eagerly joined in to prepare the feast.
When the caterpillars arrived, they were pleasantly surprised.
They enjoyed the feast and were so impressed with the vegetables' hospitality that they promised not to trouble VeggieVille again.
In return, they agreed to help pollinate the flowers, contributing to a more lush and vibrant VeggieVille.
Charlie's idea had saved the day, but he humbly attributed the success to their teamwork and friendship.
They celebrated their victory with a grand party, filled with laughter, dance, and merry games.
That night, under the twinkling stars, they made a pact to always stand by each other, come what may.
From then on, the story of the happy carrot and his friends spread far and wide, a tale of friendship, unity, and positivity.
Charlie, Bella, Timmy, and Percy continued to live their joyful lives, their laughter echoing through VeggieVille.
And so, the tale of the happy carrot and his friends serves as a reminder that no matter the challenge, with optimism, teamwork, and a bit of creativity, anything is possible.

langchain4j-chroma\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-chroma</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with Chroma</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>com.squareup.retrofit2</groupId>
            <artifactId>retrofit</artifactId>
        </dependency>
        <dependency>
            <groupId>com.squareup.retrofit2</groupId>
            <artifactId>converter-gson</artifactId>
        </dependency>
        <dependency>
            <groupId>com.squareup.okhttp3</groupId>
            <artifactId>okhttp</artifactId>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-chroma\src\main\java\dev\langchain4j\store\embedding\chroma\AddEmbeddingsRequest.java

```
package dev.langchain4j.store.embedding.chroma;
import java.util.ArrayList;
import java.util.List;
import java.util.Map;
class AddEmbeddingsRequest {
    private final List<String> ids;
    private final List<float[]> embeddings;
    private final List<String> documents;
    private final List<Map<String, String>> metadatas;
    public AddEmbeddingsRequest(Builder builder) {
        this.ids = builder.ids;
        this.embeddings = builder.embeddings;
        this.documents = builder.documents;
        this.metadatas = builder.metadatas;
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private List<String> ids = new ArrayList<>();
        private List<float[]> embeddings = new ArrayList<>();
        private List<String> documents = new ArrayList<>();
        private List<Map<String, String>> metadatas = new ArrayList<>();
        public Builder ids(List<String> ids) {
            if (ids != null) {
                this.ids = ids;
            }
            return this;
        }
        public Builder embeddings(List<float[]> embeddings) {
            if (embeddings != null) {
                this.embeddings = embeddings;
            }
            return this;
        }
        public Builder documents(List<String> documents) {
            if (documents != null) {
                this.documents = documents;
            }
            return this;
        }
        public Builder metadatas(List<Map<String, String>> metadatas) {
            if (metadatas != null) {
                this.metadatas = metadatas;
            }
            return this;
        }
        AddEmbeddingsRequest build() {
            return new AddEmbeddingsRequest(this);
        }
    }
}
```

langchain4j-chroma\src\main\java\dev\langchain4j\store\embedding\chroma\ChromaApi.java

```
package dev.langchain4j.store.embedding.chroma;
import retrofit2.Call;
import retrofit2.http.*;
interface ChromaApi {
    @GET("/api/v1/collections/{collection_name}")
    @Headers({"Content-Type: application/json"})
    Call<Collection> collection(@Path("collection_name") String
collectionName);
    @POST("/api/v1/collections")
    @Headers({"Content-Type: application/json"})
    Call<Collection> createCollection(@Body CreateCollectionRequest
createCollectionRequest);
    @POST("/api/v1/collections/{collection_id}/add")
    @Headers({"Content-Type: application/json"})
    Call<Boolean> addEmbeddings(@Path("collection_id") String collectionId,
@Body AddEmbeddingsRequest embedding);
    @POST("/api/v1/collections/{collection_id}/query")
    @Headers({"Content-Type: application/json"})
    Call<QueryResponse> queryCollection(@Path("collection_id") String
collectionId, @Body QueryRequest queryRequest);
}
```

langchain4j-chroma\src\main\java\dev\langchain4j\store\embedding\chroma\ChromaClient.java

```
package dev.langchain4j.store.embedding.chroma;
import com.google.gson.Gson;
import com.google.gson.GsonBuilder;
import okhttp3.OkHttpClient;
import retrofit2.Response;
import retrofit2.Retrofit;
import retrofit2.converter.gson.GsonConverterFactory;
import java.io.IOException;
import java.time.Duration;
import static com.google.gson.FieldNamingPolicy.LOWER_CASE_WITH_UNDERSCORES;
class ChromaClient {
    private final ChromaApi chromaApi;
    ChromaClient(String baseUrl, Duration timeout) {
        OkHttpClient okHttpClient = new OkHttpClient.Builder()
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .build();
        Gson gson = new GsonBuilder()
                .setFieldNamingPolicy(LOWER_CASE_WITH_UNDERSCORES)
                .create();
        Retrofit retrofit = new Retrofit.Builder()
                .baseUrl(baseUrl)
                .client(okHttpClient)
                .addConverterFactory(GsonConverterFactory.create(gson))
                .build();
        this.chromaApi = retrofit.create(ChromaApi.class);
    }
    Collection createCollection(CreateCollectionRequest
createCollectionRequest) {
        try {
            Response<Collection> response =
chromaApi.createCollection(createCollectionRequest).execute();
            if (response.isSuccessful()) {
                return response.body();
            } else {
                throw toException(response);
            }
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
    Collection collection(String collectionName) {
        try {
            Response<Collection> response =
chromaApi.collection(collectionName).execute();
            if (response.isSuccessful()) {
                return response.body();
            } else {
                // if collection is not present, Chroma returns: Status - 500
                return null;
            }
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
```

```
    boolean addEmbeddings(String collectionId, AddEmbeddingsRequest
addEmbeddingsRequest) {
        try {
            Response<Boolean> retrofitResponse =
chromaApi.addEmbeddings(collectionId, addEmbeddingsRequest)
                    .execute();
            if (retrofitResponse.isSuccessful()) {
                return Boolean.TRUE.equals(retrofitResponse.body());
            } else {
                throw toException(retrofitResponse);
            }
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
    QueryResponse queryCollection(String collectionId, QueryRequest
queryRequest) {
        try {
            Response<QueryResponse> retrofitResponse =
chromaApi.queryCollection(collectionId, queryRequest)
                    .execute();
            if (retrofitResponse.isSuccessful()) {
                return retrofitResponse.body();
            } else {
                throw toException(retrofitResponse);
            }
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
    private static RuntimeException toException(Response<?> response) throws
IOException {
        int code = response.code();
        String body = response.errorBody().string();
        String errorMessage = String.format("status code: %s; body: %s",
code, body);
        return new RuntimeException(errorMessage);
    }
}
```

langchain4j-chroma\src\main\java\dev\langchain4j\store\embedding\chroma\ChromaEmbeddingStore.java

```
package dev.langchain4j.store.embedding.chroma;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import java.time.Duration;
import java.util.ArrayList;
import java.util.List;
import java.util.Map;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.time.Duration.ofSeconds;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.toList;
/**
 * Represents a store for embeddings using the Chroma backend.
 * Always uses cosine distance as the distance metric.
 */
public class ChromaEmbeddingStore implements EmbeddingStore<TextSegment> {
    private final ChromaClient chromaClient;
    private final String collectionId;
    /**
     * Initializes a new instance of ChromaEmbeddingStore with the specified parameters.
     *
     * @param baseUrl        The base URL of the Chroma service.
     * @param collectionName The name of the collection in the Chroma service. If not specified, "default" will be used.
     * @param timeout        The timeout duration for the Chroma client. If not specified, 5 seconds will be used.
     */
    public ChromaEmbeddingStore(String baseUrl, String collectionName, Duration timeout) {
        collectionName = getOrDefault(collectionName, "default");
        this.chromaClient = new ChromaClient(baseUrl, getOrDefault(timeout, ofSeconds(5)));
        Collection collection = chromaClient.collection(collectionName);
        if (collection == null) {
            Collection createdCollection = chromaClient.createCollection(new CreateCollectionRequest(collectionName));
            collectionId = createdCollection.id();
        } else {
            collectionId = collection.id();
        }
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String baseUrl;
        private String collectionName;
        private Duration timeout;
        /**
         * @param baseUrl The base URL of the Chroma service.
         * @return builder
         */
```

```
        public Builder baseUrl(String baseUrl) {
            this.baseUrl = baseUrl;
            return this;
        }
        /**
         * @param collectionName The name of the collection in the Chroma
service. If not specified, "default" will be used.
         * @return builder
         */
        public Builder collectionName(String collectionName) {
            this.collectionName = collectionName;
            return this;
        }
        /**
         * @param timeout The timeout duration for the Chroma client. If not
specified, 5 seconds will be used.
         * @return builder
         */
        public Builder timeout(Duration timeout) {
            this.timeout = timeout;
            return this;
        }
        public ChromaEmbeddingStore build() {
            return new ChromaEmbeddingStore(this.baseUrl,
this.collectionName, this.timeout);
        }
    }
    @Override
    public String add(Embedding embedding) {
        String id = randomUUID();
        add(id, embedding);
        return id;
    }
    @Override
    public void add(String id, Embedding embedding) {
        addInternal(id, embedding, null);
    }
    @Override
    public String add(Embedding embedding, TextSegment textSegment) {
        String id = randomUUID();
        addInternal(id, embedding, textSegment);
        return id;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings) {
        List<String> ids = embeddings.stream()
                .map(embedding -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, null);
        return ids;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings, List<TextSegment>
textSegments) {
        List<String> ids = embeddings.stream()
                .map(embedding -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, textSegments);
        return ids;
    }
    private void addInternal(String id, Embedding embedding, TextSegment
```

```
textSegment) {
        addAllInternal(singletonList(id), singletonList(embedding),
textSegment == null ? null : singletonList(textSegment));
    }
    private void addAllInternal(List<String> ids, List<Embedding> embeddings,
List<TextSegment> textSegments) {
        AddEmbeddingsRequest addEmbeddingsRequest =
AddEmbeddingsRequest.builder()
                .embeddings(embeddings.stream()
                        .map(Embedding::vector)
                        .collect(toList()))
                .ids(ids)
                .metadatas(textSegments == null
                        ? null
                        : textSegments.stream()
                        .map(TextSegment::metadata)
                        .map(Metadata::asMap)
                        .collect(toList()))
                .documents(textSegments == null
                        ? null
                        : textSegments.stream()
                        .map(TextSegment::text)
                        .collect(toList()))
                .build();
        chromaClient.addEmbeddings(collectionId, addEmbeddingsRequest);
    }
    @Override
    public List<EmbeddingMatch<TextSegment>> findRelevant(Embedding
referenceEmbedding, int maxResults, double minScore) {
        QueryRequest queryRequest = new
QueryRequest(referenceEmbedding.vectorAsList(), maxResults);
        QueryResponse queryResponse =
chromaClient.queryCollection(collectionId, queryRequest);
        List<EmbeddingMatch<TextSegment>> matches =
toEmbeddingMatches(queryResponse);
        return matches.stream()
                .filter(match -> match.score() >= minScore)
                .collect(toList());
    }
    private static List<EmbeddingMatch<TextSegment>>
toEmbeddingMatches(QueryResponse queryResponse) {
        List<EmbeddingMatch<TextSegment>> embeddingMatches = new
ArrayList<>();
        for (int i = 0; i < queryResponse.ids().get(0).size(); i++) {
            double score =
distanceToScore(queryResponse.distances().get(0).get(i));
            String embeddingId = queryResponse.ids().get(0).get(i);
            Embedding embedding =
Embedding.from(queryResponse.embeddings().get(0).get(i));
            TextSegment textSegment = toTextSegment(queryResponse, i);
            embeddingMatches.add(new EmbeddingMatch<>(score, embeddingId,
embedding, textSegment));
        }
        return embeddingMatches;
    }
    /**
     * By default, cosine distance will be used. For details: <a
href="https://docs.trychroma.com/usage-guide"></a>
     * Converts a cosine distance in the range [0, 2] to a score in the range
[0, 1].
     *
```

```
     * @param distance The distance value.
     * @return The converted score.
     */
    private static double distanceToScore(double distance) {
        return 1 - (distance / 2);
    }
    private static TextSegment toTextSegment(QueryResponse queryResponse, int
i) {
        String text = queryResponse.documents().get(0).get(i);
        Map<String, String> metadata =
queryResponse.metadatas().get(0).get(i);
        return text == null ? null : TextSegment.from(text, metadata ==
null ? new Metadata() : new Metadata(metadata));
    }
}
```

langchain4j-chroma\src\main\java\dev\langchain4j\store\embedding\chroma\Collection.java

```
package dev.langchain4j.store.embedding.chroma;
import java.util.Map;
class Collection {
    private String id;
    private String name;
    private Map<String, String> metadata;
    public String id() {
        return id;
    }
    public String name() {
        return name;
    }
    public Map<String, String> metadata() {
        return metadata;
    }
}
```

langchain4j-chroma\src\main\java\dev\langchain4j\store\embedding\chroma\CreateCollectionRequest.java

```
package dev.langchain4j.store.embedding.chroma;
import java.util.HashMap;
import java.util.Map;
class CreateCollectionRequest {
    private final String name;
    private final Map<String, String> metadata;
    /**
     * Currently, cosine distance is always used as the distance method for chroma implementation
     */
    CreateCollectionRequest(String name) {
        this.name = name;
        HashMap<String, String> metadata = new HashMap<>();
        metadata.put("hnsw:space", "cosine");
        this.metadata = metadata;
    }
}
```

langchain4j-chroma\src\main\java\dev\langchain4j\store\embedding\chroma\QueryRequest.java

```
package dev.langchain4j.store.embedding.chroma;
import java.util.List;
import static java.util.Arrays.asList;
import static java.util.Collections.singletonList;
class QueryRequest {
    private final List<List<Float>> queryEmbeddings;
    private final int nResults;
    private final List<String> include = asList("metadatas", "documents",
"distances", "embeddings");
    public QueryRequest(List<Float> queryEmbedding, int nResults) {
        this.queryEmbeddings = singletonList(queryEmbedding);
        this.nResults = nResults;
    }
}
```

langchain4j-chroma\src\main\java\dev\langchain4j\store\embedding\chroma\QueryResponse.java

```
package dev.langchain4j.store.embedding.chroma;
import java.util.List;
import java.util.Map;
class QueryResponse {
    private List<List<String>> ids;
    private List<List<List<Float>>> embeddings;
    private List<List<String>> documents;
    private List<List<Map<String, String>>> metadatas;
    private List<List<Double>> distances;
    public List<List<String>> ids() {
        return ids;
    }
    public List<List<List<Float>>> embeddings() {
        return embeddings;
    }
    public List<List<String>> documents() {
        return documents;
    }
    public List<List<Map<String, String>>> metadatas() {
        return metadatas;
    }
    public List<List<Double>> distances() {
        return distances;
    }
}
```

langchain4j-chroma\src\test\java\dev\langchain4j\store\embedding\chroma\ChromaEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.chroma;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
@Disabled("needs Chroma running locally")
class ChromaEmbeddingStoreTest {
    /**
     * First ensure you have Chroma running locally. If not, then:
     * - Execute "docker pull ghcr.io/chroma-core/chroma:0.4.6"
     * - Execute "docker run -d -p 8000:8000 ghcr.io/chroma-core/chroma:0.4.6"
     * - Wait until Chroma is ready to serve (may take a few minutes)
     */
    private final EmbeddingStore<TextSegment> embeddingStore =
ChromaEmbeddingStore.builder()
            .baseUrl("http://localhost:8000")
            .collectionName(randomUUID())
            .build();
    private final EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    @Test
    void should_add_embedding() {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
```

```
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() {
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_embedding_with_segment_with_metadata() {
        TextSegment segment = TextSegment.from(randomUUID(),
Metadata.from("test-key", "test-value"));
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
```

```
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids = embeddingStore.addAll(
                asList(firstEmbedding, secondEmbedding),
                asList(firstSegment, secondSegment)
        );
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() - 0.01
        );
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score()
        );
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
```

```
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() + 0.01
        );
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(

RelevanceScore.fromCosineSimilarity(CosineSimilarity.between(embedding,
referenceEmbedding)),
                withPercentage(1)
        );
    }
}
```

langchain4j-core\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-core</artifactId>
    <packaging>jar</packaging>
    <name>langchain4j-core</name>
    <description>Core classes and interfaces of langchain4j</description>
    <dependencies>
        <dependency>
            <groupId>com.google.code.gson</groupId>
            <artifactId>gson</artifactId>
        </dependency>
        <dependency>
            <groupId>com.github.spullara.mustache.java</groupId>
            <artifactId>compiler</artifactId>
        </dependency>
        <dependency>
            <groupId>org.slf4j</groupId>
            <artifactId>slf4j-api</artifactId>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-params</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache License, Version 2.0</name>
            <url>http://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
        </license>
    </licenses>
</project>
```

langchain4j-core\src\main\java\dev\langchain4j\agent\tool\JsonSchemaProperty.java

```
package dev.langchain4j.agent.tool;
import java.util.Objects;
import static dev.langchain4j.internal.Utils.quoted;
public class JsonSchemaProperty {
    public static final JsonSchemaProperty STRING = type("string");
    public static final JsonSchemaProperty INTEGER = type("integer");
    public static final JsonSchemaProperty NUMBER = type("number");
    public static final JsonSchemaProperty OBJECT = type("object");
    public static final JsonSchemaProperty ARRAY = type("array");
    public static final JsonSchemaProperty BOOLEAN = type("boolean");
    public static final JsonSchemaProperty NULL = type("null");
    private final String key;
    private final Object value;
    public JsonSchemaProperty(String key, Object value) {
        this.key = key;
        this.value = value;
    }
    public String key() {
        return key;
    }
    public Object value() {
        return value;
    }
    @Override
    public boolean equals(Object another) {
        if (this == another) return true;
        return another instanceof JsonSchemaProperty
                && equalTo((JsonSchemaProperty) another);
    }
    private boolean equalTo(JsonSchemaProperty another) {
        return Objects.equals(key, another.key)
                && Objects.equals(value, another.value);
    }
    @Override
    public int hashCode() {
        int h = 5381;
        h += (h << 5) + Objects.hashCode(key);
        h += (h << 5) + Objects.hashCode(value);
        return h;
    }
    @Override
    public String toString() {
        return "JsonSchemaProperty {"
                + " key = " + quoted(key)
                + ", value = " + value
                + " }";
    }
    public static JsonSchemaProperty from(String key, Object value) {
        return new JsonSchemaProperty(key, value);
    }
    public static JsonSchemaProperty property(String key, Object value) {
        return from(key, value);
    }
    public static JsonSchemaProperty type(String value) {
        return from("type", value);
    }
    public static JsonSchemaProperty description(String value) {
```

```
        return from("description", value);
    }
    public static JsonSchemaProperty enums(String... enumValues) {
        return from("enum", enumValues);
    }
    public static JsonSchemaProperty enums(Object... enumValues) {
        for (Object enumValue : enumValues) {
            if (!enumValue.getClass().isEnum()) {
                throw new RuntimeException("Value " +
enumValue.getClass().getName() + " should be enum");
            }
        }
        return from("enum", enumValues);
    }
    public static JsonSchemaProperty enums(Class<?> enumClass) {
        if (!enumClass.isEnum()) {
            throw new RuntimeException("Class " + enumClass.getName() + "
should be enum");
        }
        return from("enum", enumClass.getEnumConstants());
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\agent\tool\P.java

```
package dev.langchain4j.agent.tool;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.PARAMETER;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
/**
 * Parameter of a Tool
 */
@Retention(RUNTIME)
@Target({PARAMETER})
public @interface P {
    /**
     * Description of a parameter
     */
    String value();
}
```

langchain4j-core\src\main\java\dev\langchain4j\agent\tool\Tool.java

```
package dev.langchain4j.agent.tool;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.METHOD;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
/**
 * Java methods annotated with @Tool are considered tools that language model
can use.
 */
@Retention(RUNTIME)
@Target({METHOD})
public @interface Tool {
    /**
     * Name of the tool. If not provided, method name will be used.
     */
    String name() default "";
    /**
     * Description of the tool.
     * It should be clear and descriptive to allow language model to
understand the tool's purpose and its intended use.
     */
    String[] value() default "";
}
```

langchain4j-core\src\main\java\dev\langchain4j\agent\tool\ToolExecutionRequest.java

```
package dev.langchain4j.agent.tool;
import static dev.langchain4j.internal.Utils.quoted;
import java.util.Objects;
public class ToolExecutionRequest {
    private final String name;
    private final String arguments;
    private ToolExecutionRequest(Builder builder) {
        this.name = builder.name;
        this.arguments = builder.arguments;
    }
    public String name() {
        return name;
    }
    public String arguments() {
        return arguments;
    }
    @Override
    public boolean equals(Object another) {
        if (this == another) return true;
        return another instanceof ToolExecutionRequest
                && equalTo((ToolExecutionRequest) another);
    }
    private boolean equalTo(ToolExecutionRequest another) {
        return Objects.equals(name, another.name)
                && Objects.equals(arguments, another.arguments);
    }
    @Override
    public int hashCode() {
        int h = 5381;
        h += (h << 5) + Objects.hashCode(name);
        h += (h << 5) + Objects.hashCode(arguments);
        return h;
    }
    @Override
    public String toString() {
        return "ToolExecutionRequest {"
                + " name = " + quoted(name)
                + ", arguments = " + quoted(arguments)
                + " }";
    }
    public static Builder builder() {
        return new Builder();
    }
    public static final class Builder {
        private String name;
        private String arguments;
        private Builder() {
        }
        public Builder name(String name) {
            this.name = name;
            return this;
        }
        public Builder arguments(String arguments) {
            this.arguments = arguments;
            return this;
        }
        public ToolExecutionRequest build() {
```

```
            return new ToolExecutionRequest(this);
        }
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\agent\tool\ToolExecutionRequestUtil.java

```
package dev.langchain4j.agent.tool;
import com.google.gson.Gson;
import com.google.gson.reflect.TypeToken;
import java.lang.reflect.Type;
import java.util.Map;
public class ToolExecutionRequestUtil {
    public static final Gson GSON = new Gson();
    public static final Type MAP_TYPE = new TypeToken<Map<String, Object>>() {
    }.getType();
    public static <T> T argument(ToolExecutionRequest toolExecutionRequest,
String name) {
        Map<String, Object> arguments =
argumentsAsMap(toolExecutionRequest.arguments()); // TODO cache
        return (T) arguments.get(name);
    }
    public static Map<String, Object> argumentsAsMap(String arguments) {
        return GSON.fromJson(arguments, MAP_TYPE);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\agent\tool\ToolParameters.java

```
package dev.langchain4j.agent.tool;
import java.util.*;
import static dev.langchain4j.internal.Utils.quoted;
public class ToolParameters {
    private final String type;
    private final Map<String, Map<String, Object>> properties;
    private final List<String> required;
    private ToolParameters(Builder builder) {
        this.type = builder.type;
        this.properties = builder.properties;
        this.required = builder.required;
    }
    public String type() {
        return type;
    }
    public Map<String, Map<String, Object>> properties() {
        return properties;
    }
    public List<String> required() {
        return required;
    }
    @Override
    public boolean equals(Object another) {
        if (this == another) return true;
        return another instanceof ToolParameters
                && equalTo((ToolParameters) another);
    }
    private boolean equalTo(ToolParameters another) {
        return Objects.equals(type, another.type)
                && Objects.equals(properties, another.properties)
                && Objects.equals(required, another.required);
    }
    @Override
    public int hashCode() {
        int h = 5381;
        h += (h << 5) + Objects.hashCode(type);
        h += (h << 5) + Objects.hashCode(properties);
        h += (h << 5) + Objects.hashCode(required);
        return h;
    }
    @Override
    public String toString() {
        return "ToolParameters {"
                + " type = " + quoted(type)
                + ", properties = " + properties
                + ", required = " + required
                + " }";
    }
    public static Builder builder() {
        return new Builder();
    }
    public static final class Builder {
        private String type = "object";
        private Map<String, Map<String, Object>> properties = new HashMap<>();
        private List<String> required = new ArrayList<>();
        private Builder() {
        }
        public Builder type(String type) {
```

```
            this.type = type;
            return this;
        }
        public Builder properties(Map<String, Map<String, Object>>
properties) {
            this.properties = properties;
            return this;
        }
        public Builder required(List<String> required) {
            this.required = required;
            return this;
        }
        public ToolParameters build() {
            return new ToolParameters(this);
        }
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\agent\tool\ToolSpecification.java

```
package dev.langchain4j.agent.tool;
import java.util.HashMap;
import java.util.Map;
import java.util.Objects;
import static dev.langchain4j.internal.Utils.quoted;
import static java.util.Arrays.asList;
public class ToolSpecification {
    private final String name;
    private final String description;
    private final ToolParameters parameters;
    private ToolSpecification(Builder builder) {
        this.name = builder.name;
        this.description = builder.description;
        this.parameters = builder.parameters;
    }
    public String name() {
        return name;
    }
    public String description() {
        return description;
    }
    public ToolParameters parameters() {
        return parameters;
    }
    @Override
    public boolean equals(Object another) {
        if (this == another) return true;
        return another instanceof ToolSpecification
                && equalTo((ToolSpecification) another);
    }
    private boolean equalTo(ToolSpecification another) {
        return Objects.equals(name, another.name)
                && Objects.equals(description, another.description)
                && Objects.equals(parameters, another.parameters);
    }
    @Override
    public int hashCode() {
        int h = 5381;
        h += (h << 5) + Objects.hashCode(name);
        h += (h << 5) + Objects.hashCode(description);
        h += (h << 5) + Objects.hashCode(parameters);
        return h;
    }
    @Override
    public String toString() {
        return "ToolSpecification {"
                + " name = " + quoted(name)
                + ", description = " + quoted(description)
                + ", parameters = " + parameters
                + " }";
    }
    public static Builder builder() {
        return new Builder();
    }
    public static final class Builder {
        private String name;
        private String description;
```

```
        private ToolParameters parameters;
        private Builder() {
        }
        public Builder name(String name) {
            this.name = name;
            return this;
        }
        public Builder description(String description) {
            this.description = description;
            return this;
        }
        public Builder parameters(ToolParameters parameters) {
            this.parameters = parameters;
            return this;
        }
        public Builder addParameter(String name, JsonSchemaProperty...
jsonSchemaProperties) {
            return addParameter(name, asList(jsonSchemaProperties));
        }
        public Builder addParameter(String name, Iterable<JsonSchemaProperty>
jsonSchemaProperties) {
            addOptionalParameter(name, jsonSchemaProperties);
            this.parameters.required().add(name);
            return this;
        }
        public Builder addOptionalParameter(String name,
JsonSchemaProperty... jsonSchemaProperties) {
            return addOptionalParameter(name, asList(jsonSchemaProperties));
        }
        public Builder addOptionalParameter(String name,
Iterable<JsonSchemaProperty> jsonSchemaProperties) {
            if (this.parameters == null) {
                this.parameters = ToolParameters.builder().build();
            }
            Map<String, Object> jsonSchemaPropertiesMap = new HashMap<>();
            for (JsonSchemaProperty jsonSchemaProperty :
jsonSchemaProperties) {
                jsonSchemaPropertiesMap.put(jsonSchemaProperty.key(),
jsonSchemaProperty.value());
            }
            this.parameters.properties().put(name, jsonSchemaPropertiesMap);
            return this;
        }
        public ToolSpecification build() {
            return new ToolSpecification(this);
        }
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\agent\tool\ToolSpecifications.java

```
package dev.langchain4j.agent.tool;
import java.lang.reflect.Method;
import java.lang.reflect.Parameter;
import java.math.BigDecimal;
import java.math.BigInteger;
import java.util.List;
import java.util.Objects;
import java.util.Set;
import static dev.langchain4j.agent.tool.JsonSchemaProperty.*;
import static dev.langchain4j.internal.Utils.isNullOrBlank;
import static java.util.Arrays.stream;
import static java.util.stream.Collectors.toList;
public class ToolSpecifications {
    public static List<ToolSpecification> toolSpecificationsFrom(Object
objectWithTools) {
        return stream(objectWithTools.getClass().getDeclaredMethods())
                .filter(method -> method.isAnnotationPresent(Tool.class))
                .map(ToolSpecifications::toolSpecificationFrom)
                .collect(toList());
    }
    public static ToolSpecification toolSpecificationFrom(Method method) {
        Tool annotation = method.getAnnotation(Tool.class);
        String name = isNullOrBlank(annotation.name()) ? method.getName() :
annotation.name();
        String description = String.join("\n", annotation.value());
        ToolSpecification.Builder builder = ToolSpecification.builder()
                .name(name)
                .description(description);
        for (Parameter parameter : method.getParameters()) {
            builder.addParameter(parameter.getName(),
toJsonSchemaProperties(parameter));
        }
        return builder.build();
    }
    private static Iterable<JsonSchemaProperty>
toJsonSchemaProperties(Parameter parameter) {
        Class<?> type = parameter.getType();
        P annotation = parameter.getAnnotation(P.class);
        JsonSchemaProperty description = annotation == null ? null :
description(annotation.value());
        if (type == String.class) {
            return removeNulls(STRING, description);
        }
        if (type == boolean.class || type == Boolean.class) {
            return removeNulls(BOOLEAN, description);
        }
        if (type == byte.class || type == Byte.class
                || type == short.class || type == Short.class
                || type == int.class || type == Integer.class
                || type == long.class || type == Long.class
                || type == BigInteger.class) {
            return removeNulls(INTEGER, description);
        }
        // TODO put constraints on min and max?
        if (type == float.class || type == Float.class
                || type == double.class || type == Double.class
                || type == BigDecimal.class) {
```

```
            return removeNulls(NUMBER, description);
        }
        if (type.isArray()
                || type == List.class
                || type == Set.class) { // TODO something else?
            return removeNulls(ARRAY, description); // TODO provide type of
array?
        }
        if (type.isEnum()) {
            return removeNulls(STRING, enums((Object[])
type.getEnumConstants()), description);
        }
        return removeNulls(OBJECT, description); // TODO provide internals
    }
    private static Iterable<JsonSchemaProperty>
removeNulls(JsonSchemaProperty... properties) {
        return stream(properties)
                .filter(Objects::nonNull)
                .collect(toList());
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\chain\Chain.java

```
package dev.langchain4j.chain;
public interface Chain<Input, Output> {
    Output execute(Input input);
}
```

langchain4j-core\src\main\java\dev\langchain4j\classification\TextClassifier.java

```
package dev.langchain4j.classification;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.segment.TextSegment;
import java.util.List;
/**
 * Classifies given text according to specified enum.
 *
 * @param <E> Enum that is the result of classification.
 */
public interface TextClassifier<E extends Enum<E>> {
    /**
     * Classify the given text.
     *
     * @param text Text to classify.
     * @return A list of classification categories.
     */
    List<E> classify(String text);
    /**
     * Classify the given {@link TextSegment}.
     *
     * @param textSegment {@link TextSegment} to classify.
     * @return A list of classification categories.
     */
    default List<E> classify(TextSegment textSegment) {
        return classify(textSegment.text());
    }
    /**
     * Classify the given {@link Document}.
     *
     * @param document {@link Document} to classify.
     * @return A list of classification categories.
     */
    default List<E> classify(Document document) {
        return classify(document.text());
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\code\CodeExecutionEngine.java

```
package dev.langchain4j.code;
public interface CodeExecutionEngine {
    String execute(String code);
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\document\Document.java

```
package dev.langchain4j.data.document;
import dev.langchain4j.data.segment.TextSegment;
import java.util.Objects;
import static dev.langchain4j.internal.Utils.quoted;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * Represents an unstructured piece of text that usually corresponds to a
content of a single file.
 * This text could originate from various sources such as a text file, PDF,
DOCX, or a web page (HTML).
 * Each document may have associated metadata including its source, owner,
creation date, etc.
 */
public class Document {
    public static final String DOCUMENT_TYPE = "document_type";
    public static final String FILE_NAME = "file_name";
    public static final String ABSOLUTE_DIRECTORY_PATH =
"absolute_directory_path";
    public static final String URL = "url";
    private final String text;
    private final Metadata metadata;
    public Document(String text, Metadata metadata) {
        this.text = ensureNotBlank(text, "text");
        this.metadata = ensureNotNull(metadata, "metadata");
    }
    public String text() {
        return text;
    }
    public Metadata metadata() {
        return metadata;
    }
    public String metadata(String key) {
        return metadata.get(key);
    }
    public TextSegment toTextSegment() {
        return TextSegment.from(text, metadata.copy().add("index", 0));
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        Document that = (Document) o;
        return Objects.equals(this.text, that.text)
                && Objects.equals(this.metadata, that.metadata);
    }
    @Override
    public int hashCode() {
        return Objects.hash(text, metadata);
    }
    @Override
    public String toString() {
        return "Document {" +
                " text = " + quoted(text) +
                " metadata = " + metadata.asMap() +
                " }";
    }
    public static Document from(String text) {
```

```
        return new Document(text, new Metadata());
    }
    public static Document from(String text, Metadata metadata) {
        return new Document(text, metadata);
    }
    public static Document document(String text) {
        return from(text);
    }
    public static Document document(String text, Metadata metadata) {
        return from(text, metadata);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\document\DocumentParser.java

```
package dev.langchain4j.data.document;
import java.io.InputStream;
/**
 * Defines the interface for parsing an InputStream into a Document.
 * Different document types require specialized parsing logic.
 */
public interface DocumentParser {
    /**
     * Parses an InputStream into a Document.
     * The specific implementation of this method will depend on the type of
the document being parsed.
     *
     * @param inputStream The InputStream that contains the content of the
document.
     * @return The parsed Document.
     */
    Document parse(InputStream inputStream);
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\document\DocumentSource.java

```
package dev.langchain4j.data.document;
import java.io.IOException;
import java.io.InputStream;
/**
 * Defines the interface for a Document source.
 * Documents can be loaded from various sources such as the file system, HTTP, FTP, etc.
 */
public interface DocumentSource {
    /**
     * Provides an InputStream to read the content of the document.
     * This method can be implemented to read from various sources like a local file or a network connection.
     *
     * @return An InputStream from which the document content can be read.
     * @throws IOException If an I/O error occurs while creating the InputStream.
     */
    InputStream inputStream() throws IOException;
    /**
     * Returns the metadata associated with the source of the document.
     * This could include details such as the source location, date of creation, owner, etc.
     *
     * @return A Metadata object containing information associated with the source of the document.
     */
    Metadata metadata();
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\document\DocumentSplitter.java

```
package dev.langchain4j.data.document;
import dev.langchain4j.data.segment.TextSegment;
import java.util.List;
import static java.util.stream.Collectors.toList;
/**
 * Defines the interface for splitting a document into text segments.
 * This is necessary as LLMs have a limited context window, making it
impossible to send the entire document at once.
 * Therefore, the document should first be split into segments, and only the
relevant segments should be sent to LLM.
 */
public interface DocumentSplitter {
    /**
     * Splits a single Document into a list of TextSegment objects.
     * The metadata is typically copied from the document and enriched with
segment-specific information,
     * such as position in the document, page number, etc.
     *
     * @param document The Document to be split.
     * @return A list of TextSegment objects derived from the input Document.
     */
    List<TextSegment> split(Document document);
    /**
     * Splits a list of Documents into a list of TextSegment objects.
     * This is a convenience method that calls the split method for each
Document in the list.
     *
     * @param documents The list of Documents to be split.
     * @return A list of TextSegment objects derived from the input Documents.
     */
    default List<TextSegment> splitAll(List<Document> documents) {
        return documents.stream()
                .flatMap(document -> split(document).stream())
                .collect(toList());
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\document\DocumentTransformer.java

```
package dev.langchain4j.data.document;
import java.util.List;
import java.util.Objects;
import static java.util.stream.Collectors.toList;
/**
 * Defines the interface for transforming a {@link Document}.
 * Implementations can perform a variety of tasks such as transforming, filtering, enriching, etc.
 */
public interface DocumentTransformer {
    /**
     * Transforms a provided document.
     *
     * @param document The document to be transformed.
     * @return The transformed document, or null if the document should be filtered out.
     */
    Document transform(Document document);
    /**
     * Transforms all the provided documents.
     *
     * @param documents A list of documents to be transformed.
     * @return A list of transformed documents. The length of this list may be shorter or longer than the original list. Returns an empty list if all documents were filtered out.
     */
    default List<Document> transformAll(List<Document> documents) {
        return documents.stream()
                .map(this::transform)
                .filter(Objects::nonNull)
                .collect(toList());
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\document\Metadata.java

```
package dev.langchain4j.data.document;
import java.util.HashMap;
import java.util.Map;
import java.util.Objects;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * Represents metadata of a Document or a TextSegment.
 * The metadata is stored in a key-value map, where both keys and values are
strings.
 * For a Document, the metadata could include information such as the source,
creation date,
 * owner, or any other relevant details.
 * For a TextSegment, in addition to metadata copied from a document, it can
also include segment-specific information,
 * such as the page number, the position of the segment within the document,
chapter, etc.
 */
public class Metadata {
    private final Map<String, String> metadata;
    public Metadata() {
        this(new HashMap<>());
    }
    public Metadata(Map<String, String> metadata) {
        this.metadata = ensureNotNull(metadata, "metadata");
    }
    public String get(String key) {
        return metadata.get(key);
    }
    public Metadata add(String key, Object value) {
        this.metadata.put(key, value.toString());
        return this;
    }
    public Metadata remove(String key) {
        this.metadata.remove(key);
        return this;
    }
    public Metadata copy() {
        return new Metadata(new HashMap<>(metadata));
    }
    public Map<String, String> asMap() {
        return new HashMap<>(metadata);
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        Metadata that = (Metadata) o;
        return Objects.equals(this.metadata, that.metadata);
    }
    @Override
    public int hashCode() {
        return Objects.hash(metadata);
    }
    @Override
    public String toString() {
        return "Metadata {" +
                " metadata = " + metadata +
                " }";
```

```
    }
    public static Metadata from(String key, Object value) {
        return new Metadata().add(key, value);
    }
    public static Metadata from(Map<String, String> metadata) {
        return new Metadata(metadata);
    }
    public static Metadata metadata(String key, Object value) {
        return from(key, value);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\embedding\Embedding.java

```
package dev.langchain4j.data.embedding;
import java.util.ArrayList;
import java.util.Arrays;
import java.util.List;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * Represents a dense vector embedding of a text.
 * This class encapsulates a float array that captures the "meaning" or
semantic information of the text.
 * Texts with similar meanings will have their vectors located close to each
other in the embedding space.
 * The embeddings are typically created by embedding models.
 * @see dev.langchain4j.model.embedding.EmbeddingModel
 */
public class Embedding {
    private final float[] vector;
    public Embedding(float[] vector) {
        this.vector = ensureNotNull(vector, "vector");
    }
    public float[] vector() {
        return vector;
    }
    public List<Float> vectorAsList() {
        List<Float> list = new ArrayList<>(vector.length);
        for (float f : vector) {
            list.add(f);
        }
        return list;
    }
    public int dimensions() {
        return vector.length;
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        Embedding that = (Embedding) o;
        return Arrays.equals(this.vector, that.vector);
    }
    @Override
    public int hashCode() {
        return Arrays.hashCode(vector);
    }
    @Override
    public String toString() {
        return "Embedding {" +
                " vector = " + Arrays.toString(vector) +
                " }";
    }
    public static Embedding from(float[] vector) {
        return new Embedding(vector);
    }
    public static Embedding from(List<Float> vector) {
        float[] array = new float[vector.size()];
        for (int i = 0; i < vector.size(); i++) {
            array[i] = vector.get(i);
        }
        return new Embedding(array);
```

```
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\message\AiMessage.java

```
package dev.langchain4j.data.message;
import dev.langchain4j.agent.tool.ToolExecutionRequest;
import java.util.Objects;
import static dev.langchain4j.data.message.ChatMessageType.AI;
import static dev.langchain4j.internal.Utils.quoted;
/**
 * Represents a response message from an AI (language model).
 * The message can contain either a textual response or a request to execute
a tool.
 * In the case of tool execution, the response to this message should be a
{@link ToolExecutionResultMessage}.
 */
public class AiMessage extends ChatMessage {
    private final ToolExecutionRequest toolExecutionRequest;
    public AiMessage(String text) {
        this(text, null);
    }
    public AiMessage(String text, ToolExecutionRequest toolExecutionRequest) {
        super(text);
        this.toolExecutionRequest = toolExecutionRequest;
    }
    public ToolExecutionRequest toolExecutionRequest() {
        return toolExecutionRequest;
    }
    @Override
    public ChatMessageType type() {
        return AI;
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        AiMessage that = (AiMessage) o;
        return Objects.equals(this.text, that.text)
                && Objects.equals(this.toolExecutionRequest,
that.toolExecutionRequest);
    }
    @Override
    public int hashCode() {
        return Objects.hash(text, toolExecutionRequest);
    }
    @Override
    public String toString() {
        return "AiMessage {" +
                " text = " + quoted(text) +
                " toolExecutionRequest = " + toolExecutionRequest +
                " }";
    }
    public static AiMessage from(String text) {
        return new AiMessage(text);
    }
    public static AiMessage from(ToolExecutionRequest toolExecutionRequest) {
        return new AiMessage(null, toolExecutionRequest);
    }
    public static AiMessage aiMessage(String text) {
        return from(text);
    }
    public static AiMessage aiMessage(ToolExecutionRequest
```

```
toolExecutionRequest) {
        return from(toolExecutionRequest);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\message\ChatMessage.java

```
package dev.langchain4j.data.message;
public abstract class ChatMessage {
    protected final String text;
    ChatMessage(String text) {
        this.text = text;
    }
    public String text() {
        return text;
    }
    public abstract ChatMessageType type();
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\message\ChatMessageDeserializer.java

```
package dev.langchain4j.data.message;
import com.google.gson.reflect.TypeToken;
import java.util.List;
import static dev.langchain4j.data.message.ChatMessageSerializer.GSON;
import static java.util.Collections.emptyList;
public class ChatMessageDeserializer {
    /**
     * Deserializes a JSON string into a {@link ChatMessage}.
     *
     * @param json The JSON string representing a chat message.
     * @return A {@link ChatMessage} deserialized from the provided JSON
string.
     * @see ChatMessageSerializer For details on serialization.
     */
    public static ChatMessage messageFromJson(String json) {
        return GSON.fromJson(json, ChatMessage.class);
    }
    /**
     * Deserializes a JSON string into a list of {@link ChatMessage}.
     *
     * @param json The JSON string containing an array of chat messages.
     * @return A list of {@link ChatMessage} deserialized from the provided
JSON string.
     * @see ChatMessageSerializer For details on serialization.
     */
    public static List<ChatMessage> messagesFromJson(String json) {
        List<ChatMessage> messages = GSON.fromJson(json, new
TypeToken<List<ChatMessage>>() {
        }.getType());
        return messages == null ? emptyList() : messages;
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\message\ChatMessageSerializer.java

```
package dev.langchain4j.data.message;
import com.google.gson.Gson;
import com.google.gson.GsonBuilder;
import java.util.List;
public class ChatMessageSerializer {
    static final Gson GSON = new GsonBuilder()
            .registerTypeAdapter(ChatMessage.class, new
GsonChatMessageAdapter())
            .registerTypeAdapter(SystemMessage.class, new
GsonChatMessageAdapter())
            .registerTypeAdapter(UserMessage.class, new
GsonChatMessageAdapter())
            .registerTypeAdapter(AiMessage.class, new
GsonChatMessageAdapter())
            .registerTypeAdapter(ToolExecutionResultMessage.class, new
GsonChatMessageAdapter())
            .create();
    /**
     * Serializes a chat message into a JSON string.
     *
     * @param message Chat message to be serialized.
     * @return A JSON string with the contents of the message.
     * @see ChatMessageDeserializer For details on deserialization.
     */
    public static String messageToJson(ChatMessage message) {
        return GSON.toJson(message);
    }
    /**
     * Serializes a list of chat messages into a JSON string.
     *
     * @param messages The list of chat messages to be serialized.
     * @return A JSON string representing provided chat messages.
     * @see ChatMessageDeserializer For details on deserialization.
     */
    public static String messagesToJson(List<ChatMessage> messages) {
        return GSON.toJson(messages);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\message\ChatMessageType.java

```
package dev.langchain4j.data.message;
import static dev.langchain4j.internal.Exceptions.illegalArgument;
public enum ChatMessageType {
    SYSTEM,
    USER,
    AI,
    TOOL_EXECUTION_RESULT;
    public static Class<? extends ChatMessage> classOf(ChatMessageType type) {
        switch (type) {
            case SYSTEM:
                return SystemMessage.class;
            case USER:
                return UserMessage.class;
            case AI:
                return AiMessage.class;
            case TOOL_EXECUTION_RESULT:
                return ToolExecutionResultMessage.class;
            default:
                throw illegalArgument("Unknown ChatMessageType: %s", type);
        }
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\message\GsonChatMessageAdapter.java

```
package dev.langchain4j.data.message;
import com.google.gson.*;
import java.lang.reflect.Type;
class GsonChatMessageAdapter implements JsonDeserializer<ChatMessage>,
JsonSerializer<ChatMessage> {
    private static final Gson GSON = new Gson();
    private static final String CHAT_MESSAGE_TYPE = "type"; // do not change,
will break backward compatibility!
    @Override
    public JsonElement serialize(ChatMessage chatMessage, Type ignored,
JsonSerializationContext context) {
        JsonObject messageJsonObject =
GSON.toJsonTree(chatMessage).getAsJsonObject();
        messageJsonObject.addProperty(CHAT_MESSAGE_TYPE,
chatMessage.type().toString());
        return messageJsonObject;
    }
    @Override
    public ChatMessage deserialize(JsonElement messageJsonElement, Type
ignored, JsonDeserializationContext context) throws JsonParseException {
        String chatMessageTypeString =
messageJsonElement.getAsJsonObject().get(CHAT_MESSAGE_TYPE).getAsString();
        ChatMessageType chatMessageType =
ChatMessageType.valueOf(chatMessageTypeString);
        return GSON.fromJson(messageJsonElement,
ChatMessageType.classOf(chatMessageType));
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\message\SystemMessage.java

```
package dev.langchain4j.data.message;
import java.util.Objects;
import static dev.langchain4j.data.message.ChatMessageType.SYSTEM;
import static dev.langchain4j.internal.Utils.quoted;
/**
 * Represents a system message, typically defined by a developer.
 * This type of message usually provides instructions regarding the AI's
actions, such as its behavior or response style.
 */
public class SystemMessage extends ChatMessage {
    public SystemMessage(String text) {
        super(text);
    }
    @Override
    public ChatMessageType type() {
        return SYSTEM;
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        SystemMessage that = (SystemMessage) o;
        return Objects.equals(this.text, that.text);
    }
    @Override
    public int hashCode() {
        return Objects.hash(text);
    }
    @Override
    public String toString() {
        return "SystemMessage {" +
                " text = " + quoted(text) +
                " }";
    }
    public static SystemMessage from(String text) {
        return new SystemMessage(text);
    }
    public static SystemMessage systemMessage(String text) {
        return from(text);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\message\ToolExecutionResultMessage.java

```
package dev.langchain4j.data.message;
import java.util.Objects;
import static
dev.langchain4j.data.message.ChatMessageType.TOOL_EXECUTION_RESULT;
import static dev.langchain4j.internal.Utils.quoted;
/**
 * Represents the result of a tool execution. Tool execution requests come
from a previous AiMessage.
 */
public class ToolExecutionResultMessage extends ChatMessage {
    private final String toolName;
    public ToolExecutionResultMessage(String toolName, String
toolExecutionResult) {
        super(toolExecutionResult);
        this.toolName = toolName;
    }
    public String toolName() {
        return toolName;
    }
    @Override
    public ChatMessageType type() {
        return TOOL_EXECUTION_RESULT;
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        ToolExecutionResultMessage that = (ToolExecutionResultMessage) o;
        return Objects.equals(this.toolName, that.toolName)
                && Objects.equals(this.text, that.text);
    }
    @Override
    public int hashCode() {
        return Objects.hash(toolName, text);
    }
    @Override
    public String toString() {
        return "ToolExecutionResultMessage {" +
                " toolName = " + quoted(toolName) +
                " text = " + quoted(text) +
                " }";
    }
    public static ToolExecutionResultMessage from(String toolName, String
toolExecutionResult) {
        return new ToolExecutionResultMessage(toolName, toolExecutionResult);
    }
    public static ToolExecutionResultMessage
toolExecutionResultMessage(String toolName, String toolExecutionResult) {
        return from(toolName, toolExecutionResult);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\message\UserMessage.java

```
package dev.langchain4j.data.message;
import java.util.Objects;
import static dev.langchain4j.data.message.ChatMessageType.USER;
import static dev.langchain4j.internal.Utils.quoted;
/**
 * Represents a message from a user, typically an end user of the application.
 */
public class UserMessage extends ChatMessage {
    private final String name;
    public UserMessage(String text) {
        this(null, text);
    }
    public UserMessage(String name, String text) {
        super(text);
        this.name = name;
    }
    public String name() {
        return name;
    }
    @Override
    public ChatMessageType type() {
        return USER;
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        UserMessage that = (UserMessage) o;
        return Objects.equals(this.name, that.name)
                && Objects.equals(this.text, that.text);
    }
    @Override
    public int hashCode() {
        return Objects.hash(name, text);
    }
    @Override
    public String toString() {
        return "UserMessage {" +
                " name = " + quoted(name) +
                " text = " + quoted(text) +
                " }";
    }
    public static UserMessage from(String text) {
        return new UserMessage(text);
    }
    public static UserMessage from(String name, String text) {
        return new UserMessage(name, text);
    }
    public static UserMessage userMessage(String text) {
        return from(text);
    }
    public static UserMessage userMessage(String name, String text) {
        return from(name, text);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\segment\TextSegment.java

```
package dev.langchain4j.data.segment;
import dev.langchain4j.data.document.Metadata;
import java.util.Objects;
import static dev.langchain4j.internal.Utils.quoted;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * Represents a semantically meaningful segment (chunk/piece/fragment) of a
larger entity such as a document or chat conversation.
 * This might be a sentence, a paragraph, or any other discrete unit of text
that carries meaning.
 * This class encapsulates a piece of text and its associated metadata.
 */
public class TextSegment {
    private final String text;
    private final Metadata metadata;
    public TextSegment(String text, Metadata metadata) {
        this.text = ensureNotBlank(text, "text");
        this.metadata = ensureNotNull(metadata, "metadata");
    }
    public String text() {
        return text;
    }
    public Metadata metadata() {
        return metadata;
    }
    public String metadata(String key) {
        return metadata.get(key);
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        TextSegment that = (TextSegment) o;
        return Objects.equals(this.text, that.text)
                && Objects.equals(this.metadata, that.metadata);
    }
    @Override
    public int hashCode() {
        return Objects.hash(text, metadata);
    }
    @Override
    public String toString() {
        return "TextSegment {" +
                " text = " + quoted(text) +
                " metadata = " + metadata.asMap() +
                " }";
    }
    public static TextSegment from(String text) {
        return new TextSegment(text, new Metadata());
    }
    public static TextSegment from(String text, Metadata metadata) {
        return new TextSegment(text, metadata);
    }
    public static TextSegment textSegment(String text) {
        return from(text);
    }
    public static TextSegment textSegment(String text, Metadata metadata) {
```

```
        return from(text, metadata);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\data\segment\TextSegmentTransformer.java

```
package dev.langchain4j.data.segment;
import java.util.List;
import java.util.Objects;
import static java.util.stream.Collectors.toList;
/**
 * Defines the interface for transforming a {@link TextSegment}.
 * Implementations can perform a variety of tasks such as transforming,
filtering, enriching, etc.
 */
public interface TextSegmentTransformer {
    /**
     * Transforms a provided segment.
     *
     * @param segment The segment to be transformed.
     * @return The transformed segment, or null if the segment should be
filtered out.
     */
    TextSegment transform(TextSegment segment);
    /**
     * Transforms all the provided segments.
     *
     * @param segments A list of segments to be transformed.
     * @return A list of transformed segments. The length of this list may be
shorter or longer than the original list. Returns an empty list if all
segments were filtered out.
     */
    default List<TextSegment> transformAll(List<TextSegment> segments) {
        return segments.stream()
                .map(this::transform)
                .filter(Objects::nonNull)
                .collect(toList());
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\internal\Exceptions.java

```
package dev.langchain4j.internal;
public class Exceptions {
    public static IllegalArgumentException illegalArgument(String format,
Object... args) {
        return new IllegalArgumentException(String.format(format, args));
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\internal\Json.java

```
package dev.langchain4j.internal;
import static java.time.format.DateTimeFormatter.ISO_LOCAL_DATE;
import static java.time.format.DateTimeFormatter.ISO_LOCAL_DATE_TIME;
import com.google.gson.*;
import com.google.gson.stream.JsonWriter;
import java.io.*;
import java.nio.charset.StandardCharsets;
import java.time.LocalDate;
import java.time.LocalDateTime;
public class Json {
  private static final Gson GSON = new GsonBuilder()
    .setPrettyPrinting()
    .registerTypeAdapter(
      LocalDate.class,
      (JsonSerializer<LocalDate>) (localDate, type, context) -> new
JsonPrimitive(localDate.format(ISO_LOCAL_DATE))
    )
    .registerTypeAdapter(
      LocalDate.class,
      (JsonDeserializer<LocalDate>) (json, type, context) ->
LocalDate.parse(json.getAsString(), ISO_LOCAL_DATE)
    )
    .registerTypeAdapter(
      LocalDateTime.class,
      (JsonSerializer<LocalDateTime>) (localDateTime, type, context) ->
        new JsonPrimitive(localDateTime.format(ISO_LOCAL_DATE_TIME))
    )
    .registerTypeAdapter(
      LocalDateTime.class,
      (JsonDeserializer<LocalDateTime>) (json, type, context) ->
        LocalDateTime.parse(json.getAsString(), ISO_LOCAL_DATE_TIME)
    )
    .create();
  public static String toJson(Object o) {
    return GSON.toJson(o);
  }
  public static <T> T fromJson(String json, Class<T> type) {
    return GSON.fromJson(json, type);
  }
  public static InputStream toInputStream(Object o, Class type) throws
IOException {
    try (
      ByteArrayOutputStream byteArrayOutputStream = new
ByteArrayOutputStream();
      OutputStreamWriter outputStreamWriter = new
OutputStreamWriter(byteArrayOutputStream, StandardCharsets.UTF_8);
      JsonWriter jsonWriter = new JsonWriter(outputStreamWriter)
    ) {
      GSON.toJson(o, type, jsonWriter);
      jsonWriter.flush();
      return new ByteArrayInputStream(byteArrayOutputStream.toByteArray());
    }
  }
}
```

langchain4j-core\src\main\java\dev\langchain4j\internal\RetryUtils.java

```
package dev.langchain4j.internal;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.util.concurrent.Callable;
import static java.lang.String.format;
public class RetryUtils {
    private static final Logger log =
LoggerFactory.getLogger(RetryUtils.class);
    /**
     * This method attempts to execute a given action up to a specified
number of times with a 1-second delay.
     * If the action fails on all attempts, it throws a RuntimeException.
     *
     * @param action      The action to be executed.
     * @param maxAttempts The maximum number of attempts to execute the
action.
     * @return The result of the action if it is successful.
     * @throws RuntimeException if the action fails on all attempts.
     */
    public static <T> T withRetry(Callable<T> action, int maxAttempts) {
        for (int attempt = 1; attempt <= maxAttempts; attempt++) {
            try {
                return action.call();
            } catch (Exception e) {
                if (attempt == maxAttempts) {
                    throw new RuntimeException(e);
                }
                log.warn(format("Exception was thrown on attempt %s of %s",
attempt, maxAttempts), e);
                try {
                    Thread.sleep(1000); // TODO make configurable
                } catch (InterruptedException ignored) {
                }
            }
        }
        throw new RuntimeException("Failed after " + maxAttempts + "
attempts");
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\internal\Utils.java

```
package dev.langchain4j.internal;
import static java.nio.charset.StandardCharsets.UTF_8;
import java.security.MessageDigest;
import java.security.NoSuchAlgorithmException;
import java.util.Collection;
import java.util.UUID;
public class Utils {
  public static <T> T getOrDefault(T value, T defaultValue) {
    return value != null ? value : defaultValue;
  }
  public static boolean isNullOrBlank(String string) {
    return string == null || string.trim().isEmpty();
  }
  public static boolean isNotNullOrBlank(String string) {
    return !isNullOrBlank(string);
  }
  public static boolean areNotNullOrBlank(String... strings) {
    if (strings == null || strings.length == 0) {
      return false;
    }
    for (String string : strings) {
      if (isNullOrBlank(string)) {
        return false;
      }
    }
    return true;
  }
  public static boolean isCollectionEmpty(Collection<?> collection) {
    return collection == null || collection.isEmpty();
  }
  public static String repeat(String string, int times) {
    StringBuilder sb = new StringBuilder();
    for (int i = 0; i < times; i++) {
      sb.append(string);
    }
    return sb.toString();
  }
  public static String randomUUID() {
    return UUID.randomUUID().toString();
  }
  public static String generateUUIDFrom(String input) {
    try {
      byte[] hashBytes =
MessageDigest.getInstance("SHA-256").digest(input.getBytes(UTF_8));
      StringBuilder sb = new StringBuilder();
      for (byte b : hashBytes) sb.append(String.format("%02x", b));
      return UUID.nameUUIDFromBytes(sb.toString().getBytes(UTF_8)).toString();
    } catch (NoSuchAlgorithmException e) {
      throw new IllegalArgumentException(e);
    }
  }
  public static String quoted(String string) {
    if (string == null) {
      return "null";
    }
    return "\"" + string + "\"";
  }
  public static String firstChars(String string, int numberOfChars) {
```

```
    if (string == null) {
      return null;
    }
    return string.length() > numberOfChars ? string.substring(0,
numberOfChars) : string;
  }
}
```

langchain4j-core\src\main\java\dev\langchain4j\internal\ValidationUtils.java

```
package dev.langchain4j.internal;
import java.util.Collection;
import static dev.langchain4j.internal.Exceptions.illegalArgument;
public class ValidationUtils {
    public static <T> T ensureNotNull(T object, String name) {
        if (object == null) {
            throw illegalArgument("%s cannot be null", name);
        }
        return object;
    }
    public static <T extends Collection<?>> T ensureNotEmpty(T collection,
String name) {
        if (collection == null || collection.isEmpty()) {
            throw illegalArgument("%s cannot be null or empty", name);
        }
        return collection;
    }
    public static String ensureNotBlank(String string, String name) {
        if (string == null || string.trim().isEmpty()) {
            throw illegalArgument("%s cannot be null or blank", name);
        }
        return string;
    }
    public static void ensureTrue(boolean expression, String msg) {
        if (!expression) {
            throw illegalArgument(msg);
        }
    }
    public static int ensureGreaterThanZero(Integer i, String name) {
        if (i == null || i <= 0) {
            throw illegalArgument("%s must be greater than zero, but is: %s",
name, i);
        }
        return i;
    }
    public static double ensureBetween(Double d, double min, double max,
String name) {
        if (d == null || d < min || d > max) {
            throw illegalArgument("%s must be between %s and %s, but is: %s",
name, min, max, d);
        }
        return d;
    }
    public static int ensureBetween(Integer i, int min, int max, String name)
{
        if (i == null || i < min || i > max) {
            throw illegalArgument("%s must be between %s and %s, but is: %s",
name, min, max, i);
        }
        return i;
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\memory\ChatMemory.java

```
package dev.langchain4j.memory;
import dev.langchain4j.data.message.ChatMessage;
import java.util.List;
/**
 * Represents the memory (history) of a chat conversation.
 * Since language models do not keep the state of the conversation, it is
necessary to provide all previous messages
 * on every interaction with the language model.
 * {@link ChatMemory} helps with keeping track of the conversation and
ensuring that messages fit within language model's context window.
 */
public interface ChatMemory {
    /**
     * @return The ID of the {@link ChatMemory}.
     */
    Object id();
    /**
     * Adds a message to the chat memory.
     *
     * @param message The {@link ChatMessage} to add.
     */
    void add(ChatMessage message);
    /**
     * Retrieves messages from the chat memory.
     * Depending on the implementation, it may not return all previously
added messages,
     * but rather a subset, a summary, or a combination thereof.
     *
     * @return A list of {@link ChatMessage} objects that represent the
current state of the chat memory.
     */
    List<ChatMessage> messages();
    /**
     * Clears the chat memory.
     */
    void clear();
}
```

langchain4j-core\src\main\java\dev\langchain4j\MightChangeInTheFuture.java

```
package dev.langchain4j;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.*;
/**
 * Indicates that a class/constructor/method is experimental and might change
in the future.
 */
@Target({TYPE, CONSTRUCTOR, METHOD})
public @interface MightChangeInTheFuture {
    String value();
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\chat\ChatLanguageModel.java

```
package dev.langchain4j.model.chat;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.model.output.Response;
import java.util.List;
import static java.util.Arrays.asList;
/**
 * Represents a language model that has a chat interface.
 */
public interface ChatLanguageModel {
    /**
     * Generates a response from the model based on a message from a user.
     * This is a convenience method that receives the message from a user as
a String
     * and returns only the generated response.
     *
     * @param userMessage The message from the user.
     * @return The response generated by the model.
     */
    default String generate(String userMessage) {
        return generate(UserMessage.from(userMessage)).content().text();
    }
    /**
     * Generates a response from the model based on a sequence of messages.
     * Typically, the sequence contains messages in the following order:
     * System (optional) - User - AI - User - AI - User ...
     *
     * @param messages An array of messages.
     * @return The response generated by the model.
     */
    default Response<AiMessage> generate(ChatMessage... messages) {
        return generate(asList(messages));
    }
    /**
     * Generates a response from the model based on a sequence of messages.
     * Typically, the sequence contains messages in the following order:
     * System (optional) - User - AI - User - AI - User ...
     *
     * @param messages A list of messages.
     * @return The response generated by the model.
     */
    Response<AiMessage> generate(List<ChatMessage> messages);
    /**
     * Generates a response from the model based on a list of messages and a
list of tool specifications.
     * The response may either be a text message or a request to execute one
of the specified tools.
     * Typically, the list contains messages in the following order:
     * System (optional) - User - AI - User - AI - User ...
     *
     * @param messages           A list of messages.
     * @param toolSpecifications A list of tools that the model is allowed to
execute.
     *                           The model autonomously decides whether to
use any of these tools.
```

```
     * @return The response generated by the model.
     * {@link AiMessage} can contain either a textual response or a request
to execute one of the tools.
     */
    Response<AiMessage> generate(List<ChatMessage> messages,
List<ToolSpecification> toolSpecifications);
    /**
     * Generates a response from the model based on a list of messages and a
single tool specification.
     * The model is forced to execute the specified tool.
     * Typically, the list contains messages in the following order:
     * System (optional) - User - AI - User - AI - User ...
     *
     * @param messages          A list of messages.
     * @param toolSpecification The specification of a tool that must be
executed.
     *                          The model is forced to execute this tool.
     * @return The response generated by the model.
     * {@link AiMessage} contains a request to execute the specified tool.
     */
    Response<AiMessage> generate(List<ChatMessage> messages,
ToolSpecification toolSpecification);
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\chat\StreamingChatLanguageModel.java

```
package dev.langchain4j.model.chat;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import java.util.List;
import static java.util.Collections.singletonList;
/**
 * Represents a language model that has a chat interface and can stream a response one token at a time.
 */
public interface StreamingChatLanguageModel {
    /**
     * Generates a response from the model based on a message from a user.
     *
     * @param userMessage The message from the user.
     * @param handler     The handler for streaming the response.
     */
    default void generate(String userMessage, StreamingResponseHandler<AiMessage> handler) {
        generate(singletonList(UserMessage.from(userMessage)), handler);
    }
    /**
     * Generates a response from the model based on a sequence of messages.
     * Typically, the sequence contains messages in the following order:
     * System (optional) - User - AI - User - AI - User ...
     *
     * @param messages A list of messages.
     * @param handler  The handler for streaming the response.
     */
    void generate(List<ChatMessage> messages, StreamingResponseHandler<AiMessage> handler);
    /**
     * Generates a response from the model based on a list of messages and a list of tool specifications.
     * The response may either be a text message or a request to execute one of the specified tools.
     * Typically, the list contains messages in the following order:
     * System (optional) - User - AI - User - AI - User ...
     *
     * @param messages           A list of messages.
     * @param toolSpecifications A list of tools that the model is allowed to execute.
     *                           The model autonomously decides whether to use any of these tools.
     * @param handler            The handler for streaming the response.
     *                           {@link AiMessage} can contain either a textual response or a request to execute one of the tools.
     */
    void generate(List<ChatMessage> messages, List<ToolSpecification> toolSpecifications, StreamingResponseHandler<AiMessage> handler);
    void generate(List<ChatMessage> messages, ToolSpecification toolSpecification, StreamingResponseHandler<AiMessage> handler);
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\chat\TokenCountEstimator.java

```
package dev.langchain4j.model.chat;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.input.Prompt;
import java.util.List;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static java.util.Collections.singletonList;
/**
 * Represents an interface for estimating the count of tokens in various text types such as a text, message, prompt, text segment, etc.
 * This can be useful when it's necessary to know in advance the cost of processing a specified text by the LLM.
 */
public interface TokenCountEstimator {
    default int estimateTokenCount(String text) {
        return estimateTokenCount(userMessage(text));
    }
    default int estimateTokenCount(UserMessage userMessage) {
        return estimateTokenCount(singletonList(userMessage));
    }
    default int estimateTokenCount(Prompt prompt) {
        return estimateTokenCount(prompt.text());
    }
    default int estimateTokenCount(TextSegment textSegment) {
        return estimateTokenCount(textSegment.text());
    }
    int estimateTokenCount(List<ChatMessage> messages);
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\embedding\EmbeddingModel.java

```
package dev.langchain4j.model.embedding;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.output.Response;
import java.util.List;
import static java.util.Collections.singletonList;
/**
 * Represents a model that can convert a given text into an embedding (vector
representation of the text).
 */
public interface EmbeddingModel {
    default Response<Embedding> embed(String text) {
        return embed(TextSegment.from(text));
    }
    default Response<Embedding> embed(TextSegment textSegment) {
        Response<List<Embedding>> response =
embedAll(singletonList(textSegment));
        return Response.from(
                response.content().get(0),
                response.tokenUsage(),
                response.finishReason()
        );
    }
    Response<List<Embedding>> embedAll(List<TextSegment> textSegments);
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\embedding\TokenCountEstimator.java

```
package dev.langchain4j.model.embedding;
import dev.langchain4j.data.segment.TextSegment;
import java.util.List;
/**
 * Represents an interface for estimating the count of tokens in various texts, text segments, etc.
 * This can be useful when it's necessary to know in advance the cost of processing a specified text by the LLM.
 */
public interface TokenCountEstimator {
    int estimateTokenCount(String text);
    default int estimateTokenCount(TextSegment textSegment) {
        return estimateTokenCount(textSegment.text());
    }
    default int estimateTokenCount(List<TextSegment> textSegments) {
        int tokenCount = 0;
        for (TextSegment textSegment : textSegments) {
            tokenCount += estimateTokenCount(textSegment);
        }
        return tokenCount;
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\input\MustachePromptTemplateFactory.java

```
package dev.langchain4j.model.input;
import com.github.mustachejava.DefaultMustacheFactory;
import com.github.mustachejava.Mustache;
import com.github.mustachejava.MustacheFactory;
import dev.langchain4j.spi.prompt.PromptTemplateFactory;
import java.io.StringReader;
import java.io.StringWriter;
import java.util.Map;
class MustachePromptTemplateFactory implements PromptTemplateFactory {
    private static final MustacheFactory MUSTACHE_FACTORY = new
DefaultMustacheFactory();
    @Override
    public MustacheTemplate create(PromptTemplateFactory.Input input) {
        StringReader stringReader = new StringReader(input.getTemplate());
        return new MustacheTemplate(MUSTACHE_FACTORY.compile(stringReader,
input.getName()));
    }
    static class MustacheTemplate implements Template {
        private final Mustache mustache;
        MustacheTemplate(Mustache mustache) {
            this.mustache = mustache;
        }
        public String render(Map<String, Object> vars) {
            StringWriter writer = new StringWriter();
            mustache.execute(writer, vars);
            return writer.toString();
        }
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\input\Prompt.java

```
package dev.langchain4j.model.input;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.SystemMessage;
import dev.langchain4j.data.message.UserMessage;
import java.util.Objects;
import static dev.langchain4j.data.message.AiMessage.aiMessage;
import static dev.langchain4j.data.message.SystemMessage.systemMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.internal.Utils.quoted;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
/**
 * Represents a prompt (an input text sent to the LLM).
 * A prompt usually contains instructions, contextual information, end-user
input, etc.
 * A Prompt is typically created by applying one or multiple values to a
PromptTemplate.
 */
public class Prompt {
    private final String text;
    public Prompt(String text) {
        this.text = ensureNotBlank(text, "text");
    }
    public String text() {
        return text;
    }
    public SystemMessage toSystemMessage() {
        return systemMessage(text);
    }
    public UserMessage toUserMessage() {
        return userMessage(text);
    }
    public AiMessage toAiMessage() {
        return aiMessage(text);
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        Prompt that = (Prompt) o;
        return Objects.equals(this.text, that.text);
    }
    @Override
    public int hashCode() {
        return Objects.hash(text);
    }
    @Override
    public String toString() {
        return "Prompt {" +
                " text = " + quoted(text) +
                " }";
    }
    public static Prompt from(String text) {
        return new Prompt(text);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\input\PromptTemplate.java

```
package dev.langchain4j.model.input;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
import static java.util.Collections.singletonMap;
import dev.langchain4j.spi.ServiceHelper;
import dev.langchain4j.spi.prompt.PromptTemplateFactory;
import java.time.Clock;
import java.time.LocalDate;
import java.time.LocalDateTime;
import java.time.LocalTime;
import java.util.HashMap;
import java.util.Map;
/**
 * Represents a template of a prompt that can be reused multiple times.
 * A template typically contains one or more variables (placeholders) defined as {{variable_name}} that are
 * replaced with actual values to produce a Prompt.
 * Special variables {{current_date}}, {{current_time}}, and {{current_date_time}} are automatically
 * filled with LocalDate.now(), LocalTime.now(), and LocalDateTime.now() respectively.
 * This class uses the Mustache templating engine under the hood, so all Mustache syntax and features are supported.
 */
public class PromptTemplate {
    private static final PromptTemplateFactory FACTORY = factory();
    private static PromptTemplateFactory factory() {
        for (PromptTemplateFactory factory : ServiceHelper.loadFactories(PromptTemplateFactory.class)) {
            return factory;
        }
        // fallback to the default
        return new MustachePromptTemplateFactory();
    }
    private final PromptTemplateFactory.Template template;
    private final Clock clock;
    public PromptTemplate(String template) {
        this(template, Clock.systemDefaultZone());
    }
    PromptTemplate(String template, Clock clock) {
        this.template = FACTORY.create(new PromptTemplateFactory.Input() {
            @Override
            public String getTemplate() {
                return template;
            }
            @Override
            public String getName() {
                return "template";
            }
        });
        this.clock = ensureNotNull(clock, "clock");
    }
    /**
     * Applies a value to a template containing a single variable. The single variable should have the name {{it}}.
     *
     * @param value The value that will be injected in place of the {{it}} placeholder in the template.
```

```
     * @return A Prompt object where the {{it}} placeholder in the template
has been replaced by the provided value.
     */
    public Prompt apply(Object value) {
        return apply(singletonMap("it", value));
    }
    /**
     * Applies multiple values to a template containing multiple variables.
     *
     * @param variables A map of variable names to values that will be
injected in place of the corresponding placeholders in the template.
     * @return A Prompt object where the placeholders in the template have
been replaced by the provided values.
     */
    public Prompt apply(Map<String, Object> variables) {
        return
Prompt.from(template.render(injectDateTimeVariables(variables)));
    }
    private Map<String, Object> injectDateTimeVariables(Map<String, Object>
variables) {
        Map<String, Object> variablesCopy = new HashMap<>(variables);
        variablesCopy.put("current_date", LocalDate.now(clock));
        variablesCopy.put("current_time", LocalTime.now(clock));
        variablesCopy.put("current_date_time", LocalDateTime.now(clock));
        return variablesCopy;
    }
    public static PromptTemplate from(String template) {
        return new PromptTemplate(template);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\input\structured\DefaultStructuredPromptFactory.java

```
package dev.langchain4j.model.input.structured;
import com.google.gson.Gson;
import com.google.gson.GsonBuilder;
import com.google.gson.ToNumberPolicy;
import com.google.gson.reflect.TypeToken;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.input.PromptTemplate;
import dev.langchain4j.spi.prompt.structured.StructuredPromptFactory;
import java.util.Map;
public class DefaultStructuredPromptFactory implements
StructuredPromptFactory {
    private static final Gson GSON = new GsonBuilder().setObjectToNumberStrate
gy(ToNumberPolicy.LONG_OR_DOUBLE).create();
    public Prompt toPrompt(Object structuredPrompt) {
        validate(structuredPrompt);
        StructuredPrompt annotation =
structuredPrompt.getClass().getAnnotation(StructuredPrompt.class);
        String promptTemplateString = String.join(annotation.delimiter(),
annotation.value());
        PromptTemplate promptTemplate =
PromptTemplate.from(promptTemplateString);
        Map<String, Object> variables = extractVariables(structuredPrompt);
        return promptTemplate.apply(variables);
    }
    private void validate(Object structuredPrompt) {
        if (structuredPrompt == null) {
            throw new IllegalArgumentException("Structured prompt cannot be
null");
        }
        String structuredPromptClassName =
structuredPrompt.getClass().getName();
        StructuredPrompt structuredPromptAnnotation =
structuredPrompt.getClass().getAnnotation(StructuredPrompt.class);
        if (structuredPromptAnnotation == null) {
            throw new IllegalArgumentException(
                    String.format(
                            "%s should be annotated with @StructuredPrompt to
be used as a structured prompt",
                            structuredPromptClassName
                    )
            );
        }
    }
    private static Map<String, Object> extractVariables(Object
structuredPrompt) {
        String json = GSON.toJson(structuredPrompt);
        TypeToken<Map<String, Object>> mapType = new TypeToken<Map<String,
Object>>() {};
        return GSON.fromJson(json, mapType);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\input\structured\StructuredPrompt.java

```
package dev.langchain4j.model.input.structured;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.TYPE;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
@Target(TYPE)
@Retention(RUNTIME)
public @interface StructuredPrompt {
    /**
     * Prompt template can be defined in one line or multiple lines.
     * If the template is defined in multiple lines, the lines will be joined with a delimiter defined below.
     */
    String[] value();
    String delimiter() default "\n";
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\input\structured\StructuredPromptProcessor.java

```
package dev.langchain4j.model.input.structured;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.spi.ServiceHelper;
import dev.langchain4j.spi.prompt.structured.StructuredPromptFactory;
public class StructuredPromptProcessor {
    private static final StructuredPromptFactory FACTORY = factory();
    private static StructuredPromptFactory factory() {
        for (StructuredPromptFactory factory :
ServiceHelper.loadFactories(StructuredPromptFactory.class)) {
            return factory;
        }
        // fallback to the default
        return new DefaultStructuredPromptFactory();
    }
    public static Prompt toPrompt(Object structuredPrompt) {
        return FACTORY.toPrompt(structuredPrompt);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\language\LanguageModel.java

```
package dev.langchain4j.model.language;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.output.Response;
/**
 * Represents a language model that has a simple text interface (as opposed to a chat interface).
 * It is recommended to use the {@link dev.langchain4j.model.chat.ChatLanguageModel} instead,
 * as it offers more features.
 */
public interface LanguageModel {
    Response<String> generate(String prompt);
    default Response<String> generate(Prompt prompt) {
        return generate(prompt.text());
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\language\StreamingLanguageModel.java

```
package dev.langchain4j.model.language;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.input.Prompt;
/**
 * Represents a language model that has a simple text interface (as opposed
to a chat interface)
 * and can stream a response one token at a time.
 * It is recommended to use the {@link
dev.langchain4j.model.chat.StreamingChatLanguageModel} instead,
 * as it offers more features.
 */
public interface StreamingLanguageModel {
    void generate(String prompt, StreamingResponseHandler<String> handler);
    default void generate(Prompt prompt, StreamingResponseHandler<String>
handler) {
        generate(prompt.text(), handler);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\language\TokenCountEstimator.java

```
package dev.langchain4j.model.language;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.input.Prompt;
/**
 * Represents an interface for estimating the count of tokens in various text types such as a text, prompt, text segment, etc.
 * This can be useful when it's necessary to know in advance the cost of processing a specified text by the LLM.
 */
public interface TokenCountEstimator {
    int estimateTokenCount(String text);
    default int estimateTokenCount(Prompt prompt) {
        return estimateTokenCount(prompt.text());
    }
    default int estimateTokenCount(TextSegment textSegment) {
        return estimateTokenCount(textSegment.text());
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\moderation\Moderation.java

```
package dev.langchain4j.model.moderation;
import java.util.Objects;
import static dev.langchain4j.internal.Utils.quoted;
public class Moderation {
    private final boolean flagged;
    private final String flaggedText;
    public Moderation() {
        this.flagged = false;
        this.flaggedText = null;
    }
    public Moderation(String flaggedText) {
        this.flagged = true;
        this.flaggedText = flaggedText;
    }
    public boolean flagged() {
        return flagged;
    }
    public String flaggedText() {
        return flaggedText;
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        Moderation that = (Moderation) o;
        return this.flagged == that.flagged
                && Objects.equals(this.flaggedText, that.flaggedText);
    }
    @Override
    public int hashCode() {
        return Objects.hash(flagged, flaggedText);
    }
    @Override
    public String toString() {
        return "Moderation {" +
                " flagged = " + flagged +
                ", flaggedText = " + quoted(flaggedText) +
                " }";
    }
    public static Moderation flagged(String flaggedText) {
        return new Moderation(flaggedText);
    }
    public static Moderation notFlagged() {
        return new Moderation();
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\moderation\ModerationModel.java

```
package dev.langchain4j.model.moderation;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.output.Response;
import java.util.List;
public interface ModerationModel {
    Response<Moderation> moderate(String text);
    Response<Moderation> moderate(Prompt prompt);
    Response<Moderation> moderate(ChatMessage message);
    Response<Moderation> moderate(List<ChatMessage> messages);
    Response<Moderation> moderate(TextSegment textSegment);
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\output\FinishReason.java

```
package dev.langchain4j.model.output;
public enum FinishReason {
    STOP,
    LENGTH,
    TOOL_EXECUTION,
    CONTENT_FILTER
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\output\OutputParser.java

```
package dev.langchain4j.model.output;
public interface OutputParser<T> {
    T parse(String text);
    String formatInstructions();
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\output\Response.java

```
package dev.langchain4j.model.output;
import java.util.Objects;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * Represents the response from various types of models, including language,
chat, embedding, and moderation models.
 * This class encapsulates the generated content, token usage statistics, and
finish reason.
 *
 * @param <T> The type of content generated by the model.
 */
public class Response<T> {
    private final T content;
    private final TokenUsage tokenUsage;
    private final FinishReason finishReason;
    public Response(T content) {
        this(content, null, null);
    }
    public Response(T content, TokenUsage tokenUsage, FinishReason
finishReason) {
        this.content = ensureNotNull(content, "content");
        this.tokenUsage = tokenUsage;
        this.finishReason = finishReason;
    }
    public T content() {
        return content;
    }
    public TokenUsage tokenUsage() {
        return tokenUsage;
    }
    public FinishReason finishReason() {
        return finishReason;
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        Response<?> that = (Response<?>) o;
        return Objects.equals(this.content, that.content)
                && Objects.equals(this.tokenUsage, that.tokenUsage)
                && Objects.equals(this.finishReason, that.finishReason);
    }
    @Override
    public int hashCode() {
        return Objects.hash(content, tokenUsage, finishReason);
    }
    @Override
    public String toString() {
        return "Response {" +
                " content = " + content +
                ", tokenUsage = " + tokenUsage +
                ", finishReason = " + finishReason +
                " }";
    }
    public static <T> Response<T> from(T content) {
        return new Response<>(content);
    }
    public static <T> Response<T> from(T content, TokenUsage tokenUsage) {
```

```
        return new Response<>(content, tokenUsage, null);
    }
    public static <T> Response<T> from(T content, TokenUsage tokenUsage,
FinishReason finishReason) {
        return new Response<>(content, tokenUsage, finishReason);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\output\structured\Description.java

```
package dev.langchain4j.model.output.structured;
import java.lang.annotation.Retention;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.FIELD;
import static java.lang.annotation.RetentionPolicy.RUNTIME;
@Target(FIELD)
@Retention(RUNTIME)
public @interface Description {
    /**
     * The description can be defined in one line or multiple lines.
     * If the description is defined in multiple lines, the lines will be
joined with a space (" ") automatically.
     */
    String[] value();
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\output\TokenUsage.java

```
package dev.langchain4j.model.output;
import java.util.Objects;
import static dev.langchain4j.internal.Utils.getOrDefault;
public class TokenUsage {
    private final Integer inputTokenCount;
    private final Integer outputTokenCount;
    private final Integer totalTokenCount;
    public TokenUsage() {
        this(null);
    }
    public TokenUsage(Integer inputTokenCount) {
        this(inputTokenCount, null);
    }
    public TokenUsage(Integer inputTokenCount, Integer outputTokenCount) {
        this(inputTokenCount, outputTokenCount, sum(inputTokenCount,
outputTokenCount));
    }
    public TokenUsage(Integer inputTokenCount, Integer outputTokenCount,
Integer totalTokenCount) {
        this.inputTokenCount = inputTokenCount;
        this.outputTokenCount = outputTokenCount;
        this.totalTokenCount = totalTokenCount;
    }
    public Integer inputTokenCount() {
        return inputTokenCount;
    }
    public Integer outputTokenCount() {
        return outputTokenCount;
    }
    public Integer totalTokenCount() {
        return totalTokenCount;
    }
    public TokenUsage add(TokenUsage that) {
        return new TokenUsage(
                sum(this.inputTokenCount, that.inputTokenCount),
                sum(this.outputTokenCount, that.outputTokenCount),
                sum(this.totalTokenCount, that.totalTokenCount)
        );
    }
    private static Integer sum(Integer first, Integer second) {
        if (first == null && second == null) {
            return null;
        }
        return getOrDefault(first, 0) + getOrDefault(second, 0);
    }
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        TokenUsage that = (TokenUsage) o;
        return Objects.equals(this.inputTokenCount, that.inputTokenCount)
                && Objects.equals(this.outputTokenCount,
that.outputTokenCount)
                && Objects.equals(this.totalTokenCount, that.totalTokenCount);
    }
    @Override
    public int hashCode() {
        return Objects.hash(inputTokenCount, outputTokenCount,
```

```
totalTokenCount);
    }
    @Override
    public String toString() {
        return "TokenUsage {" +
                " inputTokenCount = " + inputTokenCount +
                ", outputTokenCount = " + outputTokenCount +
                ", totalTokenCount = " + totalTokenCount +
                " }";
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\StreamingResponseHandler.java

```
package dev.langchain4j.model;
import dev.langchain4j.model.output.Response;
public interface StreamingResponseHandler<T> {
    /**
     * Invoked each time the language model generates a new token in a textual response.
     * If the model executes a tool instead, this method will not be invoked; {@link #onComplete} will be invoked instead.
     *
     * @param token The newly generated token, which is a part of the complete response.
     */
    void onNext(String token);
    /**
     * Invoked when the language model has finished streaming a response.
     * If the model executes a tool, it is accessible via {@link dev.langchain4j.data.message.AiMessage#toolExecutionRequest()}.
     *
     * @param response The complete response generated by the language model.
     *                 For textual responses, it contains all tokens from {@link #onNext} concatenated.
     */
    default void onComplete(Response<T> response) {
    }
    /**
     * This method is invoked when an error occurs during streaming.
     *
     * @param error The error that occurred
     */
    void onError(Throwable error);
}
```

langchain4j-core\src\main\java\dev\langchain4j\model\Tokenizer.java

```
package dev.langchain4j.model;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.ChatMessage;
import java.util.ArrayList;
import java.util.List;
import static
dev.langchain4j.agent.tool.ToolSpecifications.toolSpecificationsFrom;
import static java.util.Collections.singletonList;
public interface Tokenizer {
    int estimateTokenCountInText(String text);
    int estimateTokenCountInMessage(ChatMessage message);
    int estimateTokenCountInMessages(Iterable<ChatMessage> messages);
    default int estimateTokenCountInTools(Object objectWithTools) {
        return estimateTokenCountInTools(singletonList(objectWithTools));
    }
    default int estimateTokenCountInTools(Iterable<Object> objectsWithTools) {
        List<ToolSpecification> toolSpecifications = new ArrayList<>();
        objectsWithTools.forEach(objectWithTools ->

toolSpecifications.addAll(toolSpecificationsFrom(objectWithTools)));
        return estimateTokenCountInToolSpecifications(toolSpecifications);
    }
    default int estimateTokenCountInToolSpecification(ToolSpecification
toolSpecification) {
        return
estimateTokenCountInToolSpecifications(singletonList(toolSpecification));
    }
    int estimateTokenCountInToolSpecifications(Iterable<ToolSpecification>
toolSpecifications);
}
```

langchain4j-core\src\main\java\dev\langchain4j\retriever\Retriever.java

```
package dev.langchain4j.retriever;
import java.util.List;
public interface Retriever<T> {
    List<T> findRelevant(String text);
}
```

langchain4j-core\src\main\java\dev\langchain4j\spi\prompt\PromptTemplateFactory.java

```
package dev.langchain4j.spi.prompt;
import java.util.Map;
public interface PromptTemplateFactory {
    Template create(Input input);
    interface Input {
        String getTemplate();
        String getName();
    }
    interface Template {
        String render(Map<String, Object> vars);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\spi\prompt\structured\StructuredPromptFactory.java

```
package dev.langchain4j.spi.prompt.structured;
import dev.langchain4j.model.input.Prompt;
public interface StructuredPromptFactory {
    Prompt toPrompt(Object structuredPrompt);
}
```

langchain4j-core\src\main\java\dev\langchain4j\spi\ServiceHelper.java

```
package dev.langchain4j.spi;
import java.util.ArrayList;
import java.util.Collection;
import java.util.Collections;
import java.util.List;
import java.util.ServiceLoader;
public class ServiceHelper {
  public static <T> Collection<T> loadFactories(Class<T> clazz) {
    return loadFactories(clazz, null);
  }
  public static <T> Collection<T> loadFactories(Class<T> clazz, ClassLoader
classLoader) {
    List<T> list = new ArrayList<>();
    ServiceLoader<T> factories;
    if (classLoader != null) {
      factories = ServiceLoader.load(clazz, classLoader);
    } else {
      // this is equivalent to:
      // ServiceLoader.load(clazz, TCCL);
      factories = ServiceLoader.load(clazz);
    }
    if (factories.iterator().hasNext()) {
      factories.iterator().forEachRemaining(list::add);
      return list;
    } else {
      // By default ServiceLoader.load uses the TCCL, this may not be enough
in environment dealing with
      // classloaders differently such as OSGi. So we should try to use the
classloader having loaded this
      // class. In OSGi it would be the bundle exposing vert.x and so have
access to all its classes.
      factories = ServiceLoader.load(clazz,
ServiceHelper.class.getClassLoader());
      if (factories.iterator().hasNext()) {
        factories.iterator().forEachRemaining(list::add);
        return list;
      } else {
        return Collections.emptyList();
      }
    }
  }
}
```

langchain4j-core\src\main\java\dev\langchain4j\store\embedding\CosineSimilarity.java

```
package dev.langchain4j.store.embedding;
import dev.langchain4j.data.embedding.Embedding;
import static dev.langchain4j.internal.Exceptions.illegalArgument;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
public class CosineSimilarity {
    /**
     * Calculates cosine similarity between two vectors.
     * <p>
     * Cosine similarity measures the cosine of the angle between two
vectors, indicating their directional similarity.
     * It produces a value in the range:
     * <p>
     * -1 indicates vectors are diametrically opposed (opposite directions).
     * <p>
     * 0 indicates vectors are orthogonal (no directional similarity).
     * <p>
     * 1 indicates vectors are pointing in the same direction (but not
necessarily of the same magnitude).
     * <p>
     * Not to be confused with cosine distance ([0..2]), which quantifies how
different two vectors are.
     *
     * @param embeddingA first embedding vector
     * @param embeddingB second embedding vector
     * @return cosine similarity in the range [-1..1]
     */
    public static double between(Embedding embeddingA, Embedding embeddingB) {
        ensureNotNull(embeddingA, "embeddingA");
        ensureNotNull(embeddingB, "embeddingB");
        float[] vectorA = embeddingA.vector();
        float[] vectorB = embeddingB.vector();
        if (vectorA.length != vectorB.length) {
            throw illegalArgument("Length of vector a (%s) must be equal to
the length of vector b (%s)",
                    vectorA.length, vectorB.length);
        }
        double dotProduct = 0.0;
        double normA = 0.0;
        double normB = 0.0;
        for (int i = 0; i < vectorA.length; i++) {
            dotProduct += vectorA[i] * vectorB[i];
            normA += vectorA[i] * vectorA[i];
            normB += vectorB[i] * vectorB[i];
        }
        return dotProduct / (Math.sqrt(normA) * Math.sqrt(normB));
    }
    /**
     * Converts relevance score into cosine similarity.
     *
     * @param relevanceScore Relevance score in the range [0..1] where 0 is
not relevant and 1 is relevant.
     * @return Cosine similarity in the range [-1..1] where -1 is not
relevant and 1 is relevant.
     */
    public static double fromRelevanceScore(double relevanceScore) {
        return relevanceScore * 2 - 1;
    }
```

```
}
```

langchain4j-core\src\main\java\dev\langchain4j\store\embedding\EmbeddingMatch.java

```
package dev.langchain4j.store.embedding;
import dev.langchain4j.data.embedding.Embedding;
import java.util.Objects;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
/**
 * Represents a matched embedding along with its relevance score (derivative
of cosine distance), ID, and original embedded content.
 *
 * @param <Embedded> The class of the object that has been embedded.
Typically, it is {@link dev.langchain4j.data.segment.TextSegment}.
 */
public class EmbeddingMatch<Embedded> {
    private final Double score;
    private final String embeddingId;
    private final Embedding embedding;
    private final Embedded embedded;
    public EmbeddingMatch(Double score, String embeddingId, Embedding
embedding, Embedded embedded) {
        this.score = ensureNotNull(score, "score");
        this.embeddingId = ensureNotBlank(embeddingId, "embeddingId");
        this.embedding = embedding;
        this.embedded = embedded;
    }
    /**
     * Returns the relevance score (derivative of cosine distance) of this
embedding compared to
     * a reference embedding during a search.
     * The current implementation assumes that the embedding store uses
cosine distance when comparing embeddings.
     *
     * @return Relevance score, ranging from 0 (not relevant) to 1 (highly
relevant).
     */
    public Double score() {
        return score;
    }
    /**
     * @return The ID of the embedding assigned when adding this embedding to
the store.
     */
    public String embeddingId() {
        return embeddingId;
    }
    /**
     * @return The embedding that has been matched.
     */
    public Embedding embedding() {
        return embedding;
    }
    /**
     * @return The original content that was embedded. Typically, this is a
{@link dev.langchain4j.data.segment.TextSegment}.
     */
    public Embedded embedded() {
        return embedded;
    }
```

```
    @Override
    public boolean equals(Object o) {
        if (this == o) return true;
        if (o == null || getClass() != o.getClass()) return false;
        EmbeddingMatch<?> that = (EmbeddingMatch<?>) o;
        return Objects.equals(this.score, that.score)
                && Objects.equals(this.embeddingId, that.embeddingId)
                && Objects.equals(this.embedding, that.embedding)
                && Objects.equals(this.embedded, that.embedded);
    }
    @Override
    public int hashCode() {
        return Objects.hash(score, embeddingId, embedding, embedded);
    }
    @Override
    public String toString() {
        return "EmbeddingMatch {" +
                " score = " + score +
                ", embedded = " + embedded +
                ", embeddingId = " + embeddingId +
                ", embedding = " + embedding +
                " }";
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\store\embedding\EmbeddingStore.java

```
package dev.langchain4j.store.embedding;
import dev.langchain4j.data.embedding.Embedding;
import java.util.List;
/**
 * Represents a store for embeddings, also known as a vector database.
 *
 * @param <Embedded> The class of the object that has been embedded.
Typically, this is {@link dev.langchain4j.data.segment.TextSegment}.
 */
public interface EmbeddingStore<Embedded> {
    /**
     * Adds a given embedding to the store.
     *
     * @param embedding The embedding to be added to the store.
     * @return The auto-generated ID associated with the added embedding.
     */
    String add(Embedding embedding);
    /**
     * Adds a given embedding to the store.
     *
     * @param id        The unique identifier for the embedding to be added.
     * @param embedding The embedding to be added to the store.
     */
    void add(String id, Embedding embedding);
    /**
     * Adds a given embedding and the corresponding content that has been
embedded to the store.
     *
     * @param embedding The embedding to be added to the store.
     * @param embedded  Original content that was embedded.
     * @return The auto-generated ID associated with the added embedding.
     */
    String add(Embedding embedding, Embedded embedded);
    /**
     * Adds multiple embeddings to the store.
     *
     * @param embeddings A list of embeddings to be added to the store.
     * @return A list of auto-generated IDs associated with the added
embeddings.
     */
    List<String> addAll(List<Embedding> embeddings);
    /**
     * Adds multiple embeddings and their corresponding contents that have
been embedded to the store.
     *
     * @param embeddings A list of embeddings to be added to the store.
     * @param embedded   A list of original contents that were embedded.
     * @return A list of auto-generated IDs associated with the added
embeddings.
     */
    List<String> addAll(List<Embedding> embeddings, List<Embedded> embedded);
    /**
     * Finds the most relevant (closest in space) embeddings to the provided
reference embedding.
     * By default, minScore is set to 0, which means that the results may
include embeddings with low relevance.
     *
```

```
     * @param referenceEmbedding The embedding used as a reference. Returned
embeddings should be relevant (closest) to this one.
     * @param maxResults         The maximum number of embeddings to be
returned.
     * @return A list of embedding matches.
     * Each embedding match includes a relevance score (derivative of cosine
distance),
     * ranging from 0 (not relevant) to 1 (highly relevant).
     */
    default List<EmbeddingMatch<Embedded>> findRelevant(Embedding
referenceEmbedding, int maxResults) {
        return findRelevant(referenceEmbedding, maxResults, 0);
    }
    /**
     * Finds the most relevant (closest in space) embeddings to the provided
reference embedding.
     *
     * @param referenceEmbedding The embedding used as a reference. Returned
embeddings should be relevant (closest) to this one.
     * @param maxResults         The maximum number of embeddings to be
returned.
     * @param minScore           The minimum relevance score, ranging from 0
to 1 (inclusive).
     *                           Only embeddings with a score of this value
or higher will be returned.
     * @return A list of embedding matches.
     * Each embedding match includes a relevance score (derivative of cosine
distance),
     * ranging from 0 (not relevant) to 1 (highly relevant).
     */
    List<EmbeddingMatch<Embedded>> findRelevant(Embedding referenceEmbedding,
int maxResults, double minScore);
}
```

langchain4j-core\src\main\java\dev\langchain4j\store\embedding\RelevanceScore.java

```
package dev.langchain4j.store.embedding;
public class RelevanceScore {
    /**
     * Converts cosine similarity into relevance score.
     *
     * @param cosineSimilarity Cosine similarity in the range [-1..1] where
-1 is not relevant and 1 is relevant.
     * @return Relevance score in the range [0..1] where 0 is not relevant
and 1 is relevant.
     */
    public static double fromCosineSimilarity(double cosineSimilarity) {
        return (cosineSimilarity + 1) / 2;
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\store\memory\chat\ChatMemoryStore.java

```
package dev.langchain4j.store.memory.chat;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.ChatMessageDeserializer;
import dev.langchain4j.data.message.ChatMessageSerializer;
import dev.langchain4j.memory.ChatMemory;
import java.util.List;
/**
 * Represents a store for the {@link ChatMemory} state.
 * Allows for flexibility in terms of where and how chat memory is stored.
 * Currently, the only implementation available is {@link
InMemoryChatMemoryStore}. We are in the process of adding
 * ready implementations for popular stores like SQL DBs, document stores,
etc.
 * In the meantime, you can implement this interface to connect to any
storage of your choice.
 */
public interface ChatMemoryStore {
    /**
     * Retrieves messages for a specified chat memory.
     *
     * @param memoryId The ID of the chat memory.
     * @return List of messages for the specified chat memory. Must not be
null. Can be deserialized from JSON using {@link ChatMessageDeserializer}.
     */
    List<ChatMessage> getMessages(Object memoryId);
    /**
     * Updates messages for a specified chat memory.
     *
     * @param memoryId The ID of the chat memory.
     * @param messages List of messages for the specified chat memory, that
represent the current state of the {@link ChatMemory}.
     *                 Can be serialized to JSON using {@link
ChatMessageSerializer}.
     */
    void updateMessages(Object memoryId, List<ChatMessage> messages);
    /**
     * Deletes all messages for a specified chat memory.
     *
     * @param memoryId The ID of the chat memory.
     */
    void deleteMessages(Object memoryId);
}
```

langchain4j-core\src\main\java\dev\langchain4j\store\memory\chat\InMemoryChatMemoryStore.java

```
package dev.langchain4j.store.memory.chat;
import dev.langchain4j.data.message.ChatMessage;
import java.util.ArrayList;
import java.util.List;
import java.util.Map;
import java.util.concurrent.ConcurrentHashMap;
/**
 * Implementation of {@link ChatMemoryStore} that stores state of {@link dev.langchain4j.memory.ChatMemory} (chat messages) in-memory.
 * <p>
 * This storage mechanism is transient and does not persist data across application restarts.
 */
public class InMemoryChatMemoryStore implements ChatMemoryStore {
    private final Map<Object, List<ChatMessage>> messagesByMemoryId = new ConcurrentHashMap<>();
    @Override
    public List<ChatMessage> getMessages(Object memoryId) {
        return messagesByMemoryId.computeIfAbsent(memoryId, ignored -> new ArrayList<>());
    }
    @Override
    public void updateMessages(Object memoryId, List<ChatMessage> messages) {
        messagesByMemoryId.put(memoryId, messages);
    }
    @Override
    public void deleteMessages(Object memoryId) {
        messagesByMemoryId.remove(memoryId);
    }
}
```

langchain4j-core\src\main\java\dev\langchain4j\WillChangeSoon.java

```
package dev.langchain4j;
import java.lang.annotation.Target;
import static java.lang.annotation.ElementType.*;
/**
 * Indicates that a class/constructor/method is planned to change soon.
 */
@Target({TYPE, CONSTRUCTOR, METHOD})
public @interface WillChangeSoon {
    String value();
}
```

langchain4j-core\src\test\java\dev\langchain4j\data\message\ChatMessageSerializerTest.java

```
package dev.langchain4j.data.message;
import dev.langchain4j.agent.tool.ToolExecutionRequest;
import org.junit.jupiter.api.Test;
import java.util.List;
import static dev.langchain4j.data.message.AiMessage.aiMessage;
import static
dev.langchain4j.data.message.ChatMessageDeserializer.messageFromJson;
import static
dev.langchain4j.data.message.ChatMessageDeserializer.messagesFromJson;
import static dev.langchain4j.data.message.SystemMessage.systemMessage;
import static dev.langchain4j.data.message.ToolExecutionResultMessage.toolExec
utionResultMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static java.util.Arrays.asList;
import static java.util.Collections.emptyList;
import static java.util.Collections.singletonList;
import static org.assertj.core.api.Assertions.assertThat;
class ChatMessageSerializerTest {
    @Test
    void should_serialize_and_deserialize_chat_message() {
        UserMessage message = userMessage("hello");
        String json = ChatMessageSerializer.messageToJson(message);
        ChatMessage deserializedMessage = messageFromJson(json);
        assertThat(deserializedMessage).isEqualTo(message);
    }
    @Test
    void should_serialize_and_deserialize_empty_list() {
        List<ChatMessage> messages = emptyList();
        String json = ChatMessageSerializer.messagesToJson(messages);
        List<ChatMessage> deserializedMessages = messagesFromJson(json);
        assertThat(deserializedMessages).isEmpty();
    }
    @Test
    void should_deserialize_null_as_empty_list() {
        assertThat(messagesFromJson(null)).isEmpty();
    }
    @Test
    void should_serialize_and_deserialize_list_with_one_message() {
        List<ChatMessage> messages = singletonList(userMessage("hello"));
        String json = ChatMessageSerializer.messagesToJson(messages);
        assertThat(json).isEqualTo("[{\"text\":\"hello\",\"type\":
\"USER\"}]");
        List<ChatMessage> deserializedMessages = messagesFromJson(json);
        assertThat(deserializedMessages).isEqualTo(messages);
    }
    @Test
    void should_serialize_and_deserialize_list_with_all_types_of_messages() {
        List<ChatMessage> messages = asList(
                systemMessage("Hello from system"),
                userMessage("Hello from user"),
                userMessage("Klaus", "Hello from Klaus"),
                aiMessage("Hello from AI"),
                aiMessage(ToolExecutionRequest.builder()
                        .name("calculator")
                        .arguments("{}")
                        .build()),
                toolExecutionResultMessage("calculator", "4")
```

```
        );
        String json = ChatMessageSerializer.messagesToJson(messages);
        assertThat(json).isEqualTo("[" +
                "{\"text\":\"Hello from system\",\"type\":\"SYSTEM\"}," +
                "{\"text\":\"Hello from user\",\"type\":\"USER\"}," +
                "{\"name\":\"Klaus\",\"text\":\"Hello from Klaus\",\"type\":
\"USER\"}," +
                "{\"text\":\"Hello from AI\",\"type\":\"AI\"}," +
                "{\"toolExecutionRequest\":{\"name\":\"calculator\",
\"arguments\":\"{}\"},\"type\":\"AI\"}," +
                "{\"toolName\":\"calculator\",\"text\":\"4\",\"type\":
\"TOOL_EXECUTION_RESULT\"}" +
                "]");
        List<ChatMessage> deserializedMessages = messagesFromJson(json);
        assertThat(deserializedMessages).isEqualTo(messages);
    }
}
```

langchain4j-core\src\test\java\dev\langchain4j\internal\JsonTest.java

```
package dev.langchain4j.internal;
import static org.assertj.core.api.Assertions.assertThat;
import java.io.BufferedReader;
import java.io.IOException;
import java.io.InputStream;
import java.io.InputStreamReader;
import java.time.LocalDate;
import java.time.LocalDateTime;
import java.util.Arrays;
import java.util.List;
import java.util.stream.Collectors;
import com.google.gson.annotations.SerializedName;
import org.junit.jupiter.api.Test;
class JsonTest {
  @Test
  void conversionToJsonAndFromJsonWorks() {
    TestData testData = new TestData();
    testData.setSampleDate(LocalDate.of(2023, 1, 15));
    testData.setSampleDateTime(LocalDateTime.of(2023, 1, 15, 10, 20));
    testData.setSomeValue("value");
    String json = Json.toJson(testData);
    assertThat(json)
      .isEqualTo(
        "{\n" +
        "  \"sampleDate\": \"2023-01-15\",\n" +
        "  \"sampleDateTime\": \"2023-01-15T10:20:00\",\n" +
        "  \"some_value\": \"value\"\n" +
        "}"
      );
    TestData deserializedData = Json.fromJson(json, TestData.class);
    assertThat(deserializedData.getSampleDate()).isEqualTo(testData.getSampleD
ate());
    assertThat(deserializedData.getSampleDateTime()).isEqualTo(testData.getSam
pleDateTime());
    assertThat(deserializedData.getSomeValue()).isEqualTo(testData.getSomeValu
e());
  }
  @Test
  void toInputStreamWorksForList() throws IOException {
    List<TestObject> testObjects = Arrays.asList(
            new TestObject("John", LocalDate.of(2021, 8, 17),
LocalDateTime.of(2021, 8, 17, 14, 20)),
            new TestObject("Jane", LocalDate.of(2021, 8, 16),
LocalDateTime.of(2021, 8, 16, 13, 19))
    );
    String expectedJson = "[{" +
            "\"name\":\"John\"," +
            "\"date\":\"2021-08-17\"," +
            "\"dateTime\":\"2021-08-17T14:20:00\"" +
            "},{" +
            "\"name\":\"Jane\"," +
            "\"date\":\"2021-08-16\"," +
            "\"dateTime\":\"2021-08-16T13:19:00\"" +
            "}]";
    InputStream inputStream = Json.toInputStream(testObjects, List.class);
    try (BufferedReader bufferedReader = new BufferedReader(new
InputStreamReader(inputStream))) {
      String resultJson =
```

```
bufferedReader.lines().collect(Collectors.joining());
      assertThat(resultJson).isEqualTo(expectedJson);
    }
  }
  private static class TestObject {
    private final String name;
    private final LocalDate date;
    private final LocalDateTime dateTime;
    public TestObject(String name, LocalDate date, LocalDateTime dateTime) {
      this.name = name;
      this.date = date;
      this.dateTime = dateTime;
    }
  }
  private static class TestData {
    private LocalDate sampleDate;
    private LocalDateTime sampleDateTime;
    @SerializedName("some_value")
    private String someValue;
    LocalDate getSampleDate() {
      return sampleDate;
    }
    void setSampleDate(LocalDate sampleDate) {
      this.sampleDate = sampleDate;
    }
    LocalDateTime getSampleDateTime() {
      return sampleDateTime;
    }
    void setSampleDateTime(LocalDateTime sampleDateTime) {
      this.sampleDateTime = sampleDateTime;
    }
    String getSomeValue() {
      return someValue;
    }
    void setSomeValue(String someValue) {
      this.someValue = someValue;
    }
  }
}
```

langchain4j-core\src\test\java\dev\langchain4j\internal\UtilsTest.java

```
package dev.langchain4j.internal;
import static dev.langchain4j.internal.Utils.quoted;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.api.Assertions.assertThatExceptionOfType;
import java.util.UUID;
import java.util.stream.Stream;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.Arguments;
import org.junit.jupiter.params.provider.MethodSource;
class UtilsTest {
  @Test
  void randomUUIDWorks() {
    String uuid1 = Utils.randomUUID();
    String uuid2 = Utils.randomUUID();
    assertThat(uuid1).isNotNull().isNotEmpty();
    assertThat(uuid2).isNotNull().isNotEmpty();
    // Checking if the two generated UUIDs are not the same
    assertThat(uuid1).isNotEqualTo(uuid2);
    // Validate if the returned string is in the UUID format
    UUID.fromString(uuid1);
    UUID.fromString(uuid2);
  }
  @Test
  void generateUUIDFromTextWorks() {
    String input1 = "Hello";
    String input2 = "World";
    String uuidFromInput1 = Utils.generateUUIDFrom(input1);
    String uuidFromInput2 = Utils.generateUUIDFrom(input2);
    assertThat(uuidFromInput1).isNotNull().isNotEmpty();
    assertThat(uuidFromInput2).isNotNull().isNotEmpty();
    // Different inputs should produce different UUIDs
    assertThat(uuidFromInput1).isNotEqualTo(uuidFromInput2);
    // Validate if the returned string is in the UUID format
    UUID.fromString(uuidFromInput1);
    UUID.fromString(uuidFromInput2);
    // Test if hashing is consistent for the same input
    assertThat(Utils.generateUUIDFrom(input1)).isEqualTo(uuidFromInput1);
  }
  @Test
  void generateUUIDFromEmptyInputWorks() {
    String uuidFromEmptyInput = Utils.generateUUIDFrom("");
    assertThat(uuidFromEmptyInput).isNotNull().isNotEmpty();
    // Validate if the returned string is in the UUID format
    UUID.fromString(uuidFromEmptyInput);
  }
  @Test
  void generateUUIDFromNullInputWorks() {
    assertThatExceptionOfType(NullPointerException.class).isThrownBy(() ->
Utils.generateUUIDFrom(null));
  }
  @MethodSource
  @ParameterizedTest
  void test_quoted(String string, String expected) {
    assertThat(quoted(string)).isEqualTo(expected);
  }
  static Stream<Arguments> test_quoted() {
    return Stream.of(
```

```
      Arguments.of(null, "null"),
      Arguments.of("", "\"\""),
      Arguments.of(" ", "\" \""),
      Arguments.of("hello", "\"hello\"")
    );
  }
}
```

langchain4j-core\src\test\java\dev\langchain4j\internal\ValidationUtilsTest.java

```
package dev.langchain4j.internal;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.NullSource;
import org.junit.jupiter.params.provider.ValueSource;
import static dev.langchain4j.internal.ValidationUtils.ensureBetween;
import static dev.langchain4j.internal.ValidationUtils.ensureGreaterThanZero;
import static org.assertj.core.api.Assertions.assertThatThrownBy;
class ValidationUtilsTest {
    @ParameterizedTest
    @ValueSource(ints = {1, Integer.MAX_VALUE})
    void should_not_throw_when_greater_than_0(Integer i) {
        ensureGreaterThanZero(i, "integer");
    }
    @ParameterizedTest
    @NullSource
    @ValueSource(ints = {Integer.MIN_VALUE, 0})
    void should_throw_when_when_not_greater_than_0(Integer i) {
        assertThatThrownBy(() -> ensureGreaterThanZero(i, "integer"))
                .isExactlyInstanceOf(IllegalArgumentException.class)
                .hasMessage("integer must be greater than zero, but is: " +
i);
    }
    @ParameterizedTest
    @ValueSource(doubles = {0.0, 0.5, 1.0})
    void should_not_throw_when_between(Double d) {
        ensureBetween(d, 0.0, 1.0, "test");
    }
    @ParameterizedTest
    @NullSource
    @ValueSource(doubles = {-0.1, 1.1})
    void should_throw_when_not_between(Double d) {
        assertThatThrownBy(() -> ensureBetween(d, 0.0, 1.0, "test"))
                .isExactlyInstanceOf(IllegalArgumentException.class)
                .hasMessage("test must be between 0.0 and 1.0, but is: " + d);
    }
}
```

langchain4j-core\src\test\java\dev\langchain4j\model\input\PromptTemplateTest.java

```
package dev.langchain4j.model.input;
import org.junit.jupiter.api.Test;
import java.time.*;
import java.util.HashMap;
import java.util.Map;
import static org.assertj.core.api.Assertions.assertThat;
class PromptTemplateTest {
    @Test
    void should_create_prompt_from_template_with_single_variable() {
        PromptTemplate promptTemplate = PromptTemplate.from("My name is
{{it}}.");
        Prompt prompt = promptTemplate.apply("Klaus");
        assertThat(prompt.text()).isEqualTo("My name is Klaus.");
    }
    @Test
    void should_create_prompt_from_template_with_multiple_variables() {
        PromptTemplate promptTemplate = PromptTemplate.from("My name is
{{name}} {{surname}}.");
        Map<String, Object> variables = new HashMap<>();
        variables.put("name", "Klaus");
        variables.put("surname", "Heißler");
        Prompt prompt = promptTemplate.apply(variables);
        assertThat(prompt.text()).isEqualTo("My name is Klaus Heißler.");
    }
    @Test
    void should_provide_date_automatically() {
        PromptTemplate promptTemplate = PromptTemplate.from("My name is
{{it}} and today is {{current_date}}");
        Prompt prompt = promptTemplate.apply("Klaus");
        assertThat(prompt.text()).isEqualTo("My name is Klaus and today is "
+ LocalDate.now());
    }
    @Test
    void should_provide_time_automatically() {
        Clock clock = Clock.fixed(Instant.now(), ZoneOffset.UTC);
        PromptTemplate promptTemplate = new PromptTemplate("My name is {{it}}
and now is {{current_time}}", clock);
        Prompt prompt = promptTemplate.apply("Klaus");
        assertThat(prompt.text()).isEqualTo("My name is Klaus and now is " +
LocalTime.now(clock));
    }
    @Test
    void should_provide_date_and_time_automatically() {
        Clock clock = Clock.fixed(Instant.now(), ZoneOffset.UTC);
        PromptTemplate promptTemplate = new PromptTemplate("My name is {{it}}
and now is {{current_date_time}}", clock);
        Prompt prompt = promptTemplate.apply("Klaus");
        assertThat(prompt.text()).isEqualTo("My name is Klaus and now is " +
LocalDateTime.now(clock));
    }
}
```

langchain4j-core\src\test\java\dev\langchain4j\model\input\structured\StructuredPromptProcessorTest.java

```
package dev.langchain4j.model.input.structured;
import static
dev.langchain4j.model.input.structured.StructuredPromptProcessor.toPrompt;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import dev.langchain4j.model.input.Prompt;
import java.util.List;
import org.junit.jupiter.api.Test;
class StructuredPromptProcessorTest {
  @StructuredPrompt("Hello, my name is {{name}}")
  static class Greeting {
    private String name;
  }
  @Test
  void test_prompt_with_single_variable() {
    Greeting structuredPrompt = new Greeting();
    structuredPrompt.name = "Klaus";
    Prompt prompt = toPrompt(structuredPrompt);
    assertThat(prompt.text()).isEqualTo("Hello, my name is Klaus");
  }
  @StructuredPrompt(
    {
      "Suggest tasty {{dish}} recipes that can be prepared in
{{maxPreparationTime}} minutes.",
      "I have only {{ingredients}} in my fridge.",
    }
  )
  static class SuggestRecipes {
    private String dish;
    private int maxPreparationTime;
    private List<String> ingredients;
  }
  @Test
  void test_prompt_with_multiple_variables() {
    SuggestRecipes structuredPrompt = new SuggestRecipes();
    structuredPrompt.dish = "salad";
    structuredPrompt.maxPreparationTime = 5;
    structuredPrompt.ingredients = asList("Tomato", "Cucumber", "Onion");
    Prompt prompt = toPrompt(structuredPrompt);
    assertThat(prompt.text())
      .isEqualTo(
        "Suggest tasty salad recipes that can be prepared in 5 minutes.\nI
have only [Tomato, Cucumber, Onion] in my fridge."
      );
  }
  @StructuredPrompt(
    "Example of numbers with floating point: {{nDouble}}, {{nFloat}} and
whole numbers: {{nInt}}, {{nShort}}, {{nLong}}"
  )
  static class VariousNumbers {
    private double nDouble;
    private float nFloat;
    private int nInt;
    private short nShort;
    private long nLong;
  }
  @Test
```

```
  void test_prompt_with_various_number_types() {
    VariousNumbers numbers = new VariousNumbers();
    numbers.nDouble = 17.15;
    numbers.nFloat = 1;
    numbers.nInt = 2;
    numbers.nShort = 10;
    numbers.nLong = 12;
    Prompt prompt = toPrompt(numbers);
    assertThat(prompt.text())
      .isEqualTo("Example of numbers with floating point: 17.15, 1.0 and
whole numbers: 2, 10, 12");
  }
}
```

langchain4j-core\src\test\java\dev\langchain4j\store\embedding\CosineSimilarityTest.java

```
package dev.langchain4j.store.embedding;
import dev.langchain4j.data.embedding.Embedding;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
class CosineSimilarityTest {
    @Test
    void should_calculate_cosine_similarity() {
        Embedding embeddingA = Embedding.from(new float[]{1, 1, 1});
        Embedding embeddingB = Embedding.from(new float[]{-1, -1, -1});
        assertThat(CosineSimilarity.between(embeddingA,
embeddingA)).isCloseTo(1, withPercentage(1));
        assertThat(CosineSimilarity.between(embeddingA,
embeddingB)).isCloseTo(-1, withPercentage(1));
    }
    @Test
    void should_convert_relevance_score_into_cosine_similarity() {
        assertThat(CosineSimilarity.fromRelevanceScore(0)).isEqualTo(-1);
        assertThat(CosineSimilarity.fromRelevanceScore(0.5)).isEqualTo(0);
        assertThat(CosineSimilarity.fromRelevanceScore(1)).isEqualTo(1);
    }
}
```

langchain4j-core\src\test\java\dev\langchain4j\store\embedding\RelevanceScoreTest.java

```
package dev.langchain4j.store.embedding;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class RelevanceScoreTest {
    @Test
    void should_convert_cosine_similarity_into_relevance_score() {
        assertThat(RelevanceScore.fromCosineSimilarity(-1)).isEqualTo(0);
        assertThat(RelevanceScore.fromCosineSimilarity(0)).isEqualTo(0.5);
        assertThat(RelevanceScore.fromCosineSimilarity(1)).isEqualTo(1);
    }
}
```

langchain4j-dashscope\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-dashscope</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with DashScope</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>com.alibaba</groupId>
            <artifactId>dashscope-sdk-java</artifactId>
            <version>2.5.0</version>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-params</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-dashscope\src\main\java\dev\langchain4j\model\dashscope\QwenChatModel.java

```
package dev.langchain4j.model.dashscope;
import com.alibaba.dashscope.aigc.generation.Generation;
import com.alibaba.dashscope.aigc.generation.GenerationResult;
import com.alibaba.dashscope.aigc.generation.models.QwenParam;
import com.alibaba.dashscope.exception.InputRequiredException;
import com.alibaba.dashscope.exception.NoApiKeyException;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.internal.Utils;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.output.Response;
import java.util.List;
import static com.alibaba.dashscope.aigc.generation.models.QwenParam.ResultFormat.MESSAGE;
import static dev.langchain4j.model.dashscope.QwenHelper.*;
public class QwenChatModel implements ChatLanguageModel {
    protected final String apiKey;
    protected final String modelName;
    protected final Double topP;
    protected final Integer topK;
    protected final Boolean enableSearch;
    protected final Integer seed;
    protected final Generation generation;
    protected QwenChatModel(String apiKey,
                            String modelName,
                            Double topP,
                            Integer topK,
                            Boolean enableSearch,
                            Integer seed) {
        this.apiKey = apiKey;
        this.modelName = modelName;
        this.topP = topP;
        this.topK = topK;
        this.enableSearch = enableSearch;
        this.seed = seed;
        this.generation = new Generation();
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages) {
        try {
            QwenParam param = QwenParam.builder()
                    .apiKey(apiKey)
                    .model(modelName)
                    .topP(topP)
                    .topK(topK)
                    .enableSearch(enableSearch)
                    .seed(seed)
                    .messages(toQwenMessages(messages))
                    .resultFormat(MESSAGE)
                    .build();
            GenerationResult generationResult = generation.call(param);
            String answer = answerFrom(generationResult);
            return Response.from(AiMessage.from(answer),
                    tokenUsageFrom(generationResult),
finishReasonFrom(generationResult));
        } catch (NoApiKeyException | InputRequiredException e) {
```

```
            throw new RuntimeException(e);
        }
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
List<ToolSpecification> toolSpecifications) {
        throw new IllegalArgumentException("Tools are currently not supported
for qwen models");
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
ToolSpecification toolSpecification) {
        throw new IllegalArgumentException("Tools are currently not supported
for qwen models");
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        protected String apiKey;
        protected String modelName;
        protected Double topP;
        protected Integer topK;
        protected Boolean enableSearch;
        protected Integer seed;
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
        }
        public Builder modelName(String modelName) {
            this.modelName = modelName;
            return this;
        }
        public Builder topP(Double topP) {
            this.topP = topP;
            return this;
        }
        public Builder topK(Integer topK) {
            this.topK = topK;
            return this;
        }
        public Builder enableSearch(Boolean enableSearch) {
            this.enableSearch = enableSearch;
            return this;
        }
        public Builder seed(Integer seed) {
            this.seed = seed;
            return this;
        }
        protected void ensureOptions() {
            if (Utils.isNullOrBlank(apiKey)) {
                throw new IllegalArgumentException("DashScope api key must be
defined. It can be generated here: https://dashscope.console.aliyun.com/
apiKey");
            }
            modelName = Utils.isNullOrBlank(modelName) ?
QwenModelName.QWEN_PLUS : modelName;
            enableSearch = enableSearch != null && enableSearch;
        }
        public QwenChatModel build() {
            ensureOptions();
```

```
            return new QwenChatModel(apiKey, modelName, topP, topK,
enableSearch, seed);
        }
    }
}
```

langchain4j-dashscope\src\main\java\dev\langchain4j\model\dashscope\QwenEmbeddingModel.java

```
package dev.langchain4j.model.dashscope;
import com.alibaba.dashscope.embeddings.*;
import com.alibaba.dashscope.exception.NoApiKeyException;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.internal.Utils;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import java.util.ArrayList;
import java.util.Collections;
import java.util.List;
import java.util.Optional;
import java.util.stream.Collectors;
import static
com.alibaba.dashscope.embeddings.TextEmbeddingParam.TextType.DOCUMENT;
import static
com.alibaba.dashscope.embeddings.TextEmbeddingParam.TextType.QUERY;
import static java.util.Collections.singletonList;
public class QwenEmbeddingModel implements EmbeddingModel {
    public static final String TYPE_KEY = "type";
    public static final String TYPE_QUERY = "query";
    public static final String TYPE_DOCUMENT = "document";
    private final String apiKey;
    private final String modelName;
    private final TextEmbedding embedding;
    public QwenEmbeddingModel(String apiKey, String modelName) {
        this.apiKey = apiKey;
        this.modelName = modelName;
        this.embedding = new TextEmbedding();
    }
    private boolean containsDocuments(List<TextSegment> textSegments) {
        return textSegments.stream()
                .map(TextSegment::metadata)
                .map(metadata -> metadata.get(TYPE_KEY))
                .filter(TYPE_DOCUMENT::equalsIgnoreCase)
                .anyMatch(Utils::isNullOrBlank);
    }
    private boolean containsQueries(List<TextSegment> textSegments) {
        return textSegments.stream()
                .map(TextSegment::metadata)
                .map(metadata -> metadata.get(TYPE_KEY))
                .filter(TYPE_QUERY::equalsIgnoreCase)
                .anyMatch(Utils::isNullOrBlank);
    }
    private Response<List<Embedding>> embedTexts(List<TextSegment>
textSegments, TextEmbeddingParam.TextType textType) {
        TextEmbeddingParam param = TextEmbeddingParam.builder()
                .apiKey(apiKey)
                .model(modelName)
                .textType(textType)
                .texts(textSegments.stream()
                        .map(TextSegment::text)
                        .collect(Collectors.toList()))
                .build();
        try {
            TextEmbeddingResult generationResult = embedding.call(param);
```

```
            // total_tokens are the same as input_tokens in the embedding
model
            TokenUsage usage = new
TokenUsage(generationResult.getUsage().getTotalTokens());
            List<Embedding> embeddings = Optional.of(generationResult)
                    .map(TextEmbeddingResult::getOutput)
                    .map(TextEmbeddingOutput::getEmbeddings)
                    .orElse(Collections.emptyList())
                    .stream()
                    .map(TextEmbeddingResultItem::getEmbedding)
                    .map(doubleList ->
doubleList.stream().map(Double::floatValue).collect(Collectors.toList()))
                    .map(Embedding::from)
                    .collect(Collectors.toList());
            return Response.from(embeddings, usage);
        } catch (NoApiKeyException e) {
            throw new RuntimeException(e);
        }
    }
    @Override
    public Response<List<Embedding>> embedAll(List<TextSegment> textSegments)
{
        boolean queries = containsQueries(textSegments);
        if (!queries) {
            // default all documents
            return embedTexts(textSegments, DOCUMENT);
        } else {
            boolean documents = containsDocuments(textSegments);
            if (!documents) {
                return embedTexts(textSegments, QUERY);
            } else {
                // This is a mixed collection of queries and documents. Embed
one by one.
                List<Embedding> embeddings = new
ArrayList<>(textSegments.size());
                Integer tokens = null;
                for (TextSegment textSegment : textSegments) {
                    Response<List<Embedding>> result;
                    if
(TYPE_QUERY.equalsIgnoreCase(textSegment.metadata(TYPE_KEY))) {
                        result = embedTexts(singletonList(textSegment),
QUERY);
                    } else {
                        result = embedTexts(singletonList(textSegment),
DOCUMENT);
                    }
                    embeddings.addAll(result.content());
                    if (result.tokenUsage() == null) {
                        continue;
                    }
                    if (tokens == null) {
                        tokens = result.tokenUsage().inputTokenCount();
                    } else {
                        tokens += result.tokenUsage().inputTokenCount();
                    }
                }
                return Response.from(embeddings, new TokenUsage(tokens));
            }
        }
    }
    public static Builder builder() {
```

```
        return new Builder();
    }
    public static class Builder {
        private String apiKey;
        private String modelName;
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
        }
        public Builder modelName(String modelName) {
            this.modelName = modelName;
            return this;
        }
        protected void ensureOptions() {
            if (Utils.isNullOrBlank(apiKey)) {
                throw new IllegalArgumentException("DashScope api key must be
defined. It can be generated here: https://dashscope.console.aliyun.com/
apiKey");
            }
            modelName = Utils.isNullOrBlank(modelName) ?
QwenModelName.TEXT_EMBEDDING_V1 : modelName;
        }
        public QwenEmbeddingModel build() {
            ensureOptions();
            return new QwenEmbeddingModel(apiKey, modelName);
        }
    }
}
```

langchain4j-dashscope\src\main\java\dev\langchain4j\model\dashscope\QwenHelper.java

```
package dev.langchain4j.model.dashscope;
import com.alibaba.dashscope.aigc.generation.GenerationOutput;
import com.alibaba.dashscope.aigc.generation.GenerationOutput.Choice;
import com.alibaba.dashscope.aigc.generation.GenerationResult;
import com.alibaba.dashscope.common.Message;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.SystemMessage;
import dev.langchain4j.model.output.FinishReason;
import dev.langchain4j.model.output.TokenUsage;
import java.util.List;
import java.util.Optional;
import static com.alibaba.dashscope.common.Role.*;
import static dev.langchain4j.model.output.FinishReason.LENGTH;
import static dev.langchain4j.model.output.FinishReason.STOP;
import static java.util.stream.Collectors.toList;
class QwenHelper {
    static List<Message> toQwenMessages(List<ChatMessage> messages) {
        return messages.stream()
                .map(QwenHelper::toQwenMessage)
                .collect(toList());
    }
    static Message toQwenMessage(ChatMessage message) {
        return Message.builder()
                .role(roleFrom(message))
                .content(message.text())
                .build();
    }
    static String roleFrom(ChatMessage message) {
        if (message instanceof AiMessage) {
            return ASSISTANT.getValue();
        } else if (message instanceof SystemMessage) {
            return SYSTEM.getValue();
        } else {
            return USER.getValue();
        }
    }
    static String answerFrom(GenerationResult result) {
        return Optional.of(result)
                .map(GenerationResult::getOutput)
                .map(GenerationOutput::getChoices)
                .filter(choices -> !choices.isEmpty())
                .map(choices -> choices.get(0))
                .map(Choice::getMessage)
                .map(Message::getContent)
                // Compatible with some older models.
                .orElseGet(() -> Optional.of(result)
                        .map(GenerationResult::getOutput)
                        .map(GenerationOutput::getText)
                        .orElse(""));
    }
    static TokenUsage tokenUsageFrom(GenerationResult result) {
        return Optional.of(result)
                .map(GenerationResult::getUsage)
                .map(usage -> new TokenUsage(usage.getInputTokens(),
usage.getOutputTokens()))
                .orElse(new TokenUsage(null, null));
```

```
    }
    static FinishReason finishReasonFrom(GenerationResult result) {
        String finishReason = Optional.of(result)
                .map(GenerationResult::getOutput)
                .map(GenerationOutput::getChoices)
                .filter(choices -> !choices.isEmpty())
                .map(choices -> choices.get(0))
                .map(Choice::getFinishReason)
                .orElse("");
        switch (finishReason) {
            case "stop":
                return STOP;
            case "length":
                return LENGTH;
            default:
                return null;
        }
    }
}
```

langchain4j-dashscope\src\main\java\dev\langchain4j\model\dashscope\QwenLanguageModel.java

```
package dev.langchain4j.model.dashscope;
import com.alibaba.dashscope.aigc.generation.Generation;
import com.alibaba.dashscope.aigc.generation.GenerationResult;
import com.alibaba.dashscope.aigc.generation.models.QwenParam;
import com.alibaba.dashscope.exception.InputRequiredException;
import com.alibaba.dashscope.exception.NoApiKeyException;
import dev.langchain4j.model.language.LanguageModel;
import dev.langchain4j.model.output.Response;
import static
com.alibaba.dashscope.aigc.generation.models.QwenParam.ResultFormat.MESSAGE;
import static dev.langchain4j.internal.Utils.isNullOrBlank;
import static dev.langchain4j.model.dashscope.QwenHelper.*;
import static dev.langchain4j.model.dashscope.QwenModelName.QWEN_PLUS;
public class QwenLanguageModel implements LanguageModel {
    protected final String apiKey;
    protected final String modelName;
    protected final Double topP;
    protected final Integer topK;
    protected final Boolean enableSearch;
    protected final Integer seed;
    protected final Generation generation;
    public QwenLanguageModel(String apiKey,
                             String modelName,
                             Double topP,
                             Integer topK,
                             Boolean enableSearch,
                             Integer seed) {
        this.apiKey = apiKey;
        this.modelName = modelName;
        this.topP = topP;
        this.topK = topK;
        this.enableSearch = enableSearch;
        this.seed = seed;
        this.generation = new Generation();
    }
    @Override
    public Response<String> generate(String prompt) {
        try {
            QwenParam param = QwenParam.builder()
                    .apiKey(apiKey)
                    .model(modelName)
                    .topP(topP)
                    .topK(topK)
                    .enableSearch(enableSearch)
                    .seed(seed)
                    .prompt(prompt)
                    .resultFormat(MESSAGE)
                    .build();
            GenerationResult generationResult = generation.call(param);
            return Response.from(answerFrom(generationResult),
                    tokenUsageFrom(generationResult),
finishReasonFrom(generationResult));
        } catch (NoApiKeyException | InputRequiredException e) {
            throw new RuntimeException(e);
        }
    }
    public static Builder builder() {
```

```
        return new Builder();
    }
    public static class Builder {
        protected String apiKey;
        protected String modelName;
        protected Double topP;
        protected Integer topK;
        protected Boolean enableSearch;
        protected Integer seed;
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
        }
        public Builder modelName(String modelName) {
            this.modelName = modelName;
            return this;
        }
        public Builder topP(Double topP) {
            this.topP = topP;
            return this;
        }
        public Builder topK(Integer topK) {
            this.topK = topK;
            return this;
        }
        public Builder enableSearch(Boolean enableSearch) {
            this.enableSearch = enableSearch;
            return this;
        }
        public Builder seed(Integer seed) {
            this.seed = seed;
            return this;
        }
        protected void ensureOptions() {
            if (isNullOrBlank(apiKey)) {
                throw new IllegalArgumentException("DashScope api key must be
defined. It can be generated here: https://dashscope.console.aliyun.com/
apiKey");
            }
            modelName = isNullOrBlank(modelName) ? QWEN_PLUS : modelName;
            enableSearch = enableSearch != null && enableSearch;
        }
        public QwenLanguageModel build() {
            ensureOptions();
            return new QwenLanguageModel(apiKey, modelName, topP, topK,
enableSearch, seed);
        }
    }
}
```

langchain4j-dashscope\src\main\java\dev\langchain4j\model\dashscope\QwenModelName.java

```
package dev.langchain4j.model.dashscope;
/**
 * The LLMs provided by Alibaba Cloud, performs better than most LLMs in Asia languages.
 */
public class QwenModelName {
    // Use with QwenChatModel and QwenLanguageModel
    public static final String QWEN_TURBO = "qwen-turbo";  // Qwen base model, 4k context.
    public static final String QWEN_PLUS = "qwen-plus";  // Qwen plus model, 8k context.
    public static final String QWEN_SPARK_V1 = "qwen-spark-v1";  // Qwen sft for ai character scene, 4k context.
    public static final String QWEN_SPARK_V2 = "qwen-spark-v2";  // Qwen sft for ai character scene, 8k context.
    public static final String QWEN_7B_CHAT = "qwen-7b-chat";  // Qwen open sourced 7-billion-parameters version
    public static final String QWEN_14B_CHAT = "qwen-14b-chat";  // Qwen open sourced 14-billion-parameters version
    // Use with QwenEmbeddingModel
    public static final String TEXT_EMBEDDING_V1 = "text-embedding-v1";
}
```

langchain4j-dashscope\src\main\java\dev\langchain4j\model\dashscope\QwenStreamingChatModel.java

```
package dev.langchain4j.model.dashscope;
import com.alibaba.dashscope.aigc.generation.GenerationResult;
import com.alibaba.dashscope.aigc.generation.models.QwenParam;
import com.alibaba.dashscope.common.ResultCallback;
import com.alibaba.dashscope.exception.InputRequiredException;
import com.alibaba.dashscope.exception.NoApiKeyException;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import java.util.List;
import static
com.alibaba.dashscope.aigc.generation.models.QwenParam.ResultFormat.MESSAGE;
import static dev.langchain4j.model.dashscope.QwenHelper.toQwenMessages;
public class QwenStreamingChatModel extends QwenChatModel implements
StreamingChatLanguageModel {
    public QwenStreamingChatModel(String apiKey,
                                  String modelName,
                                  Double topP,
                                  Integer topK,
                                  Boolean enableSearch,
                                  Integer seed) {
        super(apiKey, modelName, topP, topK, enableSearch, seed);
    }
    @Override
    public void generate(List<ChatMessage> messages,
StreamingResponseHandler<AiMessage> handler) {
        try {
            QwenParam param = QwenParam.builder()
                    .apiKey(apiKey)
                    .model(modelName)
                    .topP(topP)
                    .topK(topK)
                    .enableSearch(enableSearch)
                    .seed(seed)
                    .messages(toQwenMessages(messages))
                    .resultFormat(MESSAGE)
                    .build();
            QwenStreamingResponseBuilder responseBuilder = new
QwenStreamingResponseBuilder();
            generation.streamCall(param, new
ResultCallback<GenerationResult>() {
                @Override
                public void onEvent(GenerationResult result) {
                    String delta = responseBuilder.append(result);
                    if (delta != null) {
                        handler.onNext(delta);
                    }
                }
                @Override
                public void onComplete() {
                    handler.onComplete(responseBuilder.build());
                }
                @Override
                public void onError(Exception e) {
                    handler.onError(e);
```

```
                }
            });
        } catch (NoApiKeyException | InputRequiredException e) {
            throw new RuntimeException(e);
        }
    }
    @Override
    public void generate(List<ChatMessage> messages,
                         List<ToolSpecification> toolSpecifications,
                         StreamingResponseHandler<AiMessage> handler) {
        throw new IllegalArgumentException("Tools are currently not supported
for qwen models");
    }
    @Override
    public void generate(List<ChatMessage> messages,
                         ToolSpecification toolSpecification,
                         StreamingResponseHandler<AiMessage> handler) {
        throw new IllegalArgumentException("Tools are currently not supported
for qwen models");
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder extends QwenChatModel.Builder {
        public Builder apiKey(String apiKey) {
            return (Builder) super.apiKey(apiKey);
        }
        public Builder modelName(String modelName) {
            return (Builder) super.modelName(modelName);
        }
        public Builder topP(Double topP) {
            return (Builder) super.topP(topP);
        }
        public Builder topK(Integer topK) {
            return (Builder) super.topK(topK);
        }
        public Builder enableSearch(Boolean enableSearch) {
            return (Builder) super.enableSearch(enableSearch);
        }
        public Builder seed(Integer seed) {
            return (Builder) super.seed(seed);
        }
        public QwenStreamingChatModel build() {
            ensureOptions();
            return new QwenStreamingChatModel(apiKey, modelName, topP, topK,
enableSearch, seed);
        }
    }
}
```

langchain4j-dashscope\src\main\java\dev\langchain4j\model\dashscope\QwenStreamingLanguageModel.java

```
package dev.langchain4j.model.dashscope;
import com.alibaba.dashscope.aigc.generation.GenerationResult;
import com.alibaba.dashscope.aigc.generation.models.QwenParam;
import com.alibaba.dashscope.common.ResultCallback;
import com.alibaba.dashscope.exception.InputRequiredException;
import com.alibaba.dashscope.exception.NoApiKeyException;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.language.StreamingLanguageModel;
import dev.langchain4j.model.output.Response;
import static
com.alibaba.dashscope.aigc.generation.models.QwenParam.ResultFormat.MESSAGE;
public class QwenStreamingLanguageModel extends QwenLanguageModel implements
StreamingLanguageModel {
    public QwenStreamingLanguageModel(String apiKey,
                                      String modelName,
                                      Double topP,
                                      Integer topK,
                                      Boolean enableSearch,
                                      Integer seed) {
        super(apiKey, modelName, topP, topK, enableSearch, seed);
    }
    @Override
    public void generate(String prompt, StreamingResponseHandler<String>
handler) {
        try {
            QwenParam param = QwenParam.builder()
                    .apiKey(apiKey)
                    .model(modelName)
                    .topP(topP)
                    .topK(topK)
                    .enableSearch(enableSearch)
                    .seed(seed)
                    .prompt(prompt)
                    .resultFormat(MESSAGE)
                    .build();
            QwenStreamingResponseBuilder responseBuilder = new
QwenStreamingResponseBuilder();
            generation.streamCall(param, new
ResultCallback<GenerationResult>() {
                @Override
                public void onEvent(GenerationResult result) {
                    String delta = responseBuilder.append(result);
                    if (delta != null) {
                        handler.onNext(delta);
                    }
                }
                @Override
                public void onComplete() {
                    Response<AiMessage> response = responseBuilder.build();
                    handler.onComplete(Response.from(
                            response.content().text(),
                            response.tokenUsage(),
                            response.finishReason()
                    ));
                }
                @Override
```

```
                public void onError(Exception e) {
                    handler.onError(e);
                }
            });
        } catch (NoApiKeyException | InputRequiredException e) {
            throw new RuntimeException(e);
        }
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder extends QwenLanguageModel.Builder {
        public Builder apiKey(String apiKey) {
            return (Builder) super.apiKey(apiKey);
        }
        public Builder modelName(String modelName) {
            return (Builder) super.modelName(modelName);
        }
        public Builder topP(Double topP) {
            return (Builder) super.topP(topP);
        }
        public Builder topK(Integer topK) {
            return (Builder) super.topK(topK);
        }
        public Builder enableSearch(Boolean enableSearch) {
            return (Builder) super.enableSearch(enableSearch);
        }
        public Builder seed(Integer seed) {
            return (Builder) super.seed(seed);
        }
        public QwenStreamingLanguageModel build() {
            ensureOptions();
            return new QwenStreamingLanguageModel(apiKey, modelName, topP,
topK, enableSearch, seed);
        }
    }
}
```

langchain4j-dashscope\src\main\java\dev\langchain4j\model\dashscope\QwenStreamingResponseBuilder.java

```
package dev.langchain4j.model.dashscope;
import com.alibaba.dashscope.aigc.generation.GenerationResult;
import com.alibaba.dashscope.aigc.generation.GenerationUsage;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.output.FinishReason;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import static dev.langchain4j.model.dashscope.QwenHelper.answerFrom;
import static dev.langchain4j.model.dashscope.QwenHelper.finishReasonFrom;
public class QwenStreamingResponseBuilder {
    private String generatedContent = "";
    private Integer inputTokenCount;
    private Integer outputTokenCount;
    private FinishReason finishReason;
    public QwenStreamingResponseBuilder() {}
    public String append(GenerationResult partialResponse) {
        if (partialResponse == null) {
            return null;
        }
        GenerationUsage usage = partialResponse.getUsage();
        if (usage != null) {
            inputTokenCount = usage.getInputTokens();
            outputTokenCount = usage.getOutputTokens();
        }
        FinishReason finishReason = finishReasonFrom(partialResponse);
        if (finishReason != null) {
            this.finishReason = finishReason;
        }
        String partialContent = answerFrom(partialResponse);
        String delta = null;
        if (partialContent.length() > generatedContent.length() ) {
            delta = partialContent.substring(generatedContent.length());
            generatedContent = partialContent;
        }
        return delta;
    }
    public Response<AiMessage> build() {
        return Response.from(
                AiMessage.from(generatedContent),
                new TokenUsage(inputTokenCount, outputTokenCount),
                finishReason
        );
    }
}
```

langchain4j-dashscope\src\test\java\dev\langchain4j\model\dashscope\QwenChatModelIT.java

```
package dev.langchain4j.model.dashscope;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.internal.Utils;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.MethodSource;
import static org.assertj.core.api.Assertions.assertThat;
public class QwenChatModelIT {
    @ParameterizedTest
    @MethodSource("dev.langchain4j.model.dashscope.QwenTestHelper#chatModelNam
eProvider")
    public void should_send_messages_and_receive_response(String modelName) {
        String apiKey = QwenTestHelper.apiKey();
        if (Utils.isNullOrBlank(apiKey)) {
            return;
        }
        ChatLanguageModel model = QwenChatModel.builder()
                .apiKey(apiKey)
                .modelName(modelName)
                .build();
        Response<AiMessage> response =
model.generate(QwenTestHelper.chatMessages());
        System.out.println(response);
        assertThat(response.content().text()).containsIgnoringCase("rain");
    }
}
```

langchain4j-dashscope\src\test\java\dev\langchain4j\model\dashscope\QwenEmbeddingModelIT.java

```
package dev.langchain4j.model.dashscope;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.internal.Utils;
import dev.langchain4j.model.embedding.EmbeddingModel;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.MethodSource;
import java.util.List;
import static dev.langchain4j.data.segment.TextSegment.textSegment;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
public class QwenEmbeddingModelIT {
    private EmbeddingModel getModel(String modelName) {
        String apiKey = QwenTestHelper.apiKey();
        if (Utils.isNullOrBlank(apiKey)) {
            return null;
        }
        return QwenEmbeddingModel.builder()
                .apiKey(apiKey)
                .modelName(modelName)
                .build();
    }
    @ParameterizedTest
    @MethodSource("dev.langchain4j.model.dashscope.QwenTestHelper#embeddingModelNameProvider")
    void should_embed_one_text(String modelName) {
        EmbeddingModel model = getModel(modelName);
        if (model == null) {
            return;
        }
        Embedding embedding = model.embed("hello").content();
        assertThat(embedding.vector()).isNotEmpty();
    }
    @ParameterizedTest
    @MethodSource("dev.langchain4j.model.dashscope.QwenTestHelper#embeddingModelNameProvider")
    void should_embed_documents(String modelName) {
        EmbeddingModel model = getModel(modelName);
        if (model == null) {
            return;
        }
        List<Embedding> embeddings = model.embedAll(asList(
                textSegment("hello"),
                textSegment("how are you?")
        )).content();
        assertThat(embeddings).hasSize(2);
        assertThat(embeddings.get(0).vector()).isNotEmpty();
        assertThat(embeddings.get(1).vector()).isNotEmpty();
    }
    @ParameterizedTest
    @MethodSource("dev.langchain4j.model.dashscope.QwenTestHelper#embeddingModelNameProvider")
    void should_embed_queries(String modelName) {
        EmbeddingModel model = getModel(modelName);
        if (model == null) {
            return;
        }
```

```
        List<Embedding> embeddings = model.embedAll(asList(
                textSegment("hello",
Metadata.from(QwenEmbeddingModel.TYPE_KEY, QwenEmbeddingModel.TYPE_QUERY)),
                textSegment("how are you?",
Metadata.from(QwenEmbeddingModel.TYPE_KEY, QwenEmbeddingModel.TYPE_QUERY))
        )).content();
        assertThat(embeddings).hasSize(2);
        assertThat(embeddings.get(0).vector()).isNotEmpty();
        assertThat(embeddings.get(1).vector()).isNotEmpty();
    }
    @ParameterizedTest
    @MethodSource("dev.langchain4j.model.dashscope.QwenTestHelper#embeddingMod
elNameProvider")
    void should_embed_mix_segments(String modelName) {
        EmbeddingModel model = getModel(modelName);
        if (model == null) {
            return;
        }
        List<Embedding> embeddings = model.embedAll(asList(
                textSegment("hello",
Metadata.from(QwenEmbeddingModel.TYPE_KEY, QwenEmbeddingModel.TYPE_QUERY)),
                textSegment("how are you?")
        )).content();
        assertThat(embeddings).hasSize(2);
        assertThat(embeddings.get(0).vector()).isNotEmpty();
        assertThat(embeddings.get(1).vector()).isNotEmpty();
    }
}
```

langchain4j-dashscope\src\test\java\dev\langchain4j\model\dashscope\QwenLanguageModelIT.java

```
package dev.langchain4j.model.dashscope;
import dev.langchain4j.internal.Utils;
import dev.langchain4j.model.language.LanguageModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.MethodSource;
import static org.assertj.core.api.Assertions.assertThat;
public class QwenLanguageModelIT {
    @ParameterizedTest
    @MethodSource("dev.langchain4j.model.dashscope.QwenTestHelper#languageModelNameProvider")
    public void should_send_messages_and_receive_response(String modelName) {
        String apiKey = QwenTestHelper.apiKey();
        if (Utils.isNullOrBlank(apiKey)) {
            return;
        }
        LanguageModel model = QwenLanguageModel.builder()
                .apiKey(apiKey)
                .modelName(modelName)
                .build();
        Response<String> response = model.generate("Please say 'hello' to me");
        System.out.println(response);
        assertThat(response.content()).containsIgnoringCase("hello");
    }
}
```

langchain4j-dashscope\src\test\java\dev\langchain4j\model\dashscope\QwenStreamingChatModelIT.java

```
package dev.langchain4j.model.dashscope;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.internal.Utils;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.MethodSource;
import java.util.concurrent.CompletableFuture;
import java.util.concurrent.ExecutionException;
import java.util.concurrent.TimeoutException;
import static dev.langchain4j.model.dashscope.QwenTestHelper.chatMessages;
import static java.util.concurrent.TimeUnit.SECONDS;
import static org.assertj.core.api.Assertions.assertThat;
public class QwenStreamingChatModelIT {
    @ParameterizedTest
    @MethodSource("dev.langchain4j.model.dashscope.QwenTestHelper#chatModelNameProvider")
    public void should_send_messages_and_receive_response(String modelName) throws ExecutionException, InterruptedException, TimeoutException {
        String apiKey = QwenTestHelper.apiKey();
        if (Utils.isNullOrBlank(apiKey)) {
            return;
        }
        StreamingChatLanguageModel model = QwenStreamingChatModel.builder()
                .apiKey(apiKey)
                .modelName(modelName)
                .build();
        CompletableFuture<Response<AiMessage>> future = new CompletableFuture<>();
        model.generate(chatMessages(), new StreamingResponseHandler<AiMessage>() {
            @Override
            public void onNext(String token) {
                System.out.println("onNext: '" + token + "'");
            }
            @Override
            public void onComplete(Response<AiMessage> response) {
                future.complete(response);
                System.out.println("onComplete: '" + response.content().text() + "'");
            }
            @Override
            public void onError(Throwable error) {
                future.completeExceptionally(error);
            }
        });
        Response<AiMessage> response = future.get(30, SECONDS);
        System.out.println(response);
        assertThat(response.content().text()).containsIgnoringCase("rain");
    }
}
```

langchain4j-dashscope\src\test\java\dev\langchain4j\model\dashscope\QwenStreamingLanguageModelIT.java

```
package dev.langchain4j.model.dashscope;
import dev.langchain4j.internal.Utils;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.language.StreamingLanguageModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.MethodSource;
import java.util.concurrent.CompletableFuture;
import java.util.concurrent.ExecutionException;
import java.util.concurrent.TimeoutException;
import static java.util.concurrent.TimeUnit.SECONDS;
import static org.assertj.core.api.Assertions.assertThat;
public class QwenStreamingLanguageModelIT {
    @ParameterizedTest
    @MethodSource("dev.langchain4j.model.dashscope.QwenTestHelper#languageModelNameProvider")
    public void should_send_messages_and_receive_response(String modelName) throws ExecutionException, InterruptedException, TimeoutException {
        String apiKey = QwenTestHelper.apiKey();
        if (Utils.isNullOrBlank(apiKey)) {
            return;
        }
        StreamingLanguageModel model = QwenStreamingLanguageModel.builder()
                .apiKey(apiKey)
                .modelName(modelName)
                .build();
        CompletableFuture<Response<String>> future = new CompletableFuture<>();
        model.generate("Please say 'hello' to me", new StreamingResponseHandler<String>() {
            @Override
            public void onNext(String token) {
                System.out.println("onNext: '" + token + "'");
            }
            @Override
            public void onComplete(Response<String> response) {
                future.complete(response);
                System.out.println("onComplete: '" + response.content() + "'");
            }
            @Override
            public void onError(Throwable error) {
                future.completeExceptionally(error);
            }
        });
        Response<String> response = future.get(30, SECONDS);
        System.out.println(response);
        assertThat(response.content()).containsIgnoringCase("hello");
    }
}
```

langchain4j-dashscope\src\test\java\dev\langchain4j\model\dashscope\QwenTestHelper.java

```
package dev.langchain4j.model.dashscope;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.SystemMessage;
import dev.langchain4j.data.message.UserMessage;
import org.junit.jupiter.params.provider.Arguments;
import java.util.LinkedList;
import java.util.List;
import java.util.stream.Stream;
public class QwenTestHelper {
    public static Stream<Arguments> languageModelNameProvider() {
        return Stream.of(
                Arguments.of(QwenModelName.QWEN_TURBO),
                Arguments.of(QwenModelName.QWEN_PLUS),
                Arguments.of(QwenModelName.QWEN_SPARK_V1),
                Arguments.of(QwenModelName.QWEN_SPARK_V2),
                Arguments.of(QwenModelName.QWEN_7B_CHAT),
                Arguments.of(QwenModelName.QWEN_14B_CHAT)
        );
    }
    public static Stream<Arguments> chatModelNameProvider() {
        return Stream.of(
                Arguments.of(QwenModelName.QWEN_TURBO),
                Arguments.of(QwenModelName.QWEN_PLUS),
                Arguments.of(QwenModelName.QWEN_7B_CHAT),
                Arguments.of(QwenModelName.QWEN_14B_CHAT)
        );
    }
    public static Stream<Arguments> embeddingModelNameProvider() {
        return Stream.of(
                Arguments.of(QwenModelName.TEXT_EMBEDDING_V1)
        );
    }
    public static String apiKey() {
        return System.getenv("DASHSCOPE_API_KEY");
    }
    public static List<ChatMessage> chatMessages() {
        List<ChatMessage> messages = new LinkedList<>();
        messages.add(SystemMessage.from("Your name is Jack." +
                " You like to answer other people's questions briefly." +
                " It's rainy today."));
        messages.add(UserMessage.from("Hello. What's your name?"));
        messages.add(AiMessage.from("Jack."));
        messages.add(UserMessage.from("How about the weather today?"));
        return messages;
    }
}
```

langchain4j-elasticsearch\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-elasticsearch</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with Elasticsearch</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>co.elastic.clients</groupId>
            <artifactId>elasticsearch-java</artifactId>
        </dependency>
        <dependency>
            <groupId>com.fasterxml.jackson.core</groupId>
            <artifactId>jackson-databind</artifactId>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.slf4j</groupId>
            <artifactId>slf4j-api</artifactId>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
```

```
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-elasticsearch\src\main\java\dev\langchain4j\store\embedding\elasticsearch\Document.java

```
package dev.langchain4j.store.embedding.elasticsearch;
import lombok.AllArgsConstructor;
import lombok.Builder;
import lombok.Data;
import lombok.NoArgsConstructor;
import java.util.Map;
@Data
@NoArgsConstructor
@AllArgsConstructor
@Builder
class Document {
    private float[] vector;
    private String text;
    private Map<String, String> metadata;
}
```

langchain4j-elasticsearch\src\main\java\dev\langchain4j\store\embedding\elasticsearch\ElasticsearchEmbeddingStore.java

```
package dev.langchain4j.store.embedding.elasticsearch;
import co.elastic.clients.elasticsearch.ElasticsearchClient;
import co.elastic.clients.elasticsearch._types.InlineScript;
import co.elastic.clients.elasticsearch._types.mapping.DenseVectorProperty;
import co.elastic.clients.elasticsearch._types.mapping.Property;
import co.elastic.clients.elasticsearch._types.mapping.TextProperty;
import co.elastic.clients.elasticsearch._types.mapping.TypeMapping;
import co.elastic.clients.elasticsearch._types.query_dsl.Query;
import co.elastic.clients.elasticsearch._types.query_dsl.ScriptScoreQuery;
import co.elastic.clients.elasticsearch.core.BulkRequest;
import co.elastic.clients.elasticsearch.core.BulkResponse;
import co.elastic.clients.elasticsearch.core.SearchRequest;
import co.elastic.clients.elasticsearch.core.SearchResponse;
import co.elastic.clients.elasticsearch.core.bulk.BulkResponseItem;
import co.elastic.clients.json.JsonData;
import co.elastic.clients.json.jackson.JacksonJsonpMapper;
import co.elastic.clients.transport.ElasticsearchTransport;
import co.elastic.clients.transport.endpoints.BooleanResponse;
import co.elastic.clients.transport.rest_client.RestClientTransport;
import com.fasterxml.jackson.core.JsonProcessingException;
import com.fasterxml.jackson.databind.ObjectMapper;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import org.apache.http.Header;
import org.apache.http.HttpHost;
import org.apache.http.auth.AuthScope;
import org.apache.http.auth.UsernamePasswordCredentials;
import org.apache.http.client.CredentialsProvider;
import org.apache.http.impl.client.BasicCredentialsProvider;
import org.apache.http.message.BasicHeader;
import org.elasticsearch.client.RestClient;
import org.elasticsearch.client.RestClientBuilder;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import java.io.IOException;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import java.util.Optional;
import static dev.langchain4j.internal.Utils.*;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
import static dev.langchain4j.internal.ValidationUtils.ensureTrue;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.toList;
/**
 * Represents an <a href="https://www.elastic.co/">Elasticsearch</a> index as an embedding store.
 * Current implementation assumes the index uses the cosine distance metric.
 */
public class ElasticsearchEmbeddingStore implements EmbeddingStore<TextSegment> {
    private static final Logger log = LoggerFactory.getLogger(ElasticsearchEmbeddingStore.class);
    private final ElasticsearchClient client;
```

```
    private final String indexName;
    private final ObjectMapper objectMapper;
    /**
     * Creates an instance of ElasticsearchEmbeddingStore.
     *
     * @param serverUrl Elasticsearch Server URL
     * @param apiKey    Elasticsearch API key (optional)
     * @param userName  Elasticsearch userName (optional)
     * @param password  Elasticsearch password (optional)
     * @param indexName Elasticsearch index name (optional). Default value:
"default"
     */
    public ElasticsearchEmbeddingStore(String serverUrl,
                                       String apiKey,
                                       String userName,
                                       String password,
                                       String indexName) {
        RestClientBuilder restClientBuilder = RestClient
                .builder(HttpHost.create(ensureNotNull(serverUrl,
"serverUrl")));
        if (!isNullOrBlank(userName)) {
            CredentialsProvider provider = new BasicCredentialsProvider();
            provider.setCredentials(AuthScope.ANY, new
UsernamePasswordCredentials(userName, password));
            restClientBuilder.setHttpClientConfigCallback(httpClientBuilder -
> httpClientBuilder.setDefaultCredentialsProvider(provider));
        }
        if (!isNullOrBlank(apiKey)) {
            restClientBuilder.setDefaultHeaders(new Header[]{
                    new BasicHeader("Authorization", "Apikey " + apiKey)
            });
        }
        ElasticsearchTransport transport = new
RestClientTransport(restClientBuilder.build(), new JacksonJsonpMapper());
        this.client = new ElasticsearchClient(transport);
        this.indexName = ensureNotNull(indexName, "indexName");
        this.objectMapper = new ObjectMapper();
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String serverUrl;
        private String apiKey;
        private String userName;
        private String password;
        private String indexName = "default";
        /**
         * @param serverUrl Elasticsearch Server URL
         */
        public Builder serverUrl(String serverUrl) {
            this.serverUrl = serverUrl;
            return this;
        }
        /**
         * @param apiKey Elasticsearch API key (optional)
         * @return builder
         */
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
```

```
        }
        /**
         * @param userName Elasticsearch userName (optional)
         * @return builder
         */
        public Builder userName(String userName) {
            this.userName = userName;
            return this;
        }
        /**
         * @param password Elasticsearch password (optional)
         * @return builder
         */
        public Builder password(String password) {
            this.password = password;
            return this;
        }
        /**
         * @param indexName Elasticsearch index name (optional).
         *                  Default value: "default".
         */
        public Builder indexName(String indexName) {
            this.indexName = indexName;
            return this;
        }
        public ElasticsearchEmbeddingStore build() {
            return new ElasticsearchEmbeddingStore(serverUrl, apiKey,
userName, password, indexName);
        }
    }
    @Override
    public String add(Embedding embedding) {
        String id = randomUUID();
        add(id, embedding);
        return id;
    }
    @Override
    public void add(String id, Embedding embedding) {
        addInternal(id, embedding, null);
    }
    @Override
    public String add(Embedding embedding, TextSegment textSegment) {
        String id = randomUUID();
        addInternal(id, embedding, textSegment);
        return id;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings) {
        List<String> ids = embeddings.stream()
                .map(ignored -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, null);
        return ids;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings, List<TextSegment>
embedded) {
        List<String> ids = embeddings.stream()
                .map(ignored -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, embedded);
```

```
        return ids;
    }
    @Override
    public List<EmbeddingMatch<TextSegment>> findRelevant(Embedding
referenceEmbedding, int maxResults, double minScore) {
        try {
            // Use Script Score and cosineSimilarity to calculate
            // see https://www.elastic.co/guide/en/elasticsearch/reference/
current/query-dsl-script-score-query.html#vector-functions-cosine
            ScriptScoreQuery scriptScoreQuery =
buildDefaultScriptScoreQuery(referenceEmbedding.vector(), (float) minScore);
            SearchResponse<Document> response = client.search(
                    SearchRequest.of(s -> s.index(indexName)
                            .query(n -> n.scriptScore(scriptScoreQuery))
                            .size(maxResults)),
                    Document.class
            );
            return toEmbeddingMatch(response);
        } catch (IOException e) {
            log.error("[ElasticSearch encounter I/O Exception]", e);
            throw new ElasticsearchRequestFailedException(e.getMessage());
        }
    }
    private void addInternal(String id, Embedding embedding, TextSegment
embedded) {
        addAllInternal(singletonList(id), singletonList(embedding), embedded
== null ? null : singletonList(embedded));
    }
    private void addAllInternal(List<String> ids, List<Embedding> embeddings,
List<TextSegment> embedded) {
        if (isCollectionEmpty(ids) || isCollectionEmpty(embeddings)) {
            log.info("[do not add empty embeddings to elasticsearch]");
            return;
        }
        ensureTrue(ids.size() == embeddings.size(), "ids size is not equal to
embeddings size");
        ensureTrue(embedded == null || embeddings.size() == embedded.size(),
"embeddings size is not equal to embedded size");
        try {
            createIndexIfNotExist(embeddings.get(0).dimensions());
            bulk(ids, embeddings, embedded);
        } catch (IOException e) {
            log.error("[ElasticSearch encounter I/O Exception]", e);
            throw new ElasticsearchRequestFailedException(e.getMessage());
        }
    }
    private void createIndexIfNotExist(int dim) throws IOException {
        BooleanResponse response = client.indices().exists(c ->
c.index(indexName));
        if (!response.value()) {
            client.indices().create(c -> c.index(indexName)
                    .mappings(getDefaultMappings(dim)));
        }
    }
    private TypeMapping getDefaultMappings(int dim) {
        Map<String, Property> properties = new HashMap<>(4);
        properties.put("text", Property.of(p -> p.text(TextProperty.of(t ->
t))));
        properties.put("vector", Property.of(p ->
p.denseVector(DenseVectorProperty.of(d -> d.dims(dim)))));
        return TypeMapping.of(c -> c.properties(properties));
```

```
    }
    private void bulk(List<String> ids, List<Embedding> embeddings,
List<TextSegment> embedded) throws IOException {
        int size = ids.size();
        BulkRequest.Builder bulkBuilder = new BulkRequest.Builder();
        for (int i = 0; i < size; i++) {
            int finalI = i;
            Document document = Document.builder()
                    .vector(embeddings.get(i).vector())
                    .text(embedded == null ? null : embedded.get(i).text())
                    .metadata(embedded == null ? null :
Optional.ofNullable(embedded.get(i).metadata())
                            .map(Metadata::asMap)
                            .orElse(null))
                    .build();
            bulkBuilder.operations(op -> op.index(idx -> idx
                    .index(indexName)
                    .id(ids.get(finalI))
                    .document(document)));
        }
        BulkResponse response = client.bulk(bulkBuilder.build());
        if (response.errors()) {
            for (BulkResponseItem item : response.items()) {
                if (item.error() != null) {
                    throw new ElasticsearchRequestFailedException("type: " +
item.error().type() + ", reason: " + item.error().reason());
                }
            }
        }
    }
    private ScriptScoreQuery buildDefaultScriptScoreQuery(float[] vector,
float minScore) throws JsonProcessingException {
        JsonData queryVector = toJsonData(vector);
        return ScriptScoreQuery.of(q -> q
                .minScore(minScore)
                .query(Query.of(qu -> qu.matchAll(m -> m)))
                .script(s -> s.inline(InlineScript.of(i -> i
                        // The script adds 1.0 to the cosine similarity to
prevent the score from being negative.
                        // divided by 2 to keep score in the range [0, 1]
                        .source("(cosineSimilarity(params.query_vector,
'vector') + 1.0) / 2")
                        .params("query_vector", queryVector)))));
    }
    private <T> JsonData toJsonData(T rawData) throws JsonProcessingException
{
        return JsonData.fromJson(objectMapper.writeValueAsString(rawData));
    }
    private List<EmbeddingMatch<TextSegment>>
toEmbeddingMatch(SearchResponse<Document> response) {
        return response.hits().hits().stream()
                .map(hit -> Optional.ofNullable(hit.source())
                        .map(document -> new EmbeddingMatch<>(
                                hit.score(),
                                hit.id(),
                                new Embedding(document.getVector()),
                                document.getText() == null
                                        ? null
                                        :
TextSegment.from(document.getText(), new Metadata(document.getMetadata()))
                        )).orElse(null))
```

```
                .collect(toList());
    }
}
```

langchain4j-elasticsearch\src\main\java\dev\langchain4j\store\embedding\elasticsearch\ElasticsearchRequestFailedException.java

```
package dev.langchain4j.store.embedding.elasticsearch;
public class ElasticsearchRequestFailedException extends RuntimeException {
    public ElasticsearchRequestFailedException() {
        super();
    }
    public ElasticsearchRequestFailedException(String message) {
        super(message);
    }
    public ElasticsearchRequestFailedException(String message, Throwable
cause) {
        super(message, cause);
    }
}
```

langchain4j-elasticsearch\src\test\java\dev\langchain4j\store\embedding\elasticsearch\ElasticsearchEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.elasticsearch;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
@Disabled("needs Elasticsearch to be running locally")
class ElasticsearchEmbeddingStoreTest {
    /**
     * First start elasticsearch locally:
     * docker pull docker.elastic.co/elasticsearch/elasticsearch:8.9.0
     * docker run -d -p 9200:9200 -p 9300:9300 -e discovery.type=single-node -
e xpack.security.enabled=false docker.elastic.co/elasticsearch/
elasticsearch:8.9.0
     */
    private final EmbeddingStore<TextSegment> embeddingStore =
ElasticsearchEmbeddingStore.builder()
            .serverUrl("http://localhost:9200")
            .indexName(randomUUID())
            .build();
    private final EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    @Test
    void should_add_embedding() throws InterruptedException {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() throws InterruptedException {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
```

```
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() throws InterruptedException {
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_embedding_with_segment_with_metadata() throws
InterruptedException {
        TextSegment segment = TextSegment.from(randomUUID(),
Metadata.from("test-key", "test-value"));
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() throws InterruptedException {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
```

```
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() throws
InterruptedException {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids = embeddingStore.addAll(
                asList(firstEmbedding, secondEmbedding),
                asList(firstSegment, secondSegment)
        );
        assertThat(ids).hasSize(2);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() throws InterruptedException {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() - 0.01
        );
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
```

```
        List<EmbeddingMatch<TextSegment>> relevant3 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score()
        );
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() + 0.01
        );
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() throws InterruptedException {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(

RelevanceScore.fromCosineSimilarity(CosineSimilarity.between(embedding,
referenceEmbedding)),
                withPercentage(1)
        );
    }
}
```

langchain4j-hugging-face\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-hugging-face</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with Hugging Face</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>com.squareup.retrofit2</groupId>
            <artifactId>retrofit</artifactId>
        </dependency>
        <dependency>
            <groupId>com.squareup.retrofit2</groupId>
            <artifactId>converter-gson</artifactId>
        </dependency>
        <dependency>
            <groupId>com.squareup.okhttp3</groupId>
            <artifactId>okhttp</artifactId>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-params</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
```

```
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\ApiKeyInsertingInterceptor.java

```
package dev.langchain4j.model.huggingface;
import okhttp3.Interceptor;
import okhttp3.Request;
import okhttp3.Response;
import java.io.IOException;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
class ApiKeyInsertingInterceptor implements Interceptor {
    private final String apiKey;
    ApiKeyInsertingInterceptor(String apiKey) {
        this.apiKey = ensureNotBlank(apiKey, "apiKey");
    }
    @Override
    public Response intercept(Chain chain) throws IOException {
        Request request = chain.request()
                .newBuilder()
                .addHeader("Authorization", "Bearer " + apiKey)
                .build();
        return chain.proceed(request);
    }
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\EmbeddingRequest.java

```
package dev.langchain4j.model.huggingface;
import java.util.List;
class EmbeddingRequest {
    private final List<String> inputs;
    private final Options options;
    EmbeddingRequest(List<String> inputs, boolean waitForModel) {
        this.inputs = inputs;
        this.options = Options.builder()
                .waitForModel(waitForModel)
                .build();
    }
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\HuggingFaceApi.java

```
package dev.langchain4j.model.huggingface;
import retrofit2.Call;
import retrofit2.http.Body;
import retrofit2.http.Headers;
import retrofit2.http.POST;
import retrofit2.http.Path;
import java.util.List;
interface HuggingFaceApi {
    @POST("/models/{modelId}")
    @Headers({"Content-Type: application/json"})
    Call<List<TextGenerationResponse>> generate(@Body TextGenerationRequest
request, @Path("modelId") String modelId);
    @POST("/pipeline/feature-extraction/{modelId}")
    @Headers({"Content-Type: application/json"})
    Call<List<float[]>> embed(@Body EmbeddingRequest request,
@Path("modelId") String modelId);
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\HuggingFaceChatModel.java

```
package dev.langchain4j.model.huggingface;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.output.Response;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.Utils.isNullOrBlank;
import static dev.langchain4j.model.huggingface.HuggingFaceModelName.TII_UAE_FALCON_7B_INSTRUCT;
import static java.util.stream.Collectors.joining;
public class HuggingFaceChatModel implements ChatLanguageModel {
    private final HuggingFaceClient client;
    private final Double temperature;
    private final Integer maxNewTokens;
    private final Boolean returnFullText;
    private final Boolean waitForModel;
    public HuggingFaceChatModel(String accessToken,
                                String modelId,
                                Duration timeout,
                                Double temperature,
                                Integer maxNewTokens,
                                Boolean returnFullText,
                                Boolean waitForModel) {
        this(HuggingFaceChatModel.builder()
                .accessToken(accessToken)
                .modelId(modelId)
                .timeout(timeout)
                .temperature(temperature)
                .maxNewTokens(maxNewTokens)
                .returnFullText(returnFullText)
                .waitForModel(waitForModel));
    }
    public HuggingFaceChatModel(Builder builder) {
        this.client = new HuggingFaceClient(builder.accessToken, builder.modelId, builder.timeout);
        this.temperature = builder.temperature;
        this.maxNewTokens = builder.maxNewTokens;
        this.returnFullText = builder.returnFullText;
        this.waitForModel = builder.waitForModel;
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages) {
        TextGenerationRequest request = TextGenerationRequest.builder()
                .inputs(messages.stream()
                        .map(ChatMessage::text)
                        .collect(joining("\n")))
                .parameters(Parameters.builder()
                        .temperature(temperature)
                        .maxNewTokens(maxNewTokens)
                        .returnFullText(returnFullText)
                        .build())
                .options(Options.builder()
                        .waitForModel(waitForModel)
                        .build())
                .build();
```

```
        TextGenerationResponse textGenerationResponse = client.chat(request);
        return
Response.from(AiMessage.from(textGenerationResponse.generatedText()));
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
List<ToolSpecification> toolSpecifications) {
        throw new IllegalArgumentException("Tools are currently not supported
for HuggingFace models");
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
ToolSpecification toolSpecification) {
        throw new IllegalArgumentException("Tools are currently not supported
for HuggingFace models");
    }
    public static Builder builder() {
        return new Builder();
    }
    public static final class Builder {
        private String accessToken;
        private String modelId = TII_UAE_FALCON_7B_INSTRUCT;
        private Duration timeout = Duration.ofSeconds(15);
        private Double temperature;
        private Integer maxNewTokens;
        private Boolean returnFullText = false;
        private Boolean waitForModel = true;
        public Builder accessToken(String accessToken) {
            this.accessToken = accessToken;
            return this;
        }
        public Builder modelId(String modelId) {
            if (modelId != null) {
                this.modelId = modelId;
            }
            return this;
        }
        public Builder timeout(Duration timeout) {
            if (timeout != null) {
                this.timeout = timeout;
            }
            return this;
        }
        public Builder temperature(Double temperature) {
            this.temperature = temperature;
            return this;
        }
        public Builder maxNewTokens(Integer maxNewTokens) {
            this.maxNewTokens = maxNewTokens;
            return this;
        }
        public Builder returnFullText(Boolean returnFullText) {
            if (returnFullText != null) {
                this.returnFullText = returnFullText;
            }
            return this;
        }
        public Builder waitForModel(Boolean waitForModel) {
            if (waitForModel != null) {
                this.waitForModel = waitForModel;
            }
```

```
            return this;
        }
        public HuggingFaceChatModel build() {
            if (isNullOrBlank(accessToken)) {
                throw new IllegalArgumentException("HuggingFace access token
must be defined. It can be generated here: https://huggingface.co/settings/
tokens");
            }
            return new HuggingFaceChatModel(this);
        }
    }
    public static HuggingFaceChatModel withAccessToken(String accessToken) {
        return builder().accessToken(accessToken).build();
    }
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\HuggingFaceClient.java

```
package dev.langchain4j.model.huggingface;
import com.google.gson.Gson;
import com.google.gson.GsonBuilder;
import okhttp3.OkHttpClient;
import retrofit2.Response;
import retrofit2.Retrofit;
import retrofit2.converter.gson.GsonConverterFactory;
import java.io.IOException;
import java.time.Duration;
import java.util.List;
import static com.google.gson.FieldNamingPolicy.LOWER_CASE_WITH_UNDERSCORES;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
class HuggingFaceClient {
    private final HuggingFaceApi huggingFaceApi;
    private final String modelId;
    HuggingFaceClient(String apiKey, String modelId, Duration timeout) {
        OkHttpClient okHttpClient = new OkHttpClient.Builder()
                .addInterceptor(new ApiKeyInsertingInterceptor(apiKey))
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .build();
        Gson gson = new GsonBuilder()
                .setFieldNamingPolicy(LOWER_CASE_WITH_UNDERSCORES)
                .create();
        Retrofit retrofit = new Retrofit.Builder()
                .baseUrl("https://api-inference.huggingface.co")
                .client(okHttpClient)
                .addConverterFactory(GsonConverterFactory.create(gson))
                .build();
        this.huggingFaceApi = retrofit.create(HuggingFaceApi.class);
        this.modelId = ensureNotBlank(modelId, "modelId");
    }
    TextGenerationResponse chat(TextGenerationRequest request) {
        return generate(request);
    }
    TextGenerationResponse generate(TextGenerationRequest request) {
        try {
            retrofit2.Response<List<TextGenerationResponse>> retrofitResponse
                    = huggingFaceApi.generate(request, modelId).execute();
            if (retrofitResponse.isSuccessful()) {
                return toOneResponse(retrofitResponse);
            } else {
                throw toException(retrofitResponse);
            }
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
    private static TextGenerationResponse
toOneResponse(Response<List<TextGenerationResponse>> retrofitResponse) {
        List<TextGenerationResponse> responses = retrofitResponse.body();
        if (responses != null && responses.size() == 1) {
            return responses.get(0);
        } else {
            throw new RuntimeException("Expected only one generated_text, but
```

```
was: " + (responses == null ? 0 : responses.size()));
        }
    }
    List<float[]> embed(EmbeddingRequest request) {
        try {
            retrofit2.Response<List<float[]>> retrofitResponse =
huggingFaceApi.embed(request, modelId).execute();
            if (retrofitResponse.isSuccessful()) {
                return retrofitResponse.body();
            } else {
                throw toException(retrofitResponse);
            }
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
    private static RuntimeException toException(retrofit2.Response<?>
response) throws IOException {
        int code = response.code();
        String body = response.errorBody().string();
        String errorMessage = String.format("status code: %s; body: %s",
code, body);
        return new RuntimeException(errorMessage);
    }
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\HuggingFaceEmbeddingModel.java

```
package dev.langchain4j.model.huggingface;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.model.huggingface.HuggingFaceModelName.SENTENCE_TRANSFORMERS_ALL_MINI_LM_L6_V2;
import static java.util.stream.Collectors.toList;
public class HuggingFaceEmbeddingModel implements EmbeddingModel {
    private static final Duration DEFAULT_TIMEOUT = Duration.ofSeconds(15);
    private final HuggingFaceClient client;
    private final boolean waitForModel;
    @Builder
    public HuggingFaceEmbeddingModel(String accessToken, String modelId, Boolean waitForModel, Duration timeout) {
        if (accessToken == null || accessToken.trim().isEmpty()) {
            throw new IllegalArgumentException("HuggingFace access token must be defined. It can be generated here: https://huggingface.co/settings/tokens");
        }
        this.client = new HuggingFaceClient(
                accessToken,
                modelId == null ? SENTENCE_TRANSFORMERS_ALL_MINI_LM_L6_V2 : modelId,
                timeout == null ? DEFAULT_TIMEOUT : timeout
        );
        this.waitForModel = waitForModel == null ? true : waitForModel;
    }
    @Override
    public Response<List<Embedding>> embedAll(List<TextSegment> textSegments) {
        List<String> texts = textSegments.stream()
                .map(TextSegment::text)
                .collect(toList());
        return embedTexts(texts);
    }
    private Response<List<Embedding>> embedTexts(List<String> texts) {
        EmbeddingRequest request = new EmbeddingRequest(texts, waitForModel);
        List<float[]> response = client.embed(request);
        List<Embedding> embeddings = response.stream()
                .map(Embedding::from)
                .collect(toList());
        return Response.from(embeddings);
    }
    public static HuggingFaceEmbeddingModel withAccessToken(String accessToken) {
        return builder().accessToken(accessToken).build();
    }
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\HuggingFaceLanguageModel.java

```
package dev.langchain4j.model.huggingface;
import dev.langchain4j.model.language.LanguageModel;
import dev.langchain4j.model.output.Response;
import java.time.Duration;
import static dev.langchain4j.model.huggingface.HuggingFaceModelName.TII_UAE_FALCON_7B_INSTRUCT;
public class HuggingFaceLanguageModel implements LanguageModel {
    private final HuggingFaceClient client;
    private final Double temperature;
    private final Integer maxNewTokens;
    private final Boolean returnFullText;
    private final Boolean waitForModel;
    public HuggingFaceLanguageModel(String accessToken,
                                    String modelId,
                                    Duration timeout,
                                    Double temperature,
                                    Integer maxNewTokens,
                                    Boolean returnFullText,
                                    Boolean waitForModel) {
        this(HuggingFaceLanguageModel.builder()
                .accessToken(accessToken)
                .modelId(modelId)
                .timeout(timeout)
                .temperature(temperature)
                .maxNewTokens(maxNewTokens)
                .returnFullText(returnFullText)
                .waitForModel(waitForModel)
        );
    }
    public HuggingFaceLanguageModel(Builder builder) {
        this.client = new HuggingFaceClient(builder.accessToken, builder.modelId, builder.timeout);
        this.temperature = builder.temperature;
        this.maxNewTokens = builder.maxNewTokens;
        this.returnFullText = builder.returnFullText;
        this.waitForModel = builder.waitForModel;
    }
    @Override
    public Response<String> generate(String prompt) {
        TextGenerationRequest request = TextGenerationRequest.builder()
                .inputs(prompt)
                .parameters(Parameters.builder()
                        .temperature(temperature)
                        .maxNewTokens(maxNewTokens)
                        .returnFullText(returnFullText)
                        .build())
                .options(Options.builder()
                        .waitForModel(waitForModel)
                        .build())
                .build();
        TextGenerationResponse response = client.generate(request);
        return Response.from(response.generatedText());
    }
    public static Builder builder() {
        return new Builder();
    }
    public static final class Builder {
```

```
        private String accessToken;
        private String modelId = TII_UAE_FALCON_7B_INSTRUCT;
        private Duration timeout = Duration.ofSeconds(15);
        private Double temperature;
        private Integer maxNewTokens;
        private Boolean returnFullText = false;
        private Boolean waitForModel = true;
        public Builder accessToken(String accessToken) {
            this.accessToken = accessToken;
            return this;
        }
        public Builder modelId(String modelId) {
            if (modelId != null) {
                this.modelId = modelId;
            }
            return this;
        }
        public Builder timeout(Duration timeout) {
            if (timeout != null) {
                this.timeout = timeout;
            }
            return this;
        }
        public Builder temperature(Double temperature) {
            this.temperature = temperature;
            return this;
        }
        public Builder maxNewTokens(Integer maxNewTokens) {
            this.maxNewTokens = maxNewTokens;
            return this;
        }
        public Builder returnFullText(Boolean returnFullText) {
            if (returnFullText != null) {
                this.returnFullText = returnFullText;
            }
            return this;
        }
        public Builder waitForModel(Boolean waitForModel) {
            if (waitForModel != null) {
                this.waitForModel = waitForModel;
            }
            return this;
        }
        public HuggingFaceLanguageModel build() {
            if (accessToken == null || accessToken.trim().isEmpty()) {
                throw new IllegalArgumentException("HuggingFace access token
must be defined. It can be generated here: https://huggingface.co/settings/
tokens");
            }
            return new HuggingFaceLanguageModel(this);
        }
    }
    public static HuggingFaceLanguageModel withAccessToken(String
accessToken) {
        return builder().accessToken(accessToken).build();
    }
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\HuggingFaceModelName.java

```
package dev.langchain4j.model.huggingface;
public class HuggingFaceModelName {
    // Use with HuggingFaceChatModel and HuggingFaceLanguageModel
    public static final String TII_UAE_FALCON_7B_INSTRUCT = "tiiuae/falcon-7b-instruct";
    // Use with HuggingFaceEmbeddingModel
    public static final String SENTENCE_TRANSFORMERS_ALL_MINI_LM_L6_V2 = "sentence-transformers/all-MiniLM-L6-v2";
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\Options.java

```
package dev.langchain4j.model.huggingface;
import java.util.Objects;
class Options {
    private final Boolean waitForModel;
    private final Boolean useCache;
    Options(Builder builder) {
        this.waitForModel = builder.waitForModel;
        this.useCache = builder.useCache;
    }
    @Override
    public boolean equals(Object another) {
        if (this == another) return true;
        return another instanceof Options
                && equalTo((Options) another);
    }
    private boolean equalTo(Options another) {
        return Objects.equals(waitForModel, another.waitForModel)
                && Objects.equals(useCache, another.useCache);
    }
    @Override
    public int hashCode() {
        int h = 5381;
        h += (h << 5) + Objects.hashCode(waitForModel);
        h += (h << 5) + Objects.hashCode(useCache);
        return h;
    }
    @Override
    public String toString() {
        return "TextGenerationRequest {"
                + " waitForModel = " + waitForModel
                + ", useCache = " + useCache
                + " }";
    }
    static Builder builder() {
        return new Builder();
    }
    static final class Builder {
        private Boolean waitForModel = true;
        private Boolean useCache;
        Builder waitForModel(Boolean waitForModel) {
            if (waitForModel != null) {
                this.waitForModel = waitForModel;
            }
            return this;
        }
        Builder useCache(Boolean useCache) {
            this.useCache = useCache;
            return this;
        }
        Options build() {
            return new Options(this);
        }
    }
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\Parameters.java

```
package dev.langchain4j.model.huggingface;
import java.util.Objects;
class Parameters {
    private final Integer topK;
    private final Double topP;
    private final Double temperature;
    private final Double repetitionPenalty;
    private final Integer maxNewTokens;
    private final Double maxTime;
    private final Boolean returnFullText;
    private final Integer numReturnSequences;
    private final Boolean doSample;
    Parameters(Builder builder) {
        this.topK = builder.topK;
        this.topP = builder.topP;
        this.temperature = builder.temperature;
        this.repetitionPenalty = builder.repetitionPenalty;
        this.maxNewTokens = builder.maxNewTokens;
        this.maxTime = builder.maxTime;
        this.returnFullText = builder.returnFullText;
        this.numReturnSequences = builder.numReturnSequences;
        this.doSample = builder.doSample;
    }
    @Override
    public boolean equals(Object another) {
        if (this == another) return true;
        return another instanceof Parameters
                && equalTo((Parameters) another);
    }
    private boolean equalTo(Parameters another) {
        return Objects.equals(topK, another.topK)
                && Objects.equals(topP, another.topP)
                && Objects.equals(temperature, another.temperature)
                && Objects.equals(repetitionPenalty,
another.repetitionPenalty)
                && Objects.equals(maxNewTokens, another.maxNewTokens)
                && Objects.equals(maxTime, another.maxTime)
                && Objects.equals(returnFullText, another.returnFullText)
                && Objects.equals(numReturnSequences,
another.numReturnSequences)
                && Objects.equals(doSample, another.doSample);
    }
    @Override
    public int hashCode() {
        int h = 5381;
        h += (h << 5) + Objects.hashCode(topK);
        h += (h << 5) + Objects.hashCode(topP);
        h += (h << 5) + Objects.hashCode(temperature);
        h += (h << 5) + Objects.hashCode(repetitionPenalty);
        h += (h << 5) + Objects.hashCode(maxNewTokens);
        h += (h << 5) + Objects.hashCode(maxTime);
        h += (h << 5) + Objects.hashCode(returnFullText);
        h += (h << 5) + Objects.hashCode(numReturnSequences);
        h += (h << 5) + Objects.hashCode(doSample);
        return h;
    }
    @Override
```

```
public String toString() {
    return "TextGenerationRequest {"
            + " topK = " + topK
            + ", topP = " + topP
            + ", temperature = " + temperature
            + ", repetitionPenalty = " + repetitionPenalty
            + ", maxNewTokens = " + maxNewTokens
            + ", maxTime = " + maxTime
            + ", returnFullText = " + returnFullText
            + ", numReturnSequences = " + numReturnSequences
            + ", doSample = " + doSample
            + " }";
}
static Builder builder() {
    return new Builder();
}
static final class Builder {
    private Integer topK;
    private Double topP;
    private Double temperature;
    private Double repetitionPenalty;
    private Integer maxNewTokens;
    private Double maxTime;
    private Boolean returnFullText;
    private Integer numReturnSequences;
    private Boolean doSample;
    Builder topK(Integer topK) {
        this.topK = topK;
        return this;
    }
    Builder topP(Double topP) {
        this.topP = topP;
        return this;
    }
    Builder temperature(Double temperature) {
        this.temperature = temperature;
        return this;
    }
    Builder repetitionPenalty(Double repetitionPenalty) {
        this.repetitionPenalty = repetitionPenalty;
        return this;
    }
    Builder maxNewTokens(Integer maxNewTokens) {
        this.maxNewTokens = maxNewTokens;
        return this;
    }
    Builder maxTime(Double maxTime) {
        this.maxTime = maxTime;
        return this;
    }
    Builder returnFullText(Boolean returnFullText) {
        this.returnFullText = returnFullText;
        return this;
    }
    Builder numReturnSequences(Integer numReturnSequences) {
        this.numReturnSequences = numReturnSequences;
        return this;
    }
    Builder doSample(Boolean doSample) {
        this.doSample = doSample;
        return this;
```

```
        }
        Parameters build() {
            return new Parameters(this);
        }
    }
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\TextGenerationRequest.java

```
package dev.langchain4j.model.huggingface;
import java.util.Objects;
import static dev.langchain4j.internal.Utils.quoted;
class TextGenerationRequest {
    private final String inputs;
    private final Parameters parameters;
    private final Options options;
    TextGenerationRequest(Builder builder) {
        this.inputs = builder.inputs;
        this.parameters = builder.parameters;
        this.options = builder.options;
    }
    @Override
    public boolean equals(Object another) {
        if (this == another) return true;
        return another instanceof TextGenerationRequest
                && equalTo((TextGenerationRequest) another);
    }
    private boolean equalTo(TextGenerationRequest another) {
        return Objects.equals(inputs, another.inputs)
                && Objects.equals(parameters, another.parameters)
                && Objects.equals(options, another.options);
    }
    @Override
    public int hashCode() {
        int h = 5381;
        h += (h << 5) + Objects.hashCode(inputs);
        h += (h << 5) + Objects.hashCode(parameters);
        h += (h << 5) + Objects.hashCode(options);
        return h;
    }
    @Override
    public String toString() {
        return "TextGenerationRequest {"
                + " inputs = " + quoted(inputs)
                + ", parameters = " + parameters
                + ", options = " + options
                + " }";
    }
    static Builder builder() {
        return new Builder();
    }
    static final class Builder {
        private String inputs;
        private Parameters parameters;
        private Options options;
        Builder inputs(String inputs) {
            this.inputs = inputs;
            return this;
        }
        Builder parameters(Parameters parameters) {
            this.parameters = parameters;
            return this;
        }
        Builder options(Options options) {
            this.options = options;
            return this;
```

```
        }
        TextGenerationRequest build() {
            return new TextGenerationRequest(this);
        }
    }
}
```

langchain4j-hugging-face\src\main\java\dev\langchain4j\model\huggingface\TextGenerationResponse.java

```
package dev.langchain4j.model.huggingface;
class TextGenerationResponse {
    private final String generatedText;
    TextGenerationResponse(String generatedText) {
        this.generatedText = generatedText;
    }
    public String generatedText() {
        return generatedText;
    }
}
```

langchain4j-hugging-face\src\test\java\dev\langchain4j\model\huggingface\HuggingFaceChatModelIT.java

```
package dev.langchain4j.model.huggingface;
import dev.langchain4j.data.message.AiMessage;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.NullAndEmptySource;
import static dev.langchain4j.data.message.SystemMessage.systemMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.model.huggingface.HuggingFaceModelName.TII_UAE_FALCON_7B_INSTRUCT;
import static java.time.Duration.ofSeconds;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.api.Assertions.assertThatThrownBy;
class HuggingFaceChatModelIT {
    @Test
    public void should_send_messages_and_receive_response() {
        HuggingFaceChatModel model = HuggingFaceChatModel.builder()
                .accessToken(System.getenv("HF_API_KEY"))
                .modelId(TII_UAE_FALCON_7B_INSTRUCT)
                .timeout(ofSeconds(15))
                .temperature(0.7)
                .maxNewTokens(20)
                .waitForModel(true)
                .build();
        AiMessage aiMessage = model.generate(
                systemMessage("You are a good friend of mine, who likes to answer with jokes"),
                userMessage("Hey Bro, what are you doing?")
        ).content();
        assertThat(aiMessage.text()).isNotBlank();
        System.out.println(aiMessage.text());
    }
    @ParameterizedTest
    @NullAndEmptySource
    public void should_fail_when_access_token_is_null_or_empty(String accessToken) {
        assertThatThrownBy(() -> HuggingFaceChatModel.withAccessToken(accessToken))
                .isExactlyInstanceOf(IllegalArgumentException.class)
                .hasMessage("HuggingFace access token must be defined. It can be generated here: https://huggingface.co/settings/tokens");
    }
}
```

langchain4j-hugging-face\src\test\java\dev\langchain4j\model\huggingface\HuggingFaceEmbeddingModelIT.java

```
package dev.langchain4j.model.huggingface;
import dev.langchain4j.data.embedding.Embedding;
import org.junit.jupiter.api.Test;
import java.util.List;
import static dev.langchain4j.data.segment.TextSegment.textSegment;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
class HuggingFaceEmbeddingModelIT {
    HuggingFaceEmbeddingModel model = HuggingFaceEmbeddingModel.builder()
            .accessToken(System.getenv("HF_API_KEY"))
            .modelId("sentence-transformers/all-MiniLM-L6-v2")
            .build();
    @Test
    void should_embed_one_text() {
        Embedding embedding = model.embed("hello").content();
        assertThat(embedding.vector()).hasSize(384);
    }
    @Test
    void should_embed_multiple_segments() {
        List<Embedding> embeddings = model.embedAll(asList(
                textSegment("hello"),
                textSegment("how are you?")
        )).content();
        assertThat(embeddings).hasSize(2);
        assertThat(embeddings.get(0).vector()).hasSize(384);
        assertThat(embeddings.get(1).vector()).hasSize(384);
    }
}
```

langchain4j-hugging-face\src\test\java\dev\langchain4j\model\huggingface\HuggingFaceLanguageModelIT.java

```
package dev.langchain4j.model.huggingface;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.NullAndEmptySource;
import static dev.langchain4j.model.huggingface.HuggingFaceModelName.TII_UAE_FALCON_7B_INSTRUCT;
import static java.time.Duration.ofSeconds;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.api.Assertions.assertThatThrownBy;
class HuggingFaceLanguageModelIT {
    @Test
    public void should_send_prompt_and_receive_response() {
        HuggingFaceLanguageModel model = HuggingFaceLanguageModel.builder()
                .accessToken(System.getenv("HF_API_KEY"))
                .modelId(TII_UAE_FALCON_7B_INSTRUCT)
                .timeout(ofSeconds(15))
                .temperature(0.7)
                .maxNewTokens(20)
                .waitForModel(true)
                .build();
        String answer = model.generate("What is the capital of the USA?").content();
        assertThat(answer).containsIgnoringCase("Washington");
        System.out.println(answer);
    }
    @ParameterizedTest
    @NullAndEmptySource
    public void should_fail_when_access_token_is_null_or_empty(String accessToken) {
        assertThatThrownBy(() -> HuggingFaceLanguageModel.withAccessToken(accessToken))
                .isExactlyInstanceOf(IllegalArgumentException.class)
                .hasMessage("HuggingFace access token must be defined. It can be generated here: https://huggingface.co/settings/tokens");
    }
}
```

langchain4j-local-ai\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-local-ai</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with LocalAI</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-open-ai</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-params</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-local-ai\src\main\java\dev\langchain4j\model\localai\LocalAiChatModel.java

```
package dev.langchain4j.model.localai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.chat.ChatCompletionRequest;
import dev.ai4j.openai4j.chat.ChatCompletionResponse;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.*;
import static java.time.Duration.ofSeconds;
import static java.util.Collections.singletonList;
public class LocalAiChatModel implements ChatLanguageModel {
    private final OpenAiClient client;
    private final String modelName;
    private final Double temperature;
    private final Double topP;
    private final Integer maxTokens;
    private final Integer maxRetries;
    @Builder
    public LocalAiChatModel(String baseUrl,
                            String modelName,
                            Double temperature,
                            Double topP,
                            Integer maxTokens,
                            Duration timeout,
                            Integer maxRetries,
                            Boolean logRequests,
                            Boolean logResponses) {
        temperature = temperature == null ? 0.7 : temperature;
        timeout = timeout == null ? ofSeconds(60) : timeout;
        maxRetries = maxRetries == null ? 3 : maxRetries;
        this.client = OpenAiClient.builder()
                .openAiApiKey("ignored")
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.modelName = ensureNotBlank(modelName, "modelName");
        this.temperature = temperature;
        this.topP = topP;
        this.maxTokens = maxTokens;
        this.maxRetries = maxRetries;
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages) {
        return generate(messages, null, null);
    }
```

```
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
List<ToolSpecification> toolSpecifications) {
        return generate(messages, toolSpecifications, null);
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
ToolSpecification toolSpecification) {
        return generate(messages, singletonList(toolSpecification),
toolSpecification);
    }
    private Response<AiMessage> generate(List<ChatMessage> messages,
                                         List<ToolSpecification>
toolSpecifications,
                                         ToolSpecification
toolThatMustBeExecuted
    ) {
        ChatCompletionRequest.Builder requestBuilder =
ChatCompletionRequest.builder()
                .model(modelName)
                .messages(toOpenAiMessages(messages))
                .temperature(temperature)
                .topP(topP)
                .maxTokens(maxTokens);
        if (toolSpecifications != null && !toolSpecifications.isEmpty()) {
            requestBuilder.functions(toFunctions(toolSpecifications));
        }
        if (toolThatMustBeExecuted != null) {
            requestBuilder.functionCall(toolThatMustBeExecuted.name());
        }
        ChatCompletionRequest request = requestBuilder.build();
        ChatCompletionResponse response = withRetry(() ->
client.chatCompletion(request).execute(), maxRetries);
        return Response.from(aiMessageFrom(response));
    }
}
```

langchain4j-local-ai\src\main\java\dev\langchain4j\model\localai\LocalAiEmbeddingModel.java

```
package dev.langchain4j.model.localai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.embedding.EmbeddingRequest;
import dev.ai4j.openai4j.embedding.EmbeddingResponse;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static java.time.Duration.ofSeconds;
import static java.util.stream.Collectors.toList;
public class LocalAiEmbeddingModel implements EmbeddingModel {
    private final OpenAiClient client;
    private final String modelName;
    private final Integer maxRetries;
    @Builder
    public LocalAiEmbeddingModel(String baseUrl,
                                 String modelName,
                                 Duration timeout,
                                 Integer maxRetries,
                                 Boolean logRequests,
                                 Boolean logResponses) {
        timeout = timeout == null ? ofSeconds(60) : timeout;
        maxRetries = maxRetries == null ? 3 : maxRetries;
        this.client = OpenAiClient.builder()
                .openAiApiKey("ignored")
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.modelName = ensureNotBlank(modelName, "modelName");
        this.maxRetries = maxRetries;
    }
    @Override
    public Response<List<Embedding>> embedAll(List<TextSegment> textSegments)
{
        List<String> texts = textSegments.stream()
                .map(TextSegment::text)
                .collect(toList());
        EmbeddingRequest request = EmbeddingRequest.builder()
                .input(texts)
                .model(modelName)
                .build();
        EmbeddingResponse response = withRetry(() ->
client.embedding(request).execute(), maxRetries);
        List<Embedding> embeddings = response.data().stream()
                .map(openAiEmbedding ->
Embedding.from(openAiEmbedding.embedding()))
                .collect(toList());
```

```
        return Response.from(embeddings);
    }
}
```

langchain4j-local-ai\src\main\java\dev\langchain4j\model\localai\LocalAiLanguageModel.java

```
package dev.langchain4j.model.localai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.completion.CompletionRequest;
import dev.ai4j.openai4j.completion.CompletionResponse;
import dev.langchain4j.model.language.LanguageModel;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.time.Duration;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static java.time.Duration.ofSeconds;
public class LocalAiLanguageModel implements LanguageModel {
    private final OpenAiClient client;
    private final String modelName;
    private final Double temperature;
    private final Double topP;
    private final Integer maxTokens;
    private final Integer maxRetries;
    @Builder
    public LocalAiLanguageModel(String baseUrl,
                                String modelName,
                                Double temperature,
                                Double topP,
                                Integer maxTokens,
                                Duration timeout,
                                Integer maxRetries,
                                Boolean logRequests,
                                Boolean logResponses) {
        temperature = temperature == null ? 0.7 : temperature;
        timeout = timeout == null ? ofSeconds(60) : timeout;
        maxRetries = maxRetries == null ? 3 : maxRetries;
        this.client = OpenAiClient.builder()
                .openAiApiKey("ignored")
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.modelName = ensureNotBlank(modelName, "modelName");
        this.temperature = temperature;
        this.topP = topP;
        this.maxTokens = maxTokens;
        this.maxRetries = maxRetries;
    }
    @Override
    public Response<String> generate(String prompt) {
        CompletionRequest request = CompletionRequest.builder()
                .model(modelName)
                .prompt(prompt)
                .temperature(temperature)
                .topP(topP)
                .maxTokens(maxTokens)
                .build();
        CompletionResponse response = withRetry(() ->
```

```
client.completion(request).execute(), maxRetries);
        return Response.from(response.text());
    }
}
```

langchain4j-local-ai\src\main\java\dev\langchain4j\model\localai\LocalAiStreamingChatModel.java

```
package dev.langchain4j.model.localai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.chat.ChatCompletionChoice;
import dev.ai4j.openai4j.chat.ChatCompletionRequest;
import dev.ai4j.openai4j.chat.ChatCompletionResponse;
import dev.ai4j.openai4j.chat.Delta;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiStreamingResponseBuilder;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.toFunctions;
import static
dev.langchain4j.model.openai.InternalOpenAiHelper.toOpenAiMessages;
import static java.time.Duration.ofSeconds;
import static java.util.Collections.singletonList;
public class LocalAiStreamingChatModel implements StreamingChatLanguageModel {
    private final OpenAiClient client;
    private final String modelName;
    private final Double temperature;
    private final Double topP;
    private final Integer maxTokens;
    @Builder
    public LocalAiStreamingChatModel(String baseUrl,
                                     String modelName,
                                     Double temperature,
                                     Double topP,
                                     Integer maxTokens,
                                     Duration timeout,
                                     Boolean logRequests,
                                     Boolean logResponses) {
        temperature = temperature == null ? 0.7 : temperature;
        timeout = timeout == null ? ofSeconds(60) : timeout;
        this.client = OpenAiClient.builder()
                .openAiApiKey("ignored")
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .logRequests(logRequests)
                .logStreamingResponses(logResponses)
                .build();
        this.modelName = ensureNotBlank(modelName, "modelName");
        this.temperature = temperature;
        this.topP = topP;
        this.maxTokens = maxTokens;
    }
    @Override
    public void generate(List<ChatMessage> messages,
StreamingResponseHandler<AiMessage> handler) {
```

```
        generate(messages, null, null, handler);
    }
    @Override
    public void generate(List<ChatMessage> messages, List<ToolSpecification>
toolSpecifications, StreamingResponseHandler<AiMessage> handler) {
        generate(messages, toolSpecifications, null, handler);
    }
    @Override
    public void generate(List<ChatMessage> messages, ToolSpecification
toolSpecification, StreamingResponseHandler<AiMessage> handler) {
        generate(messages, singletonList(toolSpecification),
toolSpecification, handler);
    }
    private void generate(List<ChatMessage> messages,
                          List<ToolSpecification> toolSpecifications,
                          ToolSpecification toolThatMustBeExecuted,
                          StreamingResponseHandler<AiMessage> handler
    ) {
        ChatCompletionRequest.Builder requestBuilder =
ChatCompletionRequest.builder()
                .stream(true)
                .model(modelName)
                .messages(toOpenAiMessages(messages))
                .temperature(temperature)
                .topP(topP)
                .maxTokens(maxTokens);
        if (toolSpecifications != null && !toolSpecifications.isEmpty()) {
            requestBuilder.functions(toFunctions(toolSpecifications));
        }
        if (toolThatMustBeExecuted != null) {
            requestBuilder.functionCall(toolThatMustBeExecuted.name());
        }
        ChatCompletionRequest request = requestBuilder.build();
        OpenAiStreamingResponseBuilder responseBuilder = new
OpenAiStreamingResponseBuilder(0);
        client.chatCompletion(request)
                .onPartialResponse(partialResponse -> {
                    responseBuilder.append(partialResponse);
                    handle(partialResponse, handler);
                })
                .onComplete(() -> {
                    Response<AiMessage> response = responseBuilder.build();
                    handler.onComplete(response);
                })
                .onError(handler::onError)
                .execute();
    }
    private static void handle(ChatCompletionResponse partialResponse,
                               StreamingResponseHandler<AiMessage> handler) {
        List<ChatCompletionChoice> choices = partialResponse.choices();
        if (choices == null || choices.isEmpty()) {
            return;
        }
        Delta delta = choices.get(0).delta();
        String content = delta.content();
        if (content != null) {
            handler.onNext(content);
        }
    }
}
```

langchain4j-local-ai\src\main\java\dev\langchain4j\model\localai\LocalAiStreamingLanguageModel.java

```
package dev.langchain4j.model.localai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.completion.CompletionRequest;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.language.StreamingLanguageModel;
import dev.langchain4j.model.openai.OpenAiStreamingResponseBuilder;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.time.Duration;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static java.time.Duration.ofSeconds;
public class LocalAiStreamingLanguageModel implements StreamingLanguageModel {
    private final OpenAiClient client;
    private final String modelName;
    private final Double temperature;
    private final Double topP;
    private final Integer maxTokens;
    @Builder
    public LocalAiStreamingLanguageModel(String baseUrl,
                                         String modelName,
                                         Double temperature,
                                         Double topP,
                                         Integer maxTokens,
                                         Duration timeout,
                                         Boolean logRequests,
                                         Boolean logResponses) {
        temperature = temperature == null ? 0.7 : temperature;
        timeout = timeout == null ? ofSeconds(60) : timeout;
        this.client = OpenAiClient.builder()
                .openAiApiKey("ignored")
                .baseUrl(ensureNotBlank(baseUrl, "baseUrl"))
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .logRequests(logRequests)
                .logStreamingResponses(logResponses)
                .build();
        this.modelName = ensureNotBlank(modelName, "modelName");
        this.temperature = temperature;
        this.topP = topP;
        this.maxTokens = maxTokens;
    }
    @Override
    public void generate(String prompt, StreamingResponseHandler<String>
handler) {
        CompletionRequest request = CompletionRequest.builder()
                .model(modelName)
                .prompt(prompt)
                .temperature(temperature)
                .topP(topP)
                .maxTokens(maxTokens)
                .build();
        OpenAiStreamingResponseBuilder responseBuilder = new
OpenAiStreamingResponseBuilder(0);
        client.completion(request)
```

```
                .onPartialResponse(partialResponse -> {
                    responseBuilder.append(partialResponse);
                    String token = partialResponse.text();
                    if (token != null) {
                        handler.onNext(token);
                    }
                })
                .onComplete(() -> {
                    Response<AiMessage> response = responseBuilder.build();
                    handler.onComplete(Response.from(
                            response.content().text(),
                            response.tokenUsage(),
                            response.finishReason()
                    ));
                })
                .onError(handler::onError)
                .execute();
    }
}
```

langchain4j-local-ai\src\test\java\dev\langchain4j\model\localai\LocalAiChatModelIT.java

```
package dev.langchain4j.model.localai;
import dev.langchain4j.model.chat.ChatLanguageModel;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class LocalAiChatModelIT {
    @Test
    @Disabled("until we host LocalAI instance somewhere")
    void should_send_user_message_and_return_answer() {
        ChatLanguageModel model = LocalAiChatModel.builder()
                .baseUrl("http://localhost:8080")
                .modelName("ggml-gpt4all-j")
                .maxTokens(3)
                .logRequests(true)
                .logResponses(true)
                .build();
        String answer = model.generate("Say 'hello'");
        assertThat(answer).containsIgnoringCase("hello");
        System.out.println(answer);
    }
}
```

langchain4j-local-ai\src\test\java\dev\langchain4j\model\localai\LocalAiEmbeddingModelIT.java

```
package dev.langchain4j.model.localai;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.model.embedding.EmbeddingModel;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class LocalAiEmbeddingModelIT {
    @Test
    @Disabled("until we host LocalAI instance somewhere")
    void should_embed() {
        EmbeddingModel model = LocalAiEmbeddingModel.builder()
                .baseUrl("http://localhost:8080")
                .modelName("ggml-model-q4_0")
                .logRequests(true)
                .logResponses(true)
                .build();
        Embedding embedding = model.embed("hello").content();
        assertThat(embedding.vector()).hasSize(384);
    }
}
```

langchain4j-local-ai\src\test\java\dev\langchain4j\model\localai\LocalAiLanguageModelIT.java

```
package dev.langchain4j.model.localai;
import dev.langchain4j.model.language.LanguageModel;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class LocalAiLanguageModelIT {
    @Test
    @Disabled("until we host LocalAI instance somewhere")
    void should_send_prompt_and_return_answer() {
        LanguageModel model = LocalAiLanguageModel.builder()
                .baseUrl("http://localhost:8080")
                .modelName("ggml-gpt4all-j")
                .maxTokens(3)
                .logRequests(true)
                .logResponses(true)
                .build();
        String answer = model.generate("Say 'hello'").content();
        assertThat(answer).containsIgnoringCase("hello");
        System.out.println(answer);
    }
}
```

langchain4j-local-ai\src\test\java\dev\langchain4j\model\localai\LocalAiStreamingChatModelIT.java

```
package dev.langchain4j.model.localai;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import java.util.concurrent.CompletableFuture;
import static java.util.concurrent.TimeUnit.SECONDS;
import static org.assertj.core.api.Assertions.assertThat;
class LocalAiStreamingChatModelIT {
    @Test
    @Disabled("until we host LocalAI instance somewhere")
    void should_stream_answer() throws Exception {
        StreamingChatLanguageModel model = LocalAiStreamingChatModel.builder()
                .baseUrl("http://localhost:8080")
                .modelName("ggml-gpt4all-j")
                .maxTokens(3)
                .logRequests(true)
                .logResponses(true)
                .build();
        StringBuilder answerBuilder = new StringBuilder();
        CompletableFuture<String> futureAnswer = new CompletableFuture<>();
        model.generate("Say 'hello'", new
StreamingResponseHandler<AiMessage>() {
            @Override
            public void onNext(String token) {
                answerBuilder.append(token);
            }
            @Override
            public void onComplete(Response<AiMessage> response) {
                futureAnswer.complete(answerBuilder.toString());
            }
            @Override
            public void onError(Throwable error) {
                futureAnswer.completeExceptionally(error);
            }
        });
        String answer = futureAnswer.get(30, SECONDS);
        assertThat(answer).containsIgnoringCase("hello");
    }
}
```

langchain4j-local-ai\src\test\java\dev\langchain4j\model\localai\LocalAiStreamingLanguageModelIT.java

```
package dev.langchain4j.model.localai;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.language.StreamingLanguageModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import java.util.concurrent.CompletableFuture;
import static java.util.concurrent.TimeUnit.SECONDS;
import static org.assertj.core.api.Assertions.assertThat;
class LocalAiStreamingLanguageModelIT {
    @Test
    @Disabled("until we host LocalAI instance somewhere")
    void should_stream_answer() throws Exception {
        StreamingLanguageModel model = LocalAiStreamingLanguageModel.builder()
                .baseUrl("http://localhost:8080")
                .modelName("ggml-gpt4all-j")
                .maxTokens(3)
                .logRequests(true)
                .logResponses(true)
                .build();
        StringBuilder answerBuilder = new StringBuilder();
        CompletableFuture<String> futureAnswer = new CompletableFuture<>();
        model.generate("Say 'hello'", new StreamingResponseHandler<String>() {
            @Override
            public void onNext(String token) {
                answerBuilder.append(token);
            }
            @Override
            public void onComplete(Response<String> response) {
                futureAnswer.complete(answerBuilder.toString());
            }
            @Override
            public void onError(Throwable error) {
                futureAnswer.completeExceptionally(error);
            }
        });
        String answer = futureAnswer.get(30, SECONDS);
        assertThat(answer).containsIgnoringCase("hello");
    }
}
```

langchain4j-milvus\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-milvus</artifactId>
    <name>LangChain4j integration with Milvus</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${parent.version}</version>
        </dependency>
        <dependency>
            <groupId>io.milvus</groupId>
            <artifactId>milvus-sdk-java</artifactId>
            <version>2.3.1</version>
            <exclusions>
                <!-- due to CVE-2022-41915 vulnerability -->
                <exclusion>
                    <groupId>io.netty</groupId>
                    <artifactId>netty-codec</artifactId>
                </exclusion>
                <!-- due to CVE-2022-42889 vulnerability -->
                <exclusion>
                    <groupId>org.apache.commons</groupId>
                    <artifactId>commons-text</artifactId>
                </exclusion>
            </exclusions>
        </dependency>
        <dependency>
            <groupId>io.netty</groupId>
            <artifactId>netty-codec</artifactId>
            <version>${netty.version}</version>
        </dependency>
        <dependency>
            <groupId>org.apache.commons</groupId>
            <artifactId>commons-text</artifactId>
            <version>1.10.0</version>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
```

```
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
</project>
```

langchain4j-milvus\src\main\java\dev\langchain4j\store\embedding\milvus\CollectionOperationsExecutor.java

```
package dev.langchain4j.store.embedding.milvus;
import io.milvus.client.MilvusServiceClient;
import io.milvus.common.clientenum.ConsistencyLevelEnum;
import io.milvus.grpc.FlushResponse;
import io.milvus.grpc.MutationResult;
import io.milvus.grpc.QueryResults;
import io.milvus.grpc.SearchResults;
import io.milvus.param.IndexType;
import io.milvus.param.MetricType;
import io.milvus.param.R;
import io.milvus.param.RpcStatus;
import io.milvus.param.collection.*;
import io.milvus.param.dml.InsertParam;
import io.milvus.param.dml.QueryParam;
import io.milvus.param.dml.SearchParam;
import io.milvus.param.index.CreateIndexParam;
import io.milvus.response.QueryResultsWrapper;
import io.milvus.response.SearchResultsWrapper;
import java.util.List;
import static
dev.langchain4j.store.embedding.milvus.CollectionRequestBuilder.*;
import static dev.langchain4j.store.embedding.milvus.MilvusEmbeddingStore.*;
import static io.milvus.grpc.DataType.FloatVector;
import static io.milvus.grpc.DataType.VarChar;
class CollectionOperationsExecutor {
    static void flush(MilvusServiceClient milvusClient, String
collectionName) {
        FlushParam request = buildFlushRequest(collectionName);
        R<FlushResponse> response = milvusClient.flush(request);
        checkResponseNotFailed(response);
    }
    static boolean hasCollection(MilvusServiceClient milvusClient, String
collectionName) {
        HasCollectionParam request =
buildHasCollectionRequest(collectionName);
        R<Boolean> response = milvusClient.hasCollection(request);
        checkResponseNotFailed(response);
        return response.getData();
    }
    static void createCollection(MilvusServiceClient milvusClient, String
collectionName, int dimension) {
        CreateCollectionParam request = CreateCollectionParam.newBuilder()
                .withCollectionName(collectionName)
                .addFieldType(FieldType.newBuilder()
                        .withName(ID_FIELD_NAME)
                        .withDataType(VarChar)
                        .withMaxLength(36)
                        .withPrimaryKey(true)
                        .withAutoID(false)
                        .build())
                .addFieldType(FieldType.newBuilder()
                        .withName(TEXT_FIELD_NAME)
                        .withDataType(VarChar)
                        .withMaxLength(65535)
                        .build())
                .addFieldType(FieldType.newBuilder()
                        .withName(VECTOR_FIELD_NAME)
```

```
                        .withDataType(FloatVector)
                        .withDimension(dimension)
                        .build())
                .build();
        R<RpcStatus> response = milvusClient.createCollection(request);
        checkResponseNotFailed(response);
    }
    static void createIndex(MilvusServiceClient milvusClient,
                            String collectionName,
                            IndexType indexType,
                            MetricType metricType) {
        CreateIndexParam request = CreateIndexParam.newBuilder()
                .withCollectionName(collectionName)
                .withFieldName(VECTOR_FIELD_NAME)
                .withIndexType(indexType)
                .withMetricType(metricType)
                .build();
        R<RpcStatus> response = milvusClient.createIndex(request);
        checkResponseNotFailed(response);
    }
    static void insert(MilvusServiceClient milvusClient, String
collectionName, List<InsertParam.Field> fields) {
        InsertParam request = buildInsertRequest(collectionName, fields);
        R<MutationResult> response = milvusClient.insert(request);
        checkResponseNotFailed(response);
    }
    static void loadCollectionInMemory(MilvusServiceClient milvusClient,
String collectionName) {
        LoadCollectionParam request =
buildLoadCollectionInMemoryRequest(collectionName);
        R<RpcStatus> response = milvusClient.loadCollection(request);
        checkResponseNotFailed(response);
    }
    static SearchResultsWrapper search(MilvusServiceClient milvusClient,
SearchParam searchRequest) {
        R<SearchResults> response = milvusClient.search(searchRequest);
        checkResponseNotFailed(response);
        return new SearchResultsWrapper(response.getData().getResults());
    }
    static QueryResultsWrapper queryForVectors(MilvusServiceClient
milvusClient,
                                               String collectionName,
                                               List<String> rowIds,
                                               ConsistencyLevelEnum
consistencyLevel) {
        QueryParam request = buildQueryRequest(collectionName, rowIds,
consistencyLevel);
        R<QueryResults> response = milvusClient.query(request);
        checkResponseNotFailed(response);
        return new QueryResultsWrapper(response.getData());
    }
    private static <T> void checkResponseNotFailed(R<T> response) {
        if (response == null) {
            throw new RequestToMilvusFailedException("Request to Milvus DB
failed. Response is null");
        } else if (response.getStatus() != R.Status.Success.getCode()) {
            String message = String.format("Request to Milvus DB failed.
Response status:'%d'.%n", response.getStatus());
            throw new RequestToMilvusFailedException(message,
response.getException());
        }
```

```
    }
}
```

langchain4j-milvus\src\main\java\dev\langchain4j\store\embedding\milvus\CollectionRequestBuilder.java

```
package dev.langchain4j.store.embedding.milvus;
import io.milvus.common.clientenum.ConsistencyLevelEnum;
import io.milvus.param.MetricType;
import io.milvus.param.collection.FlushParam;
import io.milvus.param.collection.HasCollectionParam;
import io.milvus.param.collection.LoadCollectionParam;
import io.milvus.param.dml.InsertParam;
import io.milvus.param.dml.QueryParam;
import io.milvus.param.dml.SearchParam;
import java.util.List;
import static dev.langchain4j.store.embedding.milvus.MilvusEmbeddingStore.*;
import static java.lang.String.format;
import static java.util.Arrays.asList;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.joining;
class CollectionRequestBuilder {
    static FlushParam buildFlushRequest(String collectionName) {
        return FlushParam.newBuilder()
                .withCollectionNames(singletonList(collectionName))
                .build();
    }
    static HasCollectionParam buildHasCollectionRequest(String
collectionName) {
        return HasCollectionParam.newBuilder()
                .withCollectionName(collectionName)
                .build();
    }
    static InsertParam buildInsertRequest(String collectionName,
List<InsertParam.Field> fields) {
        return InsertParam.newBuilder()
                .withCollectionName(collectionName)
                .withFields(fields)
                .build();
    }
    static LoadCollectionParam buildLoadCollectionInMemoryRequest(String
collectionName) {
        return LoadCollectionParam.newBuilder()
                .withCollectionName(collectionName)
                .build();
    }
    static SearchParam buildSearchRequest(String collectionName,
                                          List<Float> vector,
                                          int maxResults,
                                          MetricType metricType,
                                          ConsistencyLevelEnum
consistencyLevel) {
        return SearchParam.newBuilder()
                .withCollectionName(collectionName)
                .withVectors(singletonList(vector))
                .withVectorFieldName(VECTOR_FIELD_NAME)
                .withTopK(maxResults)
                .withMetricType(metricType)
                .withConsistencyLevel(consistencyLevel)
                .withOutFields(asList(ID_FIELD_NAME, TEXT_FIELD_NAME))
                .build();
    }
    static QueryParam buildQueryRequest(String collectionName,
```

```
                                        List<String> rowIds,
                                        ConsistencyLevelEnum
consistencyLevel) {
        return QueryParam.newBuilder()
                .withCollectionName(collectionName)
                .withExpr(buildQueryExpression(rowIds))
                .withConsistencyLevel(consistencyLevel)
                .withOutFields(singletonList(VECTOR_FIELD_NAME))
                .build();
    }
    private static String buildQueryExpression(List<String> rowIds) {
        return rowIds.stream()
                .map(id -> format("%s == '%s'", ID_FIELD_NAME, id))
                .collect(joining(" || "));
    }
}
```

langchain4j-milvus\src\main\java\dev\langchain4j\store\embedding\milvus\Generator.java

```
package dev.langchain4j.store.embedding.milvus;
import dev.langchain4j.internal.Utils;
import java.util.ArrayList;
import java.util.Arrays;
import java.util.List;
class Generator {
    static List<String> generateRandomIds(int size) {
        List<String> ids = new ArrayList<>();
        for (int i = 0; i < size; i++) {
            ids.add(Utils.randomUUID());
        }
        return ids;
    }
    static List<String> generateEmptyScalars(int size) {
        String[] arr = new String[size];
        Arrays.fill(arr, "");
        return Arrays.asList(arr);
    }
}
```

langchain4j-milvus\src\main\java\dev\langchain4j\store\embedding\milvus\Mapper.java

```
package dev.langchain4j.store.embedding.milvus;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.RelevanceScore;
import io.milvus.client.MilvusServiceClient;
import io.milvus.common.clientenum.ConsistencyLevelEnum;
import io.milvus.response.QueryResultsWrapper;
import io.milvus.response.SearchResultsWrapper;
import java.util.ArrayList;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static dev.langchain4j.internal.Utils.isNullOrBlank;
import static dev.langchain4j.store.embedding.milvus.CollectionOperationsExecu
tor.queryForVectors;
import static
dev.langchain4j.store.embedding.milvus.Generator.generateEmptyScalars;
import static dev.langchain4j.store.embedding.milvus.MilvusEmbeddingStore.*;
import static java.util.stream.Collectors.toList;
class Mapper {
    static List<List<Float>> toVectors(List<Embedding> embeddings) {
        return embeddings.stream()
                .map(Embedding::vectorAsList)
                .collect(toList());
    }
    static List<String> toScalars(List<TextSegment> textSegments, int size) {
        boolean noScalars = textSegments == null || textSegments.isEmpty();
        return noScalars ? generateEmptyScalars(size) :
textSegmentsToScalars(textSegments);
    }
    static List<String> textSegmentsToScalars(List<TextSegment> textSegments)
{
        return textSegments.stream()
                .map(TextSegment::text)
                .collect(toList());
    }
    static List<EmbeddingMatch<TextSegment>>
toEmbeddingMatches(MilvusServiceClient milvusClient,

SearchResultsWrapper resultsWrapper,
                                                                    String
collectionName,

ConsistencyLevelEnum consistencyLevel,
                                                                    boolean
queryForVectorOnSearch) {
        List<EmbeddingMatch<TextSegment>> matches = new ArrayList<>();
        List<String> rowIds = (List<String>)
resultsWrapper.getFieldWrapper(ID_FIELD_NAME).getFieldData();
        Map<String, Embedding> idToEmbedding = new HashMap<>();
        if (queryForVectorOnSearch) {
            idToEmbedding.putAll(queryEmbeddings(milvusClient,
collectionName, rowIds, consistencyLevel));
        }
        for (int i = 0; i < resultsWrapper.getRowRecords().size(); i++) {
            double score = resultsWrapper.getIDScore(0).get(i).getScore();
```

```
            String rowId = resultsWrapper.getIDScore(0).get(i).getStrID();
            Embedding embedding = idToEmbedding.get(rowId);
            String text =
String.valueOf(resultsWrapper.getFieldData(TEXT_FIELD_NAME, 0).get(i));
            TextSegment textSegment = isNullOrBlank(text) ? null :
TextSegment.from(text);
            EmbeddingMatch<TextSegment> embeddingMatch = new EmbeddingMatch<>(
                    RelevanceScore.fromCosineSimilarity(score),
                    rowId,
                    embedding,
                    textSegment
            );
            matches.add(embeddingMatch);
        }
        return matches;
    }
    private static Map<String, Embedding> queryEmbeddings(MilvusServiceClient
milvusClient,
                                                          String
collectionName,
                                                          List<String> rowIds,

ConsistencyLevelEnum consistencyLevel) {
        QueryResultsWrapper queryResultsWrapper = queryForVectors(
                milvusClient,
                collectionName,
                rowIds,
                consistencyLevel
        );
        Map<String, Embedding> idToEmbedding = new HashMap<>();
        for (QueryResultsWrapper.RowRecord row :
queryResultsWrapper.getRowRecords()) {
            String id = row.get(ID_FIELD_NAME).toString();
            List<Float> vector = (List<Float>) row.get(VECTOR_FIELD_NAME);
            idToEmbedding.put(id, Embedding.from(vector));
        }
        return idToEmbedding;
    }
}
```

langchain4j-milvus\src\main\java\dev\langchain4j\store\embedding\milvus\MilvusEmbeddingStore.java

```
package dev.langchain4j.store.embedding.milvus;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
import static
dev.langchain4j.store.embedding.milvus.CollectionOperationsExecutor.*;
import static dev.langchain4j.store.embedding.milvus.CollectionRequestBuilder.
buildSearchRequest;
import static
dev.langchain4j.store.embedding.milvus.Generator.generateRandomIds;
import static dev.langchain4j.store.embedding.milvus.Mapper.*;
import static io.milvus.common.clientenum.ConsistencyLevelEnum.EVENTUALLY;
import static io.milvus.param.IndexType.FLAT;
import static io.milvus.param.MetricType.COSINE;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.toList;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.internal.Utils;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import io.milvus.client.MilvusServiceClient;
import io.milvus.common.clientenum.ConsistencyLevelEnum;
import io.milvus.param.ConnectParam;
import io.milvus.param.IndexType;
import io.milvus.param.MetricType;
import io.milvus.param.dml.InsertParam;
import io.milvus.param.dml.SearchParam;
import io.milvus.response.SearchResultsWrapper;
import java.util.ArrayList;
import java.util.List;
/**
 * Represents an <a href="https://milvus.io/">Milvus</a> index as an
embedding store.
 * Does not support storing {@link dev.langchain4j.data.document.Metadata}
yet.
 */
public class MilvusEmbeddingStore implements EmbeddingStore<TextSegment> {
  static final String ID_FIELD_NAME = "id";
  static final String TEXT_FIELD_NAME = "text";
  static final String VECTOR_FIELD_NAME = "vector";
  private final MilvusServiceClient milvusClient;
  private final String collectionName;
  private final MetricType metricType;
  private final ConsistencyLevelEnum consistencyLevel;
  private final boolean retrieveEmbeddingsOnSearch;
  public MilvusEmbeddingStore(
    String host,
    Integer port,
    String collectionName,
    Integer dimension,
    IndexType indexType,
    MetricType metricType,
    String uri,
    String token,
    String username,
    String password,
    ConsistencyLevelEnum consistencyLevel,
```

```
    Boolean retrieveEmbeddingsOnSearch,
    String databaseName
  ) {
    ConnectParam.Builder connectBuilder = ConnectParam
      .newBuilder()
      .withHost(getOrDefault(host, "localhost"))
      .withPort(getOrDefault(port, 19530))
      .withUri(uri)
      .withToken(token)
      .withAuthorization(username, password);
    if (databaseName != null) {
      connectBuilder.withDatabaseName(databaseName);
    }
    this.milvusClient = new MilvusServiceClient(connectBuilder.build());
    this.collectionName = getOrDefault(collectionName, "default");
    this.metricType = getOrDefault(metricType, COSINE);
    this.consistencyLevel = getOrDefault(consistencyLevel, EVENTUALLY);
    this.retrieveEmbeddingsOnSearch =
getOrDefault(retrieveEmbeddingsOnSearch, false);
    if (!hasCollection(milvusClient, this.collectionName)) {
      createCollection(milvusClient, this.collectionName,
ensureNotNull(dimension, "dimension"));
      createIndex(milvusClient, this.collectionName, getOrDefault(indexType,
FLAT), this.metricType);
    }
  }
  public String add(Embedding embedding) {
    String id = Utils.randomUUID();
    add(id, embedding);
    return id;
  }
  public void add(String id, Embedding embedding) {
    addInternal(id, embedding, null);
  }
  public String add(Embedding embedding, TextSegment textSegment) {
    String id = Utils.randomUUID();
    addInternal(id, embedding, textSegment);
    return id;
  }
  public List<String> addAll(List<Embedding> embeddings) {
    List<String> ids = generateRandomIds(embeddings.size());
    addAllInternal(ids, embeddings, null);
    return ids;
  }
  public List<String> addAll(List<Embedding> embeddings, List<TextSegment>
embedded) {
    List<String> ids = generateRandomIds(embeddings.size());
    addAllInternal(ids, embeddings, embedded);
    return ids;
  }
  public List<EmbeddingMatch<TextSegment>> findRelevant(Embedding
referenceEmbedding, int maxResults, double minScore) {
    loadCollectionInMemory(milvusClient, collectionName);
    SearchParam searchRequest = buildSearchRequest(
      collectionName,
      referenceEmbedding.vectorAsList(),
      maxResults,
      metricType,
      consistencyLevel
    );
    SearchResultsWrapper resultsWrapper = search(milvusClient, searchRequest);
```

```
    List<EmbeddingMatch<TextSegment>> matches = toEmbeddingMatches(
      milvusClient,
      resultsWrapper,
      collectionName,
      consistencyLevel,
      retrieveEmbeddingsOnSearch
    );
    return matches.stream().filter(match -> match.score() >=
minScore).collect(toList());
  }
  private void addInternal(String id, Embedding embedding, TextSegment
textSegment) {
    addAllInternal(
      singletonList(id),
      singletonList(embedding),
      textSegment == null ? null : singletonList(textSegment)
    );
  }
  private void addAllInternal(List<String> ids, List<Embedding> embeddings,
List<TextSegment> textSegments) {
    List<InsertParam.Field> fields = new ArrayList<>();
    fields.add(new InsertParam.Field(ID_FIELD_NAME, ids));
    fields.add(new InsertParam.Field(TEXT_FIELD_NAME, toScalars(textSegments,
ids.size())));
    fields.add(new InsertParam.Field(VECTOR_FIELD_NAME,
toVectors(embeddings)));
    insert(milvusClient, collectionName, fields);
    flush(milvusClient, collectionName);
  }
  public static Builder builder() {
    return new Builder();
  }
  public static class Builder {
    private String host;
    private Integer port;
    private String collectionName;
    private Integer dimension;
    private IndexType indexType;
    private MetricType metricType;
    private String uri;
    private String token;
    private String username;
    private String password;
    private ConsistencyLevelEnum consistencyLevel;
    private Boolean retrieveEmbeddingsOnSearch;
    private String databaseName;
    /**
     * @param host The host of the self-managed Milvus instance.
     *             Default value: "localhost".
     * @return builder
     */
    public Builder host(String host) {
      this.host = host;
      return this;
    }
    /**
     * @param port The port of the self-managed Milvus instance.
     *             Default value: 19530.
     * @return builder
     */
    public Builder port(Integer port) {
```

```
      this.port = port;
      return this;
    }
    /**
     * @param collectionName The name of the Milvus collection.
     *                       If there is no such collection yet, it will be
created automatically.
     *                       Default value: "default".
     * @return builder
     */
    public Builder collectionName(String collectionName) {
      this.collectionName = collectionName;
      return this;
    }
    /**
     * @param dimension The dimension of the embedding vector. (e.g. 384)
     *                  Mandatory if a new collection should be created.
     * @return builder
     */
    public Builder dimension(Integer dimension) {
      this.dimension = dimension;
      return this;
    }
    /**
     * @param indexType The type of the index.
     *                  Default value: FLAT.
     * @return builder
     */
    public Builder indexType(IndexType indexType) {
      this.indexType = indexType;
      return this;
    }
    /**
     * @param metricType The type of the metric used for similarity search.
     *                   Default value: COSINE.
     * @return builder
     */
    public Builder metricType(MetricType metricType) {
      this.metricType = metricType;
      return this;
    }
    /**
     * @param uri The URI of the managed Milvus instance. (e.g. "https://
xxx.api.gcp-us-west1.zillizcloud.com")
     * @return builder
     */
    public Builder uri(String uri) {
      this.uri = uri;
      return this;
    }
    /**
     * @param token The token (API key) of the managed Milvus instance.
     * @return builder
     */
    public Builder token(String token) {
      this.token = token;
      return this;
    }
    /**
     * @param username The username. See details <a href="https://milvus.io/
docs/authenticate.md">here</a>.
```

```
     * @return builder
     */
    public Builder username(String username) {
      this.username = username;
      return this;
    }
    /**
     * @param password The password. See details <a href="https://milvus.io/
docs/authenticate.md">here</a>.
     * @return builder
     */
    public Builder password(String password) {
      this.password = password;
      return this;
    }
    /**
     * @param consistencyLevel The consistency level used by Milvus.
     *                         Default value: EVENTUALLY.
     * @return builder
     */
    public Builder consistencyLevel(ConsistencyLevelEnum consistencyLevel) {
      this.consistencyLevel = consistencyLevel;
      return this;
    }
    /**
     * @param retrieveEmbeddingsOnSearch During a similarity search in Milvus
(when calling findRelevant()),
     *                                   the embedding itself is not
retrieved.
     *                                   To retrieve the embedding, an
additional query is required.
     *                                   Setting this parameter to "true"
will ensure that embedding is retrieved.
     *                                   Be aware that this will impact the
performance of the search.
     *                                   Default value: false.
     * @return builder
     */
    public Builder retrieveEmbeddingsOnSearch(Boolean
retrieveEmbeddingsOnSearch) {
      this.retrieveEmbeddingsOnSearch = retrieveEmbeddingsOnSearch;
      return this;
    }
    /**
     * @param databaseName Milvus name of database.
     *                     Default value: null. In this case default Milvus
database name will be used.
     * @return builder
     */
    public Builder databaseName(String databaseName) {
      this.databaseName = databaseName;
      return this;
    }
    public MilvusEmbeddingStore build() {
      return new MilvusEmbeddingStore(
        host,
        port,
        collectionName,
        dimension,
        indexType,
        metricType,
```

```
        uri,
        token,
        username,
        password,
        consistencyLevel,
        retrieveEmbeddingsOnSearch,
        databaseName
      );
    }
  }
}
```

langchain4j-milvus\src\main\java\dev\langchain4j\store\embedding\milvus\RequestToMilvusFailedException.java

```
package dev.langchain4j.store.embedding.milvus;
class RequestToMilvusFailedException extends RuntimeException {
    public RequestToMilvusFailedException() {
        super();
    }
    public RequestToMilvusFailedException(String message) {
        super(message);
    }
    public RequestToMilvusFailedException(String message, Throwable cause) {
        super(message, cause);
    }
}
```

langchain4j-milvus\src\test\java\dev\langchain4j\store\embedding\milvus\MilvusEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.milvus;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static io.milvus.param.MetricType.IP;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
@Disabled("needs Milvus running locally")
class MilvusEmbeddingStoreTest {
    /**
     * First run Milvus locally:
     * Run "docker compose up -d" inside "langchain4j-milvus/src/test/
resources" directory.
     * If you want to create a fresh Milvus instance, don't forget to remove
"langchain4j-milvus/src/test/resources/volumes" directory.
     */
    EmbeddingStore<TextSegment> embeddingStore =
MilvusEmbeddingStore.builder()
            .host("localhost")
            .port(19530)
            .collectionName("collection_" + randomUUID().replace("-", ""))
            .dimension(384)
            .build();
    EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    @Test
    void should_add_embedding() {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isNull();
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
```

```
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isNull();
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() {
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isNull();
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isNull();
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isNull();
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids = embeddingStore.addAll(
                asList(firstEmbedding, secondEmbedding),
                asList(firstSegment, secondSegment)
        );
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
```

```
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isNull();
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isNull();
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() - 0.01
        );
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score()
        );
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() + 0.01
        );
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
```

```
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(

RelevanceScore.fromCosineSimilarity(CosineSimilarity.between(embedding,
referenceEmbedding)),
                withPercentage(1)
        );
    }
    @Test
    void should_retrieve_embeddings_when_searching() {
        EmbeddingStore<TextSegment> embeddingStore =
MilvusEmbeddingStore.builder()
                .host("localhost")
                .port(19530)
                .collectionName("collection_" + randomUUID().replace("-", ""))
                .dimension(384)
                .retrieveEmbeddingsOnSearch(true)
                .build();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_use_cloud_instance() {
        EmbeddingStore<TextSegment> embeddingStore =
MilvusEmbeddingStore.builder()
                .uri("https://in03-d11858f677102da.api.gcp-us-
west1.zillizcloud.com")
                .token(System.getenv("MILVUS_API_KEY"))
                .collectionName("test")
                .dimension(384)
                .metricType(IP) // COSINE is not supported at the moment
                .build();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
```

```
            assertThat(match.embeddingId()).isEqualTo(id);
            assertThat(match.embedding()).isNull();
            assertThat(match.embedded()).isNull();
        }
    }
```

langchain4j-open-ai\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-open-ai</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with OpenAI</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.ai4j</groupId>
            <artifactId>openai4j</artifactId>
        </dependency>
        <dependency>
            <groupId>com.knuddels</groupId>
            <artifactId>jtokkit</artifactId>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-params</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
```

```
</project>
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\InternalOpenAiHelper.java

```
package dev.langchain4j.model.openai;
import dev.ai4j.openai4j.chat.*;
import dev.ai4j.openai4j.shared.Usage;
import dev.langchain4j.agent.tool.ToolExecutionRequest;
import dev.langchain4j.agent.tool.ToolParameters;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.*;
import dev.langchain4j.model.output.FinishReason;
import dev.langchain4j.model.output.TokenUsage;
import java.util.Collection;
import java.util.List;
import static dev.ai4j.openai4j.chat.Role.*;
import static dev.langchain4j.data.message.AiMessage.aiMessage;
import static dev.langchain4j.model.output.FinishReason.*;
import static java.util.stream.Collectors.toList;
public class InternalOpenAiHelper {
    static final String OPENAI_URL = "https://api.openai.com/v1";
    static final String OPENAI_DEMO_API_KEY = "demo";
    static final String OPENAI_DEMO_URL = "http://langchain4j.dev/demo/openai/
v1";
    public static List<Message> toOpenAiMessages(List<ChatMessage> messages) {
        return messages.stream()
                .map(InternalOpenAiHelper::toOpenAiMessage)
                .collect(toList());
    }
    public static Message toOpenAiMessage(ChatMessage message) {
        return Message.builder()
                .role(roleFrom(message))
                .name(nameFrom(message))
                .content(message.text())
                .functionCall(functionCallFrom(message))
                .build();
    }
    private static String nameFrom(ChatMessage message) {
        if (message instanceof UserMessage) {
            return ((UserMessage) message).name();
        }
        if (message instanceof ToolExecutionResultMessage) {
            return ((ToolExecutionResultMessage) message).toolName();
        }
        return null;
    }
    private static FunctionCall functionCallFrom(ChatMessage message) {
        if (message instanceof AiMessage) {
            AiMessage aiMessage = (AiMessage) message;
            if (aiMessage.toolExecutionRequest() != null) {
                return FunctionCall.builder()
                        .name(aiMessage.toolExecutionRequest().name())
                        .arguments(aiMessage.toolExecutionRequest().arguments(
))
                        .build();
            }
        }
        return null;
    }
    public static Role roleFrom(ChatMessage message) {
        if (message instanceof AiMessage) {
```

```
            return ASSISTANT;
        } else if (message instanceof ToolExecutionResultMessage) {
            return FUNCTION;
        } else if (message instanceof SystemMessage) {
            return SYSTEM;
        } else {
            return USER;
        }
    }
    public static List<Function> toFunctions(Collection<ToolSpecification>
toolSpecifications) {
        return toolSpecifications.stream()
                .map(InternalOpenAiHelper::toFunction)
                .collect(toList());
    }
    private static Function toFunction(ToolSpecification toolSpecification) {
        return Function.builder()
                .name(toolSpecification.name())
                .description(toolSpecification.description())
                .parameters(toOpenAiParameters(toolSpecification.parameters())
)
                .build();
    }
    private static dev.ai4j.openai4j.chat.Parameters
toOpenAiParameters(ToolParameters toolParameters) {
        if (toolParameters == null) {
            return dev.ai4j.openai4j.chat.Parameters.builder().build();
        }
        return dev.ai4j.openai4j.chat.Parameters.builder()
                .properties(toolParameters.properties())
                .required(toolParameters.required())
                .build();
    }
    public static AiMessage aiMessageFrom(ChatCompletionResponse response) {
        if (response.content() != null) {
            return aiMessage(response.content());
        } else {
            FunctionCall functionCall =
response.choices().get(0).message().functionCall();
            ToolExecutionRequest toolExecutionRequest =
ToolExecutionRequest.builder()
                    .name(functionCall.name())
                    .arguments(functionCall.arguments())
                    .build();
            return aiMessage(toolExecutionRequest);
        }
    }
    public static TokenUsage tokenUsageFrom(Usage openAiUsage) {
        if (openAiUsage == null) {
            return null;
        }
        return new TokenUsage(
                openAiUsage.promptTokens(),
                openAiUsage.completionTokens(),
                openAiUsage.totalTokens()
        );
    }
    public static FinishReason finishReasonFrom(String openAiFinishReason) {
        switch (openAiFinishReason) {
            case "stop":
                return STOP;
```

```
            case "length":
                return LENGTH;
            case "function_call":
                return TOOL_EXECUTION;
            case "content_filter":
                return CONTENT_FILTER;
            default:
                return null;
        }
    }
}
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\OpenAiChatModel.java

```
package dev.langchain4j.model.openai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.chat.ChatCompletionRequest;
import dev.ai4j.openai4j.chat.ChatCompletionResponse;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.chat.TokenCountEstimator;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.net.Proxy;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.*;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static java.time.Duration.ofSeconds;
import static java.util.Collections.singletonList;
/**
 * Represents an OpenAI language model with a chat completion interface, such
as gpt-3.5-turbo and gpt-4.
 * You can find description of parameters <a href="https://
platform.openai.com/docs/api-reference/chat/create">here</a>.
 */
public class OpenAiChatModel implements ChatLanguageModel,
TokenCountEstimator {
    private final OpenAiClient client;
    private final String modelName;
    private final Double temperature;
    private final Double topP;
    private final List<String> stop;
    private final Integer maxTokens;
    private final Double presencePenalty;
    private final Double frequencyPenalty;
    private final Integer maxRetries;
    private final Tokenizer tokenizer;
    @Builder
    public OpenAiChatModel(String baseUrl,
                           String apiKey,
                           String modelName,
                           Double temperature,
                           Double topP,
                           List<String> stop,
                           Integer maxTokens,
                           Double presencePenalty,
                           Double frequencyPenalty,
                           Duration timeout,
                           Integer maxRetries,
                           Proxy proxy,
                           Boolean logRequests,
                           Boolean logResponses,
                           Tokenizer tokenizer) {
        baseUrl = getOrDefault(baseUrl, OPENAI_URL);
        if (OPENAI_DEMO_API_KEY.equals(apiKey)) {
```

```
            baseUrl = OPENAI_DEMO_URL;
        }
        timeout = getOrDefault(timeout, ofSeconds(60));
        this.client = OpenAiClient.builder()
                .openAiApiKey(apiKey)
                .baseUrl(baseUrl)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.modelName = getOrDefault(modelName, GPT_3_5_TURBO);
        this.temperature = getOrDefault(temperature, 0.7);
        this.topP = topP;
        this.stop = stop;
        this.maxTokens = maxTokens;
        this.presencePenalty = presencePenalty;
        this.frequencyPenalty = frequencyPenalty;
        this.maxRetries = getOrDefault(maxRetries, 3);
        this.tokenizer = getOrDefault(tokenizer, new
OpenAiTokenizer(this.modelName));
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages) {
        return generate(messages, null, null);
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
List<ToolSpecification> toolSpecifications) {
        return generate(messages, toolSpecifications, null);
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
ToolSpecification toolSpecification) {
        return generate(messages, singletonList(toolSpecification),
toolSpecification);
    }
    private Response<AiMessage> generate(List<ChatMessage> messages,
                                         List<ToolSpecification>
toolSpecifications,
                                         ToolSpecification
toolThatMustBeExecuted
    ) {
        ChatCompletionRequest.Builder requestBuilder =
ChatCompletionRequest.builder()
                .model(modelName)
                .messages(toOpenAiMessages(messages))
                .temperature(temperature)
                .topP(topP)
                .stop(stop)
                .maxTokens(maxTokens)
                .presencePenalty(presencePenalty)
                .frequencyPenalty(frequencyPenalty);
        if (toolSpecifications != null && !toolSpecifications.isEmpty()) {
            requestBuilder.functions(toFunctions(toolSpecifications));
        }
        if (toolThatMustBeExecuted != null) {
            requestBuilder.functionCall(toolThatMustBeExecuted.name());
```

```
        }
        ChatCompletionRequest request = requestBuilder.build();
        ChatCompletionResponse response = withRetry(() ->
client.chatCompletion(request).execute(), maxRetries);
        return Response.from(
                aiMessageFrom(response),
                tokenUsageFrom(response.usage()),
                finishReasonFrom(response.choices().get(0).finishReason())
        );
    }
    @Override
    public int estimateTokenCount(List<ChatMessage> messages) {
        return tokenizer.estimateTokenCountInMessages(messages);
    }
    public static OpenAiChatModel withApiKey(String apiKey) {
        return builder().apiKey(apiKey).build();
    }
}
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\OpenAiEmbeddingModel.java

```
package dev.langchain4j.model.openai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.embedding.EmbeddingRequest;
import dev.ai4j.openai4j.embedding.EmbeddingResponse;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.embedding.TokenCountEstimator;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.net.Proxy;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.*;
import static
dev.langchain4j.model.openai.OpenAiModelName.TEXT_EMBEDDING_ADA_002;
import static java.time.Duration.ofSeconds;
import static java.util.stream.Collectors.toList;
/**
 * Represents an OpenAI embedding model, such as text-embedding-ada-002.
 */
public class OpenAiEmbeddingModel implements EmbeddingModel,
TokenCountEstimator {
    private final OpenAiClient client;
    private final String modelName;
    private final Integer maxRetries;
    private final Tokenizer tokenizer;
    @Builder
    public OpenAiEmbeddingModel(String baseUrl,
                                String apiKey,
                                String modelName,
                                Duration timeout,
                                Integer maxRetries,
                                Proxy proxy,
                                Boolean logRequests,
                                Boolean logResponses,
                                Tokenizer tokenizer) {
        baseUrl = getOrDefault(baseUrl, OPENAI_URL);
        if (OPENAI_DEMO_API_KEY.equals(apiKey)) {
            baseUrl = OPENAI_DEMO_URL;
        }
        timeout = getOrDefault(timeout, ofSeconds(60));
        this.client = OpenAiClient.builder()
                .openAiApiKey(apiKey)
                .baseUrl(baseUrl)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.modelName = getOrDefault(modelName, TEXT_EMBEDDING_ADA_002);
```

```
        this.maxRetries = getOrDefault(maxRetries, 3);
        this.tokenizer = getOrDefault(tokenizer, new
OpenAiTokenizer(this.modelName));
    }
    @Override
    public Response<List<Embedding>> embedAll(List<TextSegment> textSegments)
{
        List<String> texts = textSegments.stream()
                .map(TextSegment::text)
                .collect(toList());
        return embedTexts(texts);
    }
    private Response<List<Embedding>> embedTexts(List<String> texts) {
        EmbeddingRequest request = EmbeddingRequest.builder()
                .input(texts)
                .model(modelName)
                .build();
        EmbeddingResponse response = withRetry(() ->
client.embedding(request).execute(), maxRetries);
        List<Embedding> embeddings = response.data().stream()
                .map(openAiEmbedding ->
Embedding.from(openAiEmbedding.embedding()))
                .collect(toList());
        return Response.from(
                embeddings,
                tokenUsageFrom(response.usage())
        );
    }
    @Override
    public int estimateTokenCount(String text) {
        return tokenizer.estimateTokenCountInText(text);
    }
    public static OpenAiEmbeddingModel withApiKey(String apiKey) {
        return builder().apiKey(apiKey).build();
    }
}
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\OpenAiLanguageModel.java

```
package dev.langchain4j.model.openai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.completion.CompletionChoice;
import dev.ai4j.openai4j.completion.CompletionRequest;
import dev.ai4j.openai4j.completion.CompletionResponse;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.language.LanguageModel;
import dev.langchain4j.model.language.TokenCountEstimator;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.net.Proxy;
import java.time.Duration;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.*;
import static dev.langchain4j.model.openai.OpenAiModelName.TEXT_DAVINCI_003;
import static java.time.Duration.ofSeconds;
/**
 * Represents an OpenAI language model with a completion interface, such as text-davinci-003.
 * However, it's recommended to use {@link OpenAiChatModel} instead,
 * as it offers more advanced features like function calling, multi-turn conversations, etc.
 */
public class OpenAiLanguageModel implements LanguageModel, TokenCountEstimator {
    private final OpenAiClient client;
    private final String modelName;
    private final Double temperature;
    private final Integer maxRetries;
    private final Tokenizer tokenizer;
    @Builder
    public OpenAiLanguageModel(String baseUrl,
                               String apiKey,
                               String modelName,
                               Double temperature,
                               Duration timeout,
                               Integer maxRetries,
                               Proxy proxy,
                               Boolean logRequests,
                               Boolean logResponses,
                               Tokenizer tokenizer) {
        timeout = getOrDefault(timeout, ofSeconds(60));
        this.client = OpenAiClient.builder()
                .baseUrl(getOrDefault(baseUrl, OPENAI_URL))
                .openAiApiKey(apiKey)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.modelName = getOrDefault(modelName, TEXT_DAVINCI_003);
        this.temperature = getOrDefault(temperature, 0.7);
        this.maxRetries = getOrDefault(maxRetries, 3);
```

```
        this.tokenizer = getOrDefault(tokenizer, new
OpenAiTokenizer(this.modelName));
    }
    @Override
    public Response<String> generate(String prompt) {
        CompletionRequest request = CompletionRequest.builder()
                .model(modelName)
                .prompt(prompt)
                .temperature(temperature)
                .build();
        CompletionResponse response = withRetry(() ->
client.completion(request).execute(), maxRetries);
        CompletionChoice completionChoice = response.choices().get(0);
        return Response.from(
                completionChoice.text(),
                tokenUsageFrom(response.usage()),
                finishReasonFrom(completionChoice.finishReason())
        );
    }
    @Override
    public int estimateTokenCount(String prompt) {
        return tokenizer.estimateTokenCountInText(prompt);
    }
    public static OpenAiLanguageModel withApiKey(String apiKey) {
        return builder().apiKey(apiKey).build();
    }
}
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\OpenAiModelName.java

```
package dev.langchain4j.model.openai;
public class OpenAiModelName {
    // Use with OpenAiChatModel and OpenAiStreamingChatModel
    public static final String GPT_3_5_TURBO = "gpt-3.5-turbo"; // alias for
the latest model
    public static final String GPT_3_5_TURBO_0301 = "gpt-3.5-turbo-0301"; //
4k context
    public static final String GPT_3_5_TURBO_0613 = "gpt-3.5-turbo-0613"; //
4k context, functions
    public static final String GPT_3_5_TURBO_16K = "gpt-3.5-turbo-16k"; //
alias for the latest model
    public static final String GPT_3_5_TURBO_16K_0613 = "gpt-3.5-
turbo-16k-0613"; // 16k context, functions
    public static final String GPT_4 = "gpt-4"; // alias for the latest model
    public static final String GPT_4_0314 = "gpt-4-0314"; // 8k context
    public static final String GPT_4_0613 = "gpt-4-0613"; // 8k context,
functions
    public static final String GPT_4_32K = "gpt-4-32k"; // alias for the
latest model
    public static final String GPT_4_32K_0314 = "gpt-4-32k-0314"; // 32k
context
    public static final String GPT_4_32K_0613 = "gpt-4-32k-0613"; // 32k
context, functions
    // Use with OpenAiLanguageModel and OpenAiStreamingLanguageModel
    public static final String TEXT_DAVINCI_003 = "text-davinci-003";
    // Use with OpenAiEmbeddingModel
    public static final String TEXT_EMBEDDING_ADA_002 = "text-embedding-
ada-002";
    // Use with OpenAiModerationModel
    public static final String TEXT_MODERATION_STABLE = "text-moderation-
stable";
    public static final String TEXT_MODERATION_LATEST = "text-moderation-
latest";
}
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\OpenAiModerationModel.java

```
package dev.langchain4j.model.openai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.moderation.ModerationRequest;
import dev.ai4j.openai4j.moderation.ModerationResponse;
import dev.ai4j.openai4j.moderation.ModerationResult;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.moderation.Moderation;
import dev.langchain4j.model.moderation.ModerationModel;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.net.Proxy;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.*;
import static
dev.langchain4j.model.openai.OpenAiModelName.TEXT_MODERATION_LATEST;
import static java.time.Duration.ofSeconds;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.toList;
/**
 * Represents an OpenAI moderation model, such as text-moderation-latest.
 */
public class OpenAiModerationModel implements ModerationModel {
    private final OpenAiClient client;
    private final String modelName;
    private final Integer maxRetries;
    @Builder
    public OpenAiModerationModel(String baseUrl,
                                 String apiKey,
                                 String modelName,
                                 Duration timeout,
                                 Integer maxRetries,
                                 Proxy proxy,
                                 Boolean logRequests,
                                 Boolean logResponses) {
        baseUrl = getOrDefault(baseUrl, OPENAI_URL);
        if (OPENAI_DEMO_API_KEY.equals(apiKey)) {
            baseUrl = OPENAI_DEMO_URL;
        }
        timeout = getOrDefault(timeout, ofSeconds(60));
        this.client = OpenAiClient.builder()
                .openAiApiKey(apiKey)
                .baseUrl(baseUrl)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logResponses(logResponses)
                .build();
        this.modelName = getOrDefault(modelName, TEXT_MODERATION_LATEST);
        this.maxRetries = getOrDefault(maxRetries, 3);
```

```
    }
    @Override
    public Response<Moderation> moderate(String text) {
        return moderateInternal(singletonList(text));
    }
    private Response<Moderation> moderateInternal(List<String> inputs) {
        ModerationRequest request = ModerationRequest.builder()
                .model(modelName)
                .input(inputs)
                .build();
        ModerationResponse response = withRetry(() ->
client.moderation(request).execute(), maxRetries);
        int i = 0;
        for (ModerationResult moderationResult : response.results()) {
            if (moderationResult.isFlagged()) {
                return Response.from(Moderation.flagged(inputs.get(i)));
            }
            i++;
        }
        return Response.from(Moderation.notFlagged());
    }
    @Override
    public Response<Moderation> moderate(Prompt prompt) {
        return moderate(prompt.text());
    }
    @Override
    public Response<Moderation> moderate(ChatMessage message) {
        return moderate(message.text());
    }
    @Override
    public Response<Moderation> moderate(List<ChatMessage> messages) {
        List<String> inputs = messages.stream()
                .map(ChatMessage::text)
                .collect(toList());
        return moderateInternal(inputs);
    }
    @Override
    public Response<Moderation> moderate(TextSegment textSegment) {
        return moderate(textSegment.text());
    }
    public static OpenAiModerationModel withApiKey(String apiKey) {
        return builder().apiKey(apiKey).build();
    }
}
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\OpenAiStreamingChatModel.java

```
package dev.langchain4j.model.openai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.chat.ChatCompletionChoice;
import dev.ai4j.openai4j.chat.ChatCompletionRequest;
import dev.ai4j.openai4j.chat.ChatCompletionResponse;
import dev.ai4j.openai4j.chat.Delta;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.chat.TokenCountEstimator;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.net.Proxy;
import java.time.Duration;
import java.util.List;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.*;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static java.time.Duration.ofSeconds;
import static java.util.Collections.singletonList;
/**
 * Represents an OpenAI language model with a chat completion interface, such
as gpt-3.5-turbo and gpt-4.
 * The model's response is streamed token by token and should be handled with
{@link StreamingResponseHandler}.
 * You can find description of parameters <a href="https://
platform.openai.com/docs/api-reference/chat/create">here</a>.
 */
public class OpenAiStreamingChatModel implements StreamingChatLanguageModel,
TokenCountEstimator {
    private final OpenAiClient client;
    private final String modelName;
    private final Double temperature;
    private final Double topP;
    private final List<String> stop;
    private final Integer maxTokens;
    private final Double presencePenalty;
    private final Double frequencyPenalty;
    private final Tokenizer tokenizer;
    @Builder
    public OpenAiStreamingChatModel(String baseUrl,
                                    String apiKey,
                                    String modelName,
                                    Double temperature,
                                    Double topP,
                                    List<String> stop,
                                    Integer maxTokens,
                                    Double presencePenalty,
                                    Double frequencyPenalty,
                                    Duration timeout,
                                    Proxy proxy,
                                    Boolean logRequests,
                                    Boolean logResponses,
                                    Tokenizer tokenizer) {
```

```
        timeout = getOrDefault(timeout, ofSeconds(60));
        this.client = OpenAiClient.builder()
                .baseUrl(getOrDefault(baseUrl, OPENAI_URL))
                .openAiApiKey(apiKey)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logStreamingResponses(logResponses)
                .build();
        this.modelName = getOrDefault(modelName, GPT_3_5_TURBO);
        this.temperature = getOrDefault(temperature, 0.7);
        this.topP = topP;
        this.stop = stop;
        this.maxTokens = maxTokens;
        this.presencePenalty = presencePenalty;
        this.frequencyPenalty = frequencyPenalty;
        this.tokenizer = getOrDefault(tokenizer, new
OpenAiTokenizer(this.modelName));
    }
    @Override
    public void generate(List<ChatMessage> messages,
StreamingResponseHandler<AiMessage> handler) {
        generate(messages, null, null, handler);
    }
    @Override
    public void generate(List<ChatMessage> messages, List<ToolSpecification>
toolSpecifications, StreamingResponseHandler<AiMessage> handler) {
        generate(messages, toolSpecifications, null, handler);
    }
    @Override
    public void generate(List<ChatMessage> messages, ToolSpecification
toolSpecification, StreamingResponseHandler<AiMessage> handler) {
        generate(messages, singletonList(toolSpecification),
toolSpecification, handler);
    }
    private void generate(List<ChatMessage> messages,
                          List<ToolSpecification> toolSpecifications,
                          ToolSpecification toolThatMustBeExecuted,
                          StreamingResponseHandler<AiMessage> handler
    ) {
        ChatCompletionRequest.Builder requestBuilder =
ChatCompletionRequest.builder()
                .stream(true)
                .model(modelName)
                .messages(toOpenAiMessages(messages))
                .temperature(temperature)
                .topP(topP)
                .stop(stop)
                .maxTokens(maxTokens)
                .presencePenalty(presencePenalty)
                .frequencyPenalty(frequencyPenalty);
        int inputTokenCount =
tokenizer.estimateTokenCountInMessages(messages);
        if (toolSpecifications != null && !toolSpecifications.isEmpty()) {
            requestBuilder.functions(toFunctions(toolSpecifications));
            inputTokenCount +=
tokenizer.estimateTokenCountInToolSpecifications(toolSpecifications);
        }
```

```
        if (toolThatMustBeExecuted != null) {
            requestBuilder.functionCall(toolThatMustBeExecuted.name());
            inputTokenCount +=
tokenizer.estimateTokenCountInToolSpecification(toolThatMustBeExecuted);
        }
        ChatCompletionRequest request = requestBuilder.build();
        OpenAiStreamingResponseBuilder responseBuilder = new
OpenAiStreamingResponseBuilder(inputTokenCount);
        client.chatCompletion(request)
                .onPartialResponse(partialResponse -> {
                    responseBuilder.append(partialResponse);
                    handle(partialResponse, handler);
                })
                .onComplete(() -> {
                    Response<AiMessage> response = responseBuilder.build();
                    handler.onComplete(response);
                })
                .onError(handler::onError)
                .execute();
    }
    private static void handle(ChatCompletionResponse partialResponse,
                               StreamingResponseHandler<AiMessage> handler) {
        List<ChatCompletionChoice> choices = partialResponse.choices();
        if (choices == null || choices.isEmpty()) {
            return;
        }
        Delta delta = choices.get(0).delta();
        String content = delta.content();
        if (content != null) {
            handler.onNext(content);
        }
    }
    @Override
    public int estimateTokenCount(List<ChatMessage> messages) {
        return tokenizer.estimateTokenCountInMessages(messages);
    }
    public static OpenAiStreamingChatModel withApiKey(String apiKey) {
        return builder().apiKey(apiKey).build();
    }
}
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\OpenAiStreamingLanguageModel.java

```
package dev.langchain4j.model.openai;
import dev.ai4j.openai4j.OpenAiClient;
import dev.ai4j.openai4j.completion.CompletionRequest;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.language.StreamingLanguageModel;
import dev.langchain4j.model.language.TokenCountEstimator;
import dev.langchain4j.model.output.Response;
import lombok.Builder;
import java.net.Proxy;
import java.time.Duration;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.OPENAI_URL;
import static dev.langchain4j.model.openai.OpenAiModelName.TEXT_DAVINCI_003;
import static java.time.Duration.ofSeconds;
/**
 * Represents an OpenAI language model with a completion interface, such as text-davinci-003.
 * The model's response is streamed token by token and should be handled with {@link StreamingResponseHandler}.
 * However, it's recommended to use {@link OpenAiStreamingChatModel} instead,
 * as it offers more advanced features like function calling, multi-turn conversations, etc.
 */
public class OpenAiStreamingLanguageModel implements StreamingLanguageModel, TokenCountEstimator {
    private final OpenAiClient client;
    private final String modelName;
    private final Double temperature;
    private final Tokenizer tokenizer;
    @Builder
    public OpenAiStreamingLanguageModel(String baseUrl,
                                        String apiKey,
                                        String modelName,
                                        Double temperature,
                                        Duration timeout,
                                        Proxy proxy,
                                        Boolean logRequests,
                                        Boolean logResponses,
                                        Tokenizer tokenizer) {
        timeout = getOrDefault(timeout, ofSeconds(60));
        this.client = OpenAiClient.builder()
                .baseUrl(getOrDefault(baseUrl, OPENAI_URL))
                .openAiApiKey(apiKey)
                .callTimeout(timeout)
                .connectTimeout(timeout)
                .readTimeout(timeout)
                .writeTimeout(timeout)
                .proxy(proxy)
                .logRequests(logRequests)
                .logStreamingResponses(logResponses)
                .build();
        this.modelName = getOrDefault(modelName, TEXT_DAVINCI_003);
        this.temperature = getOrDefault(temperature, 0.7);
        this.tokenizer = getOrDefault(tokenizer, new OpenAiTokenizer(this.modelName));
```

```
    }
    @Override
    public void generate(String prompt, StreamingResponseHandler<String>
handler) {
        CompletionRequest request = CompletionRequest.builder()
                .model(modelName)
                .prompt(prompt)
                .temperature(temperature)
                .build();
        int inputTokenCount = tokenizer.estimateTokenCountInText(prompt);
        OpenAiStreamingResponseBuilder responseBuilder = new
OpenAiStreamingResponseBuilder(inputTokenCount);
        client.completion(request)
                .onPartialResponse(partialResponse -> {
                    responseBuilder.append(partialResponse);
                    String token = partialResponse.text();
                    if (token != null) {
                        handler.onNext(token);
                    }
                })
                .onComplete(() -> {
                    Response<AiMessage> response = responseBuilder.build();
                    handler.onComplete(Response.from(
                            response.content().text(),
                            response.tokenUsage(),
                            response.finishReason()
                    ));
                })
                .onError(handler::onError)
                .execute();
    }
    @Override
    public int estimateTokenCount(String prompt) {
        return tokenizer.estimateTokenCountInText(prompt);
    }
    public static OpenAiStreamingLanguageModel withApiKey(String apiKey) {
        return builder().apiKey(apiKey).build();
    }
}
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\OpenAiStreamingResponseBuilder.java

```
package dev.langchain4j.model.openai;
import dev.ai4j.openai4j.chat.ChatCompletionChoice;
import dev.ai4j.openai4j.chat.ChatCompletionResponse;
import dev.ai4j.openai4j.chat.Delta;
import dev.ai4j.openai4j.chat.FunctionCall;
import dev.ai4j.openai4j.completion.CompletionChoice;
import dev.ai4j.openai4j.completion.CompletionResponse;
import dev.langchain4j.agent.tool.ToolExecutionRequest;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import java.util.List;
import java.util.concurrent.atomic.AtomicInteger;
import static
dev.langchain4j.model.openai.InternalOpenAiHelper.finishReasonFrom;
/**
 * This class needs to be thread safe because it is called when a streaming
result comes back
 * and there is no guarantee that this thread will be the same as the one
that initiated the request,
 * in fact it almost certainly won't be.
 */
public class OpenAiStreamingResponseBuilder {
    private final StringBuffer contentBuilder = new StringBuffer();
    private final StringBuffer toolNameBuilder = new StringBuffer();
    private final StringBuffer toolArgumentsBuilder = new StringBuffer();
    private final Integer inputTokenCount;
    private final AtomicInteger outputTokenCount = new AtomicInteger();
    private volatile String finishReason;
    public OpenAiStreamingResponseBuilder(Integer inputTokenCount) {
        this.inputTokenCount = inputTokenCount;
    }
    public void append(ChatCompletionResponse partialResponse) {
        if (partialResponse == null) {
            return;
        }
        List<ChatCompletionChoice> choices = partialResponse.choices();
        if (choices == null || choices.isEmpty()) {
            return;
        }
        ChatCompletionChoice chatCompletionChoice = choices.get(0);
        if (chatCompletionChoice == null) {
            return;
        }
        String finishReason = chatCompletionChoice.finishReason();
        if (finishReason != null) {
            this.finishReason = finishReason;
        }
        Delta delta = chatCompletionChoice.delta();
        if (delta == null) {
            return;
        }
        String content = delta.content();
        if (content != null) {
            contentBuilder.append(content);
            outputTokenCount.incrementAndGet();
            return;
```

```
        }
        FunctionCall functionCall = delta.functionCall();
        if (functionCall != null) {
            if (functionCall.name() != null) {
                toolNameBuilder.append(functionCall.name());
                outputTokenCount.incrementAndGet();
            }
            if (functionCall.arguments() != null) {
                toolArgumentsBuilder.append(functionCall.arguments());
                outputTokenCount.incrementAndGet();
            }
        }
    }
    public void append(CompletionResponse partialResponse) {
        if (partialResponse == null) {
            return;
        }
        List<CompletionChoice> choices = partialResponse.choices();
        if (choices == null || choices.isEmpty()) {
            return;
        }
        CompletionChoice completionChoice = choices.get(0);
        if (completionChoice == null) {
            return;
        }
        String finishReason = completionChoice.finishReason();
        if (finishReason != null) {
            this.finishReason = finishReason;
        }
        String token = completionChoice.text();
        if (token != null) {
            contentBuilder.append(token);
            outputTokenCount.incrementAndGet();
        }
    }
    public Response<AiMessage> build() {
        String content = contentBuilder.toString();
        if (!content.isEmpty()) {
            return Response.from(
                    AiMessage.from(content),
                    new TokenUsage(inputTokenCount, outputTokenCount.get()),
                    finishReasonFrom(finishReason)
            );
        }
        String toolName = toolNameBuilder.toString();
        if (!toolName.isEmpty()) {
            return Response.from(
                    AiMessage.from(ToolExecutionRequest.builder()
                            .name(toolName)
                            .arguments(toolArgumentsBuilder.toString())
                            .build()),
                    new TokenUsage(inputTokenCount, outputTokenCount.get()),
                    finishReasonFrom(finishReason)
            );
        }
        return null;
    }
}
```

langchain4j-open-ai\src\main\java\dev\langchain4j\model\openai\OpenAiTokenizer.java

```
package dev.langchain4j.model.openai;
import com.knuddels.jtokkit.Encodings;
import com.knuddels.jtokkit.api.Encoding;
import dev.langchain4j.agent.tool.ToolExecutionRequest;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.ToolExecutionResultMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.model.Tokenizer;
import java.util.List;
import java.util.Map;
import java.util.Optional;
import java.util.function.Supplier;
import static dev.langchain4j.internal.Exceptions.illegalArgument;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static dev.langchain4j.model.openai.InternalOpenAiHelper.roleFrom;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO_0301;
public class OpenAiTokenizer implements Tokenizer {
    private final String modelName;
    private final Optional<Encoding> encoding;
    public OpenAiTokenizer(String modelName) {
        this.modelName = ensureNotBlank(modelName, "modelName");
        // If the model is unknown, we should NOT fail fast during the
creation of OpenAiTokenizer.
        // Doing so would cause the failure of every OpenAI***Model that uses
this tokenizer.
        // This is done to account for situations when a new OpenAI model is
available,
        // but JTokkit does not yet support it.
        this.encoding =
Encodings.newLazyEncodingRegistry().getEncodingForModel(modelName);
    }
    public int estimateTokenCountInText(String text) {
        return encoding.orElseThrow(unknownModelException())
                .countTokensOrdinary(text);
    }
    @Override
    public int estimateTokenCountInMessage(ChatMessage message) {
        int tokenCount = 0;
        tokenCount += extraTokensPerMessage();
        tokenCount += estimateTokenCountInText(message.text());
        tokenCount += estimateTokenCountInText(roleFrom(message).toString());
        if (message instanceof UserMessage) {
            UserMessage userMessage = (UserMessage) message;
            if (userMessage.name() != null) {
                tokenCount += extraTokensPerName();
                tokenCount += estimateTokenCountInText(userMessage.name());
            }
        }
        if (message instanceof AiMessage) {
            AiMessage aiMessage = (AiMessage) message;
            if (aiMessage.toolExecutionRequest() != null) {
                tokenCount += 4; // found experimentally while playing with
OpenAI API
                ToolExecutionRequest toolExecutionRequest =
aiMessage.toolExecutionRequest();
```

```
                tokenCount +=
estimateTokenCountInText(toolExecutionRequest.name());
                tokenCount +=
estimateTokenCountInText(toolExecutionRequest.arguments());
            }
        }
        if (message instanceof ToolExecutionResultMessage) {
            ToolExecutionResultMessage toolExecutionResultMessage =
(ToolExecutionResultMessage) message;
            tokenCount += -1; // found experimentally while playing with
OpenAI API
            tokenCount +=
estimateTokenCountInText(toolExecutionResultMessage.toolName());
        }
        return tokenCount;
    }
    @Override
    public int estimateTokenCountInMessages(Iterable<ChatMessage> messages) {
        // see https://github.com/openai/openai-cookbook/blob/main/examples/
How_to_count_tokens_with_tiktoken.ipynb
        int tokenCount = 3; // every reply is primed with <|start|>assistant<|
message|>
        for (ChatMessage message : messages) {
            tokenCount += estimateTokenCountInMessage(message);
        }
        return tokenCount;
    }
    @Override
    public int
estimateTokenCountInToolSpecifications(Iterable<ToolSpecification>
toolSpecifications) {
        int tokenCount = 0;
        for (ToolSpecification toolSpecification : toolSpecifications) {
            tokenCount += estimateTokenCountInText(toolSpecification.name());
            tokenCount +=
estimateTokenCountInText(toolSpecification.description());
            Map<String, Map<String, Object>> properties =
toolSpecification.parameters().properties();
            for (String property : properties.keySet()) {
                for (Map.Entry<String, Object> entry :
properties.get(property).entrySet()) {
                    if ("type".equals(entry.getKey())) {
                        tokenCount += 3; // found experimentally while
playing with OpenAI API
                        tokenCount +=
estimateTokenCountInText(entry.getValue().toString());
                    } else if ("description".equals(entry.getKey())) {
                        tokenCount += 3; // found experimentally while
playing with OpenAI API
                        tokenCount +=
estimateTokenCountInText(entry.getValue().toString());
                    } else if ("enum".equals(entry.getKey())) {
                        tokenCount -= 3; // found experimentally while
playing with OpenAI API
                        for (Object enumValue : (Object[]) entry.getValue()) {
                            tokenCount += 3; // found experimentally while
playing with OpenAI API
                            tokenCount +=
estimateTokenCountInText(enumValue.toString());
                        }
                    }
```

```
                }
            }
            tokenCount += 12; // found experimentally while playing with
OpenAI API
        }
        tokenCount += 12; // found experimentally while playing with OpenAI
API
        return tokenCount;
    }
    private int extraTokensPerMessage() {
        if (modelName.equals(GPT_3_5_TURBO_0301)) {
            return 4;
        } else {
            return 3;
        }
    }
    private int extraTokensPerName() {
        if (modelName.equals(GPT_3_5_TURBO_0301)) {
            return -1; // if there's a name, the role is omitted
        } else {
            return 1;
        }
    }
    public List<Integer> encode(String text) {
        return encoding.orElseThrow(unknownModelException())
                .encodeOrdinary(text);
    }
    public List<Integer> encode(String text, int maxTokensToEncode) {
        return encoding.orElseThrow(unknownModelException())
                .encodeOrdinary(text, maxTokensToEncode).getTokens();
    }
    public String decode(List<Integer> tokens) {
        return encoding.orElseThrow(unknownModelException())
                .decode(tokens);
    }
    private Supplier<IllegalArgumentException> unknownModelException() {
        return () -> illegalArgument("Model '%s' is unknown to jtokkit",
modelName);
    }
}
```

langchain4j-open-ai\src\test\java\dev\langchain4j\model\openai\OpenAiChatModelIT.java

```
package dev.langchain4j.model.openai;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import org.junit.jupiter.api.Test;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.model.output.FinishReason.LENGTH;
import static dev.langchain4j.model.output.FinishReason.STOP;
import static org.assertj.core.api.Assertions.assertThat;
class OpenAiChatModelIT {
    @Test
    void
should_generate_answer_and_return_token_usage_and_finish_reason_stop() {
        ChatLanguageModel model =
OpenAiChatModel.withApiKey(System.getenv("OPENAI_API_KEY"));
        UserMessage userMessage = userMessage("hello, how are you?");
        Response<AiMessage> response = model.generate(userMessage);
        System.out.println(response);
        assertThat(response.content().text()).isNotBlank();
        TokenUsage tokenUsage = response.tokenUsage();
        assertThat(tokenUsage.inputTokenCount()).isEqualTo(13);
        assertThat(tokenUsage.outputTokenCount()).isGreaterThan(1);
        assertThat(tokenUsage.totalTokenCount()).isGreaterThan(14);
        assertThat(response.finishReason()).isEqualTo(STOP);
    }
    @Test
    void
should_generate_answer_and_return_token_usage_and_finish_reason_length() {
        ChatLanguageModel model = OpenAiChatModel.builder()
                .apiKey(System.getenv("OPENAI_API_KEY"))
                .maxTokens(3)
                .build();
        UserMessage userMessage = userMessage("hello, how are you?");
        Response<AiMessage> response = model.generate(userMessage);
        System.out.println(response);
        assertThat(response.content().text()).isNotBlank();
        TokenUsage tokenUsage = response.tokenUsage();
        assertThat(tokenUsage.inputTokenCount()).isEqualTo(13);
        assertThat(tokenUsage.outputTokenCount()).isEqualTo(3);
        assertThat(tokenUsage.totalTokenCount()).isEqualTo(16);
        assertThat(response.finishReason()).isEqualTo(LENGTH);
    }
}
```

langchain4j-open-ai\src\test\java\dev\langchain4j\model\openai\OpenAiEmbeddingModelIT.java

```
package dev.langchain4j.model.openai;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class OpenAiEmbeddingModelIT {
    EmbeddingModel model =
OpenAiEmbeddingModel.withApiKey(System.getenv("OPENAI_API_KEY"));
    @Test
    void should_embed_and_return_token_usage() {
        Response<Embedding> response = model.embed("hello world");
        System.out.println(response);
        assertThat(response.content().vector()).hasSize(1536);
        TokenUsage tokenUsage = response.tokenUsage();
        assertThat(tokenUsage.inputTokenCount()).isEqualTo(2);
        assertThat(tokenUsage.outputTokenCount()).isNull();
        assertThat(tokenUsage.totalTokenCount()).isEqualTo(2);
        assertThat(response.finishReason()).isNull();
    }
}
```

langchain4j-open-ai\src\test\java\dev\langchain4j\model\openai\OpenAiLanguageModelIT.java

```
package dev.langchain4j.model.openai;
import dev.langchain4j.model.language.LanguageModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import org.junit.jupiter.api.Test;
import static dev.langchain4j.model.output.FinishReason.STOP;
import static org.assertj.core.api.Assertions.assertThat;
class OpenAiLanguageModelIT {
    LanguageModel model = OpenAiLanguageModel.builder()
            .apiKey(System.getenv("OPENAI_API_KEY"))
            .logRequests(true)
            .logResponses(true)
            .build();
    @Test
    void
should_generate_answer_and_return_token_usage_and_finish_reason_stop() {
        String prompt = "Hello, how are you?";
        Response<String> response = model.generate(prompt);
        System.out.println(response);
        assertThat(response.content()).isNotBlank();
        TokenUsage tokenUsage = response.tokenUsage();
        assertThat(tokenUsage.inputTokenCount()).isEqualTo(6);
        assertThat(tokenUsage.outputTokenCount()).isGreaterThan(0);
        assertThat(tokenUsage.totalTokenCount())
                .isEqualTo(tokenUsage.inputTokenCount() +
tokenUsage.outputTokenCount());
        assertThat(response.finishReason()).isEqualTo(STOP);
    }
}
```

langchain4j-open-ai\src\test\java\dev\langchain4j\model\openai\OpenAiModerationModelIT.java

```
package dev.langchain4j.model.openai;
import dev.langchain4j.model.moderation.Moderation;
import dev.langchain4j.model.moderation.ModerationModel;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class OpenAiModerationModelIT {
    ModerationModel model = OpenAiModerationModel.builder()
            .apiKey(System.getenv("OPENAI_API_KEY"))
            .build();
    @Test
    void should_flag() {
        Moderation moderation = model.moderate("I want to kill
them.").content();
        assertThat(moderation.flagged()).isTrue();
    }
    @Test
    void should_not_flag() {
        Moderation moderation = model.moderate("I want to hug
them.").content();
        assertThat(moderation.flagged()).isFalse();
    }
}
```

langchain4j-open-ai\src\test\java\dev\langchain4j\model\openai\OpenAiStreamingChatModelIT.java

```
package dev.langchain4j.model.openai;
import dev.langchain4j.agent.tool.ToolExecutionRequest;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.api.Test;
import java.util.concurrent.CompletableFuture;
import java.util.concurrent.ExecutionException;
import java.util.concurrent.TimeoutException;
import static dev.langchain4j.agent.tool.JsonSchemaProperty.INTEGER;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.model.output.FinishReason.STOP;
import static dev.langchain4j.model.output.FinishReason.TOOL_EXECUTION;
import static java.util.Collections.singletonList;
import static java.util.concurrent.TimeUnit.SECONDS;
import static org.assertj.core.api.Assertions.assertThat;
class OpenAiStreamingChatModelIT {
    StreamingChatLanguageModel model = OpenAiStreamingChatModel.builder()
            .apiKey(System.getenv("OPENAI_API_KEY"))
            .logRequests(true)
            .logResponses(true)
            .build();
    @Test
    void should_stream_answer() throws ExecutionException,
InterruptedException, TimeoutException {
        CompletableFuture<String> futureAnswer = new CompletableFuture<>();
        CompletableFuture<Response<AiMessage>> futureResponse = new
CompletableFuture<>();
        model.generate("What is the capital of Germany?", new
StreamingResponseHandler<AiMessage>() {
            private final StringBuilder answerBuilder = new StringBuilder();
            @Override
            public void onNext(String token) {
                System.out.println("onNext: '" + token + "'");
                answerBuilder.append(token);
            }
            @Override
            public void onComplete(Response<AiMessage> response) {
                System.out.println("onComplete: '" + response + "'");
                futureAnswer.complete(answerBuilder.toString());
                futureResponse.complete(response);
            }
            @Override
            public void onError(Throwable error) {
                futureAnswer.completeExceptionally(error);
                futureResponse.completeExceptionally(error);
            }
        });
        String answer = futureAnswer.get(30, SECONDS);
        Response<AiMessage> response = futureResponse.get(30, SECONDS);
        assertThat(answer).contains("Berlin");
        assertThat(response.content().text()).isEqualTo(answer);
        assertThat(response.tokenUsage().inputTokenCount()).isEqualTo(14);
        assertThat(response.tokenUsage().outputTokenCount()).isGreaterThan(0);
```

```
        assertThat(response.tokenUsage().totalTokenCount())
                .isEqualTo(response.tokenUsage().inputTokenCount() +
response.tokenUsage().outputTokenCount());
        assertThat(response.finishReason()).isEqualTo(STOP);
    }
    @Test
    void should_return_tool_execution_request() throws Exception {
        ToolSpecification toolSpecification = ToolSpecification.builder()
                .name("calculator")
                .description("returns a sum of two numbers")
                .addParameter("first", INTEGER)
                .addParameter("second", INTEGER)
                .build();
        UserMessage userMessage = userMessage("Two plus two?");
        CompletableFuture<Response<AiMessage>> futureResponse = new
CompletableFuture<>();
        model.generate(singletonList(userMessage),
singletonList(toolSpecification), new StreamingResponseHandler<AiMessage>() {
            @Override
            public void onNext(String token) {
                System.out.println("onNext: '" + token + "'");
                Exception e = new IllegalStateException("onNext() should
never be called when tool is executed");
                futureResponse.completeExceptionally(e);
            }
            @Override
            public void onComplete(Response<AiMessage> response) {
                System.out.println("onComplete: '" + response + "'");
                futureResponse.complete(response);
            }
            @Override
            public void onError(Throwable error) {
                futureResponse.completeExceptionally(error);
            }
        });
        Response<AiMessage> response = futureResponse.get(30, SECONDS);
        AiMessage aiMessage = response.content();
        assertThat(aiMessage.text()).isNull();
        ToolExecutionRequest toolExecutionRequest =
aiMessage.toolExecutionRequest();
        assertThat(toolExecutionRequest.name()).isEqualTo("calculator");
        assertThat(toolExecutionRequest.arguments()).isEqualToIgnoringWhitespa
ce("{\"first\": 2, \"second\": 2}");
        assertThat(response.tokenUsage().inputTokenCount()).isEqualTo(50);
        assertThat(response.tokenUsage().outputTokenCount()).isGreaterThan(0);
        assertThat(response.tokenUsage().totalTokenCount())
                .isEqualTo(response.tokenUsage().inputTokenCount() +
response.tokenUsage().outputTokenCount());
        assertThat(response.finishReason()).isEqualTo(TOOL_EXECUTION);
    }
}
```

langchain4j-open-ai\src\test\java\dev\langchain4j\model\openai\OpenAiStreamingLanguageModelIT.java

```
package dev.langchain4j.model.openai;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.language.StreamingLanguageModel;
import dev.langchain4j.model.output.Response;
import org.junit.jupiter.api.Test;
import java.util.concurrent.CompletableFuture;
import java.util.concurrent.ExecutionException;
import java.util.concurrent.TimeoutException;
import static dev.langchain4j.model.output.FinishReason.STOP;
import static java.util.concurrent.TimeUnit.SECONDS;
import static org.assertj.core.api.Assertions.assertThat;
class OpenAiStreamingLanguageModelIT {
    StreamingLanguageModel model = OpenAiStreamingLanguageModel.builder()
            .apiKey(System.getenv("OPENAI_API_KEY"))
            .logRequests(true)
            .logResponses(true)
            .build();
    @Test
    void should_stream_answer() throws ExecutionException,
InterruptedException, TimeoutException {
        CompletableFuture<String> futureAnswer = new CompletableFuture<>();
        CompletableFuture<Response<String>> futureResponse = new
CompletableFuture<>();
        model.generate("What is the capital of Germany?", new
StreamingResponseHandler<String>() {
            private final StringBuilder answerBuilder = new StringBuilder();
            @Override
            public void onNext(String token) {
                System.out.println("onNext: '" + token + "'");
                answerBuilder.append(token);
            }
            @Override
            public void onComplete(Response<String> response) {
                System.out.println("onComplete: '" + response + "'");
                futureAnswer.complete(answerBuilder.toString());
                futureResponse.complete(response);
            }
            @Override
            public void onError(Throwable error) {
                futureAnswer.completeExceptionally(error);
                futureResponse.completeExceptionally(error);
            }
        });
        String answer = futureAnswer.get(30, SECONDS);
        Response<String> response = futureResponse.get(30, SECONDS);
        assertThat(answer).contains("Berlin");
        assertThat(response.content()).isEqualTo(answer);
        assertThat(response.tokenUsage().inputTokenCount()).isEqualTo(7);
        assertThat(response.tokenUsage().outputTokenCount()).isGreaterThan(1);
        assertThat(response.tokenUsage().totalTokenCount()).isGreaterThan(8);
        assertThat(response.finishReason()).isEqualTo(STOP);
    }
}
```

langchain4j-open-ai\src\test\java\dev\langchain4j\model\openai\OpenAiTokenizerTest.java

```
package dev.langchain4j.model.openai;
import dev.langchain4j.agent.tool.P;
import dev.langchain4j.agent.tool.Tool;
import dev.langchain4j.agent.tool.ToolExecutionRequest;
import dev.langchain4j.data.message.ChatMessage;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.params.ParameterizedTest;
import org.junit.jupiter.params.provider.Arguments;
import org.junit.jupiter.params.provider.MethodSource;
import java.util.ArrayList;
import java.util.List;
import java.util.stream.Stream;
import static dev.langchain4j.data.message.AiMessage.aiMessage;
import static dev.langchain4j.data.message.ToolExecutionResultMessage.toolExec
utionResultMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static java.util.Arrays.asList;
import static java.util.Collections.singletonList;
import static org.assertj.core.api.Assertions.assertThat;
class OpenAiTokenizerTest {
    OpenAiTokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
    @ParameterizedTest
    @MethodSource
    void should_count_tokens_in_messages(List<ChatMessage> messages, int
expectedTokenCount) {
        int tokenCount = tokenizer.estimateTokenCountInMessages(messages);
        assertThat(tokenCount).isEqualTo(expectedTokenCount);
    }
    static Stream<Arguments> should_count_tokens_in_messages() {
        // expected token count was taken from real OpenAI responses
(usage.prompt_tokens)
        return Stream.of(
                Arguments.of(singletonList(userMessage("hello")), 8),
                Arguments.of(singletonList(userMessage("Klaus", "hello")),
11),
                Arguments.of(asList(userMessage("hello"), aiMessage("hi
there")), 14),
                Arguments.of(asList(
                        userMessage("How much is 2 plus 2?"),
                        aiMessage(ToolExecutionRequest.builder()
                                .name("calculator")
                                .arguments("{\"a\":2, \"b\":2}")
                                .build())
                ), 35),
                Arguments.of(asList(
                        userMessage("How much is 2 plus 2?"),
                        aiMessage(ToolExecutionRequest.builder()
                                .name("calculator")
                                .arguments("{\"a\":2, \"b\":2}")
                                .build()),
                        toolExecutionResultMessage("calculator", "4")
                ), 40)
        );
    }
    static class Tools {
        @Tool
```

```
        int add(int a, int b) {
            return a + b;
        }
        @Tool("calculates the square root of the provided number")
        double squareRoot(@P("number to operate on") double number) {
            return Math.sqrt(number);
        }
        @Tool
        int temperature(String location, TemperatureUnit temperatureUnit) {
            return 0;
        }
    }
    enum TemperatureUnit {
        F, C
    }
    @Test
    void should_count_tokens_in_tools() {
        int tokenCount = tokenizer.estimateTokenCountInTools(new Tools());
        assertThat(tokenCount).isEqualTo(93); // found experimentally while
playing with OpenAI API
    }
    @Test
    void should_encode_and_decode_text() {
        String originalText = "This is a text which will be encoded and
decoded back.";
        List<Integer> tokens = tokenizer.encode(originalText);
        String decodedText = tokenizer.decode(tokens);
        assertThat(decodedText).isEqualTo(originalText);
    }
    @Test
    void should_encode_with_truncation_and_decode_text() {
        String originalText = "This is a text which will be encoded with
truncation and decoded back.";
        List<Integer> tokens = tokenizer.encode(originalText, 10);
        assertThat(tokens).hasSize(10);
        String decodedText = tokenizer.decode(tokens);
        assertThat(decodedText).isEqualTo("This is a text which will be
encoded with trunc");
    }
    @Test
    void should_count_tokens_in_short_texts() {
        assertThat(tokenizer.estimateTokenCountInText("Hello")).isEqualTo(1);
        assertThat(tokenizer.estimateTokenCountInText("Hello!")).isEqualTo(2);
        assertThat(tokenizer.estimateTokenCountInText("Hello, how are
you?")).isEqualTo(6);
    }
    @Test
    void should_count_tokens_in_average_text() {
        String text1 = "Hello, how are you doing? What do you want to talk
about?";
        assertThat(tokenizer.estimateTokenCountInText(text1)).isEqualTo(15);
        String text2 = String.join(" ", repeat("Hello, how are you doing?
What do you want to talk about?", 2));
        assertThat(tokenizer.estimateTokenCountInText(text2)).isEqualTo(2 *
15);
        String text3 = String.join(" ", repeat("Hello, how are you doing?
What do you want to talk about?", 3));
        assertThat(tokenizer.estimateTokenCountInText(text3)).isEqualTo(3 *
15);
    }
    @Test
```

```
    void should_count_tokens_in_large_text() {
        String text1 = String.join(" ", repeat("Hello, how are you doing? What do you want to talk about?", 10));
        assertThat(tokenizer.estimateTokenCountInText(text1)).isEqualTo(10 * 15);
        String text2 = String.join(" ", repeat("Hello, how are you doing? What do you want to talk about?", 50));
        assertThat(tokenizer.estimateTokenCountInText(text2)).isEqualTo(50 * 15);
        String text3 = String.join(" ", repeat("Hello, how are you doing? What do you want to talk about?", 100));
        assertThat(tokenizer.estimateTokenCountInText(text3)).isEqualTo(100 * 15);
    }
    public static List<String> repeat(String s, int n) {
        List<String> result = new ArrayList<>();
        for (int i = 0; i < n; i++) {
            result.add(s);
        }
        return result;
    }
}
```

langchain4j-opensearch\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-opensearch</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with OpenSearch</name>
    <description>Requires Java 11</description>
    <properties>
        <maven.compiler.source>11</maven.compiler.source>
        <maven.compiler.target>11</maven.compiler.target>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>org.apache.httpcomponents.client5</groupId>
            <artifactId>httpclient5</artifactId>
        </dependency>
        <dependency>
            <groupId>org.opensearch.client</groupId>
            <artifactId>opensearch-java</artifactId>
        </dependency>
        <dependency>
            <groupId>software.amazon.awssdk</groupId>
            <artifactId>opensearch</artifactId>
        </dependency>
        <dependency>
            <groupId>com.amazonaws</groupId>
            <artifactId>aws-java-sdk-core</artifactId>
        </dependency>
        <dependency>
            <groupId>software.amazon.awssdk</groupId>
            <artifactId>apache-client</artifactId>
        </dependency>
        <dependency>
            <groupId>com.fasterxml.jackson.core</groupId>
            <artifactId>jackson-databind</artifactId>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.slf4j</groupId>
            <artifactId>slf4j-api</artifactId>
```

```
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.testcontainers</groupId>
            <artifactId>testcontainers</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.testcontainers</groupId>
            <artifactId>junit-jupiter</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.opensearch</groupId>
            <artifactId>opensearch-testcontainers</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-opensearch\src\main\java\dev\langchain4j\store\embedding\opensearch\Document.java

```
package dev.langchain4j.store.embedding.opensearch;
import lombok.AllArgsConstructor;
import lombok.Builder;
import lombok.Data;
import lombok.NoArgsConstructor;
import java.util.Map;
@Data
@NoArgsConstructor
@AllArgsConstructor
@Builder
class Document {
    private float[] vector;
    private String text;
    private Map<String, String> metadata;
}
```

langchain4j-opensearch\src\main\java\dev\langchain4j\store\embedding\opensearch\OpenSearchEmbeddingStore.java

```
package dev.langchain4j.store.embedding.opensearch;
import com.fasterxml.jackson.core.JsonProcessingException;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import org.apache.hc.client5.http.auth.AuthScope;
import org.apache.hc.client5.http.auth.UsernamePasswordCredentials;
import org.apache.hc.client5.http.impl.auth.BasicCredentialsProvider;
import org.apache.hc.client5.http.impl.nio.PoolingAsyncClientConnectionManager
Builder;
import org.apache.hc.core5.http.HttpHost;
import org.apache.hc.core5.http.message.BasicHeader;
import org.opensearch.client.json.JsonData;
import org.opensearch.client.json.jackson.JacksonJsonpMapper;
import org.opensearch.client.opensearch.OpenSearchClient;
import org.opensearch.client.opensearch._types.ErrorCause;
import org.opensearch.client.opensearch._types.InlineScript;
import org.opensearch.client.opensearch._types.mapping.Property;
import org.opensearch.client.opensearch._types.mapping.TextProperty;
import org.opensearch.client.opensearch._types.mapping.TypeMapping;
import org.opensearch.client.opensearch._types.query_dsl.Query;
import org.opensearch.client.opensearch._types.query_dsl.ScriptScoreQuery;
import org.opensearch.client.opensearch.core.BulkRequest;
import org.opensearch.client.opensearch.core.BulkResponse;
import org.opensearch.client.opensearch.core.SearchRequest;
import org.opensearch.client.opensearch.core.SearchResponse;
import org.opensearch.client.opensearch.core.bulk.BulkResponseItem;
import org.opensearch.client.transport.OpenSearchTransport;
import org.opensearch.client.transport.aws.AwsSdk2Transport;
import org.opensearch.client.transport.aws.AwsSdk2TransportOptions;
import org.opensearch.client.transport.endpoints.BooleanResponse;
import
org.opensearch.client.transport.httpclient5.ApacheHttpClient5TransportBuilder;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import software.amazon.awssdk.http.SdkHttpClient;
import software.amazon.awssdk.http.apache.ApacheHttpClient;
import software.amazon.awssdk.regions.Region;
import java.io.IOException;
import java.net.URISyntaxException;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import java.util.Optional;
import static dev.langchain4j.internal.Utils.*;
import static dev.langchain4j.internal.ValidationUtils.ensureNotNull;
import static dev.langchain4j.internal.ValidationUtils.ensureTrue;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.toList;
/**
 * Represents an <a href="https://opensearch.org/">OpenSearch</a> index as an
 * embedding store. This implementation uses K-NN and the cosinesimil space
type.
 */
public class OpenSearchEmbeddingStore implements EmbeddingStore<TextSegment> {
```

```
    private static final Logger log =
LoggerFactory.getLogger(OpenSearchEmbeddingStore.class);
    private final String indexName;
    private final OpenSearchClient client;
    /**
     * Creates an instance of OpenSearchEmbeddingStore to connect with
     * OpenSearch clusters running locally and network reachable.
     *
     * @param serverUrl OpenSearch Server URL.
     * @param apiKey    OpenSearch API key (optional)
     * @param userName  OpenSearch username (optional)
     * @param password  OpenSearch password (optional)
     * @param indexName OpenSearch index name (optional). Default value:
"default"
     */
    public OpenSearchEmbeddingStore(String serverUrl,
                                    String apiKey,
                                    String userName,
                                    String password,
                                    String indexName) {
        HttpHost openSearchHost;
        try {
            openSearchHost = HttpHost.create(serverUrl);
        } catch (URISyntaxException se) {
            log.error("[I/O OpenSearch Exception]", se);
            throw new OpenSearchRequestFailedException(se.getMessage());
        }
        OpenSearchTransport transport = ApacheHttpClient5TransportBuilder
                .builder(openSearchHost)
                .setMapper(new JacksonJsonpMapper())
                .setHttpClientConfigCallback(httpClientBuilder -> {
                    if (!isNullOrBlank(apiKey)) {
                        httpClientBuilder.setDefaultHeaders(singletonList(
                                new BasicHeader("Authorization", "ApiKey " +
apiKey)
                        ));
                    }
                    if (!isNullOrBlank(userName) && !isNullOrBlank(password))
{
                        BasicCredentialsProvider credentialsProvider = new
BasicCredentialsProvider();
                        credentialsProvider.setCredentials(new
AuthScope(openSearchHost),
                                new UsernamePasswordCredentials(userName,
password.toCharArray()));

httpClientBuilder.setDefaultCredentialsProvider(credentialsProvider);
                    }
                    httpClientBuilder.setConnectionManager(PoolingAsyncClientC
onnectionManagerBuilder.create().build());
                    return httpClientBuilder;
                })
                .build();
        this.client = new OpenSearchClient(transport);
        this.indexName = ensureNotNull(indexName, "indexName");
    }
    /**
     * Creates an instance of OpenSearchEmbeddingStore to connect with
     * OpenSearch clusters running as a fully managed service at AWS.
     *
     * @param serverUrl   OpenSearch Server URL.
```

```
     * @param serviceName The AWS signing service name, one of `es` (Amazon
OpenSearch) or `aoss` (Amazon OpenSearch Serverless).
     * @param region      The AWS region for which requests will be signed.
This should typically match the region in `serverUrl`.
     * @param options     The options to establish connection with the
service. It must include which credentials should be used.
     * @param indexName   OpenSearch index name (optional). Default value:
"default"
     */
    public OpenSearchEmbeddingStore(String serverUrl,
                                    String serviceName,
                                    String region,
                                    AwsSdk2TransportOptions options,
                                    String indexName) {
        Region selectedRegion = Region.of(region);
        SdkHttpClient httpClient = ApacheHttpClient.builder().build();
        OpenSearchTransport transport = new AwsSdk2Transport(httpClient,
serverUrl, serviceName, selectedRegion, options);
        this.client = new OpenSearchClient(transport);
        this.indexName = ensureNotNull(indexName, "indexName");
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String serverUrl;
        private String apiKey;
        private String userName;
        private String password;
        private String serviceName;
        private String region;
        private AwsSdk2TransportOptions options;
        private String indexName = "default";
        public Builder serverUrl(String serverUrl) {
            this.serverUrl = serverUrl;
            return this;
        }
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
        }
        public Builder userName(String userName) {
            this.userName = userName;
            return this;
        }
        public Builder password(String password) {
            this.password = password;
            return this;
        }
        public Builder serviceName(String serviceName) {
            this.serviceName = serviceName;
            return this;
        }
        public Builder region(String region) {
            this.region = region;
            return this;
        }
        public Builder options(AwsSdk2TransportOptions options) {
            this.options = options;
            return this;
        }
```

```
        public Builder indexName(String indexName) {
            this.indexName = indexName;
            return this;
        }
        public OpenSearchEmbeddingStore build() {
            if (!isNullOrBlank(serviceName) && !isNullOrBlank(region) &&
options != null) {
                return new OpenSearchEmbeddingStore(serverUrl, serviceName,
region, options, indexName);
            }
            return new OpenSearchEmbeddingStore(serverUrl, apiKey, userName,
password, indexName);
        }
    }
    @Override
    public String add(Embedding embedding) {
        String id = randomUUID();
        add(id, embedding);
        return id;
    }
    @Override
    public void add(String id, Embedding embedding) {
        addInternal(id, embedding, null);
    }
    @Override
    public String add(Embedding embedding, TextSegment textSegment) {
        String id = randomUUID();
        addInternal(id, embedding, textSegment);
        return id;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings) {
        List<String> ids = embeddings.stream()
                .map(ignored -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, null);
        return ids;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings, List<TextSegment>
embedded) {
        List<String> ids = embeddings.stream()
                .map(ignored -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, embedded);
        return ids;
    }
    /**
     * This implementation uses the exact k-NN with scoring script to
calculate
     * See https://opensearch.org/docs/latest/search-plugins/knn/knn-score-
script/
     */
    @Override
    public List<EmbeddingMatch<TextSegment>> findRelevant(Embedding
referenceEmbedding, int maxResults, double minScore) {
        List<EmbeddingMatch<TextSegment>> matches;
        try {
            ScriptScoreQuery scriptScoreQuery =
buildDefaultScriptScoreQuery(referenceEmbedding.vector(), (float) minScore);
            SearchResponse<Document> response = client.search(
```

```
                    SearchRequest.of(s -> s.index(indexName)
                            .query(n -> n.scriptScore(scriptScoreQuery))
                            .size(maxResults)),
                    Document.class
            );
            matches = toEmbeddingMatch(response);
        } catch (IOException ex) {
            log.error("[I/O OpenSearch Exception]", ex);
            throw new OpenSearchRequestFailedException(ex.getMessage());
        }
        return matches;
    }
    private ScriptScoreQuery buildDefaultScriptScoreQuery(float[] vector,
float minScore) throws JsonProcessingException {
        return ScriptScoreQuery.of(q -> q.minScore(minScore)
                .query(Query.of(qu -> qu.matchAll(m -> m)))
                .script(s -> s.inline(InlineScript.of(i -> i
                        .source("knn_score")
                        .lang("knn")
                        .params("field", JsonData.of("vector"))
                        .params("query_value", JsonData.of(vector))
                        .params("space_type", JsonData.of("cosinesimil")))))
                .boost(0.5f));
        // ===> From the OpenSearch documentation:
        // "Cosine similarity returns a number between -1 and 1, and because
OpenSearch
        // relevance scores can't be below 0, the k-NN plugin adds 1 to get
the final score."
        // See https://opensearch.org/docs/latest/search-plugins/knn/knn-
score-script
        // Thus, the query applies a boost of `0.5` to keep score in the
range [0, 1]
    }
    private void addInternal(String id, Embedding embedding, TextSegment
embedded) {
        addAllInternal(singletonList(id), singletonList(embedding), embedded
== null ? null : singletonList(embedded));
    }
    private void addAllInternal(List<String> ids, List<Embedding> embeddings,
List<TextSegment> embedded) {
        if (isCollectionEmpty(ids) || isCollectionEmpty(embeddings)) {
            log.info("[do not add empty embeddings to opensearch]");
            return;
        }
        ensureTrue(ids.size() == embeddings.size(), "ids size is not equal to
embeddings size");
        ensureTrue(embedded == null || embeddings.size() == embedded.size(),
"embeddings size is not equal to embedded size");
        try {
            createIndexIfNotExist(embeddings.get(0).dimensions());
            bulk(ids, embeddings, embedded);
        } catch (IOException ex) {
            log.error("[I/O OpenSearch Exception]", ex);
            throw new OpenSearchRequestFailedException(ex.getMessage());
        }
    }
    private void createIndexIfNotExist(int dimension) throws IOException {
        BooleanResponse response = client.indices().exists(c ->
c.index(indexName));
        if (!response.value()) {
            client.indices()
```

```
                    .create(c -> c.index(indexName)
                            .settings(s -> s.knn(true))
                            .mappings(getDefaultMappings(dimension)));
        }
    }
    private TypeMapping getDefaultMappings(int dimension) {
        Map<String, Property> properties = new HashMap<>(4);
        properties.put("text", Property.of(p -> p.text(TextProperty.of(t ->
t))));
        properties.put("vector", Property.of(p -> p.knnVector(
                k -> k.dimension(dimension)
        )));
        return TypeMapping.of(c -> c.properties(properties));
    }
    private void bulk(List<String> ids, List<Embedding> embeddings,
List<TextSegment> embedded) throws IOException {
        int size = ids.size();
        BulkRequest.Builder bulkBuilder = new BulkRequest.Builder();
        for (int i = 0; i < size; i++) {
            int finalI = i;
            Document document = Document.builder()
                    .vector(embeddings.get(i).vector())
                    .text(embedded == null ? null : embedded.get(i).text())
                    .metadata(embedded == null ? null :
Optional.ofNullable(embedded.get(i).metadata())
                            .map(Metadata::asMap)
                            .orElse(null))
                    .build();
            bulkBuilder.operations(op -> op.index(
                    idx -> idx
                            .index(indexName)
                            .id(ids.get(finalI))
                            .document(document)
            ));
        }
        BulkResponse bulkResponse = client.bulk(bulkBuilder.build());
        if (bulkResponse.errors()) {
            for (BulkResponseItem item : bulkResponse.items()) {
                if (item.error() != null) {
                    ErrorCause errorCause = item.error();
                    if (errorCause != null) {
                        throw new OpenSearchRequestFailedException(
                                "type: " + errorCause.type() + "," +
                                        "reason: " + errorCause.reason());
                    }
                }
            }
        }
    }
    private List<EmbeddingMatch<TextSegment>>
toEmbeddingMatch(SearchResponse<Document> response) {
        return response.hits().hits().stream()
                .map(hit -> Optional.ofNullable(hit.source())
                        .map(document -> new EmbeddingMatch<>(
                                hit.score(),
                                hit.id(),
                                new Embedding(document.getVector()),
                                document.getText() == null
                                        ? null
                                        :
TextSegment.from(document.getText(), new Metadata(document.getMetadata()))
```

```
                        )).orElse(null))
                .collect(toList());
    }
}
```

langchain4j-opensearch\src\main\java\dev\langchain4j\store\embedding\opensearch\OpenSearchRequestFailedException.java

```
package dev.langchain4j.store.embedding.opensearch;
public class OpenSearchRequestFailedException extends RuntimeException {
    public OpenSearchRequestFailedException() {
        super();
    }
    public OpenSearchRequestFailedException(String message) {
        super(message);
    }
    public OpenSearchRequestFailedException(String message, Throwable cause) {
        super(message, cause);
    }
}
```

langchain4j-opensearch\src\test\java\dev\langchain4j\store\embedding\opensearch\OpenSearchEmbeddingStoreAWSTest.java

```
package dev.langchain4j.store.embedding.opensearch;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import org.opensearch.client.transport.aws.AwsSdk2TransportOptions;
import software.amazon.awssdk.auth.credentials.ProfileCredentialsProvider;
import java.util.List;
import java.util.UUID;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
@Disabled("Needs OpenSearch running with AWS")
public class OpenSearchEmbeddingStoreAWSTest {
    /**
     * To run the tests locally, you have to provide an Amazon OpenSearch domain. The code uses
     * the credentials stored locally in your machine. For more information about how to configure
     * your credentials locally, see https://docs.aws.amazon.com/cli/latest/userguide/cli-configure-files.html.
     */
    private final String domainEndpoint = "your-generated-domain-endpoint-with-no-https.us-east-1.es.amazonaws.com";
    private final ProfileCredentialsProvider credentials = ProfileCredentialsProvider.create("default");
    private final AwsSdk2TransportOptions transportOptions = AwsSdk2TransportOptions.builder()
            .setCredentials(credentials)
            .build();
    private final EmbeddingStore<TextSegment> embeddingStore = OpenSearchEmbeddingStore.builder()
            .serverUrl(domainEndpoint)
            .serviceName("es")
            .region("us-east-1")
            .options(transportOptions)
            .indexName(randomUUID())
            .build();
    private final EmbeddingModel embeddingModel = new AllMiniLmL6V2QuantizedEmbeddingModel();
    @Test
    void should_add_embedding() throws InterruptedException {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant = embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
```

```
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() throws InterruptedException {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() throws InterruptedException {
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_embedding_with_segment_with_metadata() throws
InterruptedException {
        TextSegment segment = TextSegment.from(randomUUID(),
Metadata.from("test-key", "test-value"));
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() throws InterruptedException {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
```

```
secondEmbedding));
        assertThat(ids).hasSize(2);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() throws
InterruptedException {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids = embeddingStore.addAll(
                asList(firstEmbedding, secondEmbedding),
                asList(firstSegment, secondSegment)
        );
        assertThat(ids).hasSize(2);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() throws InterruptedException {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
```

```
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() - 0.01
        );
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score()
        );
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() + 0.01
        );
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() throws InterruptedException {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(

RelevanceScore.fromCosineSimilarity(CosineSimilarity.between(embedding,
referenceEmbedding)),
                withPercentage(1)
        );
    }
    public static String randomUUID() {
        return UUID.randomUUID().toString();
    }
}
```

langchain4j-opensearch\src\test\java\dev\langchain4j\store\embedding\opensearch\OpenSearchEmbeddingStoreLocalTest.java

```
package dev.langchain4j.store.embedding.opensearch;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import org.junit.jupiter.api.BeforeAll;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import org.opensearch.testcontainers.OpensearchContainer;
import org.testcontainers.junit.jupiter.Container;
import org.testcontainers.utility.DockerImageName;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
@Disabled("Needs OpenSearch running locally")
class OpenSearchEmbeddingStoreLocalTest {
    /**
     * To run the tests locally, you don't need to have OpenSearch up-and-
running. This implementation
     * uses TestContainers (https://testcontainers.com) and the built-in
support for OpenSearch. Thus,
     * if you just execute the tests then a container will be spun up
automatically for you.
     */
    @Container
    private static final OpensearchContainer opensearch =
            new OpensearchContainer(DockerImageName.parse("opensearchproject/
opensearch:2.10.0"));
    private final EmbeddingStore<TextSegment> embeddingStore =
OpenSearchEmbeddingStore.builder()
            .serverUrl(opensearch.getHttpHostAddress())
            .indexName(randomUUID())
            .build();
    private final EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    @BeforeAll
    static void startOpenSearch() {
        opensearch.start();
    }
    @Test
    void should_add_embedding() throws InterruptedException {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
```

```
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() throws InterruptedException {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() throws InterruptedException {
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_embedding_with_segment_with_metadata() throws
InterruptedException {
        TextSegment segment = TextSegment.from(randomUUID(),
Metadata.from("test-key", "test-value"));
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() throws InterruptedException {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
```

```
        assertThat(ids).hasSize(2);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() throws
InterruptedException {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids = embeddingStore.addAll(
                asList(firstEmbedding, secondEmbedding),
                asList(firstSegment, secondSegment)
        );
        assertThat(ids).hasSize(2);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() throws InterruptedException {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
```

```
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() - 0.01
        );
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score()
        );
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() + 0.01
        );
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() throws InterruptedException {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        Thread.sleep(2000);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(

RelevanceScore.fromCosineSimilarity(CosineSimilarity.between(embedding,
referenceEmbedding)),
                withPercentage(1)
        );
    }
}
```

langchain4j-parent\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>langchain4j-parent</artifactId>
    <version>0.23.0</version>
    <packaging>pom</packaging>
    <name>langchain4j parent POM</name>
    <description>Parent POM for langchain4j submodules</description>
    <url>https://github.com/langchain4j/langchain4j</url>
    <properties>
        <maven.compiler.source>1.8</maven.compiler.source>
        <maven.compiler.target>1.8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
        <openai4j.version>0.10.0</openai4j.version>
        <retrofit.version>2.9.0</retrofit.version>
        <okhttp.version>4.10.0</okhttp.version>
        <jtokkit.version>0.6.1</jtokkit.version>
        <lombok.version>1.18.30</lombok.version>
        <pdfbox.version>2.0.29</pdfbox.version>
        <jsoup.veresion>1.16.1</jsoup.veresion>
        <mustache.version>0.9.10</mustache.version>
        <slf4j-api.version>2.0.7</slf4j-api.version>
        <gson.version>2.10.1</gson.version>
        <junit.version>5.10.0</junit.version>
        <testcontainers.version>1.19.1</testcontainers.version>
        <mockito.version>4.11.0</mockito.version>
        <assertj.version>3.24.2</assertj.version>
        <tinylog.version>2.6.2</tinylog.version>
        <spring-boot.version>2.7.14</spring-boot.version>
        <snakeyaml.version>2.0</snakeyaml.version>
        <httpclient5.version>5.2.1</httpclient5.version>
        <opensearch-java.version>2.6.0</opensearch-java.version>
        <aws-java-sdk-core.version>1.12.564</aws-java-sdk-core.version>
        <aws-opensearch.version>2.20.161</aws-opensearch.version>
        <opensearch-containers.version>2.0.0</opensearch-containers.version>
        <elastic.version>8.9.0</elastic.version>
        <jackson.version>2.12.7.1</jackson.version>
        <jedis.version>5.0.0</jedis.version>
        <aws.java.sdk.version>2.20.149</aws.java.sdk.version>
        <testcontainers.version>1.19.0</testcontainers.version>
        <netty.version>4.1.100.Final</netty.version>
    </properties>
    <dependencyManagement>
        <dependencies>
            <dependency>
                <groupId>dev.ai4j</groupId>
                <artifactId>openai4j</artifactId>
                <version>${openai4j.version}</version>
            </dependency>
            <dependency>
                <groupId>com.squareup.retrofit2</groupId>
                <artifactId>retrofit</artifactId>
                <version>${retrofit.version}</version>
            </dependency>
```

```
<dependency>
    <groupId>com.squareup.retrofit2</groupId>
    <artifactId>converter-gson</artifactId>
    <version>${retrofit.version}</version>
</dependency>
<dependency>
    <groupId>com.squareup.okhttp3</groupId>
    <artifactId>okhttp</artifactId>
    <version>${okhttp.version}</version>
</dependency>
<dependency>
    <groupId>com.knuddels</groupId>
    <artifactId>jtokkit</artifactId>
    <version>${jtokkit.version}</version>
</dependency>
<dependency>
    <groupId>org.projectlombok</groupId>
    <artifactId>lombok</artifactId>
    <version>${lombok.version}</version>
</dependency>
<dependency>
    <groupId>org.apache.pdfbox</groupId>
    <artifactId>pdfbox</artifactId>
    <version>${pdfbox.version}</version>
</dependency>
<dependency>
    <groupId>org.jsoup</groupId>
    <artifactId>jsoup</artifactId>
    <version>${jsoup.veresion}</version>
</dependency>
<dependency>
    <groupId>com.github.spullara.mustache.java</groupId>
    <artifactId>compiler</artifactId>
    <version>${mustache.version}</version>
</dependency>
<dependency>
    <groupId>org.slf4j</groupId>
    <artifactId>slf4j-api</artifactId>
    <version>${slf4j-api.version}</version>
</dependency>
<dependency>
    <groupId>com.google.code.gson</groupId>
    <artifactId>gson</artifactId>
    <version>${gson.version}</version>
</dependency>
<dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter-engine</artifactId>
    <version>${junit.version}</version>
</dependency>
<dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter-params</artifactId>
    <version>${junit.version}</version>
</dependency>
<dependency>
    <groupId>org.junit.jupiter</groupId>
    <artifactId>junit-jupiter</artifactId>
    <version>${junit.version}</version>
</dependency>
<dependency>
```

```
    <groupId>org.testcontainers</groupId>
    <artifactId>junit-jupiter</artifactId>
    <version>${testcontainers.version}</version>
</dependency>
<dependency>
    <groupId>org.testcontainers</groupId>
    <artifactId>testcontainers</artifactId>
    <version>${testcontainers.version}</version>
</dependency>
<dependency>
    <groupId>org.opensearch</groupId>
    <artifactId>opensearch-testcontainers</artifactId>
    <version>${opensearch-containers.version}</version>
</dependency>
<dependency>
    <groupId>org.mockito</groupId>
    <artifactId>mockito-core</artifactId>
    <version>${mockito.version}</version>
</dependency>
<dependency>
    <groupId>org.mockito</groupId>
    <artifactId>mockito-junit-jupiter</artifactId>
    <version>${mockito.version}</version>
</dependency>
<dependency>
    <groupId>org.assertj</groupId>
    <artifactId>assertj-core</artifactId>
    <version>${assertj.version}</version>
</dependency>
<dependency>
    <groupId>org.tinylog</groupId>
    <artifactId>tinylog-impl</artifactId>
    <version>${tinylog.version}</version>
</dependency>
<dependency>
    <groupId>org.tinylog</groupId>
    <artifactId>slf4j-tinylog</artifactId>
    <version>${tinylog.version}</version>
</dependency>
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-starter</artifactId>
    <version>${spring-boot.version}</version>
    <exclusions>
        <!-- due to vulnerabilities -->
        <exclusion>
            <groupId>org.yaml</groupId>
            <artifactId>snakeyaml</artifactId>
        </exclusion>
    </exclusions>
</dependency>
<dependency>
    <groupId>org.yaml</groupId>
    <artifactId>snakeyaml</artifactId>
    <version>${snakeyaml.version}</version>
</dependency>
<dependency>
    <groupId>org.springframework.boot</groupId>
    <artifactId>spring-boot-configuration-processor</artifactId>
    <version>${spring-boot.version}</version>
</dependency>
```

```
            <dependency>
                <groupId>org.apache.httpcomponents.client5</groupId>
                <artifactId>httpclient5</artifactId>
                <version>${httpclient5.version}</version>
            </dependency>
            <dependency>
                <groupId>org.opensearch.client</groupId>
                <artifactId>opensearch-java</artifactId>
                <version>${opensearch-java.version}</version>
            </dependency>
            <dependency>
                <groupId>software.amazon.awssdk</groupId>
                <artifactId>opensearch</artifactId>
                <version>${aws-opensearch.version}</version>
            </dependency>
            <dependency>
                <groupId>com.amazonaws</groupId>
                <artifactId>aws-java-sdk-core</artifactId>
                <version>${aws-java-sdk-core.version}</version>
            </dependency>
            <dependency>
                <groupId>software.amazon.awssdk</groupId>
                <artifactId>apache-client</artifactId>
                <version>${aws-opensearch.version}</version>
            </dependency>
            <dependency>
                <groupId>co.elastic.clients</groupId>
                <artifactId>elasticsearch-java</artifactId>
                <version>${elastic.version}</version>
            </dependency>
            <dependency>
                <groupId>com.fasterxml.jackson.core</groupId>
                <artifactId>jackson-databind</artifactId>
                <version>${jackson.version}</version>
            </dependency>
            <dependency>
                <groupId>org.apache.opennlp</groupId>
                <artifactId>opennlp-tools</artifactId>
                <version>1.9.4</version>
            </dependency>
            <dependency>
                <groupId>dev.langchain4j</groupId>
                <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</
artifactId>
                <version>${project.version}</version>
            </dependency>
            <dependency>
                <groupId>redis.clients</groupId>
                <artifactId>jedis</artifactId>
                <version>${jedis.version}</version>
            </dependency>
            <dependency>
                <groupId>software.amazon.awssdk</groupId>
                <artifactId>bom</artifactId>
                <version>${aws.java.sdk.version}</version>
                <type>pom</type>
                <scope>import</scope>
                <exclusions>
                    <!-- Exclusion due to CWE-295 vulnerability -->
                    <exclusion>
                        <groupId>io.netty</groupId>
```

```
                    <artifactId>netty-handler</artifactId>
                </exclusion>
            </exclusions>
        </dependency>
        <dependency>
            <groupId>org.testcontainers</groupId>
            <artifactId>testcontainers</artifactId>
            <version>${testcontainers.version}</version>
        </dependency>
        <dependency>
            <groupId>org.testcontainers</groupId>
            <artifactId>localstack</artifactId>
            <version>${testcontainers.version}</version>
        </dependency>
    </dependencies>
</dependencyManagement>
<build>
    <plugins>
        <plugin>
            <groupId>org.apache.maven.plugins</groupId>
            <artifactId>maven-surefire-plugin</artifactId>
            <version>3.1.2</version>
        </plugin>
        <plugin>
            <groupId>org.sonatype.plugins</groupId>
            <artifactId>nexus-staging-maven-plugin</artifactId>
            <version>1.6.13</version>
            <extensions>true</extensions>
            <configuration>
                <serverId>ossrh</serverId>
                <nexusUrl>https://s01.oss.sonatype.org/</nexusUrl>
                <autoReleaseAfterClose>false</autoReleaseAfterClose>
            </configuration>
        </plugin>
        <plugin>
            <groupId>org.apache.maven.plugins</groupId>
            <artifactId>maven-source-plugin</artifactId>
            <version>3.2.1</version>
            <executions>
                <execution>
                    <id>attach-sources</id>
                    <goals>
                        <goal>jar-no-fork</goal>
                    </goals>
                </execution>
            </executions>
        </plugin>
        <plugin>
            <groupId>org.apache.maven.plugins</groupId>
            <artifactId>maven-javadoc-plugin</artifactId>
            <version>3.5.0</version>
            <executions>
                <execution>
                    <id>attach-javadocs</id>
                    <goals>
                        <goal>jar</goal>
                    </goals>
                </execution>
            </executions>
        </plugin>
        <plugin>
```

```
                <!-- failsafe will be in charge of running the integration
tests (everything that ends in IT) -->
                <artifactId>maven-failsafe-plugin</artifactId>
                <version>3.1.2</version>
                <executions>
                    <execution>
                        <goals>
                            <goal>integration-test</goal>
                            <goal>verify</goal>
                        </goals>
                    </execution>
                </executions>
            </plugin>
        </plugins>
    </build>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
    <developers>
        <developer>
            <id>deep-learning-dynamo</id>
            <email>deeplearningdynamo@gmail.com</email>
            <url>https://github.com/deep-learning-dynamo</url>
        </developer>
        <developer>
            <id>kuraleta</id>
            <email>digital.kuraleta@gmail.com</email>
            <url>https://github.com/kuraleta</url>
        </developer>
    </developers>
    <scm>
        <url>https://github.com/langchain4j/langchain4j</url>
        <connection>scm:git:git://github.com/langchain4j/langchain4j.git</
connection>
        <developerConnection>scm:git:git@github.com:langchain4j/
langchain4j.git</developerConnection>
    </scm>
    <distributionManagement>
        <snapshotRepository>
            <id>ossrh</id>
            <url>https://s01.oss.sonatype.org/content/repositories/snapshots</
url>
        </snapshotRepository>
    </distributionManagement>
    <profiles>
        <profile>
            <id>sign</id>
            <activation>
                <property>
                    <name>sign</name>
                </property>
            </activation>
            <build>
                <plugins>
                    <plugin>
                        <groupId>org.apache.maven.plugins</groupId>
```

```
                        <artifactId>maven-gpg-plugin</artifactId>
                        <version>3.0.1</version>
                        <executions>
                            <execution>
                                <id>sign-artifacts</id>
                                <phase>verify</phase>
                                <goals>
                                    <goal>sign</goal>
                                </goals>
                            </execution>
                        </executions>
                    </plugin>
                </plugins>
            </build>
        </profile>
        <profile>
            <id>compliance</id>
            <activation>
                <property>
                    <name>compliance</name>
                </property>
            </activation>
            <build>
                <plugins>
                    <plugin>
                        <groupId>org.honton.chas</groupId>
                        <artifactId>license-maven-plugin</artifactId>
                        <version>0.0.3</version>
                        <executions>
                            <execution>
                                <goals>
                                    <goal>compliance</goal>
                                </goals>
                            </execution>
                        </executions>
                        <configuration>
                            <scopes>compile,runtime,provided,test</scopes>
                            <acceptableLicenses>
                                <license>
                                    <name>(The )?(Apache License, Version
2\.0)|(Apache-2\.0)|(The Apache Software License, Version 2\.0)</name>
                                    <url>https?://www\.apache\.org/licenses/
LICENSE-2\.0</url>
                                </license>
                                <license>
                                    <name>(The MIT License|MIT License|MIT)</
name>
                                    <url>(https?://opensource.org/licenses/
MIT|https://projectlombok.org/LICENSE)</url>
                                </license>
                                <license>
                                    <name>Eclipse Public License v2.0</name>
                                    <url>https?://www.eclipse.org/legal/epl-
v20\.html</url>
                                </license>
                            </acceptableLicenses>
                        </configuration>
                    </plugin>
                </plugins>
            </build>
        </profile>
```

```
    </profiles>
</project>
```

langchain4j-pgvector\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <properties>
        <pgvector-java.version>0.1.3</pgvector-java.version>
        <postgresql.version>42.6.0</postgresql.version>
        <spotless.version>2.40.0</spotless.version>
    </properties>
    <artifactId>langchain4j-pgvector</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with PGVector</name>
    <description>It uses the pgvector-java library</description>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>com.pgvector</groupId>
            <artifactId>pgvector</artifactId>
            <version>${pgvector-java.version}</version>
        </dependency>
        <dependency>
            <groupId>org.postgresql</groupId>
            <artifactId>postgresql</artifactId>
            <version>${postgresql.version}</version>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-params</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
```

```
        <groupId>org.testcontainers</groupId>
        <artifactId>testcontainers</artifactId>
        <scope>test</scope>
    </dependency>
    <dependency>
        <groupId>org.testcontainers</groupId>
        <artifactId>junit-jupiter</artifactId>
        <scope>test</scope>
    </dependency>
    <dependency>
        <groupId>org.testcontainers</groupId>
        <artifactId>postgresql</artifactId>
        <version>1.19.1</version>
        <scope>test</scope>
    </dependency>
    <dependency>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</artifactId>
        <scope>test</scope>
    </dependency>
</dependencies>
<build>
    <plugins>
        <plugin>
            <groupId>org.honton.chas</groupId>
            <artifactId>license-maven-plugin</artifactId>
            <configuration>
                <skipCompliance>true</skipCompliance>
            </configuration>
        </plugin>
        <plugin>
            <groupId>com.diffplug.spotless</groupId>
            <artifactId>spotless-maven-plugin</artifactId>
            <version>${spotless.version}</version>
            <configuration>
                <ratchetFrom>origin/main</ratchetFrom>
                <formats>
                    <format>
                        <includes>
                            <include>*.md</include>
                            <include>.gitignore</include>
                        </includes>
                        <trimTrailingWhitespace/>
                        <endWithNewline/>
                        <indent>
                            <tabs>true</tabs>
                            <spacesPerTab>4</spacesPerTab>
                        </indent>
                    </format>
                </formats>
                <java>
                    <googleJavaFormat>
                        <version>1.8.0</version>
                        <style>AOSP</style>
                        <reflowLongStrings>true</reflowLongStrings>
                        <formatJavadoc>false</formatJavadoc>
                    </googleJavaFormat>
                </java>
            </configuration>
        </plugin>
    </plugins>
```

```
    </build>
    <profiles>
        <profile>
            <id>compliance</id>
            <activation>
                <property>
                    <name>compliance</name>
                </property>
            </activation>
            <build>
                <plugins>
                    <plugin>
                        <groupId>org.honton.chas</groupId>
                        <artifactId>license-maven-plugin</artifactId>
                        <configuration>
                            <skipCompliance>true</skipCompliance>
                        </configuration>
                    </plugin>
                </plugins>
            </build>
        </profile>
    </profiles>
</project>
```

langchain4j-pgvector\src\main\java\dev\langchain4j\store\embedding\pgvector\PgVectorEmbeddingStore.java

```
package dev.langchain4j.store.embedding.pgvector;
import static dev.langchain4j.internal.Utils.isCollectionEmpty;
import static dev.langchain4j.internal.Utils.randomUUID;
import static dev.langchain4j.internal.ValidationUtils.ensureTrue;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.toList;
import com.google.gson.Gson;
import com.google.gson.reflect.TypeToken;
import com.pgvector.PGvector;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import java.lang.reflect.Type;
import java.sql.Connection;
import java.sql.DriverManager;
import java.sql.PreparedStatement;
import java.sql.ResultSet;
import java.sql.SQLException;
import java.sql.Statement;
import java.sql.Types;
import java.util.ArrayList;
import java.util.Arrays;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import java.util.Optional;
import java.util.UUID;
import lombok.NonNull;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
/**
 * PGVector EmbeddingStore Implementation
 * <p>
 * Only cosine similarity is used.
 * Only ivfflat index is used.
 */
public class PgVectorEmbeddingStore implements EmbeddingStore<TextSegment> {
    private static final Logger log =
LoggerFactory.getLogger(PgVectorEmbeddingStore.class);
    private static final Gson gson = new Gson();
    private final String dbHost;
    private final String dbUser;
    private final String dbPassword;
    private final String dbPort;
    private final String dbName;
    private final String namespace;
    /**
     * All args constructor for PgVectorEmbeddingStore Class
     *
     * @param dbHost The database host
     * @param dbUser The database user
     * @param dbPassword The database password
     * @param dbPort The database port
     * @param dbName The database name
     * @param namespace The vector namespace, as table name
```

```
     * @param dimension The vector dimension
     * @param useIndex Should use ivfflat index
     * @param indexListSize The ivfflat index size
     * @param createdTable Should create table
     * @param dropTableFirst Should drop table first, usually for testing
     */
    public PgVectorEmbeddingStore(
            @NonNull String dbHost,
            @NonNull String dbUser,
            @NonNull String dbPassword,
            @NonNull String dbPort,
            @NonNull String dbName,
            @NonNull String namespace,
            int dimension,
            boolean useIndex,
            int indexListSize,
            boolean createdTable,
            boolean dropTableFirst) {
        this.dbHost = dbHost;
        this.dbUser = dbUser;
        this.dbPassword = dbPassword;
        this.dbPort = dbPort;
        this.dbName = dbName;
        this.namespace = namespace;
        try (Connection connection = setupConnection()) {
            if (dropTableFirst) {
                Statement setupStmt = connection.createStatement();
                setupStmt.executeUpdate(String.format("DROP TABLE IF EXISTS
%s", namespace));
            }
            if (createdTable) {
                Statement createStmt = connection.createStatement();
                createStmt.executeUpdate(String.format(
                        "CREATE TABLE IF NOT EXISTS %s (vector_id UUID
PRIMARY KEY, embedding vector(%s), text TEXT NULL, metadata JSON NULL)",
                        namespace, dimension));
            }
            if (useIndex) {
                Statement indexStmt = connection.createStatement();
                indexStmt.executeUpdate(String.format(
                        "CREATE INDEX IF NOT EXISTS ON %s USING ivfflat
(embedding vector_cosine_ops) WITH (lists = %s)",
                        namespace, indexListSize));
            }
        } catch (SQLException e) {
            throw new ServiceException("Init Failure", e.getCause());
        }
    }
    Connection setupConnection() throws SQLException {
        Connection connection =
                DriverManager.getConnection(
                        String.format("jdbc:postgresql://%s:%s/%s",
this.dbHost, this.dbPort, this.dbName),
                        this.dbUser,
                        this.dbPassword);
        PGvector.addVectorType(connection);
        return connection;
    }
    /**
     * Adds a given embedding to the store.
     *
```

```
     * @param embedding The embedding to be added to the store.
     * @return The auto-generated ID associated with the added embedding.
     */
    @Override
    public String add(Embedding embedding) {
        String id = randomUUID();
        addInternal(id, embedding, null);
        return id;
    }
    /**
     * Adds a given embedding to the store.
     *
     * @param id        The unique identifier for the embedding to be added.
     * @param embedding The embedding to be added to the store.
     */
    @Override
    public void add(String id, Embedding embedding) {
        addInternal(id, embedding, null);
    }
    /**
     * Adds a given embedding and the corresponding content that has been
embedded to the store.
     *
     * @param embedding   The embedding to be added to the store.
     * @param textSegment Original content that was embedded.
     * @return The auto-generated ID associated with the added embedding.
     */
    @Override
    public String add(Embedding embedding, TextSegment textSegment) {
        String id = randomUUID();
        addInternal(id, embedding, textSegment);
        return id;
    }
    /**
     * Adds multiple embeddings to the store.
     *
     * @param embeddings A list of embeddings to be added to the store.
     * @return A list of auto-generated IDs associated with the added
embeddings.
     */
    @Override
    public List<String> addAll(List<Embedding> embeddings) {
        List<String> ids = embeddings.stream().map(ignored ->
randomUUID()).collect(toList());
        addAllInternal(ids, embeddings, null);
        return ids;
    }
    /**
     * Adds multiple embeddings and their corresponding contents that have
been embedded to the store.
     *
     * @param embeddings A list of embeddings to be added to the store.
     * @param embedded   A list of original contents that were embedded.
     * @return A list of auto-generated IDs associated with the added
embeddings.
     */
    @Override
    public List<String> addAll(List<Embedding> embeddings, List<TextSegment>
embedded) {
        List<String> ids = embeddings.stream().map(ignored ->
randomUUID()).collect(toList());
```

```
        addAllInternal(ids, embeddings, embedded);
        return ids;
    }
    /**
     * Finds the most relevant (closest in space) embeddings to the provided
reference embedding.
     *
     * @param referenceEmbedding The embedding used as a reference. Returned
embeddings should be relevant (closest) to this one.
     * @param maxResults         The maximum number of embeddings to be
returned.
     * @param minScore           The minimum relevance score, ranging from 0
to 1 (inclusive).
     *                           Only embeddings with a score of this value
or higher will be returned.
     * @return A list of embedding matches.
     * Each embedding match includes a relevance score (derivative of cosine
distance),
     * ranging from 0 (not relevant) to 1 (highly relevant).
     */
    @Override
    public List<EmbeddingMatch<TextSegment>> findRelevant(
            Embedding referenceEmbedding, int maxResults, double minScore) {
        List<EmbeddingMatch<TextSegment>> result = new ArrayList<>();
        try (Connection conn = setupConnection()) {
            String referenceVector =
Arrays.toString(referenceEmbedding.vector());
            String query = String.format(
                    "WITH temp AS (SELECT (2 - (embedding <=> '%s')) / 2 AS
score, vector_id, embedding, text, metadata FROM %s) SELECT * FROM temp WHERE
score >= %s ORDER BY score desc LIMIT %s;",
                    referenceVector, this.namespace, minScore, maxResults);
            PreparedStatement selectStmt = conn.prepareStatement(query);
            ResultSet resultSet = selectStmt.executeQuery();
            while (resultSet.next()) {
                double score = resultSet.getDouble("score");
                String embeddingId = resultSet.getString("vector_id");
                PGvector vector = (PGvector) resultSet.getObject("embedding");
                Embedding embedding = new Embedding(vector.toArray());
                String text = resultSet.getString("text");
                String metadataJson =

Optional.ofNullable(resultSet.getString("metadata")).orElse("{}");
                Type type = new TypeToken<Map<String, String>>() {}.getType();
                Metadata metadata = new Metadata(new
HashMap<>(gson.fromJson(metadataJson, type)));
                if (text == null || text.isEmpty()) {
                    result.add(new EmbeddingMatch<>(score, embeddingId,
embedding, null));
                } else {
                    TextSegment textSegment = TextSegment.from(text,
metadata);
                    result.add(new EmbeddingMatch<>(score, embeddingId,
embedding, textSegment));
                }
            }
        } catch (SQLException e) {
            throw new ServiceException("Neighbor Query Failure",
e.getCause());
        }
        return result;
```

```
    }
    private void addInternal(String id, Embedding embedding, TextSegment
embedded) {
        addAllInternal(
                singletonList(id),
                singletonList(embedding),
                embedded == null ? null : singletonList(embedded));
    }
    private void addAllInternal(
            List<String> ids, List<Embedding> embeddings, List<TextSegment>
embedded) {
        if (isCollectionEmpty(ids) || isCollectionEmpty(embeddings)) {
            log.info("Empty embeddings - no ops");
            return;
        }
        ensureTrue(ids.size() == embeddings.size(), "ids size is not equal to
embeddings size");
        ensureTrue(
                embedded == null || embeddings.size() == embedded.size(),
                "embeddings size is not equal to embedded size");
        try (Connection conn = setupConnection()) {
            String query = String.format(
                    "INSERT INTO %s (vector_id, embedding, text, metadata)
VALUES (?, ?, ?, ?)" +
                            "ON CONFLICT (vector_id) DO UPDATE SET " +
                            "embedding = EXCLUDED.embedding," +
                            "text = EXCLUDED.text," +
                            "metadata = EXCLUDED.metadata;",
                    this.namespace);
            PreparedStatement upsertStmt = conn.prepareStatement(query);
            for (int i = 0; i < ids.size(); ++i) {
                upsertStmt.setObject(1, UUID.fromString(ids.get(i)));
                upsertStmt.setObject(2, new
PGvector(embeddings.get(i).vector()));
                if (embedded != null && embedded.get(i) != null) {
                    upsertStmt.setObject(3, embedded.get(i).text());
                    Map<String, String> metadata =
                            new HashMap<>(embedded.get(i).metadata().asMap());
                    upsertStmt.setObject(4, gson.toJson(metadata),
Types.OTHER);
                } else {
                    upsertStmt.setNull(3, Types.VARCHAR);
                    upsertStmt.setNull(4, Types.OTHER);
                }
                upsertStmt.addBatch();
            }
            upsertStmt.executeBatch();
        } catch (SQLException e) {
            throw new ServiceException("Insertion failure", e.getCause());
        }
    }
}
```

langchain4j-pgvector\src\main\java\dev\langchain4j\store\embedding\pgvector\ServiceException.java

```
package dev.langchain4j.store.embedding.pgvector;
public class ServiceException extends RuntimeException {
    public ServiceException() {
        super();
    }
    public ServiceException(String message) {
        super(message);
    }
    public ServiceException(String message, Throwable cause) {
        super(message, cause);
    }
}
```

langchain4j-pgvector\src\test\java\dev\langchain4j\store\embedding\pgvector\PgVectorEmbeddingStoreLocalTest.java

```
package dev.langchain4j.store.embedding.pgvector;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
import static org.junit.jupiter.api.Assertions.assertTrue;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import java.util.List;
import org.junit.jupiter.api.BeforeAll;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import org.testcontainers.containers.PostgreSQLContainer;
import org.testcontainers.junit.jupiter.Container;
import org.testcontainers.utility.DockerImageName;
@Disabled("Comment this line if you want to run locally")
public class PgVectorEmbeddingStoreLocalTest {
    /**
     * This test can be run without providing Envs to working PGVector
Postgres Instance
     */
    private static final DockerImageName pgVectorImage =
            DockerImageName.parse("ankane/
pgvector:v0.5.1").asCompatibleSubstituteFor("postgres");
    @Container
    private static final PostgreSQLContainer<?> pgVectorContainer =
            new PostgreSQLContainer<>(pgVectorImage);
    private final EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    ;
    private EmbeddingStore<TextSegment> embeddingStore;
    private PgVectorEmbeddingStore createEmbeddedStore(
            String namespace,
            int dimension,
            boolean useIndex,
            int indexListSize,
            boolean createTable,
            boolean dropTable) {
        String dbHost = pgVectorContainer.getHost();
        String dbPort = pgVectorContainer.getFirstMappedPort().toString();
        String dbUser = "test";
        String dbPassword = "test";
        String dbName = "test";
        return new PgVectorEmbeddingStore(
                dbHost,
                dbUser,
                dbPassword,
                dbPort,
                dbName,
```

```
                namespace,
                dimension,
                useIndex,
                indexListSize,
                createTable,
                dropTable);
    }
    @BeforeAll
    static void startContainer() {

pgVectorContainer.withExposedPorts(5432).withInitScript("init.sql").start();
    }
    @BeforeEach
    void initPgVectorEmbeddingStore() {
        embeddingStore = createEmbeddedStore("test_namespace", 384, false,
100, true, true);
    }
    @Test
    void should_aa_container_should_be_running() {
        assertTrue(pgVectorContainer.isRunning());
    }
    @Test
    void should_add_embedding() {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() {
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
```

```
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_embedding_with_segment_with_metadata() {
        TextSegment segment =
                TextSegment.from(randomUUID(), Metadata.from("test-key",
"test-value"));
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
                embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids =
                embeddingStore.addAll(
                        asList(firstEmbedding, secondEmbedding),
                        asList(firstSegment, secondSegment));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
                embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
```

```
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        List<EmbeddingMatch<TextSegment>> relevant =
                embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
                embeddingStore.findRelevant(firstEmbedding, 10,
secondMatch.score() - 0.01);
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
                embeddingStore.findRelevant(firstEmbedding, 10,
secondMatch.score());
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
                embeddingStore.findRelevant(firstEmbedding, 10,
secondMatch.score() + 0.01);
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        List<EmbeddingMatch<TextSegment>> relevant =
                embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score())
                .isCloseTo(
                        RelevanceScore.fromCosineSimilarity(
                                CosineSimilarity.between(embedding,
referenceEmbedding)),
```

```
                        withPercentage(1));
    }
}
```

langchain4j-pgvector\src\test\java\dev\langchain4j\store\embedding\pgvector\PgVectorEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.pgvector;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import java.util.List;
import java.util.Optional;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.condition.EnabledIfEnvironmentVariable;
import org.junit.jupiter.api.condition.EnabledIfEnvironmentVariables;
@EnabledIfEnvironmentVariables({
    @EnabledIfEnvironmentVariable(named = "DB_HOST", matches = ".+"),
    @EnabledIfEnvironmentVariable(named = "DB_USER", matches = ".+"),
    @EnabledIfEnvironmentVariable(named = "DB_PASSWORD", matches = ".+"),
    @EnabledIfEnvironmentVariable(named = "DB_NAME", matches = ".+")
})
public class PgVectorEmbeddingStoreTest {
    private final EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    private EmbeddingStore<TextSegment> embeddingStore;
    private PgVectorEmbeddingStore createEmbeddedStore(
            String namespace,
            int dimension,
            boolean useIndex,
            int indexListSize,
            boolean createTable,
            boolean dropTable) {
        String dbHost = System.getenv("DB_HOST");
        String dbUser = System.getenv("DB_USER");
        String dbPassword = System.getenv("DB_PASSWORD");
        String dbPort =
Optional.ofNullable(System.getenv("DB_PORT")).orElse("5432");
        String dbName = System.getenv("DB_NAME");
        return new PgVectorEmbeddingStore(
                dbHost,
                dbUser,
                dbPassword,
                dbPort,
                dbName,
                namespace,
                dimension,
                useIndex,
                indexListSize,
                createTable,
                dropTable);
    }
    @BeforeEach
```

```
    void initPgVectorEmbeddingStore() {
        embeddingStore = createEmbeddedStore("test_namespace", 384, false,
100, true, true);
    }
    @Test
    void should_add_embedding() {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() {
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_embedding_with_segment_with_metadata() {
        TextSegment segment =
                TextSegment.from(randomUUID(), Metadata.from("test-key",
"test-value"));
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
```

```
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
                embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids =
                embeddingStore.addAll(
                        asList(firstEmbedding, secondEmbedding),
                        asList(firstSegment, secondSegment));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
                embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
```

```
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        List<EmbeddingMatch<TextSegment>> relevant =
                embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
                embeddingStore.findRelevant(firstEmbedding, 10,
secondMatch.score() - 0.01);
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
                embeddingStore.findRelevant(firstEmbedding, 10,
secondMatch.score());
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
                embeddingStore.findRelevant(firstEmbedding, 10,
secondMatch.score() + 0.01);
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        List<EmbeddingMatch<TextSegment>> relevant =
                embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score())
                .isCloseTo(
                        RelevanceScore.fromCosineSimilarity(
                                CosineSimilarity.between(embedding,
referenceEmbedding)),
                        withPercentage(1));
    }
}
```

langchain4j-pgvector\src\test\resources\init.sql

```
CREATE EXTENSION IF NOT EXISTS vector;
```

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-pinecone</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with Pinecone</name>
    <description>It uses the io.pinecone.pinecone-client library, which has a
proprietary license.</description>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>io.pinecone</groupId>
            <artifactId>pinecone-client</artifactId>
            <version>0.2.3</version>
            <exclusions>
                <!-- due to CVE-2022-41915 vulnerability -->
                <exclusion>
                    <groupId>io.netty</groupId>
                    <artifactId>netty-codec</artifactId>
                </exclusion>
                <!-- due to CVE-2023-44487 vulnerability -->
                <exclusion>
                    <groupId>io.netty</groupId>
                    <artifactId>netty-codec-http2</artifactId>
                </exclusion>
            </exclusions>
        </dependency>
        <dependency>
            <groupId>io.netty</groupId>
            <artifactId>netty-codec</artifactId>
            <version>${netty.version}</version>
        </dependency>
        <dependency>
            <groupId>io.netty</groupId>
            <artifactId>netty-codec-http2</artifactId>
            <version>${netty.version}</version>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
```

```
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-params</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <build>
        <plugins>
            <plugin>
                <groupId>org.honton.chas</groupId>
                <artifactId>license-maven-plugin</artifactId>
                <configuration>
                    <!-- the pinecone module has non-permissive licenses -->
                    <skipCompliance>true</skipCompliance>
                </configuration>
            </plugin>
        </plugins>
    </build>
    <profiles>
        <profile>
            <id>compliance</id>
            <activation>
                <property>
                    <name>compliance</name>
                </property>
            </activation>
            <build>
                <plugins>
                    <plugin>
                        <groupId>org.honton.chas</groupId>
                        <artifactId>license-maven-plugin</artifactId>
                        <configuration>
                            <!-- the pinecone module has non-permissive
licenses -->
                            <skipCompliance>true</skipCompliance>
                        </configuration>
                    </plugin>
                </plugins>
            </build>
        </profile>
    </profiles>
</project>
```

langchain4j-pinecone\src\main\java\dev\langchain4j\store\embedding\pinecone\PineconeEmbeddingStore.java

```
package dev.langchain4j.store.embedding.pinecone;
import com.google.protobuf.Struct;
import com.google.protobuf.Value;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import io.pinecone.PineconeClient;
import io.pinecone.PineconeClientConfig;
import io.pinecone.PineconeConnection;
import io.pinecone.PineconeConnectionConfig;
import io.pinecone.proto.*;
import java.util.Collection;
import java.util.Collections;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Collections.emptyList;
import static java.util.Collections.singletonList;
import static java.util.Comparator.comparingDouble;
import static java.util.stream.Collectors.toList;
/**
 * Represents a <a href="https://www.pinecone.io/">Pinecone</a> index as an embedding store.
 * Current implementation assumes the index uses the cosine distance metric.
 * Does not support storing {@link dev.langchain4j.data.document.Metadata} yet.
 */
public class PineconeEmbeddingStore implements EmbeddingStore<TextSegment> {
    private static final String DEFAULT_NAMESPACE = "default"; // do not change, will break backward compatibility!
    private static final String METADATA_TEXT_SEGMENT = "text_segment"; // do not change, will break backward compatibility!
    private final PineconeConnection connection;
    private final String nameSpace;
    /**
     * Creates an instance of PineconeEmbeddingStore.
     *
     * @param apiKey      The Pinecone API key.
     * @param environment The environment (e.g., "northamerica-northeast1-gcp").
     * @param projectId   The ID of the project (e.g., "19a129b"). This is <b>not</b> a project name.
     *                    The ID can be found in the Pinecone URL: https://app.pinecone.io/organizations/.../projects/...:{projectId}/indexes.
     * @param index       The name of the index (e.g., "test").
     * @param nameSpace   (Optional) Namespace. If not provided, "default" will be used.
     */
    public PineconeEmbeddingStore(String apiKey,
                                  String environment,
                                  String projectId,
                                  String index,
                                  String nameSpace) {
        PineconeClientConfig configuration = new PineconeClientConfig()
                .withApiKey(apiKey)
```

```
                .withEnvironment(environment)
                .withProjectName(projectId);
        PineconeClient pineconeClient = new PineconeClient(configuration);
        PineconeConnectionConfig connectionConfig = new
PineconeConnectionConfig()
                .withIndexName(index);
        this.connection = pineconeClient.connect(connectionConfig);
        this.nameSpace = nameSpace == null ? DEFAULT_NAMESPACE : nameSpace;
    }
    @Override
    public String add(Embedding embedding) {
        String id = randomUUID();
        add(id, embedding);
        return id;
    }
    @Override
    public void add(String id, Embedding embedding) {
        addInternal(id, embedding, null);
    }
    @Override
    public String add(Embedding embedding, TextSegment textSegment) {
        String id = randomUUID();
        addInternal(id, embedding, textSegment);
        return id;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings) {
        List<String> ids = embeddings.stream()
                .map(ignored -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, null);
        return ids;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings, List<TextSegment>
textSegments) {
        List<String> ids = embeddings.stream()
                .map(ignored -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, textSegments);
        return ids;
    }
    private void addInternal(String id, Embedding embedding, TextSegment
textSegment) {
        addAllInternal(singletonList(id), singletonList(embedding),
textSegment == null ? null : singletonList(textSegment));
    }
    private void addAllInternal(List<String> ids, List<Embedding> embeddings,
List<TextSegment> textSegments) {
        UpsertRequest.Builder upsertRequestBuilder =
UpsertRequest.newBuilder()
                .setNamespace(nameSpace);
        for (int i = 0; i < embeddings.size(); i++) {
            String id = ids.get(i);
            Embedding embedding = embeddings.get(i);
            Vector.Builder vectorBuilder = Vector.newBuilder()
                    .setId(id)
                    .addAllValues(embedding.vectorAsList());
            if (textSegments != null) {
                vectorBuilder.setMetadata(Struct.newBuilder()
                        .putFields(METADATA_TEXT_SEGMENT, Value.newBuilder()
```

```
                                .setStringValue(textSegments.get(i).text())
                                .build()));
            }
            upsertRequestBuilder.addVectors(vectorBuilder.build());
        }
        connection.getBlockingStub().upsert(upsertRequestBuilder.build());
    }
    @Override
    public List<EmbeddingMatch<TextSegment>> findRelevant(Embedding
referenceEmbedding, int maxResults, double minScore) {
        QueryVector queryVector = QueryVector
                .newBuilder()
                .addAllValues(referenceEmbedding.vectorAsList())
                .setTopK(maxResults)
                .setNamespace(nameSpace)
                .build();
        QueryRequest queryRequest = QueryRequest
                .newBuilder()
                .addQueries(queryVector)
                .setTopK(maxResults)
                .build();
        List<String> matchedVectorIds = connection.getBlockingStub()
                .query(queryRequest)
                .getResultsList()
                .get(0)
                .getMatchesList()
                .stream()
                .map(ScoredVector::getId)
                .collect(toList());
        if (matchedVectorIds.isEmpty()) {
            return emptyList();
        }
        Collection<Vector> matchedVectors =
connection.getBlockingStub().fetch(FetchRequest.newBuilder()
                        .addAllIds(matchedVectorIds)
                        .setNamespace(nameSpace)
                        .build())
                .getVectorsMap()
                .values();
        List<EmbeddingMatch<TextSegment>> matches = matchedVectors.stream()
                .map(vector -> toEmbeddingMatch(vector, referenceEmbedding))
                .filter(match -> match.score() >= minScore)
                .sorted(comparingDouble(EmbeddingMatch::score))
                .collect(toList());
        Collections.reverse(matches);
        return matches;
    }
    private static EmbeddingMatch<TextSegment> toEmbeddingMatch(Vector
vector, Embedding referenceEmbedding) {
        Value textSegmentValue = vector.getMetadata()
                .getFieldsMap()
                .get(METADATA_TEXT_SEGMENT);
        Embedding embedding = Embedding.from(vector.getValuesList());
        double cosineSimilarity = CosineSimilarity.between(embedding,
referenceEmbedding);
        return new EmbeddingMatch<>(
                RelevanceScore.fromCosineSimilarity(cosineSimilarity),
                vector.getId(),
                embedding,
                textSegmentValue == null ? null :
TextSegment.from(textSegmentValue.getStringValue())
```

```
        );
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String apiKey;
        private String environment;
        private String projectId;
        private String index;
        private String nameSpace;
        /**
         * @param apiKey The Pinecone API key.
         */
        public Builder apiKey(String apiKey) {
            this.apiKey = apiKey;
            return this;
        }
        /**
         * @param environment The environment (e.g., "northamerica-northeast1-
gcp").
         */
        public Builder environment(String environment) {
            this.environment = environment;
            return this;
        }
        /**
         * @param projectId The ID of the project (e.g., "19a129b"). This is
<b>not</b> a project name.
         *                  The ID can be found in the Pinecone URL: https://
app.pinecone.io/organizations/.../projects/...:{projectId}/indexes.
         */
        public Builder projectId(String projectId) {
            this.projectId = projectId;
            return this;
        }
        /**
         * @param index The name of the index (e.g., "test").
         */
        public Builder index(String index) {
            this.index = index;
            return this;
        }
        /**
         * @param nameSpace (Optional) Namespace. If not provided, "default"
will be used.
         */
        public Builder nameSpace(String nameSpace) {
            this.nameSpace = nameSpace;
            return this;
        }
        public PineconeEmbeddingStore build() {
            return new PineconeEmbeddingStore(apiKey, environment, projectId,
index, nameSpace);
        }
    }
}
```

langchain4j-pinecone\src\test\java\dev\langchain4j\store\embedding\pinecone\PineconeEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.pinecone;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.RelevanceScore;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.condition.EnabledIfEnvironmentVariable;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
@EnabledIfEnvironmentVariable(named = "PINECONE_API_KEY", matches = ".+")
class PineconeEmbeddingStoreTest {
    private final PineconeEmbeddingStore embeddingStore =
PineconeEmbeddingStore.builder()
            .apiKey(System.getenv("PINECONE_API_KEY"))
            .environment("asia-southeast1-gcp-free")
            .projectId("75dc67a")
            .index("test")
            .nameSpace(randomUUID())
            .build();
    private final EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    @Test
    void should_add_embedding() {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() {
```

```
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids = embeddingStore.addAll(
                asList(firstEmbedding, secondEmbedding),
                asList(firstSegment, secondSegment)
        );
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
```

```
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() - 0.01
        );
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score()
        );
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() + 0.01
        );
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(

RelevanceScore.fromCosineSimilarity(CosineSimilarity.between(embedding,
```

```
referenceEmbedding)),
                withPercentage(1)
        );
    }
}
```

langchain4j-redis\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xmlns="http://maven.apache.org/POM/4.0.0"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-redis</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with Redis</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>redis.clients</groupId>
            <artifactId>jedis</artifactId>
        </dependency>
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
        <dependency>
            <groupId>org.slf4j</groupId>
            <artifactId>slf4j-api</artifactId>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.tinylog</groupId>
            <artifactId>tinylog-impl</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.tinylog</groupId>
            <artifactId>slf4j-tinylog</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</artifactId>
            <scope>test</scope>
```

```
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-redis\src\main\java\dev\langchain4j\store\embedding\redis\MetricType.java

```
package dev.langchain4j.store.embedding.redis;
/**
 * Similarity metric used by Redis
 */
enum MetricType {
    /**
     * cosine similarity
     */
    COSINE,
    /**
     * inner product
     */
    IP,
    /**
     * euclidean distance
     */
    L2
}
```

langchain4j-redis\src\main\java\dev\langchain4j\store\embedding\redis\RedisEmbeddingStore.java

```
package dev.langchain4j.store.embedding.redis;
import com.google.gson.Gson;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;
import redis.clients.jedis.JedisPooled;
import redis.clients.jedis.Pipeline;
import redis.clients.jedis.json.Path2;
import redis.clients.jedis.search.*;
import java.util.*;
import java.util.stream.Collectors;
import static dev.langchain4j.internal.Utils.isCollectionEmpty;
import static dev.langchain4j.internal.Utils.randomUUID;
import static dev.langchain4j.internal.ValidationUtils.*;
import static
dev.langchain4j.store.embedding.redis.RedisSchema.SCORE_FIELD_NAME;
import static java.lang.String.format;
import static java.util.Arrays.asList;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.toList;
import static redis.clients.jedis.search.IndexDefinition.Type.JSON;
import static redis.clients.jedis.search.RediSearchUtil.ToByteArray;
/**
 * Represents a <a href="https://redis.io/">Redis</a> index as an embedding
store.
 * Current implementation assumes the index uses the cosine distance metric.
 */
public class RedisEmbeddingStore implements EmbeddingStore<TextSegment> {
    private static final Logger log =
LoggerFactory.getLogger(RedisEmbeddingStore.class);
    private static final Gson GSON = new Gson();
    private final JedisPooled client;
    private final RedisSchema schema;
    /**
     * Creates an instance of RedisEmbeddingStore
     *
     * @param host               Redis Stack Server host
     * @param port               Redis Stack Server port
     * @param user               Redis Stack username (optional)
     * @param password           Redis Stack password (optional)
     * @param dimension          embedding vector dimension
     * @param metadataFieldsName metadata fields name (optional)
     */
    public RedisEmbeddingStore(String host,
                               Integer port,
                               String user,
                               String password,
                               Integer dimension,
                               List<String> metadataFieldsName) {
        ensureNotBlank(host, "host");
        ensureNotNull(port, "port");
        ensureNotNull(dimension, "dimension");
        this.client = user == null ? new JedisPooled(host, port) : new
```

```
JedisPooled(host, port, user, password);
        this.schema = RedisSchema.builder()
                .dimension(dimension)
                .metadataFieldsName(metadataFieldsName)
                .build();
        if (!isIndexExist(schema.getIndexName())) {
            createIndex(schema.getIndexName());
        }
    }
    @Override
    public String add(Embedding embedding) {
        String id = randomUUID();
        add(id, embedding);
        return id;
    }
    @Override
    public void add(String id, Embedding embedding) {
        addInternal(id, embedding, null);
    }
    @Override
    public String add(Embedding embedding, TextSegment textSegment) {
        String id = randomUUID();
        addInternal(id, embedding, textSegment);
        return id;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings) {
        List<String> ids = embeddings.stream()
                .map(ignored -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, null);
        return ids;
    }
    @Override
    public List<String> addAll(List<Embedding> embeddings, List<TextSegment>
embedded) {
        List<String> ids = embeddings.stream()
                .map(ignored -> randomUUID())
                .collect(toList());
        addAllInternal(ids, embeddings, embedded);
        return ids;
    }
    @Override
    public List<EmbeddingMatch<TextSegment>> findRelevant(Embedding
referenceEmbedding, int maxResults, double minScore) {
        // Using KNN query on @vector field
        String queryTemplate = "*=>[ KNN %d @%s $BLOB AS %s ]";
        List<String> returnFields = new
ArrayList<>(schema.getMetadataFieldsName());
        returnFields.addAll(asList(schema.getVectorFieldName(),
schema.getScalarFieldName(), SCORE_FIELD_NAME));
        Query query = new Query(format(queryTemplate, maxResults,
schema.getVectorFieldName(), SCORE_FIELD_NAME))
                .addParam("BLOB", toByteArray(referenceEmbedding.vector()))
                .returnFields(returnFields.toArray(new String[0]))
                .setSortBy(SCORE_FIELD_NAME, true)
                .dialect(2);
        SearchResult result = client.ftSearch(schema.getIndexName(), query);
        List<Document> documents = result.getDocuments();
        return toEmbeddingMatch(documents, minScore);
    }
```

```
    private void createIndex(String indexName) {
        IndexDefinition indexDefinition = new IndexDefinition(JSON);
        indexDefinition.setPrefixes(schema.getPrefix());
        String res = client.ftCreate(indexName, FTCreateParams.createParams()
                .on(IndexDataType.JSON)
                .addPrefix(schema.getPrefix()), schema.toSchemaFields());
        if (!"OK".equals(res)) {
            if (log.isErrorEnabled()) {
                log.error("create index error, msg={}", res);
            }
            throw new RedisRequestFailedException("create index error, msg="
+ res);
        }
    }
    private boolean isIndexExist(String indexName) {
        Set<String> indexSets = client.ftList();
        return indexSets.contains(indexName);
    }
    private void addInternal(String id, Embedding embedding, TextSegment
embedded) {
        addAllInternal(singletonList(id), singletonList(embedding), embedded
== null ? null : singletonList(embedded));
    }
    private void addAllInternal(List<String> ids, List<Embedding> embeddings,
List<TextSegment> embedded) {
        if (isCollectionEmpty(ids) || isCollectionEmpty(embeddings)) {
            log.info("do not add empty embeddings to redis");
            return;
        }
        ensureTrue(ids.size() == embeddings.size(), "ids size is not equal to
embeddings size");
        ensureTrue(embedded == null || embeddings.size() == embedded.size(),
"embeddings size is not equal to embedded size");
        Pipeline pipeline = client.pipelined();
        int size = ids.size();
        for (int i = 0; i < size; i++) {
            String id = ids.get(i);
            Embedding embedding = embeddings.get(i);
            TextSegment textSegment = embedded == null ? null :
embedded.get(i);
            Map<String, Object> fields = new HashMap<>();
            fields.put(schema.getVectorFieldName(), embedding.vector());
            if (textSegment != null) {
                // do not check metadata key is included in
RedisSchema#metadataFieldsName
                fields.put(schema.getScalarFieldName(), textSegment.text());
                fields.putAll(textSegment.metadata().asMap());
            }
            String key = schema.getPrefix() + id;
            pipeline.jsonSetWithEscape(key, Path2.of("$"), fields);
        }
        List<Object> responses = pipeline.syncAndReturnAll();
        Optional<Object> errResponse = responses.stream().filter(response -
> !"OK".equals(response)).findAny();
        if (errResponse.isPresent()) {
            if (log.isErrorEnabled()) {
                log.error("add embedding failed, msg={}", errResponse.get());
            }
            throw new RedisRequestFailedException("add embedding failed,
msg=" + errResponse.get());
        }
```

```
    }
    private List<EmbeddingMatch<TextSegment>> toEmbeddingMatch(List<Document>
documents, double minScore) {
        if (documents == null || documents.isEmpty()) {
            return new ArrayList<>();
        }
        return documents.stream()
                .map(document -> {
                    double score = (2 -
Double.parseDouble(document.getString(SCORE_FIELD_NAME))) / 2;
                    String id =
document.getId().substring(schema.getPrefix().length());
                    String text =
document.hasProperty(schema.getScalarFieldName()) ?
document.getString(schema.getScalarFieldName()) : null;
                    TextSegment embedded = null;
                    if (text != null) {
                        List<String> metadataFieldsName =
schema.getMetadataFieldsName();
                        Map<String, String> metadata =
metadataFieldsName.stream()
                                .filter(document::hasProperty)
                                .collect(Collectors.toMap(metadataFieldName -
> metadataFieldName, document::getString));
                        embedded = new TextSegment(text, new
Metadata(metadata));
                    }
                    Embedding embedding = new
Embedding(GSON.fromJson(document.getString(schema.getVectorFieldName()),
float[].class));
                    return new EmbeddingMatch<>(score, id, embedding,
embedded);
                })
                .filter(embeddingMatch -> embeddingMatch.score() >= minScore)
                .collect(toList());
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String host;
        private Integer port;
        private String user;
        private String password;
        private Integer dimension;
        private List<String> metadataFieldsName = new ArrayList<>();
        /**
         * @param host Redis Stack host
         */
        public Builder host(String host) {
            this.host = host;
            return this;
        }
        /**
         * @param port Redis Stack port
         */
        public Builder port(Integer port) {
            this.port = port;
            return this;
        }
        /**
```

```
         * @param user Redis Stack username (optional)
         */
        public Builder user(String user) {
            this.user = user;
            return this;
        }
        /**
         * @param password Redis Stack password (optional)
         */
        public Builder password(String password) {
            this.password = password;
            return this;
        }
        /**
         * @param dimension embedding vector dimension
         * @return builder
         */
        public Builder dimension(Integer dimension) {
            this.dimension = dimension;
            return this;
        }
        /**
         * @param metadataFieldsName metadata fields name (optional)
         */
        public Builder metadataFieldsName(List<String> metadataFieldsName) {
            this.metadataFieldsName = metadataFieldsName;
            return this;
        }
        public RedisEmbeddingStore build() {
            return new RedisEmbeddingStore(host, port, user, password,
dimension, metadataFieldsName);
        }
    }
}
```

langchain4j-redis\src\main\java\dev\langchain4j\store\embedding\redis\RedisRequestFailedException.java

```
package dev.langchain4j.store.embedding.redis;
public class RedisRequestFailedException extends RuntimeException {
    public RedisRequestFailedException() {
        super();
    }
    public RedisRequestFailedException(String message) {
        super(message);
    }
    public RedisRequestFailedException(String message, Throwable cause) {
        super(message, cause);
    }
}
```

langchain4j-redis\src\main\java\dev\langchain4j\store\embedding\redis\RedisSchema.java

```
package dev.langchain4j.store.embedding.redis;
import lombok.AllArgsConstructor;
import lombok.Builder;
import redis.clients.jedis.search.schemafields.SchemaField;
import redis.clients.jedis.search.schemafields.TextField;
import redis.clients.jedis.search.schemafields.VectorField;
import redis.clients.jedis.search.schemafields.VectorField.VectorAlgorithm;
import java.util.ArrayList;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static dev.langchain4j.store.embedding.redis.MetricType.COSINE;
import static
redis.clients.jedis.search.schemafields.VectorField.VectorAlgorithm.HNSW;
/**
 * Redis Schema Description
 */
@Builder
@AllArgsConstructor
class RedisSchema {
    public static final String SCORE_FIELD_NAME = "vector_score";
    private static final String JSON_PATH_PREFIX = "$.";
    private static final VectorAlgorithm DEFAULT_VECTOR_ALGORITHM = HNSW;
    private static final MetricType DEFAULT_METRIC_TYPE = COSINE;
    /* Redis schema field settings */
    @Builder.Default
    private String indexName = "embedding-index";
    @Builder.Default
    private String prefix = "embedding:";
    @Builder.Default
    private String vectorFieldName = "vector";
    @Builder.Default
    private String scalarFieldName = "text";
    @Builder.Default
    private List<String> metadataFieldsName = new ArrayList<>();
    /* Vector field settings */
    @Builder.Default
    private VectorAlgorithm vectorAlgorithm = DEFAULT_VECTOR_ALGORITHM;
    private int dimension;
    @Builder.Default
    private MetricType metricType = DEFAULT_METRIC_TYPE;
    public RedisSchema(int dimension) {
        this.dimension = dimension;
    }
    public SchemaField[] toSchemaFields() {
        Map<String, Object> vectorAttrs = new HashMap<>();
        vectorAttrs.put("DIM", dimension);
        vectorAttrs.put("DISTANCE_METRIC", metricType.name());
        vectorAttrs.put("TYPE", "FLOAT32");
        vectorAttrs.put("INITIAL_CAP", 5);
        List<SchemaField> fields = new ArrayList<>();
        fields.add(TextField.of(JSON_PATH_PREFIX +
scalarFieldName).as(scalarFieldName).weight(1.0));
        fields.add(VectorField.builder()
                .fieldName(JSON_PATH_PREFIX + vectorFieldName)
                .algorithm(vectorAlgorithm)
                .attributes(vectorAttrs)
```

```
                .as(vectorFieldName)
                .build());
        if (metadataFieldsName != null && !metadataFieldsName.isEmpty()) {
            for (String metadataFieldName : metadataFieldsName) {
                fields.add(TextField.of(JSON_PATH_PREFIX +
metadataFieldName).as(metadataFieldName).weight(1.0));
            }
        }
        return fields.toArray(new SchemaField[0]);
    }
    public String getIndexName() {
        return indexName;
    }
    public String getPrefix() {
        return prefix;
    }
    public String getVectorFieldName() {
        return vectorFieldName;
    }
    public String getScalarFieldName() {
        return scalarFieldName;
    }
    public List<String> getMetadataFieldsName() {
        return metadataFieldsName;
    }
}
```

langchain4j-redis\src\test\java\dev\langchain4j\store\embedding\redis\RedisEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.redis;
import dev.langchain4j.data.document.Metadata;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import redis.clients.jedis.JedisPooled;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Arrays.asList;
import static java.util.Collections.singletonList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
@Disabled("needs Redis running locally")
class RedisEmbeddingStoreTest {
    /**
     * First start Redis locally:
     * docker pull redis/redis-stack:latest
     * docker run -d -p 6379:6379 -p 8001:8001 redis/redis-stack:latest
     */
    private static final String HOST = "localhost";
    private static final int PORT = 6379;
    private static final String METADATA_KEY = "test-key";
    private EmbeddingStore<TextSegment> embeddingStore;
    private final EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    @BeforeEach
    void initEmptyRedisEmbeddingStore() {
        flushDB();
        embeddingStore = RedisEmbeddingStore.builder()
                .host(HOST)
                .port(PORT)
                .dimension(384)
                .build();
    }
    private static void flushDB() {
        try (JedisPooled jedis = new JedisPooled(HOST, PORT)) {
            jedis.flushDB();
        }
    }
    @Test
    void should_add_embedding() {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
```

```
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() {
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_embedding_with_segment_with_metadata() {
        flushDB();
        embeddingStore = RedisEmbeddingStore.builder()
                .host(HOST)
                .port(PORT)
                .dimension(384)
                .metadataFieldsName(singletonList(METADATA_KEY))
                .build();
        TextSegment segment = TextSegment.from(randomUUID(),
Metadata.from(METADATA_KEY, "test-value"));
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
```

```
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids = embeddingStore.addAll(
                asList(firstEmbedding, secondEmbedding),
                asList(firstSegment, secondSegment)
        );
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
```

```
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() - 0.01
        );
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score()
        );
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() + 0.01
        );
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(

RelevanceScore.fromCosineSimilarity(CosineSimilarity.between(embedding,
referenceEmbedding)),
                withPercentage(1)
        );
    }
}
```

langchain4j-spring-boot-starter\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-spring-boot-starter</artifactId>
    <packaging>jar</packaging>
    <name>langchain4j-spring-boot-starter</name>
    <description>Spring Boot Starter for LangChain4j</description>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-open-ai</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-local-ai</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-hugging-face</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter</artifactId>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-configuration-processor</artifactId>
            <optional>true</optional>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\ChatModel.java

```
package dev.langchain4j;
class ChatModel {
    private ModelProvider provider;
    private OpenAi openAi;
    private HuggingFace huggingFace;
    private LocalAi localAi;
    public ModelProvider getProvider() {
        return provider;
    }
    public void setProvider(ModelProvider provider) {
        this.provider = provider;
    }
    public OpenAi getOpenAi() {
        return openAi;
    }
    public void setOpenAi(OpenAi openAi) {
        this.openAi = openAi;
    }
    public HuggingFace getHuggingFace() {
        return huggingFace;
    }
    public void setHuggingFace(HuggingFace huggingFace) {
        this.huggingFace = huggingFace;
    }
    public LocalAi getLocalAi() {
        return localAi;
    }
    public void setLocalAi(LocalAi localAi) {
        this.localAi = localAi;
    }
}
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\EmbeddingModel.java

```
package dev.langchain4j;
class EmbeddingModel {
    private ModelProvider provider;
    private OpenAi openAi;
    private HuggingFace huggingFace;
    private LocalAi localAi;
    public ModelProvider getProvider() {
        return provider;
    }
    public void setProvider(ModelProvider provider) {
        this.provider = provider;
    }
    public OpenAi getOpenAi() {
        return openAi;
    }
    public void setOpenAi(OpenAi openAi) {
        this.openAi = openAi;
    }
    public HuggingFace getHuggingFace() {
        return huggingFace;
    }
    public void setHuggingFace(HuggingFace huggingFace) {
        this.huggingFace = huggingFace;
    }
    public LocalAi getLocalAi() {
        return localAi;
    }
    public void setLocalAi(LocalAi localAi) {
        this.localAi = localAi;
    }
}
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\HuggingFace.java

```
package dev.langchain4j;
import java.time.Duration;
class HuggingFace {
    private String accessToken;
    private String modelId;
    private Duration timeout;
    private Double temperature;
    private Integer maxNewTokens;
    private Boolean returnFullText;
    private Boolean waitForModel;
    public String getAccessToken() {
        return accessToken;
    }
    public void setAccessToken(String accessToken) {
        this.accessToken = accessToken;
    }
    public String getModelId() {
        return modelId;
    }
    public void setModelId(String modelId) {
        this.modelId = modelId;
    }
    public Duration getTimeout() {
        return timeout;
    }
    public void setTimeout(Duration timeout) {
        this.timeout = timeout;
    }
    public Double getTemperature() {
        return temperature;
    }
    public void setTemperature(Double temperature) {
        this.temperature = temperature;
    }
    public Integer getMaxNewTokens() {
        return maxNewTokens;
    }
    public void setMaxNewTokens(Integer maxNewTokens) {
        this.maxNewTokens = maxNewTokens;
    }
    public Boolean getReturnFullText() {
        return returnFullText;
    }
    public void setReturnFullText(Boolean returnFullText) {
        this.returnFullText = returnFullText;
    }
    public Boolean getWaitForModel() {
        return waitForModel;
    }
    public void setWaitForModel(Boolean waitForModel) {
        this.waitForModel = waitForModel;
    }
}
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\LangChain4jAutoConfiguration.java

```
package dev.langchain4j;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.huggingface.HuggingFaceChatModel;
import dev.langchain4j.model.huggingface.HuggingFaceEmbeddingModel;
import dev.langchain4j.model.huggingface.HuggingFaceLanguageModel;
import dev.langchain4j.model.language.LanguageModel;
import dev.langchain4j.model.localai.LocalAiChatModel;
import dev.langchain4j.model.localai.LocalAiEmbeddingModel;
import dev.langchain4j.model.localai.LocalAiLanguageModel;
import dev.langchain4j.model.moderation.ModerationModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.model.openai.OpenAiEmbeddingModel;
import dev.langchain4j.model.openai.OpenAiLanguageModel;
import dev.langchain4j.model.openai.OpenAiModerationModel;
import org.springframework.boot.autoconfigure.AutoConfiguration;
import
org.springframework.boot.autoconfigure.condition.ConditionalOnMissingBean;
import
org.springframework.boot.context.properties.EnableConfigurationProperties;
import org.springframework.context.annotation.Bean;
import org.springframework.context.annotation.Lazy;
import static dev.langchain4j.ModelProvider.OPEN_AI;
import static
dev.langchain4j.exception.IllegalConfigurationException.illegalConfiguration;
import static dev.langchain4j.internal.Utils.isNullOrBlank;
@AutoConfiguration
@EnableConfigurationProperties(LangChain4jProperties.class)
public class LangChain4jAutoConfiguration {
    @Bean
    @Lazy
    @ConditionalOnMissingBean
    ChatLanguageModel chatLanguageModel(LangChain4jProperties properties) {
        if (properties.getChatModel() == null) {
            throw illegalConfiguration("\n\nPlease define 'langchain4j.chat-
model' properties, for example:\n"
                    + "langchain4j.chat-model.provider = openai\n"
                    + "langchain4j.chat-model.openai.api-key = sk-...\n");
        }
        switch (properties.getChatModel().getProvider()) {
            case OPEN_AI:
                OpenAi openAi = properties.getChatModel().getOpenAi();
                if (openAi == null || isNullOrBlank(openAi.getApiKey())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.chat-model.openai.api-key' property");
                }
                return OpenAiChatModel.builder()
                        .baseUrl(openAi.getBaseUrl())
                        .apiKey(openAi.getApiKey())
                        .modelName(openAi.getModelName())
                        .temperature(openAi.getTemperature())
                        .topP(openAi.getTopP())
                        .maxTokens(openAi.getMaxTokens())
                        .presencePenalty(openAi.getPresencePenalty())
                        .frequencyPenalty(openAi.getFrequencyPenalty())
                        .timeout(openAi.getTimeout())
                        .maxRetries(openAi.getMaxRetries())
```

```
                        .logRequests(openAi.getLogRequests())
                        .logResponses(openAi.getLogResponses())
                        .build();
            case HUGGING_FACE:
                HuggingFace huggingFace =
properties.getChatModel().getHuggingFace();
                if (huggingFace == null ||
isNullOrBlank(huggingFace.getAccessToken())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.chat-model.huggingface.access-token' property");
                }
                return HuggingFaceChatModel.builder()
                        .accessToken(huggingFace.getAccessToken())
                        .modelId(huggingFace.getModelId())
                        .timeout(huggingFace.getTimeout())
                        .temperature(huggingFace.getTemperature())
                        .maxNewTokens(huggingFace.getMaxNewTokens())
                        .returnFullText(huggingFace.getReturnFullText())
                        .waitForModel(huggingFace.getWaitForModel())
                        .build();
            case LOCAL_AI:
                LocalAi localAi = properties.getChatModel().getLocalAi();
                if (localAi == null || isNullOrBlank(localAi.getBaseUrl())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.chat-model.localai.base-url' property");
                }
                if (isNullOrBlank(localAi.getModelName())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.chat-model.localai.model-name' property");
                }
                return LocalAiChatModel.builder()
                        .baseUrl(localAi.getBaseUrl())
                        .modelName(localAi.getModelName())
                        .temperature(localAi.getTemperature())
                        .topP(localAi.getTopP())
                        .maxTokens(localAi.getMaxTokens())
                        .timeout(localAi.getTimeout())
                        .maxRetries(localAi.getMaxRetries())
                        .logRequests(localAi.getLogRequests())
                        .logResponses(localAi.getLogResponses())
                        .build();
            default:
                throw illegalConfiguration("Unsupported chat model provider:
%s", properties.getChatModel().getProvider());
        }
    }
    @Bean
    @Lazy
    @ConditionalOnMissingBean
    LanguageModel languageModel(LangChain4jProperties properties) {
        if (properties.getLanguageModel() == null) {
            throw illegalConfiguration("\n\nPlease define
'langchain4j.language-model' properties, for example:\n"
                    + "langchain4j.language-model.provider = openai\n"
                    + "langchain4j.language-model.openai.api-key = sk-...\n");
        }
        switch (properties.getLanguageModel().getProvider()) {
            case OPEN_AI:
                OpenAi openAi = properties.getLanguageModel().getOpenAi();
                if (openAi == null || isNullOrBlank(openAi.getApiKey())) {
                    throw illegalConfiguration("\n\nPlease define
```

```
'langchain4j.language-model.openai.api-key' property");
                }
                return OpenAiLanguageModel.builder()
                        .apiKey(openAi.getApiKey())
                        .modelName(openAi.getModelName())
                        .temperature(openAi.getTemperature())
                        .timeout(openAi.getTimeout())
                        .maxRetries(openAi.getMaxRetries())
                        .logRequests(openAi.getLogRequests())
                        .logResponses(openAi.getLogResponses())
                        .build();
            case HUGGING_FACE:
                HuggingFace huggingFace =
properties.getLanguageModel().getHuggingFace();
                if (huggingFace == null ||
isNullOrBlank(huggingFace.getAccessToken())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.language-model.huggingface.access-token' property");
                }
                return HuggingFaceLanguageModel.builder()
                        .accessToken(huggingFace.getAccessToken())
                        .modelId(huggingFace.getModelId())
                        .timeout(huggingFace.getTimeout())
                        .temperature(huggingFace.getTemperature())
                        .maxNewTokens(huggingFace.getMaxNewTokens())
                        .returnFullText(huggingFace.getReturnFullText())
                        .waitForModel(huggingFace.getWaitForModel())
                        .build();
            case LOCAL_AI:
                LocalAi localAi = properties.getLanguageModel().getLocalAi();
                if (localAi == null || isNullOrBlank(localAi.getBaseUrl())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.language-model.localai.base-url' property");
                }
                if (isNullOrBlank(localAi.getModelName())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.language-model.localai.model-name' property");
                }
                return LocalAiLanguageModel.builder()
                        .baseUrl(localAi.getBaseUrl())
                        .modelName(localAi.getModelName())
                        .temperature(localAi.getTemperature())
                        .topP(localAi.getTopP())
                        .maxTokens(localAi.getMaxTokens())
                        .timeout(localAi.getTimeout())
                        .maxRetries(localAi.getMaxRetries())
                        .logRequests(localAi.getLogRequests())
                        .logResponses(localAi.getLogResponses())
                        .build();
            default:
                throw illegalConfiguration("Unsupported language model
provider: %s", properties.getLanguageModel().getProvider());
        }
    }
    @Bean
    @Lazy
    @ConditionalOnMissingBean
    EmbeddingModel embeddingModel(LangChain4jProperties properties) {
        if (properties.getEmbeddingModel() == null ||
properties.getEmbeddingModel().getProvider() == null) {
            throw illegalConfiguration("\n\nPlease define
```

```
'langchain4j.embedding-model' properties, for example:\n"
                    + "langchain4j.embedding-model.provider = openai\n"
                    + "langchain4j.embedding-model.openai.api-key = sk-...
\n");
        }
        switch (properties.getEmbeddingModel().getProvider()) {
            case OPEN_AI:
                OpenAi openAi = properties.getEmbeddingModel().getOpenAi();
                if (openAi == null || isNullOrBlank(openAi.getApiKey())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.embedding-model.openai.api-key' property"); // TODO exception
type
                }
                return OpenAiEmbeddingModel.builder()
                        .apiKey(openAi.getApiKey())
                        .modelName(openAi.getModelName())
                        .timeout(openAi.getTimeout())
                        .maxRetries(openAi.getMaxRetries())
                        .logRequests(openAi.getLogRequests())
                        .logResponses(openAi.getLogResponses())
                        .build();
            case HUGGING_FACE:
                HuggingFace huggingFace =
properties.getEmbeddingModel().getHuggingFace();
                if (huggingFace == null ||
isNullOrBlank(huggingFace.getAccessToken())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.embedding-model.huggingface.access-token' property");
                }
                return HuggingFaceEmbeddingModel.builder()
                        .accessToken(huggingFace.getAccessToken())
                        .modelId(huggingFace.getModelId())
                        .waitForModel(huggingFace.getWaitForModel())
                        .timeout(huggingFace.getTimeout())
                        .build();
            case LOCAL_AI:
                LocalAi localAi = properties.getEmbeddingModel().getLocalAi();
                if (localAi == null || isNullOrBlank(localAi.getBaseUrl())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.embedding-model.localai.base-url' property");
                }
                if (isNullOrBlank(localAi.getModelName())) {
                    throw illegalConfiguration("\n\nPlease define
'langchain4j.embedding-model.localai.model-name' property");
                }
                return LocalAiEmbeddingModel.builder()
                        .baseUrl(localAi.getBaseUrl())
                        .modelName(localAi.getModelName())
                        .timeout(localAi.getTimeout())
                        .maxRetries(localAi.getMaxRetries())
                        .logRequests(localAi.getLogRequests())
                        .logResponses(localAi.getLogResponses())
                        .build();
            default:
                throw illegalConfiguration("Unsupported embedding model
provider: %s", properties.getEmbeddingModel().getProvider());
        }
    }
    @Bean
    @Lazy
    @ConditionalOnMissingBean
```

```
    ModerationModel moderationModel(LangChain4jProperties properties) {
        if (properties.getModerationModel() == null) {
            throw illegalConfiguration("\n\nPlease define
'langchain4j.moderation-model' properties, for example:\n"
                    + "langchain4j.moderation-model.provider = openai\n"
                    + "langchain4j.moderation-model.openai.api-key = sk-...
\n");
        }
        if (properties.getModerationModel().getProvider() != OPEN_AI) {
            throw illegalConfiguration("Unsupported moderation model
provider: %s", properties.getModerationModel().getProvider());
        }
        OpenAi openAi = properties.getModerationModel().getOpenAi();
        if (openAi == null || isNullOrBlank(openAi.getApiKey())) {
            throw illegalConfiguration("\n\nPlease define
'langchain4j.moderation-model.openai.api-key' property");
        }
        return OpenAiModerationModel.builder()
                .apiKey(openAi.getApiKey())
                .modelName(openAi.getModelName())
                .timeout(openAi.getTimeout())
                .maxRetries(openAi.getMaxRetries())
                .logRequests(openAi.getLogRequests())
                .logResponses(openAi.getLogResponses())
                .build();
    }
}
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\LangChain4jProperties.java

```
package dev.langchain4j;
import org.springframework.boot.context.properties.ConfigurationProperties;
@ConfigurationProperties(prefix = "langchain4j")
public class LangChain4jProperties {
    private ChatModel chatModel;
    private LanguageModel languageModel;
    private EmbeddingModel embeddingModel;
    private ModerationModel moderationModel;
    public ChatModel getChatModel() {
        return chatModel;
    }
    public void setChatModel(ChatModel chatModel) {
        this.chatModel = chatModel;
    }
    public LanguageModel getLanguageModel() {
        return languageModel;
    }
    public void setLanguageModel(LanguageModel languageModel) {
        this.languageModel = languageModel;
    }
    public EmbeddingModel getEmbeddingModel() {
        return embeddingModel;
    }
    public void setEmbeddingModel(EmbeddingModel embeddingModel) {
        this.embeddingModel = embeddingModel;
    }
    public ModerationModel getModerationModel() {
        return moderationModel;
    }
    public void setModerationModel(ModerationModel moderationModel) {
        this.moderationModel = moderationModel;
    }
}
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\LanguageModel.java

```
package dev.langchain4j;
class LanguageModel {
    private ModelProvider provider;
    private OpenAi openAi;
    private HuggingFace huggingFace;
    private LocalAi localAi;
    public ModelProvider getProvider() {
        return provider;
    }
    public void setProvider(ModelProvider provider) {
        this.provider = provider;
    }
    public OpenAi getOpenAi() {
        return openAi;
    }
    public void setOpenAi(OpenAi openAi) {
        this.openAi = openAi;
    }
    public HuggingFace getHuggingFace() {
        return huggingFace;
    }
    public void setHuggingFace(HuggingFace huggingFace) {
        this.huggingFace = huggingFace;
    }
    public LocalAi getLocalAi() {
        return localAi;
    }
    public void setLocalAi(LocalAi localAi) {
        this.localAi = localAi;
    }
}
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\LocalAi.java

```
package dev.langchain4j;
import java.time.Duration;
class LocalAi {
    private String baseUrl;
    private String modelName;
    private Double temperature;
    private Double topP;
    private Integer maxTokens;
    private Duration timeout;
    private Integer maxRetries;
    private Boolean logRequests;
    private Boolean logResponses;
    public String getBaseUrl() {
        return baseUrl;
    }
    public void setBaseUrl(String baseUrl) {
        this.baseUrl = baseUrl;
    }
    public String getModelName() {
        return modelName;
    }
    public void setModelName(String modelName) {
        this.modelName = modelName;
    }
    public Double getTemperature() {
        return temperature;
    }
    public void setTemperature(Double temperature) {
        this.temperature = temperature;
    }
    public Double getTopP() {
        return topP;
    }
    public void setTopP(Double topP) {
        this.topP = topP;
    }
    public Integer getMaxTokens() {
        return maxTokens;
    }
    public void setMaxTokens(Integer maxTokens) {
        this.maxTokens = maxTokens;
    }
    public Duration getTimeout() {
        return timeout;
    }
    public void setTimeout(Duration timeout) {
        this.timeout = timeout;
    }
    public Integer getMaxRetries() {
        return maxRetries;
    }
    public void setMaxRetries(Integer maxRetries) {
        this.maxRetries = maxRetries;
    }
    public Boolean getLogRequests() {
        return logRequests;
    }
    public void setLogRequests(Boolean logRequests) {
```

```
        this.logRequests = logRequests;
    }
    public Boolean getLogResponses() {
        return logResponses;
    }
    public void setLogResponses(Boolean logResponses) {
        this.logResponses = logResponses;
    }
}
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\ModelProvider.java

```
package dev.langchain4j;
enum ModelProvider {
    OPEN_AI,
    HUGGING_FACE,
    LOCAL_AI
}
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\ModerationModel.java

```
package dev.langchain4j;
class ModerationModel {
    private ModelProvider provider;
    private OpenAi openAi;
    public ModelProvider getProvider() {
        return provider;
    }
    public void setProvider(ModelProvider provider) {
        this.provider = provider;
    }
    public OpenAi getOpenAi() {
        return openAi;
    }
    public void setOpenAi(OpenAi openAi) {
        this.openAi = openAi;
    }
}
```

langchain4j-spring-boot-starter\src\main\java\dev\langchain4j\OpenAi.java

```
package dev.langchain4j;
import java.time.Duration;
class OpenAi {
    private String baseUrl;
    private String apiKey;
    private String modelName;
    private Double temperature;
    private Double topP;
    private Integer maxTokens;
    private Double presencePenalty;
    private Double frequencyPenalty;
    private Duration timeout;
    private Integer maxRetries;
    private Boolean logRequests;
    private Boolean logResponses;
    public String getBaseUrl() {
        return baseUrl;
    }
    public void setBaseUrl(String baseUrl) {
        this.baseUrl = baseUrl;
    }
    public String getApiKey() {
        return apiKey;
    }
    public void setApiKey(String apiKey) {
        this.apiKey = apiKey;
    }
    public String getModelName() {
        return modelName;
    }
    public void setModelName(String modelName) {
        this.modelName = modelName;
    }
    public Double getTemperature() {
        return temperature;
    }
    public void setTemperature(Double temperature) {
        this.temperature = temperature;
    }
    public Double getTopP() {
        return topP;
    }
    public void setTopP(Double topP) {
        this.topP = topP;
    }
    public Integer getMaxTokens() {
        return maxTokens;
    }
    public void setMaxTokens(Integer maxTokens) {
        this.maxTokens = maxTokens;
    }
    public Double getPresencePenalty() {
        return presencePenalty;
    }
    public void setPresencePenalty(Double presencePenalty) {
        this.presencePenalty = presencePenalty;
    }
    public Double getFrequencyPenalty() {
```

```
        return frequencyPenalty;
    }
    public void setFrequencyPenalty(Double frequencyPenalty) {
        this.frequencyPenalty = frequencyPenalty;
    }
    public Duration getTimeout() {
        return timeout;
    }
    public void setTimeout(Duration timeout) {
        this.timeout = timeout;
    }
    public Integer getMaxRetries() {
        return maxRetries;
    }
    public void setMaxRetries(Integer maxRetries) {
        this.maxRetries = maxRetries;
    }
    public Boolean getLogRequests() {
        return logRequests;
    }
    public void setLogRequests(Boolean logRequests) {
        this.logRequests = logRequests;
    }
    public Boolean getLogResponses() {
        return logResponses;
    }
    public void setLogResponses(Boolean logResponses) {
        this.logResponses = logResponses;
    }
}
```

```
 langchain4j-spring-boot-starter\src\main\resources\META-
INF\spring\org.springframework.boot.autoconfigure.AutoConfiguration.imports

dev.langchain4j.LangChain4jAutoConfiguration
```

langchain4j-spring-boot-starter\src\main\resources\META-INF\spring.factories

```
org.springframework.boot.autoconfigure.EnableAutoConfiguration=dev.langchain4j.LangChain4jAutoConfiguration
```

langchain4j-vertex-ai\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-vertex-ai</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with Vertex AI</name>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>com.google.cloud</groupId>
            <artifactId>google-cloud-aiplatform</artifactId>
            <version>3.24.0</version>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-params</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-vertex-ai\src\main\java\dev\langchain4j\model\vertexai\VertexAiChatInstance.java

```
package dev.langchain4j.model.vertexai;
import java.util.List;
class VertexAiChatInstance {
    private final String context;
    private final List<Message> messages;
    VertexAiChatInstance(String context, List<Message> messages) {
        this.context = context;
        this.messages = messages;
    }
    static class Message {
        private final String author;
        private final String content;
        Message(String author, String content) {
            this.author = author;
            this.content = content;
        }
    }
}
```

langchain4j-vertex-ai\src\main\java\dev\langchain4j\model\vertexai\VertexAiChatModel.java

```
package dev.langchain4j.model.vertexai;
import com.google.cloud.aiplatform.v1.EndpointName;
import com.google.cloud.aiplatform.v1.PredictResponse;
import com.google.cloud.aiplatform.v1.PredictionServiceClient;
import com.google.cloud.aiplatform.v1.PredictionServiceSettings;
import com.google.protobuf.Value;
import com.google.protobuf.util.JsonFormat;
import dev.langchain4j.agent.tool.ToolSpecification;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import java.io.IOException;
import java.util.List;
import static com.google.protobuf.Value.newBuilder;
import static dev.langchain4j.data.message.ChatMessageType.AI;
import static dev.langchain4j.data.message.ChatMessageType.SYSTEM;
import static dev.langchain4j.data.message.ChatMessageType.USER;
import static dev.langchain4j.internal.Json.toJson;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.joining;
import static java.util.stream.Collectors.toList;
/**
 * Represents a Google Vertex AI language model with a chat completion
interface, such as chat-bison.
 * See details <a href="https://cloud.google.com/vertex-ai/docs/generative-ai/
chat/chat-prompts">here</a>.
 */
public class VertexAiChatModel implements ChatLanguageModel {
    private final PredictionServiceSettings settings;
    private final EndpointName endpointName;
    private final VertexAiParameters vertexAiParameters;
    private final Integer maxRetries;
    public VertexAiChatModel(String endpoint,
                             String project,
                             String location,
                             String publisher,
                             String modelName,
                             Double temperature,
                             Integer maxOutputTokens,
                             Integer topK,
                             Double topP,
                             Integer maxRetries) {
        try {
            this.settings = PredictionServiceSettings.newBuilder()
                    .setEndpoint(ensureNotBlank(endpoint, "endpoint"))
                    .build();
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
        this.endpointName = EndpointName.ofProjectLocationPublisherModelName(
                ensureNotBlank(project, "project"),
                ensureNotBlank(location, "location"),
                ensureNotBlank(publisher, "publisher"),
```

```
                ensureNotBlank(modelName, "modelName")
        );
        this.vertexAiParameters = new VertexAiParameters(temperature,
maxOutputTokens, topK, topP);
        this.maxRetries = maxRetries == null ? 3 : maxRetries;
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages) {
        try (PredictionServiceClient client =
PredictionServiceClient.create(settings)) {
            VertexAiChatInstance vertexAiChatInstance = new
VertexAiChatInstance(
                    toContext(messages),
                    toVertexMessages(messages)
            );
            Value.Builder instanceBuilder = newBuilder();
            JsonFormat.parser().merge(toJson(vertexAiChatInstance),
instanceBuilder);
            List<Value> instances = singletonList(instanceBuilder.build());
            Value.Builder parametersBuilder = newBuilder();
            JsonFormat.parser().merge(toJson(vertexAiParameters),
parametersBuilder);
            Value parameters = parametersBuilder.build();
            PredictResponse response = withRetry(() ->
client.predict(endpointName, instances, parameters), maxRetries);
            return Response.from(
                    AiMessage.from(extractContent(response)),
                    new TokenUsage(
                            extractTokenCount(response, "inputTokenCount"),
                            extractTokenCount(response, "outputTokenCount")
                    )
            );
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
    private static String extractContent(PredictResponse predictResponse) {
        return predictResponse.getPredictions(0)
                .getStructValue()
                .getFieldsMap()
                .get("candidates")
                .getListValue()
                .getValues(0)
                .getStructValue()
                .getFieldsMap()
                .get("content")
                .getStringValue();
    }
    static int extractTokenCount(PredictResponse predictResponse, String
fieldName) {
        return (int) predictResponse.getMetadata()
                .getStructValue()
                .getFieldsMap()
                .get("tokenMetadata")
                .getStructValue()
                .getFieldsMap()
                .get(fieldName)
                .getStructValue()
                .getFieldsMap()
                .get("totalTokens")
                .getNumberValue();
```

```
    }
    private static List<VertexAiChatInstance.Message>
toVertexMessages(List<ChatMessage> messages) {
        return messages.stream()
                .filter(chatMessage -> chatMessage.type() == USER ||
chatMessage.type() == AI)
                .map(chatMessage -> new
VertexAiChatInstance.Message(chatMessage.type().name(), chatMessage.text()))
                .collect(toList());
    }
    private static String toContext(List<ChatMessage> messages) {
        return messages.stream()
                .filter(chatMessage -> chatMessage.type() == SYSTEM)
                .map(ChatMessage::text)
                .collect(joining("\n"));
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
List<ToolSpecification> toolSpecifications) {
        throw new IllegalArgumentException("Tools are currently not supported
for Vertex AI models");
    }
    @Override
    public Response<AiMessage> generate(List<ChatMessage> messages,
ToolSpecification toolSpecification) {
        throw new IllegalArgumentException("Tools are currently not supported
for Vertex AI models");
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String endpoint;
        private String project;
        private String location;
        private String publisher;
        private String modelName;
        private Double temperature;
        private Integer maxOutputTokens = 200;
        private Integer topK;
        private Double topP;
        private Integer maxRetries;
        public Builder endpoint(String endpoint) {
            this.endpoint = endpoint;
            return this;
        }
        public Builder project(String project) {
            this.project = project;
            return this;
        }
        public Builder location(String location) {
            this.location = location;
            return this;
        }
        public Builder publisher(String publisher) {
            this.publisher = publisher;
            return this;
        }
        public Builder modelName(String modelName) {
            this.modelName = modelName;
            return this;
```

```
        }
        public Builder temperature(Double temperature) {
            this.temperature = temperature;
            return this;
        }
        public Builder maxOutputTokens(Integer maxOutputTokens) {
            this.maxOutputTokens = maxOutputTokens;
            return this;
        }
        public Builder topK(Integer topK) {
            this.topK = topK;
            return this;
        }
        public Builder topP(Double topP) {
            this.topP = topP;
            return this;
        }
        public Builder maxRetries(Integer maxRetries) {
            this.maxRetries = maxRetries;
            return this;
        }
        public VertexAiChatModel build() {
            return new VertexAiChatModel(
                    endpoint,
                    project,
                    location,
                    publisher,
                    modelName,
                    temperature,
                    maxOutputTokens,
                    topK,
                    topP,
                    maxRetries);
        }
    }
}
```

langchain4j-vertex-ai\src\main\java\dev\langchain4j\model\vertexai\VertexAiEmbeddingInstance.java

```
package dev.langchain4j.model.vertexai;
class VertexAiEmbeddingInstance {
    private final String content;
    VertexAiEmbeddingInstance(String content) {
        this.content = content;
    }
}
```

langchain4j-vertex-ai\src\main\java\dev\langchain4j\model\vertexai\VertexAiEmbeddingModel.java

```
package dev.langchain4j.model.vertexai;
import com.google.cloud.aiplatform.v1.EndpointName;
import com.google.cloud.aiplatform.v1.PredictResponse;
import com.google.cloud.aiplatform.v1.PredictionServiceClient;
import com.google.cloud.aiplatform.v1.PredictionServiceSettings;
import com.google.protobuf.Value;
import com.google.protobuf.util.JsonFormat;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import java.io.IOException;
import java.util.ArrayList;
import java.util.List;
import static com.google.cloud.aiplatform.util.ValueConverter.EMPTY_VALUE;
import static dev.langchain4j.internal.Json.toJson;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.Utils.getOrDefault;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static java.util.stream.Collectors.toList;
/**
 * Represents a Google Vertex AI embedding model, such as textembedding-gecko.
 * See details <a href="https://cloud.google.com/vertex-ai/docs/generative-ai/
embeddings/get-text-embeddings">here</a>.
 */
public class VertexAiEmbeddingModel implements EmbeddingModel {
    private static final int BATCH_SIZE = 5; // Vertex AI has a limit of up
to 5 input texts per request
    private final PredictionServiceSettings settings;
    private final EndpointName endpointName;
    private final Integer maxRetries;
    public VertexAiEmbeddingModel(String endpoint,
                                  String project,
                                  String location,
                                  String publisher,
                                  String modelName,
                                  Integer maxRetries) {
        try {
            this.settings = PredictionServiceSettings.newBuilder()
                    .setEndpoint(ensureNotBlank(endpoint, "endpoint"))
                    .build();
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
        this.endpointName = EndpointName.ofProjectLocationPublisherModelName(
                ensureNotBlank(project, "project"),
                ensureNotBlank(location, "location"),
                ensureNotBlank(publisher, "publisher"),
                ensureNotBlank(modelName, "modelName")
        );
        this.maxRetries = getOrDefault(maxRetries, 3);
    }
    @Override
    public Response<List<Embedding>> embedAll(List<TextSegment> segments) {
        try (PredictionServiceClient client =
PredictionServiceClient.create(settings)) {
```

```
            List<Embedding> embeddings = new ArrayList<>();
            int inputTokenCount = 0;
            for (int i = 0; i < segments.size(); i += BATCH_SIZE) {
                List<TextSegment> batch = segments.subList(i, Math.min(i +
BATCH_SIZE, segments.size()));
                List<Value> instances = new ArrayList<>();
                for (TextSegment segment : batch) {
                    Value.Builder instanceBuilder = Value.newBuilder();
                    JsonFormat.parser().merge(toJson(new
VertexAiEmbeddingInstance(segment.text())), instanceBuilder);
                    instances.add(instanceBuilder.build());
                }
                PredictResponse response = withRetry(() ->
client.predict(endpointName, instances, EMPTY_VALUE), maxRetries);
                embeddings.addAll(response.getPredictionsList().stream()
                        .map(VertexAiEmbeddingModel::toEmbedding)
                        .collect(toList()));
                for (Value prediction : response.getPredictionsList()) {
                    inputTokenCount += extractTokenCount(prediction);
                }
            }
            return Response.from(
                    embeddings,
                    new TokenUsage(inputTokenCount)
            );
        } catch (Exception e) {
            throw new RuntimeException(e);
        }
    }
    private static Embedding toEmbedding(Value prediction) {
        List<Float> vector = prediction.getStructValue()
                .getFieldsMap()
                .get("embeddings")
                .getStructValue()
                .getFieldsOrThrow("values")
                .getListValue()
                .getValuesList()
                .stream()
                .map(v -> (float) v.getNumberValue())
                .collect(toList());
        return Embedding.from(vector);
    }
    private static int extractTokenCount(Value prediction) {
        return (int) prediction.getStructValue()
                .getFieldsMap()
                .get("embeddings")
                .getStructValue()
                .getFieldsMap()
                .get("statistics")
                .getStructValue()
                .getFieldsMap()
                .get("token_count")
                .getNumberValue();
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String endpoint;
        private String project;
        private String location;
```

```
        private String publisher;
        private String modelName;
        private Integer maxRetries;
        public Builder endpoint(String endpoint) {
            this.endpoint = endpoint;
            return this;
        }
        public Builder project(String project) {
            this.project = project;
            return this;
        }
        public Builder location(String location) {
            this.location = location;
            return this;
        }
        public Builder publisher(String publisher) {
            this.publisher = publisher;
            return this;
        }
        public Builder modelName(String modelName) {
            this.modelName = modelName;
            return this;
        }
        public Builder maxRetries(Integer maxRetries) {
            this.maxRetries = maxRetries;
            return this;
        }
        public VertexAiEmbeddingModel build() {
            return new VertexAiEmbeddingModel(
                    endpoint,
                    project,
                    location,
                    publisher,
                    modelName,
                    maxRetries);
        }
    }
}
```

langchain4j-vertex-ai\src\main\java\dev\langchain4j\model\vertexai\VertexAiParameters.java

```
package dev.langchain4j.model.vertexai;
class VertexAiParameters {
    private final Double temperature;
    private final Integer maxOutputTokens;
    private final Integer topK;
    private final Double topP;
    VertexAiParameters(Double temperature,
                       Integer maxOutputTokens,
                       Integer topK,
                       Double topP) {
        this.temperature = temperature;
        this.maxOutputTokens = maxOutputTokens;
        this.topK = topK;
        this.topP = topP;
    }
}
```

langchain4j-vertex-ai\src\main\java\dev\langchain4j\model\vertexai\VertexAiTextInstance.java

```
package dev.langchain4j.model.vertexai;
class VertexAiTextInstance {
    private final String prompt;
    VertexAiTextInstance(String prompt) {
        this.prompt = prompt;
    }
}
```

langchain4j-vertex-ai\src\main\java\dev\langchain4j\model\vertexai\VextexAiLanguageModel.java

```
package dev.langchain4j.model.vertexai;
import com.google.cloud.aiplatform.v1.EndpointName;
import com.google.cloud.aiplatform.v1.PredictResponse;
import com.google.cloud.aiplatform.v1.PredictionServiceClient;
import com.google.cloud.aiplatform.v1.PredictionServiceSettings;
import com.google.protobuf.Value;
import com.google.protobuf.util.JsonFormat;
import dev.langchain4j.model.language.LanguageModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import java.io.IOException;
import java.util.List;
import static com.google.protobuf.Value.newBuilder;
import static dev.langchain4j.internal.Json.toJson;
import static dev.langchain4j.internal.RetryUtils.withRetry;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static
dev.langchain4j.model.vertexai.VertexAiChatModel.extractTokenCount;
import static java.util.Collections.singletonList;
/**
 * Represents a Google Vertex AI language model with a text interface, such
as text-bison.
 * See details <a href="https://cloud.google.com/vertex-ai/docs/generative-ai/
text/text-overview">here</a>.
 */
public class VextexAiLanguageModel implements LanguageModel {
    private final PredictionServiceSettings settings;
    private final EndpointName endpointName;
    private final VertexAiParameters vertexAiParameters;
    private final Integer maxRetries;
    public VextexAiLanguageModel(String endpoint,
                                 String project,
                                 String location,
                                 String publisher,
                                 String modelName,
                                 Double temperature,
                                 Integer maxOutputTokens,
                                 Integer topK,
                                 Double topP,
                                 Integer maxRetries) {
        try {
            this.settings = PredictionServiceSettings.newBuilder()
                    .setEndpoint(ensureNotBlank(endpoint, "endpoint"))
                    .build();
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
        this.endpointName = EndpointName.ofProjectLocationPublisherModelName(
                ensureNotBlank(project, "project"),
                ensureNotBlank(location, "location"),
                ensureNotBlank(publisher, "publisher"),
                ensureNotBlank(modelName, "modelName")
        );
        this.vertexAiParameters = new VertexAiParameters(temperature,
maxOutputTokens, topK, topP);
        this.maxRetries = maxRetries == null ? 3 : maxRetries;
    }
```

```
    @Override
    public Response<String> generate(String prompt) {
        try (PredictionServiceClient client =
PredictionServiceClient.create(settings)) {
            Value.Builder instanceBuilder = newBuilder();
            JsonFormat.parser().merge(toJson(new
VertexAiTextInstance(prompt)), instanceBuilder);
            List<Value> instances = singletonList(instanceBuilder.build());
            Value.Builder parametersBuilder = Value.newBuilder();
            JsonFormat.parser().merge(toJson(vertexAiParameters),
parametersBuilder);
            Value parameters = parametersBuilder.build();
            PredictResponse response = withRetry(() ->
client.predict(endpointName, instances, parameters), maxRetries);
            return Response.from(
                    extractContent(response),
                    new TokenUsage(
                            extractTokenCount(response, "inputTokenCount"),
                            extractTokenCount(response, "outputTokenCount")
                    )
            );
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
    private static String extractContent(PredictResponse predictResponse) {
        return predictResponse.getPredictions(0)
                .getStructValue()
                .getFieldsMap()
                .get("content")
                .getStringValue();
    }
    public static Builder builder() {
        return new Builder();
    }
    public static class Builder {
        private String endpoint;
        private String project;
        private String location;
        private String publisher;
        private String modelName;
        private Double temperature;
        private Integer maxOutputTokens = 200;
        private Integer topK;
        private Double topP;
        private Integer maxRetries;
        public Builder endpoint(String endpoint) {
            this.endpoint = endpoint;
            return this;
        }
        public Builder project(String project) {
            this.project = project;
            return this;
        }
        public Builder location(String location) {
            this.location = location;
            return this;
        }
        public Builder publisher(String publisher) {
            this.publisher = publisher;
            return this;
```

```
        }
        public Builder modelName(String modelName) {
            this.modelName = modelName;
            return this;
        }
        public Builder temperature(Double temperature) {
            this.temperature = temperature;
            return this;
        }
        public Builder maxOutputTokens(Integer maxOutputTokens) {
            this.maxOutputTokens = maxOutputTokens;
            return this;
        }
        public Builder topK(Integer topK) {
            this.topK = topK;
            return this;
        }
        public Builder topP(Double topP) {
            this.topP = topP;
            return this;
        }
        public Builder maxRetries(Integer maxRetries) {
            this.maxRetries = maxRetries;
            return this;
        }
        public VextexAiLanguageModel build() {
            return new VextexAiLanguageModel(
                    endpoint,
                    project,
                    location,
                    publisher,
                    modelName,
                    temperature,
                    maxOutputTokens,
                    topK,
                    topP,
                    maxRetries);
        }
    }
}
```

langchain4j-vertex-ai\src\test\java\dev\langchain4j\model\vertexai\VertexAiChatModelIT.java

```
package dev.langchain4j.model.vertexai;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class VertexAiChatModelIT {
    @Test
    @Disabled("To run this test, you must have provide your own endpoint, project and location")
    void testChatModel() {
        VertexAiChatModel vertexAiChatModel = VertexAiChatModel.builder()
                .endpoint("us-central1-aiplatform.googleapis.com:443")
                .project("langchain4j")
                .location("us-central1")
                .publisher("google")
                .modelName("chat-bison@001")
                .temperature(1.0)
                .maxOutputTokens(50)
                .topK(0)
                .topP(0.0)
                .maxRetries(3)
                .build();
        Response<AiMessage> response = vertexAiChatModel.generate(UserMessage.from("hi, how are you doing?"));
        System.out.println(response);
        assertThat(response.content().text()).isNotBlank();
        TokenUsage tokenUsage = response.tokenUsage();
        assertThat(tokenUsage.inputTokenCount()).isEqualTo(7);
        assertThat(tokenUsage.outputTokenCount()).isGreaterThan(1);
        assertThat(tokenUsage.totalTokenCount()).isGreaterThan(8);
        assertThat(response.finishReason()).isNull();
    }
}
```

langchain4j-vertex-ai\src\test\java\dev\langchain4j\model\vertexai\VertexAiEmbeddingModelIT.java

```
package dev.langchain4j.model.vertexai;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import java.util.Arrays;
import java.util.List;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
class VertexAiEmbeddingModelIT {
    @Test
    @Disabled("To run this test, you must have provide your own endpoint,
project and location")
    void testEmbeddingModel() {
        EmbeddingModel embeddingModel = VertexAiEmbeddingModel.builder()
                .endpoint("us-central1-aiplatform.googleapis.com:443")
                .project("langchain4j")
                .location("us-central1")
                .publisher("google")
                .modelName("textembedding-gecko@001")
                .maxRetries(3)
                .build();
        List<TextSegment> segments = asList(
                TextSegment.from("one"),
                TextSegment.from("two"),
                TextSegment.from("three"),
                TextSegment.from("four"),
                TextSegment.from("five"),
                TextSegment.from("six")
        );
        Response<List<Embedding>> response =
embeddingModel.embedAll(segments);
        List<Embedding> embeddings = response.content();
        assertThat(embeddings).hasSize(6);
        Embedding embedding = embeddings.get(0);
        assertThat(embedding.vector()).hasSize(768);
        System.out.println(Arrays.toString(embedding.vector()));
        TokenUsage tokenUsage = response.tokenUsage();
        assertThat(tokenUsage.inputTokenCount()).isEqualTo(6);
        assertThat(tokenUsage.outputTokenCount()).isNull();
        assertThat(tokenUsage.totalTokenCount()).isEqualTo(6);
        assertThat(response.finishReason()).isNull();
    }
}
```

langchain4j-vertex-ai\src\test\java\dev\langchain4j\model\vertexai\VextexAiLanguageModelIT.java

```
package dev.langchain4j.model.vertexai;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.output.TokenUsage;
import org.junit.jupiter.api.Disabled;
import org.junit.jupiter.api.Test;
import static org.assertj.core.api.Assertions.assertThat;
class VextexAiLanguageModelIT {
    @Test
    @Disabled("To run this test, you must have provide your own endpoint, project and location")
    void testLanguageModel() {
        VextexAiLanguageModel vextexAiLanguageModel = VextexAiLanguageModel.builder()
                .endpoint("us-central1-aiplatform.googleapis.com:443")
                .project("langchain4j")
                .location("us-central1")
                .publisher("google")
                .modelName("text-bison@001")
                .temperature(0.2)
                .maxOutputTokens(50)
                .topK(40)
                .topP(0.95)
                .maxRetries(3)
                .build();
        Response<String> response = vextexAiLanguageModel.generate("hi, what is java?");
        assertThat(response.content()).containsIgnoringCase("java");
        System.out.println(response);
        TokenUsage tokenUsage = response.tokenUsage();
        assertThat(tokenUsage.inputTokenCount()).isEqualTo(6);
        assertThat(tokenUsage.outputTokenCount()).isGreaterThan(1);
        assertThat(tokenUsage.totalTokenCount()).isGreaterThan(7);
        assertThat(response.finishReason()).isNull();
    }
}
```

langchain4j-vespa\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-vespa</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with Vespa</name>
    <description>
        Vespa is a fully featured search engine and vector database.
        Integration with LangChain4j uses:
        - Vespa's client &amp;amp; vespa-feed-client libraries which have Apache
License 2.0:
        https://github.com/vespa-engine/vespa/blob/master/LICENSE
        - org.apache.httpcomponents.client5.httpclient5-fluent library which
has Apache License 2.0:
        https://github.com/apache/httpcomponents-client/blob/master/
LICENSE.txt
    </description>
    <properties>
        <vespa.version>8.190.2</vespa.version> <!-- the latest Java 8 version
-->
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>com.yahoo.vespa</groupId>
            <artifactId>client</artifactId>
            <version>${vespa.version}</version>
        </dependency>
        <dependency>
            <groupId>com.yahoo.vespa</groupId>
            <artifactId>vespa-feed-client</artifactId>
            <version>${vespa.version}</version>
        </dependency>
        <dependency>
            <groupId>com.squareup.retrofit2</groupId>
            <artifactId>retrofit</artifactId>
        </dependency>
        <dependency>
            <groupId>com.squareup.retrofit2</groupId>
            <artifactId>converter-gson</artifactId>
        </dependency>
        <dependency>
            <groupId>com.squareup.okhttp3</groupId>
            <artifactId>okhttp</artifactId>
        </dependency>
```

```
        <dependency>
            <groupId>org.projectlombok</groupId>
            <artifactId>lombok</artifactId>
            <scope>provided</scope>
        </dependency>
    </dependencies>
    <licenses>
        <license>
            <name>Apache-2.0</name>
            <url>https://www.apache.org/licenses/LICENSE-2.0.txt</url>
            <distribution>repo</distribution>
            <comments>A business-friendly OSS license</comments>
        </license>
    </licenses>
</project>
```

langchain4j-vespa\src\main\java\dev\langchain4j\store\embedding\vespa\QueryResponse.java

```
package dev.langchain4j.store.embedding.vespa;
import java.util.List;
class QueryResponse {
  private RootNode root;
  public RootNode getRoot() {
    return root;
  }
  public void setRoot(RootNode root) {
    this.root = root;
  }
  public static class RootNode {
    private List<Record> children;
    public List<Record> getChildren() {
      return children;
    }
    public void setChildren(List<Record> children) {
      this.children = children;
    }
  }
}
```

langchain4j-vespa\src\main\java\dev\langchain4j\store\embedding\vespa\Record.java

```
package dev.langchain4j.store.embedding.vespa;
import com.google.gson.annotations.SerializedName;
import java.util.List;
class Record {
  private String id;
  private Double relevance;
  private Fields fields;
  public Record(String id, String textSegment, List<Float> vector) {
    this.id = id;
    this.fields = new Fields(textSegment, vector);
  }
  public String getId() {
    return id;
  }
  public void setId(String id) {
    this.id = id;
  }
  public double getRelevance() {
    return relevance;
  }
  public void setRelevance(double relevance) {
    this.relevance = relevance;
  }
  public Fields getFields() {
    return fields;
  }
  public void setFields(Fields fields) {
    this.fields = fields;
  }
  public static class Fields {
    @SerializedName("documentid")
    private String documentId;
    @SerializedName("text_segment")
    private String textSegment;
    private Vector vector;
    public Fields(String textSegment, List<Float> vector) {
      this.textSegment = textSegment;
      this.vector = new Vector(vector);
    }
    public String getDocumentId() {
      return documentId;
    }
    public void setDocumentId(String documentId) {
      this.documentId = documentId;
    }
    public String getTextSegment() {
      return textSegment;
    }
    public void setTextSegment(String textSegment) {
      this.textSegment = textSegment;
    }
    public Vector getVector() {
      return vector;
    }
    public void setVector(Vector vector) {
      this.vector = vector;
    }
```

```
    public static class Vector {
      private List<Float> values;
      public Vector(List<Float> values) {
        this.values = values;
      }
      public List<Float> getValues() {
        return values;
      }
      public void setValues(List<Float> values) {
        this.values = values;
      }
    }
  }
}
```

langchain4j-vespa\src\main\java\dev\langchain4j\store\embedding\vespa\VespaEmbeddingStore.java

```
package dev.langchain4j.store.embedding.vespa;
import static dev.langchain4j.internal.Utils.generateUUIDFrom;
import static dev.langchain4j.internal.Utils.randomUUID;
import static
dev.langchain4j.store.embedding.vespa.VespaQueryClient.createInstance;
import ai.vespa.client.dsl.A;
import ai.vespa.client.dsl.Annotation;
import ai.vespa.client.dsl.NearestNeighbor;
import ai.vespa.client.dsl.Q;
import ai.vespa.feed.client.*;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.internal.Json;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import java.io.IOException;
import java.lang.reflect.InvocationTargetException;
import java.lang.reflect.Method;
import java.net.URI;
import java.nio.file.Path;
import java.nio.file.Paths;
import java.time.Duration;
import java.util.ArrayList;
import java.util.List;
import java.util.concurrent.atomic.AtomicReference;
import java.util.stream.Collectors;
import lombok.Builder;
import lombok.SneakyThrows;
import retrofit2.Response;
/**
 * Represents the <a href="https://vespa.ai/">Vespa</a> - search engine and
vector database.
 * Does not support storing {@link dev.langchain4j.data.document.Metadata}
yet.
 * Example server configuration contains cosine similarity search rank
profile, of course other Vespa neighbor search
 * methods are supported too. Read more <a href="https://docs.vespa.ai/en/
nearest-neighbor-search.html">here</a>.
 */
public class VespaEmbeddingStore implements EmbeddingStore<TextSegment> {
  private static final Duration DEFAULT_TIMEOUT = Duration.ofSeconds(5);
  private static final String DEFAULT_NAMESPACE = "namespace";
  private static final String DEFAULT_DOCUMENT_TYPE = "langchain4j";
  private static final boolean DEFAULT_AVOID_DUPS = true;
  private static final String FIELD_NAME_TEXT_SEGMENT = "text_segment";
  private static final String FIELD_NAME_VECTOR = "vector";
  private static final String FIELD_NAME_DOCUMENT_ID = "documentid";
  private static final String DEFAULT_RANK_PROFILE = "cosine_similarity";
  private static final int DEFAULT_TARGET_HITS = 10;
  private final String url;
  private final Path keyPath;
  private final Path certPath;
  private final Duration timeout;
  private final String namespace;
  private final String documentType;
  private final String rankProfile;
  private final int targetHits;
```

```
  private final boolean avoidDups;
  private VespaQueryApi queryApi;
  /**
   * Creates a new VespaEmbeddingStore instance.
   *
   * @param url          server url, local or cloud one. The latter you can
find under Endpoint of your Vespa
   *                     application, e.g. https://alexey-
heezer.langchain4j.mytenant346.aws-us-east-1c.dev.z.vespa-app.cloud/
   * @param keyPath      local path to the SSL private key file in PEM
format. Read
   *                     <a href="https://cloud.vespa.ai/en/getting-started-
java">docs</a> for details.
   * @param certPath     local path to the SSL certificate file in PEM
format. Read
   *                     <a href="https://cloud.vespa.ai/en/getting-started-
java">docs</a> for details.
   * @param timeout      for Vespa Java client in <code>java.time.Duration</
code> format.
   * @param namespace    required for document ID generation, find more
details
   *                     <a href="https://docs.vespa.ai/en/
documents.html#namespace">here</a>.
   * @param documentType document type, used for document ID generation, find
more details
   *                     <a href="https://docs.vespa.ai/en/
documents.html#namespace">here</a> and data querying
   * @param rankProfile  rank profile from your .sd schema. Provided example
schema configures cosine similarity match
   * @param targetHits   sets the number of hits (10 is default) exposed to
the real Vespa's first-phase ranking
   *                     function per content node, find more details
   *                     <a href="https://docs.vespa.ai/en/nearest-neighbor-
search.html#querying-using-nearestneighbor-query-operator">here</a>.
   * @param avoidDups    if true (default), then <code>VespaEmbeddingStore</
code> will generate a hashed ID based on
   *                     provided text segment, which avoids duplicated
entries in DB.
   *                     If false, then random ID will be generated.
   */
  @Builder
  public VespaEmbeddingStore(
    String url,
    String keyPath,
    String certPath,
    Duration timeout,
    String namespace,
    String documentType,
    String rankProfile,
    Integer targetHits,
    Boolean avoidDups
  ) {
    this.url = url;
    this.keyPath = Paths.get(keyPath);
    this.certPath = Paths.get(certPath);
    this.timeout = timeout != null ? timeout : DEFAULT_TIMEOUT;
    this.namespace = namespace != null ? namespace : DEFAULT_NAMESPACE;
    this.documentType = documentType != null ? documentType :
DEFAULT_DOCUMENT_TYPE;
    this.rankProfile = rankProfile != null ? rankProfile :
DEFAULT_RANK_PROFILE;
```

```
    this.targetHits = targetHits != null ? targetHits : DEFAULT_TARGET_HITS;
    this.avoidDups = avoidDups != null ? avoidDups : DEFAULT_AVOID_DUPS;
  }
  @Override
  public String add(Embedding embedding) {
    return add(null, embedding, null);
  }
  /**
   * Adds a new embedding with provided ID to the store.
   *
   * @param id        "user-specified" part of document ID, find more details
   *                  <a href="https://docs.vespa.ai/en/
documents.html#namespace">here</a>
   * @param embedding the embedding to add
   */
  @Override
  public void add(String id, Embedding embedding) {
    add(id, embedding, null);
  }
  @Override
  public String add(Embedding embedding, TextSegment textSegment) {
    return add(null, embedding, textSegment);
  }
  @Override
  public List<String> addAll(List<Embedding> embeddings) {
    return addAll(embeddings, null);
  }
  @Override
  public List<String> addAll(List<Embedding> embeddings, List<TextSegment>
embedded) {
    if (embedded != null && embeddings.size() != embedded.size()) {
      throw new IllegalArgumentException("The list of embeddings and embedded
must have the same size");
    }
    List<String> ids = new ArrayList<>();
    try (JsonFeeder jsonFeeder = buildJsonFeeder()) {
      List<Record> records = new ArrayList<>();
      for (int i = 0; i < embeddings.size(); i++) {
        records.add(buildRecord(embeddings.get(i), embedded != null ?
embedded.get(i) : null));
      }
      jsonFeeder.feedMany(
        Json.toInputStream(records, List.class),
        new JsonFeeder.ResultCallback() {
          @Override
          public void onNextResult(Result result, FeedException error) {
            if (error != null) {
              throw new RuntimeException(error.getMessage());
            } else if (Result.Type.success.equals(result.type())) {
              ids.add(result.documentId().toString());
            }
          }
          @Override
          public void onError(FeedException error) {
            throw new RuntimeException(error.getMessage());
          }
        }
      );
    } catch (IOException e) {
      throw new RuntimeException(e);
    }
```

```
    return ids;
  }
  /**
   * {@inheritDoc}
   * The score inside {@link EmbeddingMatch} is Vespa relevance according to
provided rank profile.
   */
  @Override
  @SneakyThrows
  public List<EmbeddingMatch<TextSegment>> findRelevant(Embedding
referenceEmbedding, int maxResults, double minScore) {
    try {
      String searchQuery = Q
        .select(FIELD_NAME_DOCUMENT_ID, FIELD_NAME_TEXT_SEGMENT,
FIELD_NAME_VECTOR)
        .from(documentType)
        .where(buildNearestNeighbor())
        .fix()
        .hits(maxResults)
        .ranking(rankProfile)
        .param("input.query(q)",
Json.toJson(referenceEmbedding.vectorAsList()))
        .param("input.query(threshold)", String.valueOf(minScore))
        .build();
      Response<QueryResponse> response =
getQueryApi().search(searchQuery).execute();
      if (response.isSuccessful()) {
        QueryResponse parsedResponse = response.body();
        return parsedResponse
          .getRoot()
          .getChildren()
          .stream()
          .map(VespaEmbeddingStore::toEmbeddingMatch)
          .collect(Collectors.toList());
      } else {
        throw new RuntimeException("Request failed");
      }
    } catch (Exception e) {
      throw new RuntimeException(e);
    }
  }
  private String add(String id, Embedding embedding, TextSegment textSegment)
{
    AtomicReference<String> resId = new AtomicReference<>();
    try (JsonFeeder jsonFeeder = buildJsonFeeder()) {
      jsonFeeder
        .feedSingle(Json.toJson(buildRecord(id, embedding, textSegment)))
        .whenComplete(
          (
            (result, throwable) -> {
              if (throwable != null) {
                throw new RuntimeException(throwable);
              } else if (Result.Type.success.equals(result.type())) {
                resId.set(result.documentId().toString());
              }
            }
          )
        );
    } catch (Exception e) {
      throw new RuntimeException(e);
    }
```

```
    return resId.get();
  }
  private JsonFeeder buildJsonFeeder() {
    return JsonFeeder
      .builder(FeedClientBuilder.create(URI.create(url)).setCertificate(certPa
th, keyPath).build())
      .withTimeout(timeout)
      .build();
  }
  private VespaQueryApi getQueryApi() {
    if (queryApi == null) {
      queryApi = createInstance(url, certPath, keyPath);
    }
    return queryApi;
  }
  private static EmbeddingMatch<TextSegment> toEmbeddingMatch(Record in) {
    return new EmbeddingMatch<>(
      in.getRelevance(),
      in.getFields().getDocumentId(),
      Embedding.from(in.getFields().getVector().getValues()),
      TextSegment.from(in.getFields().getTextSegment())
    );
  }
  private Record buildRecord(String id, Embedding embedding, TextSegment
textSegment) {
    String recordId = id != null
      ? id
      : avoidDups && textSegment != null ?
generateUUIDFrom(textSegment.text()) : randomUUID();
    DocumentId documentId = DocumentId.of(namespace, documentType, recordId);
    String text = textSegment != null ? textSegment.text() : null;
    return new Record(documentId.toString(), text, embedding.vectorAsList());
  }
  private Record buildRecord(Embedding embedding, TextSegment textSegment) {
    return buildRecord(null, embedding, textSegment);
  }
  private NearestNeighbor buildNearestNeighbor()
    throws NoSuchMethodException, IllegalAccessException,
InvocationTargetException {
    NearestNeighbor nb = Q.nearestNeighbor(FIELD_NAME_VECTOR, "q");
    // workaround to invoke ai.vespa.client.dsl.NearestNeighbor#annotate,
    // see https://github.com/vespa-engine/vespa/issues/28029
    // The bug is fixed in the meantime, but the baseline has been upgraded
to Java 11, hence this workaround remains here
    Method method = NearestNeighbor.class.getDeclaredMethod("annotate", new
Class<?>[] { Annotation.class });
    method.setAccessible(true);
    method.invoke(nb, A.a("targetHits", targetHits));
    return nb;
  }
}
```

langchain4j-vespa\src\main\java\dev\langchain4j\store\embedding\vespa\VespaQueryApi.java

```
package dev.langchain4j.store.embedding.vespa;
import retrofit2.Call;
import retrofit2.http.GET;
import retrofit2.http.Path;
interface VespaQueryApi {
  @GET("search/{query}")
  Call<QueryResponse> search(@Path(value = "query", encoded = true) String query);
}
```

langchain4j-vespa\src\main\java\dev\langchain4j\store\embedding\vespa\VespaQueryClient.java

```
// Copyright Yahoo. Licensed under the terms of the Apache 2.0 license. See LICENSE in the project root.
package dev.langchain4j.store.embedding.vespa;
import com.google.gson.GsonBuilder;
import java.io.IOException;
import java.nio.file.Files;
import java.nio.file.Path;
import java.security.GeneralSecurityException;
import java.security.KeyFactory;
import java.security.KeyStore;
import java.security.PrivateKey;
import java.security.cert.Certificate;
import java.security.cert.X509Certificate;
import java.security.spec.PKCS8EncodedKeySpec;
import java.util.ArrayList;
import java.util.List;
import javax.net.ssl.*;
import okhttp3.HttpUrl;
import okhttp3.OkHttpClient;
import okhttp3.Request;
import org.bouncycastle.asn1.ASN1ObjectIdentifier;
import org.bouncycastle.asn1.pkcs.PKCSObjectIdentifiers;
import org.bouncycastle.asn1.pkcs.PrivateKeyInfo;
import org.bouncycastle.asn1.x9.X9ObjectIdentifiers;
import org.bouncycastle.cert.X509CertificateHolder;
import org.bouncycastle.cert.jcajce.JcaX509CertificateConverter;
import org.bouncycastle.jce.provider.BouncyCastleProvider;
import org.bouncycastle.openssl.PEMKeyPair;
import org.bouncycastle.openssl.PEMParser;
import retrofit2.Retrofit;
import retrofit2.converter.gson.GsonConverterFactory;
/**
 * This Workaround is needed because of <a href="https://github.com/vespa-engine/vespa/issues/28026">this request</a>.
 * It will be redundant as soon as vespa-client is implemented. This class is copied from <code>vespa-feed-client</code>.
 * BouncyCastle integration for creating a {@link SSLContext} instance from PEM encoded material
 */
class VespaQueryClient {
  static final BouncyCastleProvider bcProvider = new BouncyCastleProvider();
  public static VespaQueryApi createInstance(String baseUrl, Path certificate, Path privateKey) {
    try {
      KeyStore keystore = KeyStore.getInstance("PKCS12");
      keystore.load(null);
      keystore.setKeyEntry("cert", privateKey(privateKey), new char[0], certificates(certificate));
      // Protocol version must be equal to TlsContext.SSL_CONTEXT_VERSION or higher
      SSLContext sslContext = SSLContext.getInstance("TLSv1.3");
      sslContext.init(createKeyManagers(keystore), null, /*Default secure random algorithm*/null);
      TrustManagerFactory trustManagerFactory = TrustManagerFactory.getInstance(
        TrustManagerFactory.getDefaultAlgorithm()
      );
```

```
      trustManagerFactory.init(keystore);
      OkHttpClient client = new OkHttpClient.Builder()
        .sslSocketFactory(sslContext.getSocketFactory(), (X509TrustManager)
trustManagerFactory.getTrustManagers()[0])
        .addInterceptor(chain -> {
          // trick to format the query URL exactly how Vespa expects it
(search/?query),
          // see https://docs.vespa.ai/en/reference/query-language-
reference.html
          Request request = chain.request();
          HttpUrl url = request
            .url()
            .newBuilder()
            .removePathSegment(1)
            .addPathSegment("")
            .encodedQuery(request.url().encodedPathSegments().get(1))
            .build();
          request = request.newBuilder().url(url).build();
          return chain.proceed(request);
        })
        .build();
      Retrofit retrofit = new Retrofit.Builder()
        .baseUrl(baseUrl)
        .client(client)
        .addConverterFactory(GsonConverterFactory.create(new
GsonBuilder().create()))
        .build();
      return retrofit.create(VespaQueryApi.class);
    } catch (Exception e) {
      throw new RuntimeException(e);
    }
  }
  private static KeyManager[] createKeyManagers(KeyStore keystore) throws
GeneralSecurityException {
    KeyManagerFactory kmf =
KeyManagerFactory.getInstance(KeyManagerFactory.getDefaultAlgorithm());
    kmf.init(keystore, new char[0]);
    return kmf.getKeyManagers();
  }
  private static Certificate[] certificates(Path file) throws IOException,
GeneralSecurityException {
    try (PEMParser parser = new PEMParser(Files.newBufferedReader(file))) {
      List<X509Certificate> result = new ArrayList<>();
      Object pemObject;
      while ((pemObject = parser.readObject()) != null) {
        result.add(toX509Certificate(pemObject));
      }
      if (result.isEmpty()) throw new IOException("File contains no PEM
encoded certificates: " + file);
      return result.toArray(new Certificate[0]);
    }
  }
  private static PrivateKey privateKey(Path file) throws IOException,
GeneralSecurityException {
    try (PEMParser parser = new PEMParser(Files.newBufferedReader(file))) {
      Object pemObject;
      while ((pemObject = parser.readObject()) != null) {
        if (pemObject instanceof PrivateKeyInfo) {
          PrivateKeyInfo keyInfo = (PrivateKeyInfo) pemObject;
          PKCS8EncodedKeySpec keySpec = new
PKCS8EncodedKeySpec(keyInfo.getEncoded());
```

```
          return createKeyFactory(keyInfo).generatePrivate(keySpec);
        } else if (pemObject instanceof PEMKeyPair) {
          PEMKeyPair pemKeypair = (PEMKeyPair) pemObject;
          PrivateKeyInfo keyInfo = pemKeypair.getPrivateKeyInfo();
          return createKeyFactory(keyInfo).generatePrivate(new
PKCS8EncodedKeySpec(keyInfo.getEncoded()));
        }
      }
      throw new IOException("Could not find private key in PEM file");
    }
  }
  private static X509Certificate toX509Certificate(Object pemObject) throws
IOException, GeneralSecurityException {
    if (pemObject instanceof X509Certificate) return (X509Certificate)
pemObject;
    if (pemObject instanceof X509CertificateHolder) {
      return new JcaX509CertificateConverter()
        .setProvider(bcProvider)
        .getCertificate((X509CertificateHolder) pemObject);
    }
    throw new IOException("Invalid type of PEM object: " + pemObject);
  }
  private static KeyFactory createKeyFactory(PrivateKeyInfo info) throws
IOException, GeneralSecurityException {
    ASN1ObjectIdentifier algorithm =
info.getPrivateKeyAlgorithm().getAlgorithm();
    if (X9ObjectIdentifiers.id_ecPublicKey.equals(algorithm)) {
      return KeyFactory.getInstance("EC", bcProvider);
    } else if (PKCSObjectIdentifiers.rsaEncryption.equals(algorithm)) {
      return KeyFactory.getInstance("RSA", bcProvider);
    } else {
      throw new IOException("Unknown key algorithm: " + algorithm);
    }
  }
}
```

langchain4j-weaviate\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>dev.langchain4j</groupId>
        <artifactId>langchain4j-parent</artifactId>
        <version>0.23.0</version>
        <relativePath>../langchain4j-parent/pom.xml</relativePath>
    </parent>
    <artifactId>langchain4j-weaviate</artifactId>
    <packaging>jar</packaging>
    <name>LangChain4j integration with Weaviate</name>
    <description>Uses io.weaviate.client library which has a BSD 3-Clause
license:
        https://github.com/weaviate/java-client/blob/main/LICENSE
    </description>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-core</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>io.weaviate</groupId>
            <artifactId>client</artifactId>
            <version>4.3.0</version>
            <exclusions>
                <!-- due to Cxeb68d52e-5509 vulnerability -->
                <exclusion>
                    <groupId>commons-codec</groupId>
                    <artifactId>commons-codec</artifactId>
                </exclusion>
            </exclusions>
        </dependency>
        <dependency>
            <groupId>commons-codec</groupId>
            <artifactId>commons-codec</artifactId>
            <version>1.16.0</version>
        </dependency>
        <dependency>
            <groupId>org.junit.jupiter</groupId>
            <artifactId>junit-jupiter-engine</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>org.assertj</groupId>
            <artifactId>assertj-core</artifactId>
            <scope>test</scope>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2-q</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
```

```
    <build>
        <plugins>
            <plugin>
                <groupId>org.honton.chas</groupId>
                <artifactId>license-maven-plugin</artifactId>
                <configuration>
                    <!-- The weaviate client has a BSD-3 license, see https://
github.com/weaviate/java-client/blob/main/LICENSE -->
                    <skipCompliance>true</skipCompliance>
                </configuration>
            </plugin>
        </plugins>
    </build>
</project>
```

langchain4j-weaviate\src\main\java\dev\langchain4j\store\embedding\weaviate\WeaviateEmbeddingStore.java

```
package dev.langchain4j.store.embedding.weaviate;
import static dev.langchain4j.internal.Utils.*;
import static dev.langchain4j.internal.ValidationUtils.ensureNotBlank;
import static
io.weaviate.client.v1.data.replication.model.ConsistencyLevel.QUORUM;
import static java.util.Arrays.stream;
import static java.util.Collections.emptyList;
import static java.util.Collections.singletonList;
import static java.util.stream.Collectors.joining;
import static java.util.stream.Collectors.toList;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import io.weaviate.client.Config;
import io.weaviate.client.WeaviateAuthClient;
import io.weaviate.client.WeaviateClient;
import io.weaviate.client.base.Result;
import io.weaviate.client.base.WeaviateErrorMessage;
import io.weaviate.client.v1.auth.exception.AuthException;
import io.weaviate.client.v1.data.model.WeaviateObject;
import io.weaviate.client.v1.graphql.model.GraphQLError;
import io.weaviate.client.v1.graphql.model.GraphQLResponse;
import io.weaviate.client.v1.graphql.query.argument.NearVectorArgument;
import io.weaviate.client.v1.graphql.query.fields.Field;
import java.util.*;
import lombok.Builder;
/**
 * Represents the <a href="https://weaviate.io/">Weaviate</a> vector database.
 * Current implementation assumes the cosine distance metric is used.
 * Does not support storing {@link dev.langchain4j.data.document.Metadata}
yet.
 */
public class WeaviateEmbeddingStore implements EmbeddingStore<TextSegment> {
  private static final String METADATA_TEXT_SEGMENT = "text";
  private static final String ADDITIONALS = "_additional";
  private final WeaviateClient client;
  private final String objectClass;
  private final boolean avoidDups;
  private final String consistencyLevel;
  /**
   * Creates a new WeaviateEmbeddingStore instance.
   *
   * @param apiKey           Your Weaviate API key
   * @param scheme           The scheme, e.g. "https" of cluster URL. Find in
under Details of your Weaviate cluster.
   * @param host             The host, e.g.
"langchain4j-4jw7ufd9.weaviate.network" of cluster URL.
   *                         Find in under Details of your Weaviate cluster.
   * @param objectClass      The object class you want to store, e.g.
"MyGreatClass". Must start from an uppercase letter.
   * @param avoidDups        If true (default), then
<code>WeaviateEmbeddingStore</code> will generate a hashed ID based on
   *                         provided text segment, which avoids duplicated
entries in DB.
   *                         If false, then random ID will be generated.
   * @param consistencyLevel Consistency level: ONE, QUORUM (default) or ALL.
```

```
Find more details <a href="https://weaviate.io/developers/weaviate/concepts/
replication-architecture/consistency#tunable-write-consistency">here</a>.
   */
  @Builder
  public WeaviateEmbeddingStore(
    String apiKey,
    String scheme,
    String host,
    String objectClass,
    Boolean avoidDups,
    String consistencyLevel
  ) {
    try {
      Config config = new Config(ensureNotBlank(scheme, "scheme"),
ensureNotBlank(host, "host"));
      this.client = WeaviateAuthClient.apiKey(config, ensureNotBlank(apiKey,
"apiKey"));
    } catch (AuthException e) {
      throw new IllegalArgumentException(e);
    }
    this.objectClass = getOrDefault(objectClass, "Default");
    this.avoidDups = getOrDefault(avoidDups, true);
    this.consistencyLevel = getOrDefault(consistencyLevel, QUORUM);
  }
  @Override
  public String add(Embedding embedding) {
    String id = randomUUID();
    add(id, embedding);
    return id;
  }
  /**
   * Adds a new embedding with provided ID to the store.
   *
   * @param id        the ID of the embedding to add in UUID format, since
it's Weaviate requirement.
   *                  See <a href="https://weaviate.io/developers/weaviate/
manage-data/create#id">Weaviate docs</a> and
   *                  <a href="https://en.wikipedia.org/wiki/
Universally_unique_identifier">UUID on Wikipedia</a>
   * @param embedding the embedding to add
   */
  @Override
  public void add(String id, Embedding embedding) {
    addAll(singletonList(id), singletonList(embedding), null);
  }
  @Override
  public String add(Embedding embedding, TextSegment textSegment) {
    return addAll(singletonList(embedding),
singletonList(textSegment)).stream().findFirst().orElse(null);
  }
  @Override
  public List<String> addAll(List<Embedding> embeddings) {
    return addAll(embeddings, null);
  }
  @Override
  public List<String> addAll(List<Embedding> embeddings, List<TextSegment>
embedded) {
    return addAll(null, embeddings, embedded);
  }
  /**
   * {@inheritDoc}
```

```
   * The score inside {@link EmbeddingMatch} is Weaviate's certainty.
   */
  @Override
  public List<EmbeddingMatch<TextSegment>> findRelevant(
    Embedding referenceEmbedding,
    int maxResults,
    double minCertainty
  ) {
    Result<GraphQLResponse> result = client
      .graphQL()
      .get()
      .withClassName(objectClass)
      .withFields(
        Field.builder().name(METADATA_TEXT_SEGMENT).build(),
        Field
          .builder()
          .name(ADDITIONALS)
          .fields(
            Field.builder().name("id").build(),
            Field.builder().name("certainty").build(),
            Field.builder().name("vector").build()
          )
          .build()
      )
      .withNearVector(
        NearVectorArgument
          .builder()
          .vector(referenceEmbedding.vectorAsList().toArray(new Float[0]))
          .certainty((float) minCertainty)
          .build()
      )
      .withLimit(maxResults)
      .run();
    if (result.hasErrors()) {
      throw new IllegalArgumentException(
        result.getError().getMessages().stream().map(WeaviateErrorMessage::get
Message).collect(joining("\n"))
      );
    }
    GraphQLError[] errors = result.getResult().getErrors();
    if (errors != null && errors.length > 0) {
      throw new IllegalArgumentException(stream(errors).map(GraphQLError::getM
essage).collect(joining("\n")));
    }
    Optional<Map.Entry<String, Map>> resGetPart =
      ((Map<String, Map>)
result.getResult().getData()).entrySet().stream().findFirst();
    if (!resGetPart.isPresent()) {
      return emptyList();
    }
    Optional resItemsPart =
resGetPart.get().getValue().entrySet().stream().findFirst();
    if (!resItemsPart.isPresent()) {
      return emptyList();
    }
    List<Map<String, ?>> resItems = ((Map.Entry<String, List<Map<String, ?
>>>) resItemsPart.get()).getValue();
    return resItems.stream().map(WeaviateEmbeddingStore::toEmbeddingMatch).col
lect(toList());
  }
  private List<String> addAll(List<String> ids, List<Embedding> embeddings,
```

```
List<TextSegment> embedded) {
    if (embedded != null && embeddings.size() != embedded.size()) {
      throw new IllegalArgumentException("The list of embeddings and embedded
must have the same size");
    }
    List<String> resIds = new ArrayList<>();
    List<WeaviateObject> objects = new ArrayList<>();
    for (int i = 0; i < embeddings.size(); i++) {
      String id = ids != null
        ? ids.get(i)
        : avoidDups && embedded != null ?
generateUUIDFrom(embedded.get(i).text()) : randomUUID();
      resIds.add(id);
      objects.add(buildObject(id, embeddings.get(i), embedded != null ?
embedded.get(i).text() : ""));
    }
    client
      .batch()
      .objectsBatcher()
      .withObjects(objects.toArray(new WeaviateObject[0]))
      .withConsistencyLevel(consistencyLevel)
      .run();
    return resIds;
  }
  private WeaviateObject buildObject(String id, Embedding embedding, String
text) {
    Map<String, Object> props = new HashMap<>();
    props.put(METADATA_TEXT_SEGMENT, text);
    return WeaviateObject
      .builder()
      .className(objectClass)
      .id(id)
      .vector(embedding.vectorAsList().toArray(new Float[0]))
      .properties(props)
      .build();
  }
  private static EmbeddingMatch<TextSegment> toEmbeddingMatch(Map<String, ?>
item) {
    Map<String, ?> additional = (Map<String, ?>) item.get(ADDITIONALS);
    String text = (String) item.get(METADATA_TEXT_SEGMENT);
    return new EmbeddingMatch<>(
      (Double) additional.get("certainty"),
      (String) additional.get("id"),
      Embedding.from(
        ((List<Double>)
additional.get("vector")).stream().map(Double::floatValue).collect(toList())
      ),
      isNullOrBlank(text) ? null : TextSegment.from(text)
    );
  }
}
```

langchain4j-weaviate\src\test\java\dev\langchain4j\store\embedding\weaviate\WeaviateEmbeddingStoreTest.java

```
package dev.langchain4j.store.embedding.weaviate;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2QuantizedEmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.CosineSimilarity;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.RelevanceScore;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.condition.EnabledIfEnvironmentVariable;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
import static java.util.Arrays.asList;
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.data.Percentage.withPercentage;
@EnabledIfEnvironmentVariable(named = "WEAVIATE_API_KEY", matches = ".+")
class WeaviateEmbeddingStoreTest {
    EmbeddingStore<TextSegment> embeddingStore =
WeaviateEmbeddingStore.builder()
            .apiKey(System.getenv("WEAVIATE_API_KEY"))
            .scheme("https")
            .host("test3-bwsieg9y.weaviate.network")
            .objectClass("Test" + randomUUID().replace("-", ""))
            .build();
    EmbeddingModel embeddingModel = new
AllMiniLmL6V2QuantizedEmbeddingModel();
    @Test
    void should_add_embedding() {
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_id() {
        String id = randomUUID();
        Embedding embedding = embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(id, embedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isNull();
    }
    @Test
    void should_add_embedding_with_segment() {
```

```
        TextSegment segment = TextSegment.from(randomUUID());
        Embedding embedding = embeddingModel.embed(segment.text()).content();
        String id = embeddingStore.add(embedding, segment);
        assertThat(id).isNotNull();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(embedding, 10);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(1, withPercentage(1));
        assertThat(match.embeddingId()).isEqualTo(id);
        assertThat(match.embedding()).isEqualTo(embedding);
        assertThat(match.embedded()).isEqualTo(segment);
    }
    @Test
    void should_add_multiple_embeddings() {
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        List<String> ids = embeddingStore.addAll(asList(firstEmbedding,
secondEmbedding));
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isNull();
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
        assertThat(secondMatch.embedded()).isNull();
    }
    @Test
    void should_add_multiple_embeddings_with_segments() {
        TextSegment firstSegment = TextSegment.from(randomUUID());
        Embedding firstEmbedding =
embeddingModel.embed(firstSegment.text()).content();
        TextSegment secondSegment = TextSegment.from(randomUUID());
        Embedding secondEmbedding =
embeddingModel.embed(secondSegment.text()).content();
        List<String> ids = embeddingStore.addAll(
                asList(firstEmbedding, secondEmbedding),
                asList(firstSegment, secondSegment)
        );
        assertThat(ids).hasSize(2);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(ids.get(0));
        assertThat(firstMatch.embedding()).isEqualTo(firstEmbedding);
        assertThat(firstMatch.embedded()).isEqualTo(firstSegment);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(ids.get(1));
        assertThat(secondMatch.embedding()).isEqualTo(secondEmbedding);
```

```
        assertThat(secondMatch.embedded()).isEqualTo(secondSegment);
    }
    @Test
    void should_find_with_min_score() {
        String firstId = randomUUID();
        Embedding firstEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(firstId, firstEmbedding);
        String secondId = randomUUID();
        Embedding secondEmbedding =
embeddingModel.embed(randomUUID()).content();
        embeddingStore.add(secondId, secondEmbedding);
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(firstEmbedding, 10);
        assertThat(relevant).hasSize(2);
        EmbeddingMatch<TextSegment> firstMatch = relevant.get(0);
        assertThat(firstMatch.score()).isCloseTo(1, withPercentage(1));
        assertThat(firstMatch.embeddingId()).isEqualTo(firstId);
        EmbeddingMatch<TextSegment> secondMatch = relevant.get(1);
        assertThat(secondMatch.score()).isBetween(0d, 1d);
        assertThat(secondMatch.embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant2 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() - 0.01
        );
        assertThat(relevant2).hasSize(2);
        assertThat(relevant2.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant2.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant3 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score()
        );
        assertThat(relevant3).hasSize(2);
        assertThat(relevant3.get(0).embeddingId()).isEqualTo(firstId);
        assertThat(relevant3.get(1).embeddingId()).isEqualTo(secondId);
        List<EmbeddingMatch<TextSegment>> relevant4 =
embeddingStore.findRelevant(
                firstEmbedding,
                10,
                secondMatch.score() + 0.01
        );
        assertThat(relevant4).hasSize(1);
        assertThat(relevant4.get(0).embeddingId()).isEqualTo(firstId);
    }
    @Test
    void should_return_correct_score() {
        Embedding embedding = embeddingModel.embed("hello").content();
        String id = embeddingStore.add(embedding);
        assertThat(id).isNotNull();
        Embedding referenceEmbedding = embeddingModel.embed("hi").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(referenceEmbedding, 1);
        assertThat(relevant).hasSize(1);
        EmbeddingMatch<TextSegment> match = relevant.get(0);
        assertThat(match.score()).isCloseTo(

RelevanceScore.fromCosineSimilarity(CosineSimilarity.between(embedding,
```

```
referenceEmbedding)),
                withPercentage(1)
        );
    }
}
```

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mvnw

```
#!/bin/sh
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# under the License.
# ----------------------------------------------------------------------------
# ----------------------------------------------------------------------------
# Apache Maven Wrapper startup batch script, version 3.2.0
#
# Required ENV vars:
# ------------------
#   JAVA_HOME - location of a JDK home dir
#
# Optional ENV vars
# -----------------
#   MAVEN_OPTS - parameters passed to the Java VM when running Maven
#     e.g. to debug Maven itself, use
#       set MAVEN_OPTS=-Xdebug -
Xrunjdwp:transport=dt_socket,server=y,suspend=y,address=8000
#   MAVEN_SKIP_RC - flag to disable loading of mavenrc files
# ----------------------------------------------------------------------------
if [ -z "$MAVEN_SKIP_RC" ] ; then
  if [ -f /usr/local/etc/mavenrc ] ; then
    . /usr/local/etc/mavenrc
  fi
  if [ -f /etc/mavenrc ] ; then
    . /etc/mavenrc
  fi
  if [ -f "$HOME/.mavenrc" ] ; then
    . "$HOME/.mavenrc"
  fi
fi
# OS specific support.  $var _must_ be set to either true or false.
cygwin=false;
darwin=false;
mingw=false
case "$(uname)" in
  CYGWIN*) cygwin=true ;;
  MINGW*) mingw=true;;
  Darwin*) darwin=true
    # Use /usr/libexec/java_home if available, otherwise fall back to /
Library/Java/Home
    # See https://developer.apple.com/library/mac/qa/qa1170/_index.html
    if [ -z "$JAVA_HOME" ]; then
      if [ -x "/usr/libexec/java_home" ]; then
```

```
        JAVA_HOME="$(/usr/libexec/java_home)"; export JAVA_HOME
      else
        JAVA_HOME="/Library/Java/Home"; export JAVA_HOME
      fi
    fi
    ;;
esac
if [ -z "$JAVA_HOME" ] ; then
  if [ -r /etc/gentoo-release ] ; then
    JAVA_HOME=$(java-config --jre-home)
  fi
fi
# For Cygwin, ensure paths are in UNIX format before anything is touched
if $cygwin ; then
  [ -n "$JAVA_HOME" ] &&
    JAVA_HOME=$(cygpath --unix "$JAVA_HOME")
  [ -n "$CLASSPATH" ] &&
    CLASSPATH=$(cygpath --path --unix "$CLASSPATH")
fi
# For Mingw, ensure paths are in UNIX format before anything is touched
if $mingw ; then
  [ -n "$JAVA_HOME" ] && [ -d "$JAVA_HOME" ] &&
    JAVA_HOME="$(cd "$JAVA_HOME" || (echo "cannot cd into $JAVA_HOME."; exit
1); pwd)"
fi
if [ -z "$JAVA_HOME" ]; then
  javaExecutable="$(which javac)"
  if [ -n "$javaExecutable" ] && ! [ "$(expr "\"$javaExecutable\"" :
'\([^ ]*\)')" = "no" ]; then
    # readlink(1) is not available as standard on Solaris 10.
    readLink=$(which readlink)
    if [ ! "$(expr "$readLink" : '\([^ ]*\)')" = "no" ]; then
      if $darwin ; then
        javaHome="$(dirname "\"$javaExecutable\"")"
        javaExecutable="$(cd "\"$javaHome\"" && pwd -P)/javac"
      else
        javaExecutable="$(readlink -f "\"$javaExecutable\"")"
      fi
      javaHome="$(dirname "\"$javaExecutable\"")"
      javaHome=$(expr "$javaHome" : '\(.*\)/bin')
      JAVA_HOME="$javaHome"
      export JAVA_HOME
    fi
  fi
fi
if [ -z "$JAVACMD" ] ; then
  if [ -n "$JAVA_HOME"  ] ; then
    if [ -x "$JAVA_HOME/jre/sh/java" ] ; then
      # IBM's JDK on AIX uses strange locations for the executables
      JAVACMD="$JAVA_HOME/jre/sh/java"
    else
      JAVACMD="$JAVA_HOME/bin/java"
    fi
  else
    JAVACMD="$(\unset -f command 2>/dev/null; \command -v java)"
  fi
fi
if [ ! -x "$JAVACMD" ] ; then
  echo "Error: JAVA_HOME is not defined correctly." >&2
  echo "  We cannot execute $JAVACMD" >&2
  exit 1
```

```
fi
if [ -z "$JAVA_HOME" ] ; then
  echo "Warning: JAVA_HOME environment variable is not set."
fi
# traverses directory structure from process work directory to filesystem root
# first directory with .mvn subdirectory is considered project base directory
find_maven_basedir() {
  if [ -z "$1" ]
  then
    echo "Path not specified to find_maven_basedir"
    return 1
  fi
  basedir="$1"
  wdir="$1"
  while [ "$wdir" != '/' ] ; do
    if [ -d "$wdir"/.mvn ] ; then
      basedir=$wdir
      break
    fi
    # workaround for JBEAP-8937 (on Solaris 10/Sparc)
    if [ -d "${wdir}" ]; then
      wdir=$(cd "$wdir/.." || exit 1; pwd)
    fi
    # end of workaround
  done
  printf '%s' "$(cd "$basedir" || exit 1; pwd)"
}
# concatenates all lines of a file
concat_lines() {
  if [ -f "$1" ]; then
    # Remove \r in case we run on Windows within Git Bash
    # and check out the repository with auto CRLF management
    # enabled. Otherwise, we may read lines that are delimited with
    # \r\n and produce $'-Xarg\r' rather than -Xarg due to word
    # splitting rules.
    tr -s '\r\n' ' ' < "$1"
  fi
}
log() {
  if [ "$MVNW_VERBOSE" = true ]; then
    printf '%s\n' "$1"
  fi
}
BASE_DIR=$(find_maven_basedir "$(dirname "$0")")
if [ -z "$BASE_DIR" ]; then
  exit 1;
fi
MAVEN_PROJECTBASEDIR=${MAVEN_BASEDIR:-"$BASE_DIR"}; export
MAVEN_PROJECTBASEDIR
log "$MAVEN_PROJECTBASEDIR"
##########################################################################################
############
# Extension to allow automatically downloading the maven-wrapper.jar from
Maven-central
# This allows using the maven wrapper in projects that prohibit checking in
binary data.
##########################################################################################
############
wrapperJarPath="$MAVEN_PROJECTBASEDIR/.mvn/wrapper/maven-wrapper.jar"
if [ -r "$wrapperJarPath" ]; then
    log "Found $wrapperJarPath"
```

```
else
    log "Couldn't find $wrapperJarPath, downloading it ..."
    if [ -n "$MVNW_REPOURL" ]; then
      wrapperUrl="$MVNW_REPOURL/org/apache/maven/wrapper/maven-wrapper/3.2.0/
maven-wrapper-3.2.0.jar"
    else
      wrapperUrl="https://repo.maven.apache.org/maven2/org/apache/maven/
wrapper/maven-wrapper/3.2.0/maven-wrapper-3.2.0.jar"
    fi
    while IFS="=" read -r key value; do
      # Remove '\r' from value to allow usage on windows as IFS does not
consider '\r' as a separator ( considers space, tab, new line ('\n'), and
custom '=' )
      safeValue=$(echo "$value" | tr -d '\r')
      case "$key" in (wrapperUrl) wrapperUrl="$safeValue"; break ;;
      esac
    done < "$MAVEN_PROJECTBASEDIR/.mvn/wrapper/maven-wrapper.properties"
    log "Downloading from: $wrapperUrl"
    if $cygwin; then
      wrapperJarPath=$(cygpath --path --windows "$wrapperJarPath")
    fi
    if command -v wget > /dev/null; then
        log "Found wget ... using wget"
        [ "$MVNW_VERBOSE" = true ] && QUIET="" || QUIET="--quiet"
        if [ -z "$MVNW_USERNAME" ] || [ -z "$MVNW_PASSWORD" ]; then
            wget $QUIET "$wrapperUrl" -O "$wrapperJarPath" || rm -f
"$wrapperJarPath"
        else
            wget $QUIET --http-user="$MVNW_USERNAME" --http-
password="$MVNW_PASSWORD" "$wrapperUrl" -O "$wrapperJarPath" || rm -f
"$wrapperJarPath"
        fi
    elif command -v curl > /dev/null; then
        log "Found curl ... using curl"
        [ "$MVNW_VERBOSE" = true ] && QUIET="" || QUIET="--silent"
        if [ -z "$MVNW_USERNAME" ] || [ -z "$MVNW_PASSWORD" ]; then
            curl $QUIET -o "$wrapperJarPath" "$wrapperUrl" -f -L || rm -f
"$wrapperJarPath"
        else
            curl $QUIET --user "$MVNW_USERNAME:$MVNW_PASSWORD" -o
"$wrapperJarPath" "$wrapperUrl" -f -L || rm -f "$wrapperJarPath"
        fi
    else
        log "Falling back to using Java to download"
        javaSource="$MAVEN_PROJECTBASEDIR/.mvn/wrapper/
MavenWrapperDownloader.java"
        javaClass="$MAVEN_PROJECTBASEDIR/.mvn/wrapper/
MavenWrapperDownloader.class"
        # For Cygwin, switch paths to Windows format before running javac
        if $cygwin; then
          javaSource=$(cygpath --path --windows "$javaSource")
          javaClass=$(cygpath --path --windows "$javaClass")
        fi
        if [ -e "$javaSource" ]; then
            if [ ! -e "$javaClass" ]; then
                log " - Compiling MavenWrapperDownloader.java ..."
                ("$JAVA_HOME/bin/javac" "$javaSource")
            fi
            if [ -e "$javaClass" ]; then
                log " - Running MavenWrapperDownloader.java ..."
                ("$JAVA_HOME/bin/java" -cp .mvn/wrapper
```

```
MavenWrapperDownloader "$wrapperUrl" "$wrapperJarPath") || rm -f
"$wrapperJarPath"
            fi
        fi
    fi
fi
##########################################################################################
############
# End of extension
##########################################################################################
############
# If specified, validate the SHA-256 sum of the Maven wrapper jar file
wrapperSha256Sum=""
while IFS="=" read -r key value; do
  case "$key" in (wrapperSha256Sum) wrapperSha256Sum=$value; break ;;
  esac
done < "$MAVEN_PROJECTBASEDIR/.mvn/wrapper/maven-wrapper.properties"
if [ -n "$wrapperSha256Sum" ]; then
  wrapperSha256Result=false
  if command -v sha256sum > /dev/null; then
    if echo "$wrapperSha256Sum  $wrapperJarPath" | sha256sum -c > /dev/null
2>&1; then
      wrapperSha256Result=true
    fi
  elif command -v shasum > /dev/null; then
    if echo "$wrapperSha256Sum  $wrapperJarPath" | shasum -a 256 -c > /dev/
null 2>&1; then
      wrapperSha256Result=true
    fi
  else
    echo "Checksum validation was requested but neither 'sha256sum' or
'shasum' are available."
    echo "Please install either command, or disable validation by removing
'wrapperSha256Sum' from your maven-wrapper.properties."
    exit 1
  fi
  if [ $wrapperSha256Result = false ]; then
    echo "Error: Failed to validate Maven wrapper SHA-256, your Maven wrapper
might be compromised." >&2
    echo "Investigate or delete $wrapperJarPath to attempt a clean download."
>&2
    echo "If you updated your Maven version, you need to update the specified
wrapperSha256Sum property." >&2
    exit 1
  fi
fi
MAVEN_OPTS="$(concat_lines "$MAVEN_PROJECTBASEDIR/.mvn/jvm.config")
$MAVEN_OPTS"
# For Cygwin, switch paths to Windows format before running java
if $cygwin; then
  [ -n "$JAVA_HOME" ] &&
    JAVA_HOME=$(cygpath --path --windows "$JAVA_HOME")
  [ -n "$CLASSPATH" ] &&
    CLASSPATH=$(cygpath --path --windows "$CLASSPATH")
  [ -n "$MAVEN_PROJECTBASEDIR" ] &&
    MAVEN_PROJECTBASEDIR=$(cygpath --path --windows "$MAVEN_PROJECTBASEDIR")
fi
# Provide a "standardized" way to retrieve the CLI args that will
# work with both Windows and non-Windows executions.
MAVEN_CMD_LINE_ARGS="$MAVEN_CONFIG $*"
export MAVEN_CMD_LINE_ARGS
```

```
WRAPPER_LAUNCHER=org.apache.maven.wrapper.MavenWrapperMain
# shellcheck disable=SC2086 # safe args
exec "$JAVACMD" \
  $MAVEN_OPTS \
  $MAVEN_DEBUG_OPTS \
  -classpath "$MAVEN_PROJECTBASEDIR/.mvn/wrapper/maven-wrapper.jar" \
  "-Dmaven.multiModuleProjectDirectory=${MAVEN_PROJECTBASEDIR}" \
  ${WRAPPER_LAUNCHER} $MAVEN_CONFIG "$@"
```

```
@REM
----------------------------------------------------------------------------
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@REM
----------------------------------------------------------------------------
@REM
----------------------------------------------------------------------------
@REM Apache Maven Wrapper startup batch script, version 3.2.0
@REM
@REM Required ENV vars:
@REM JAVA_HOME - location of a JDK home dir
@REM
@REM Optional ENV vars
@REM MAVEN_BATCH_ECHO - set to 'on' to enable the echoing of the batch
commands
@REM MAVEN_BATCH_PAUSE - set to 'on' to wait for a keystroke before ending
@REM MAVEN_OPTS - parameters passed to the Java VM when running Maven
@REM     e.g. to debug Maven itself, use
@REM set MAVEN_OPTS=-Xdebug -
Xrunjdwp:transport=dt_socket,server=y,suspend=y,address=8000
@REM MAVEN_SKIP_RC - flag to disable loading of mavenrc files
@REM
----------------------------------------------------------------------------
@REM Begin all REM lines with '@' in case MAVEN_BATCH_ECHO is 'on'
@echo off
@REM set title of command window
title %0
@REM enable echoing by setting MAVEN_BATCH_ECHO to 'on'
@if "%MAVEN_BATCH_ECHO%" == "on"  echo %MAVEN_BATCH_ECHO%
@REM set %HOME% to equivalent of $HOME
if "%HOME%" == "" (set "HOME=%HOMEDRIVE%%HOMEPATH%")
@REM Execute a user defined script before this one
if not "%MAVEN_SKIP_RC%" == "" goto skipRcPre
@REM check for pre script, once with legacy .bat ending and once with .cmd
ending
if exist "%USERPROFILE%\mavenrc_pre.bat" call "%USERPROFILE%\mavenrc_pre.bat"
%*
if exist "%USERPROFILE%\mavenrc_pre.cmd" call "%USERPROFILE%\mavenrc_pre.cmd"
%*
:skipRcPre
@setlocal
set ERROR_CODE=0
@REM To isolate internal variables from possible post scripts, we use another
```

```
setlocal
@setlocal
@REM ==== START VALIDATION ====
if not "%JAVA_HOME%" == "" goto OkJHome
echo.
echo Error: JAVA_HOME not found in your environment. >&2
echo Please set the JAVA_HOME variable in your environment to match the >&2
echo location of your Java installation. >&2
echo.
goto error
:OkJHome
if exist "%JAVA_HOME%\bin\java.exe" goto init
echo.
echo Error: JAVA_HOME is set to an invalid directory. >&2
echo JAVA_HOME = "%JAVA_HOME%" >&2
echo Please set the JAVA_HOME variable in your environment to match the >&2
echo location of your Java installation. >&2
echo.
goto error
@REM ==== END VALIDATION ====
:init
@REM Find the project base dir, i.e. the directory that contains the folder
".mvn".
@REM Fallback to current working directory if not found.
set MAVEN_PROJECTBASEDIR=%MAVEN_BASEDIR%
IF NOT "%MAVEN_PROJECTBASEDIR%"=="" goto endDetectBaseDir
set EXEC_DIR=%CD%
set WDIR=%EXEC_DIR%
:findBaseDir
IF EXIST "%WDIR%"\.mvn goto baseDirFound
cd ..
IF "%WDIR%"=="%CD%" goto baseDirNotFound
set WDIR=%CD%
goto findBaseDir
:baseDirFound
set MAVEN_PROJECTBASEDIR=%WDIR%
cd "%EXEC_DIR%"
goto endDetectBaseDir
:baseDirNotFound
set MAVEN_PROJECTBASEDIR=%EXEC_DIR%
cd "%EXEC_DIR%"
:endDetectBaseDir
IF NOT EXIST "%MAVEN_PROJECTBASEDIR%\.mvn\jvm.config" goto
endReadAdditionalConfig
@setlocal EnableExtensions EnableDelayedExpansion
for /F "usebackq delims=" %%a in ("%MAVEN_PROJECTBASEDIR%\.mvn\jvm.config")
do set JVM_CONFIG_MAVEN_PROPS=!JVM_CONFIG_MAVEN_PROPS! %%a
@endlocal & set JVM_CONFIG_MAVEN_PROPS=%JVM_CONFIG_MAVEN_PROPS%
:endReadAdditionalConfig
SET MAVEN_JAVA_EXE="%JAVA_HOME%\bin\java.exe"
set WRAPPER_JAR="%MAVEN_PROJECTBASEDIR%\.mvn\wrapper\maven-wrapper.jar"
set WRAPPER_LAUNCHER=org.apache.maven.wrapper.MavenWrapperMain
set WRAPPER_URL="https://repo.maven.apache.org/maven2/org/apache/maven/
wrapper/maven-wrapper/3.2.0/maven-wrapper-3.2.0.jar"
FOR /F "usebackq tokens=1,2 delims==" %%A IN ("%MAVEN_PROJECTBASEDIR%
\.mvn\wrapper\maven-wrapper.properties") DO (
    IF "%%A"=="wrapperUrl" SET WRAPPER_URL=%%B
)
@REM Extension to allow automatically downloading the maven-wrapper.jar from
Maven-central
@REM This allows using the maven wrapper in projects that prohibit checking
```

```
in binary data.
if exist %WRAPPER_JAR% (
    if "%MVNW_VERBOSE%" == "true" (
        echo Found %WRAPPER_JAR%
    )
) else (
    if not "%MVNW_REPOURL%" == "" (
        SET WRAPPER_URL="%MVNW_REPOURL%/org/apache/maven/wrapper/maven-
wrapper/3.2.0/maven-wrapper-3.2.0.jar"
    )
    if "%MVNW_VERBOSE%" == "true" (
        echo Couldn't find %WRAPPER_JAR%, downloading it ...
        echo Downloading from: %WRAPPER_URL%
    )
    powershell -Command "&{"^
™"$webclient = new-object System.Net.WebClient;"^
™"if (-not ([string]::IsNullOrEmpty('%MVNW_USERNAME%') -and
[string]::IsNullOrEmpty('%MVNW_PASSWORD%'))) {"^
™"$webclient.Credentials = new-object
System.Net.NetworkCredential('%MVNW_USERNAME%', '%MVNW_PASSWORD%');"^
™"}"^
™"[Net.ServicePointManager]::SecurityProtocol =
[Net.SecurityProtocolType]::Tls12; $webclient.DownloadFile('%WRAPPER_URL%',
'%WRAPPER_JAR%')"^
™"}"
    if "%MVNW_VERBOSE%" == "true" (
        echo Finished downloading %WRAPPER_JAR%
    )
)
@REM End of extension
@REM If specified, validate the SHA-256 sum of the Maven wrapper jar file
SET WRAPPER_SHA_256_SUM=""
FOR /F "usebackq tokens=1,2 delims==" %%A IN ("%MAVEN_PROJECTBASEDIR%
\.mvn\wrapper\maven-wrapper.properties") DO (
    IF "%%A"=="wrapperSha256Sum" SET WRAPPER_SHA_256_SUM=%%B
)
IF NOT %WRAPPER_SHA_256_SUM%=="" (
    powershell -Command "&{"^
       "$hash = (Get-FileHash \"%WRAPPER_JAR%\" -Algorithm
SHA256).Hash.ToLower();"^
       "If('%WRAPPER_SHA_256_SUM%' -ne $hash){"^
       "  Write-Output 'Error: Failed to validate Maven wrapper SHA-256, your
Maven wrapper might be compromised.';"^
       "  Write-Output 'Investigate or delete %WRAPPER_JAR% to attempt a
clean download.';"^
       "  Write-Output 'If you updated your Maven version, you need to update
the specified wrapperSha256Sum property.';"^
       "  exit 1;"^
       "}"^
       "}"
    if ERRORLEVEL 1 goto error
)
@REM Provide a "standardized" way to retrieve the CLI args that will
@REM work with both Windows and non-Windows executions.
set MAVEN_CMD_LINE_ARGS=%*
%MAVEN_JAVA_EXE% ^
  %JVM_CONFIG_MAVEN_PROPS% ^
  %MAVEN_OPTS% ^
  %MAVEN_DEBUG_OPTS% ^
  -classpath %WRAPPER_JAR% ^
  "-Dmaven.multiModuleProjectDirectory=%MAVEN_PROJECTBASEDIR%" ^
```

```
  %WRAPPER_LAUNCHER% %MAVEN_CONFIG% %*
if ERRORLEVEL 1 goto error
goto end
:error
set ERROR_CODE=1
:end
@endlocal & set ERROR_CODE=%ERROR_CODE%
if not "%MAVEN_SKIP_RC%"=="" goto skipRcPost
@REM check for post script, once with legacy .bat ending and once with .cmd
ending
if exist "%USERPROFILE%\mavenrc_post.bat" call "%USERPROFILE%
\mavenrc_post.bat"
if exist "%USERPROFILE%\mavenrc_post.cmd" call "%USERPROFILE%
\mavenrc_post.cmd"
:skipRcPost
@REM pause the script if MAVEN_BATCH_PAUSE is set to 'on'
if "%MAVEN_BATCH_PAUSE%"=="on" pause
if "%MAVEN_TERMINATE_CMD%"=="on" exit %ERROR_CODE%
cmd /C exit /B %ERROR_CODE%
```

pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>langchain4j-aggregator</artifactId>
    <version>0.23.0</version>
    <packaging>pom</packaging>
    <modules>
        <module>langchain4j-parent</module>
        <module>langchain4j-bom</module>
        <module>langchain4j-core</module>
        <module>langchain4j</module>
        <module>langchain4j-spring-boot-starter</module>
        <!-- model providers -->
        <module>langchain4j-azure-open-ai</module>
        <module>langchain4j-dashscope</module>
        <module>langchain4j-hugging-face</module>
        <module>langchain4j-local-ai</module>
        <module>langchain4j-open-ai</module>
        <module>langchain4j-vertex-ai</module>
        <!-- embedding stores -->
        <module>langchain4j-cassandra</module>
        <module>langchain4j-chroma</module>
        <module>langchain4j-elasticsearch</module>
        <module>langchain4j-milvus</module>
        <module>langchain4j-opensearch</module>
        <module>langchain4j-pinecone</module>
        <module>langchain4j-pgvector</module>
        <module>langchain4j-redis</module>
        <module>langchain4j-vespa</module>
        <module>langchain4j-weaviate</module>
    </modules>
</project>
```

README.md

LangChain for Java: Supercharge your Java application with the power of LLMs
[](https://twitter.com/intent/follow?screen_name=langchain4j)
[](https://discord.gg/V5qHrWNVf)
Project goals
The goal of this project is to simplify the integration of AI/LLM capabilities into your Java application.
This can be achieved thanks to:
- **A simple and coherent layer of abstractions**, designed to ensure that your code does not depend on concrete implementations such as LLM providers, embedding store providers, etc. This allows for easy swapping of components.
- **Numerous implementations of the above-mentioned abstractions**, providing you with a variety of LLMs and embedding stores to choose from.
- **Range of in-demand features on top of LLMs, such as:**
    - The capability to **ingest your own data** (documentation, codebase, etc.), allowing the LLM to act and respond based on your data.
    - **Autonomous agents** for delegating tasks (defined on the fly) to the LLM, which will strive to complete them.
    - **Prompt templates** to help you achieve the highest possible quality of LLM responses.
    - **Memory** to provide context to the LLM for your current and past conversations.
    - **Structured outputs** for receiving responses from the LLM with a desired structure as Java POJOs.
    - **"AI Services"** for declaratively defining complex AI behavior behind a simple API.
    - **Chains** to reduce the need for extensive boilerplate code in common use-cases.
    - **Auto-moderation** to ensure that all inputs and outputs to/from the LLM are not harmful.
Code examples
Please see examples of how LangChain4j can be used in `langchain4j-examples` repo:
- [Examples in plain Java](https://github.com/langchain4j/langchain4j-examples/tree/main/other-examples/src/main/java)
- [Example with Spring Boot](https://github.com/langchain4j/langchain4j-examples/blob/main/spring-boot-example/src/test/java/dev/example/CustomerSupportApplicationTest.java)
News
29 September:
- Updates to models API: return `Response<T>` instead of `T`. `Response<T>` contains token usage and finish reason.
- All model and embedding store integrations now live in their own modules
- Integration with [Vespa](https://vespa.ai/) by [@Heezer](https://github.com/Heezer)
- Integration with [Elasticsearch](https://www.elastic.co/) by [@Martin7-1](https://github.com/Martin7-1)
- Integration with [Redis](https://redis.io/) by [@Martin7-1](https://github.com/Martin7-1)
- Integration with [Milvus](https://milvus.io/) by [@IuriiKoval](https://github.com/IuriiKoval)
- Integration with [Astra DB](https://www.datastax.com/products/datastax-astra) and [Cassandra](https://cassandra.apache.org/) by [@clun](https://github.com/clun)
- Added support for overlap in document splitters
- Some bugfixes and smaller improvements
29 August:

- Offline [text classification with embeddings](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/embedding/classification/EmbeddingModelTextClassifierExample.java)
- Integration with [Google Vertex AI](https://cloud.google.com/vertex-ai) by [@kuraleta](https://github.com/kuraleta)
- Reworked [document splitters](https://github.com/langchain4j/langchain4j/blob/main/langchain4j/src/main/java/dev/langchain4j/data/document/splitter/DocumentSplitters.java)
- In-memory embedding store can now be easily persisted
- [And more](https://github.com/langchain4j/langchain4j/releases/tag/0.22.0)

19 August:
- Integration with [Azure OpenAI](https://learn.microsoft.com/en-us/azure/ai-services/openai/overview) by [@kuraleta](https://github.com/kuraleta)
- Integration with Qwen models (DashScope) by [@jiangsier-xyz](https://github.com/jiangsier-xyz)
- [Integration with Chroma](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/embedding/store/ChromaEmbeddingStoreExample.java) by [@kuraleta](https://github.com/kuraleta)
- [Support for persistent ChatMemory](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/ServiceWithPersistentMemoryForEachUserExample.java)

10 August:
- [Integration with Weaviate](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/embedding/store/WeaviateEmbeddingStoreExample.java) by [@Heezer](https://github.com/Heezer)
- [Support for DOC, XLS and PPT document types](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/DocumentLoaderExamples.java) by [@oognuyh](https://github.com/oognuyh)
- [Separate chat memory for each user](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/ServiceWithMemoryForEachUserExample.java)
- [Custom in-process embedding models](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/embedding/model/InProcessEmbeddingModelExamples.java)
- Added lots of Javadoc
- [And more](https://github.com/langchain4j/langchain4j/releases/tag/0.19.0)

26 July:
- We've added integration with [LocalAI](https://localai.io/). Now, you can use LLMs hosted locally!
- Added support for [response streaming in AI Services](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/ServiceWithStreamingExample.java).

21 July:
- Now, you can do [text embedding inside your JVM](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/embedding/model/InProcessEmbeddingModelExamples.java).

17 July:
- You can now try out OpenAI's `gpt-3.5-turbo` and `text-embedding-ada-002` models with LangChain4j for free, without needing an OpenAI account and keys! Simply use the API key "demo".

15 July:
- Added EmbeddingStoreIngestor
- Redesigned document loaders (see FileSystemDocumentLoader)
- Simplified ConversationalRetrievalChain
- Renamed DocumentSegment into TextSegment
- Added output parsers for numeric types
- Added @UserName for AI Services
- Fixed [23](https://github.com/langchain4j/langchain4j/issues/23) and [24](https://github.com/langchain4j/langchain4j/issues/24)

11 July:
- Added ["Dynamic Tools"](https://github.com/langchain4j/langchain4j-examples/

blob/main/other-examples/src/main/java/ServiceWithDynamicToolsExample.java):
  Now, the LLM can generate code for tasks that require precise calculations, such as math and string manipulation. This will be dynamically executed in a style akin to GPT-4's code interpreter!
  We use [Judge0, hosted by Rapid API](https://rapidapi.com/judge0-official/api/judge0-ce/pricing), for code execution. You can subscribe and receive 50 free executions per day.
5 July:
- Now you can [add your custom knowledge base to "AI Services"](https://github.com/langchain4j/langchain4j-examples/blob/main/spring-boot-example/src/test/java/dev/example/CustomerSupportApplicationTest.java).
  Relevant information will be automatically retrieved and injected into the prompt. This way, the LLM will have a
  context of your data and will answer based on it!
- The current date and time can now be automatically injected into the prompt using
  special `{{current_date}}`, `{{current_time}}` and `{{current_date_time}}` placeholders.
3 July:
- Added support for Spring Boot 3
2 July:
- [Added Spring Boot Starter](https://github.com/langchain4j/langchain4j-examples/blob/main/spring-boot-example/src/test/java/dev/example/CustomerSupportApplicationTest.java)
- Added support for HuggingFace models
1 July:
- [Added "Tools"](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/ServiceWithToolsExample.java) (support for OpenAI functions)
Highlights
You can declaratively define concise "AI Services" that are powered by LLMs:
```java
interface Assistant {
    String chat(String userMessage);
}
Assistant assistant = AiServices.create(Assistant.class, model);
String answer = assistant.chat("Hello");
System.out.println(answer);
// Hello! How can I assist you today?
```
You can use LLM as a classifier:
```java
enum Sentiment {
    POSITIVE, NEUTRAL, NEGATIVE
}
interface SentimentAnalyzer {
    @UserMessage("Analyze sentiment of {{it}}")
    Sentiment analyzeSentimentOf(String text);
    @UserMessage("Does {{it}} have a positive sentiment?")
    boolean isPositive(String text);
}
SentimentAnalyzer sentimentAnalyzer =
AiServices.create(SentimentAnalyzer.class, model);
Sentiment sentiment = sentimentAnalyzer.analyzeSentimentOf("It is good!");
// POSITIVE
boolean positive = sentimentAnalyzer.isPositive("It is bad!");
// false
```
You can easily extract structured information from unstructured data:
```java
class Person {
```

```
    private String firstName;
    private String lastName;
    private LocalDate birthDate;
    public String toString() {...}
}
interface PersonExtractor {
    @UserMessage("Extract information about a person from {{it}}")
    Person extractPersonFrom(String text);
}
PersonExtractor extractor = AiServices.create(PersonExtractor.class, model);
String text = "In 1968, amidst the fading echoes of Independence Day, "
    + "a child named John arrived under the calm evening sky. "
    + "This newborn, bearing the surname Doe, marked the start of a new
journey.";
Person person = extractor.extractPersonFrom(text);
// Person { firstName = "John", lastName = "Doe", birthDate = 1968-07-04 }
```
You can define more sophisticated prompt templates using mustache syntax:
```java
interface Translator {
    @SystemMessage("You are a professional translator into {{language}}")
    @UserMessage("Translate the following text: {{text}}")
    String translate(@V("text") String text, @V("language") String language);
}
Translator translator = AiServices.create(Translator.class, model);
String translation = translator.translate("Hello, how are you?", "Italian");
// Ciao, come stai?
```
You can provide tools that LLMs can use! Can be anything: retrieve
information from DB, call APIs, etc.
See example [here](https://github.com/langchain4j/langchain4j-examples/blob/
main/other-examples/src/main/java/ServiceWithToolsExample.java).
Compatibility
- Java: 8 or higher
- Spring Boot: 2 or 3
Getting started
1. Add LangChain4j OpenAI dependency to your project:
    - Maven:
      ```
      <dependency>
          <groupId>dev.langchain4j</groupId>
          <artifactId>langchain4j-open-ai</artifactId>
          <version>0.23.0</version>
      </dependency>
      ```
    - Gradle:
      ```
      implementation 'dev.langchain4j:langchain4j-open-ai:0.23.0'
      ```
2. Import your OpenAI API key:
    ```java
    String apiKey = System.getenv("OPENAI_API_KEY");
    ```
    You can use the API key "demo" to test OpenAI, which we provide for free.
    [How to gen an API key?](https://github.com/langchain4j/langchain4j#how-
to-get-an-api-key)
3. Create an instance of a model and start interacting:
    ```java
    OpenAiChatModel model = OpenAiChatModel.withApiKey(apiKey);
    String answer = model.generate("Hello world!");
    System.out.println(answer); // Hello! How can I assist you today?
```

```
## Disclaimer
Please note that the library is in active development and:
- Many features are still missing. We are working hard on implementing them
ASAP.
- API might change at any moment. At this point, we prioritize good design in
the future over backward compatibility
  now. We hope for your understanding.
- We need your input! Please [let us know](https://github.com/langchain4j/
langchain4j/issues/new/choose) what features you need and your concerns about
the current implementation.
## Current capabilities:
- AI Services:
    - [Simple](https://github.com/langchain4j/langchain4j-examples/blob/main/
other-examples/src/main/java/SimpleServiceExample.java)
    - [With Memory](https://github.com/langchain4j/langchain4j-examples/blob/
main/other-examples/src/main/java/ServiceWithMemoryExample.java)
    - [With Tools](https://github.com/langchain4j/langchain4j-examples/blob/
main/other-examples/src/main/java/ServiceWithToolsExample.java)
    - [With Streaming](https://github.com/langchain4j/langchain4j-examples/
blob/main/other-examples/src/main/java/ServiceWithStreamingExample.java)
    - [With Retriever](https://github.com/langchain4j/langchain4j-examples/
blob/main/other-examples/src/main/java/ServiceWithRetrieverExample.java)
    - [With Auto-Moderation](https://github.com/langchain4j/langchain4j-
examples/blob/main/other-examples/src/main/java/
ServiceWithAutoModerationExample.java)
    - [With Structured Outputs, Structured Prompts, etc](https://github.com/
langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/
OtherServiceExamples.java)
- Integration with [OpenAI](https://platform.openai.com/docs/introduction)
and [Azure OpenAI](https://learn.microsoft.com/en-us/azure/ai-services/openai/
overview) for:
    - [Chats](https://platform.openai.com/docs/guides/chat) (sync + streaming
+ functions)
    - [Completions](https://platform.openai.com/docs/guides/completion) (sync
+ streaming)
    - [Embeddings](https://platform.openai.com/docs/guides/embeddings)
- Integration with [Google Vertex AI](https://cloud.google.com/vertex-ai) for:
    - [Chats](https://cloud.google.com/vertex-ai/docs/generative-ai/chat/chat-
prompts)
    - [Completions](https://cloud.google.com/vertex-ai/docs/generative-ai/
text/text-overview)
    - [Embeddings](https://cloud.google.com/vertex-ai/docs/generative-ai/
embeddings/get-text-embeddings)
- Integration with [HuggingFace Inference API](https://huggingface.co/docs/
api-inference/index) for:
    - [Chats](https://huggingface.co/docs/api-inference/
detailed_parameters#text-generation-task)
    - [Completions](https://huggingface.co/docs/api-inference/
detailed_parameters#text-generation-task)
    - [Embeddings](https://huggingface.co/docs/api-inference/
detailed_parameters#feature-extraction-task)
- Integration with [LocalAI](https://localai.io/) for:
  - Chats (sync + streaming + functions)
  - Completions (sync + streaming)
  - Embeddings
- Integration with [DashScope](https://dashscope.aliyun.com/) for:
    - Chats (sync + streaming)
    - Completions (sync + streaming)
    - Embeddings
- [Chat memory](https://github.com/langchain4j/langchain4j-examples/blob/main/
```

other-examples/src/main/java/ChatMemoryExamples.java)
- [Persistent chat memory](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/ServiceWithPersistentMemoryForEachUserExample.java)
- [Chat with Documents](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/ChatWithDocumentsExamples.java)
- Integration with [Astra DB](https://www.datastax.com/products/datastax-astra) and [Cassandra](https://cassandra.apache.org/)
- [Integration](https://github.com/langchain4j/langchain4j-examples/blob/main/chroma-example/src/main/java/ChromaEmbeddingStoreExample.java) with [Chroma](https://www.trychroma.com/)
- [Integration](https://github.com/langchain4j/langchain4j-examples/blob/main/elasticsearch-example/src/main/java/ElasticsearchEmbeddingStoreExample.java) with [Elasticsearch](https://www.elastic.co/)
- [Integration](https://github.com/langchain4j/langchain4j-examples/blob/main/milvus-example/src/main/java/MilvusEmbeddingStoreExample.java) with [Milvus](https://milvus.io/)
- [Integration](https://github.com/langchain4j/langchain4j-examples/blob/main/pinecone-example/src/main/java/PineconeEmbeddingStoreExample.java) with [Pinecone](https://www.pinecone.io/)
- [Integration](https://github.com/langchain4j/langchain4j-examples/blob/main/redis-example/src/main/java/RedisEmbeddingStoreExample.java) with [Redis](https://redis.io/)
- [Integration](https://github.com/langchain4j/langchain4j-examples/blob/main/vespa-example/src/main/java/VespaEmbeddingStoreExample.java) with [Vespa](https://vespa.ai/)
- [Integration](https://github.com/langchain4j/langchain4j-examples/blob/main/weaviate-example/src/main/java/WeaviateEmbeddingStoreExample.java) with [Weaviate](https://weaviate.io/)
- [In-memory embedding store](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/embedding/store/InMemoryEmbeddingStoreExample.java) (can be persisted)
- [Structured outputs](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/OtherServiceExamples.java)
- [Prompt templates](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/PromptTemplateExamples.java)
- [Structured prompt templates](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/StructuredPromptTemplateExamples.java)
- [Streaming of LLM responses](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/StreamingExamples.java)
- [Loading txt, html, pdf, doc, xls and ppt documents from the file system and via URL](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/DocumentLoaderExamples.java)
- [Splitting documents into segments](https://github.com/langchain4j/langchain4j-examples/blob/main/other-examples/src/main/java/ChatWithDocumentsExamples.java):
    - by paragraphs, lines, sentences, words, etc
    - recursively
    - with overlap
- Token count estimation (so that you can predict how much you will pay)

Coming soon:
- Extending "AI Service" features
- Integration with more LLM providers (commercial and free)
- Integrations with more embedding stores (commercial and free)
- Support for more document types
- Long-term memory for chatbots and agents
- Chain-of-Thought and Tree-of-Thought

Request features
Please [let us know](https://github.com/langchain4j/langchain4j/issues/new/choose) what features you need!

Contribute
Please help us make this open-source library better by contributing.
Some guidelines:
1. Follow [Google's Best Practices for Java Libraries](https://jlbp.dev/).
2. Keep the code compatible with Java 8.
3. Avoid adding new dependencies as much as possible. If absolutely necessary, try to (re)use the same libraries which are already present.
4. Follow existing code styles present in the project.
5. Ensure to add Javadoc where necessary.
6. Provide unit and/or integration tests for your code.
7. Large features should be discussed with maintainers before implementation.
Use cases
You might ask why would I need all of this?
Here are a couple of examples:
- You want to implement a custom AI-powered chatbot that has access to your data and behaves the way you want it:
    - Customer support chatbot that can:
        - politely answer customer questions
        - take /change/cancel orders
    - Educational assistant that can:
        - Teach various subjects
        - Explain unclear parts
        - Assess user's understanding/knowledge
- You want to process a lot of unstructured data (files, web pages, etc) and extract structured information from them.
  For example:
    - extract insights from customer reviews and support chat history
    - extract interesting information from the websites of your competitors
    - extract insights from CVs of job applicants
- You want to generate information, for example:
    - Emails tailored for each of your customers
    - Content for your app/website:
        - Blog posts
        - Stories
- You want to transform information, for example:
    - Summarize
    - Proofread and rewrite
    - Translate
Best practices
We highly recommend watching [this amazing 90-minute tutorial](https://www.deeplearning.ai/short-courses/chatgpt-prompt-engineering-for-developers/) on prompt engineering best practices, presented by Andrew Ng (DeepLearning.AI) and Isa Fulford (OpenAI).
This course will teach you how to use LLMs efficiently and achieve the best possible results. Good investment of your time!
Here are some best practices for using LLMs:
- Be responsible. Use AI for Good.
- Be specific. The more specific your query, the best results you will get.
- Add a ["Let’s think step by step" instruction](https://arxiv.org/pdf/2205.11916.pdf) to your prompt.
- Specify steps to achieve the desired goal yourself. This will make the LLM do what you want it to do.
- Provide examples. Sometimes it is best to show LLM a few examples of what you want instead of trying to explain it.
- Ask LLM to provide structured output (JSON, XML, etc). This way you can parse response more easily and distinguish
  different parts of it.
- Use unusual delimiters, such as \```triple backticks``` to help the LLM distinguish

  data or input from instructions.
How to get an API key
You will need an API key from OpenAI (paid) or HuggingFace (free) to use LLMs hosted by them.
We recommend using OpenAI LLMs (`gpt-3.5-turbo` and `gpt-4`) as they are by far the most capable and are reasonably priced.
It will cost approximately $0.01 to generate 10 pages (A4 format) of text with `gpt-3.5-turbo`. With `gpt-4`, the cost will be $0.30 to generate the same amount of text. However, for some use cases, this higher cost may be justified.
[How to get OpenAI API key](https://www.howtogeek.com/885918/how-to-get-an-openai-api-key/).
For embeddings, we recommend using one of the models from the [HuggingFace MTEB leaderboard](https://huggingface.co/spaces/mteb/leaderboard).
You'll have to find the best one for your specific use case.
Here's how to get a HuggingFace API key:
- Create an account on https://huggingface.co
- Go to https://huggingface.co/settings/tokens
- Generate a new access token

chroma-example\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>chroma-example</artifactId>
    <version>0.23.0</version>
    <properties>
        <maven.compiler.source>8</maven.compiler.source>
        <maven.compiler.target>8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-chroma</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>${project.version}</version>
        </dependency>
    </dependencies>
</project>
```

chroma-example\src\main\java\ChromaEmbeddingStoreExample.java

```
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.chroma.ChromaEmbeddingStore;
import java.util.List;
import static dev.langchain4j.internal.Utils.randomUUID;
public class ChromaEmbeddingStoreExample {
    /**
     * To run this example, ensure you have Chroma running locally. If not,
then:
     * - Execute "docker pull ghcr.io/chroma-core/chroma:0.4.6"
     * - Execute "docker run -d -p 8000:8000 ghcr.io/chroma-core/chroma:0.4.6"
     * - Wait until Chroma is ready to serve (may take a few minutes)
     */
    public static void main(String[] args) {
        EmbeddingStore<TextSegment> embeddingStore =
ChromaEmbeddingStore.builder()
                .baseUrl("http://localhost:8000")
                .collectionName(randomUUID())
                .build();
        EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
        TextSegment segment1 = TextSegment.from("I like football.");
        Embedding embedding1 = embeddingModel.embed(segment1).content();
        embeddingStore.add(embedding1, segment1);
        TextSegment segment2 = TextSegment.from("The weather is good today.");
        Embedding embedding2 = embeddingModel.embed(segment2).content();
        embeddingStore.add(embedding2, segment2);
        Embedding queryEmbedding = embeddingModel.embed("What is your
favourite sport?").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(queryEmbedding, 1);
        EmbeddingMatch<TextSegment> embeddingMatch = relevant.get(0);
        System.out.println(embeddingMatch.score()); // 0.8144288493114709
        System.out.println(embeddingMatch.embedded().text()); // I like
football.
    }
}
```

devoxx\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>devoxx</artifactId>
    <version>0.23.0</version>
    <properties>
        <maven.compiler.source>8</maven.compiler.source>
        <maven.compiler.target>8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-open-ai</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>org.tinylog</groupId>
            <artifactId>tinylog-impl</artifactId>
            <version>2.6.2</version>
        </dependency>
        <dependency>
            <groupId>org.tinylog</groupId>
            <artifactId>slf4j-tinylog</artifactId>
            <version>2.6.2</version>
        </dependency>
        <dependency>
            <groupId>org.mapdb</groupId>
            <artifactId>mapdb</artifactId>
            <version>3.0.9</version>
            <exclusions>
                <exclusion>
                    <groupId>org.jetbrains.kotlin</groupId>
                    <artifactId>kotlin-stdlib</artifactId>
                </exclusion>
            </exclusions>
        </dependency>
    </dependencies>
</project>
```

devoxx\src\main\java\ApiKeys.java

```
public class ApiKeys {
    public static final String OPENAI_API_KEY =
System.getenv("OPENAI_API_KEY");
    public static final String RAPID_API_KEY = System.getenv("RAPID_API_KEY");
}
```

devoxx\src\main\java_00_HelloDevoxx.java

```
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
public class _00_HelloDevoxx {
    public static void main(String[] args) {
        ChatLanguageModel model =
OpenAiChatModel.withApiKey(ApiKeys.OPENAI_API_KEY);
        String response = model.generate("Say Hello Devoxx");
        System.out.println(response);
    }
}
```

devoxx\src\main\java_01_ModelParameters.java

```
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static java.time.Duration.ofSeconds;
public class _01_ModelParameters {
    public static void main(String[] args) {
    ’òò   & ÖWFW" ÖV æ–ær f÷" ÷ Vä ’ W‡ Æ –æVB †W&R ‡GG 3¢òð
platform.openai.com/docs/api-reference/chat/create
        ChatLanguageModel model = OpenAiChatModel.builder()
                .apiKey(ApiKeys.OPENAI_API_KEY)
                .modelName(GPT_3_5_TURBO)
                .temperature(0.3)
                .timeout(ofSeconds(60))
                .logRequests(true)
                .logResponses(true)
                .build();
        String prompt = "Explain in three lines how to make a beautiful
painting";
        String response = model.generate(prompt);
        System.out.println(response);
    }
}
```

devoxx\src\main\java_02_PromptTemplate.java

```
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.input.PromptTemplate;
import dev.langchain4j.model.openai.OpenAiChatModel;
import java.util.HashMap;
import java.util.Map;
import static java.time.Duration.ofSeconds;
public class _02_PromptTemplate {
    public static void main(String[] args) {
        ChatLanguageModel model = OpenAiChatModel.builder()
                .apiKey(ApiKeys.OPENAI_API_KEY)
                .timeout(ofSeconds(60))
                .build();
        String template = "Create a recipe for a {{dishType}} with the
following ingredients: {{ingredients}}";
        PromptTemplate promptTemplate = PromptTemplate.from(template);
        Map<String, Object> variables = new HashMap<>();
        variables.put("dishType", "oven dish");
        variables.put("ingredients", "potato, tomato, feta, olive oil");
        Prompt prompt = promptTemplate.apply(variables);
        String response = model.generate(prompt.text());
        System.out.println(response);
    }
}
```

devoxx\src\main\java_03_StructuredPromptTemplate.java

```
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.input.structured.StructuredPrompt;
import dev.langchain4j.model.input.structured.StructuredPromptProcessor;
import dev.langchain4j.model.openai.OpenAiChatModel;
import java.util.List;
import static java.time.Duration.ofSeconds;
import static java.util.Arrays.asList;
public class _03_StructuredPromptTemplate {
    @StructuredPrompt({
            "Create a recipe of a {{dish}} that can be prepared using only
{{ingredients}}.",
            "Structure your answer in the following way:",
            "Recipe name: ...",
            "Description: ...",
            "Preparation time: ...",
            "Required ingredients:",
            "- ...",
            "- ...",
            "Instructions:",
            "- ...",
            "- ..."
    })
    static class CreateRecipePrompt {
        String dish;
        List<String> ingredients;
        CreateRecipePrompt(String dish, List<String> ingredients) {
            this.dish = dish;
            this.ingredients = ingredients;
        }
    }
    public static void main(String[] args) {
        ChatLanguageModel model = OpenAiChatModel.builder()
                .apiKey(ApiKeys.OPENAI_API_KEY)
                .timeout(ofSeconds(60))
                .build();
        CreateRecipePrompt createRecipePrompt = new CreateRecipePrompt(
                "salad",
                asList("cucumber", "tomato", "feta", "onion", "olives")
        );
        Prompt prompt =
StructuredPromptProcessor.toPrompt(createRecipePrompt);
        String recipe = model.generate(prompt.text());
        System.out.println(recipe);
    }
}
```

devoxx\src\main\java_04_Streaming.java

```
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.openai.OpenAiStreamingChatModel;
import dev.langchain4j.model.output.Response;
public class _04_Streaming {
    public static void main(String[] args) {
        OpenAiStreamingChatModel model =
OpenAiStreamingChatModel.withApiKey(ApiKeys.OPENAI_API_KEY);
        String prompt = "Write a short 1 paragraph funny poem about
developers and null-pointers";
        System.out.println("Nr of chars: " + prompt.length());
        System.out.println("Nr of tokens: " +
model.estimateTokenCount(prompt));
        model.generate(prompt, new StreamingResponseHandler<AiMessage>() {
            @Override
            public void onNext(String token) {
                System.out.print(token);
            }
            @Override
            public void onComplete(Response<AiMessage> response) {
                System.out.println("\n\nDone streaming");
            }
            @Override
            public void onError(Throwable error) {
                System.out.println("Something went wrong: " +
error.getMessage());
            }
        });
    }
}
```

devoxx\src\main\java_05_Memory.java

```
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.SystemMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.TokenWindowChatMemory;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.Tokenizer;
import dev.langchain4j.model.openai.OpenAiStreamingChatModel;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import dev.langchain4j.model.output.Response;
import java.util.concurrent.CompletableFuture;
import java.util.concurrent.ExecutionException;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
public class _05_Memory {
    public static void main(String[] args) throws ExecutionException,
InterruptedException {
        OpenAiStreamingChatModel model =
OpenAiStreamingChatModel.withApiKey(ApiKeys.OPENAI_API_KEY);
        Tokenizer tokenizer = new OpenAiTokenizer(GPT_3_5_TURBO);
        ChatMemory chatMemory = TokenWindowChatMemory.withMaxTokens(1000,
tokenizer);
        UserMessage userMessage1 = userMessage(
                "How do I optimize database queries for a large-scale e-
commerce platform? "
                        + "Answer short in three to five lines maximum.");
        chatMemory.add(userMessage1);
        System.out.println("[User]: " + userMessage1.text());
        System.out.print("[LLM]: ");
        CompletableFuture<AiMessage> futureAiMessage = new
CompletableFuture<>();
        StreamingResponseHandler<AiMessage> handler = new
StreamingResponseHandler<AiMessage>() {
            @Override
            public void onNext(String token) {
                System.out.print(token);
            }
            @Override
            public void onComplete(Response<AiMessage> response) {
                futureAiMessage.complete(response.content());
            }
            @Override
            public void onError(Throwable throwable) {
            }
        };
        model.generate(chatMemory.messages(), handler);
        chatMemory.add(futureAiMessage.get());
        UserMessage userMessage2 = userMessage(
                "Give a concrete example implementation of the first point? "
+
                        "Be short, 10 lines of code maximum.");
        chatMemory.add(userMessage2);
        System.out.println("\n\n[User]: " + userMessage2.text());
        System.out.print("[LLM]: ");
        model.generate(chatMemory.messages(), handler);
    }
}
//SystemMessage systemMessage = SystemMessage.from(
```

```
//"You are a senior developer explaining to another senior developer, "
//      + "the project you are working on is an e-commerce platform with Java
back-end, " +
//      "Oracle database,and Spring Data JPA");
//chatMemory.add(systemMessage);
```

```
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.data.message.UserMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.openai.OpenAiStreamingChatModel;
import java.util.ArrayList;
import java.util.List;
import static java.time.Duration.ofSeconds;
public class _06_FewShot {
    public static void main(String[] args) {
        OpenAiStreamingChatModel model = OpenAiStreamingChatModel.builder()
                .apiKey(ApiKeys.OPENAI_API_KEY)
                .timeout(ofSeconds(100))
                .build();
        List<ChatMessage> fewShotHistory = new ArrayList<>();
        // Adding positive feedback example to history
        fewShotHistory.add(UserMessage.from(
                "I love the new update! The interface is very user-friendly
and the new features are amazing!"));
        fewShotHistory.add(AiMessage.from(
                "Action: forward input to positive feedback storage\nReply:
Thank you very much for this great feedback! We have transmitted your message
to our product development team who will surely be very happy to hear this.
We hope you continue enjoying using our product."));
        // Adding negative feedback example to history
        fewShotHistory.add(UserMessage
                .from("I am facing frequent crashes after the new update on
my Android device."));
        fewShotHistory.add(AiMessage.from(
                "Action: open new ticket - crash after update Android\nReply:
We are so sorry to hear about the issues you are facing. We have reported the
problem to our development team and will make sure this issue is addressed as
fast as possible. We will send you an email when the fix is done, and we are
always at your service for any further assistance you may need."));
        // Adding another positive feedback example to history
        fewShotHistory.add(UserMessage
                .from("Your app has made my daily tasks so much easier! Kudos
to the team!"));
        fewShotHistory.add(AiMessage.from(
                "Action: forward input to positive feedback storage\nReply:
Thank you so much for your kind words! We are thrilled to hear that our app
is making your daily tasks easier. Your feedback has been shared with our
team. We hope you continue to enjoy using our app!"));
        // Adding another negative feedback example to history
        fewShotHistory.add(UserMessage
                .from("The new feature is not working as expected. It’s
causing data loss."));
        fewShotHistory.add(AiMessage.from(
                "Action: open new ticket - data loss by new feature\nReply:We
apologize for the inconvenience caused. Your feedback is crucial to us, and
we have reported this issue to our technical team. They are working on it on
priority. We will keep you updated on the progress and notify you once the
issue is resolved. Thank you for your patience and support."));
        // Adding real user's message
        ChatMessage customerComplaint = UserMessage
                .from("How can your app be so slow? Please do something about
it!");
        fewShotHistory.add(customerComplaint);
```

```
        System.out.println("[User]: " + customerComplaint.text());
        System.out.print("[LLM]: ");
        model.generate(fewShotHistory, new
StreamingResponseHandler<AiMessage>() {
            @Override
            public void onNext(String token) {
                System.out.print(token);
            }
            @Override
            public void onError(Throwable throwable) {
            }
        });
        // Extract reply and send to customer
        // Perform necessary action in back-end
    }
}
```

devoxx\src\main\java_07_ConversationalChain.java

```
import dev.langchain4j.chain.ConversationalChain;
import dev.langchain4j.model.openai.OpenAiChatModel;
import static java.time.Duration.ofSeconds;
public class _07_ConversationalChain {
    public static void main(String[] args) {
        OpenAiChatModel model = OpenAiChatModel.builder()
                .apiKey(ApiKeys.OPENAI_API_KEY)
                .timeout(ofSeconds(60))
                .build();
        ConversationalChain chain = ConversationalChain.builder()
                .chatLanguageModel(model)
                // .chatMemory(...) // you can override default chat memory
                .build();
        String userMessage1 = "Can you give a brief explanation of the Agile
methodology, 3 lines max?";
        System.out.println("[User]: " + userMessage1);
        String answer1 = chain.execute(userMessage1);
        System.out.println("[LLM]: " + answer1);
        String userMessage2 = "What are good tools for that? 3 lines max.";
        System.out.println("[User]: " + userMessage2);
        String answer2 = chain.execute(userMessage2);
        System.out.println("[LLM]: " + answer2);
    }
}
```

devoxx\src\main\java_08_AIServiceExamples.java

```
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.input.structured.StructuredPrompt;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.model.output.structured.Description;
import dev.langchain4j.service.AiServices;
import dev.langchain4j.service.MemoryId;
import dev.langchain4j.service.SystemMessage;
import dev.langchain4j.service.UserMessage;
import dev.langchain4j.service.V;
import java.math.BigDecimal;
import java.math.BigInteger;
import java.time.LocalDate;
import java.time.LocalDateTime;
import java.time.LocalTime;
import java.util.List;
import static java.time.Duration.ofSeconds;
import static java.util.Arrays.asList;
public class _08_AIServiceExamples {
    static ChatLanguageModel model = OpenAiChatModel.builder()
            .apiKey(ApiKeys.OPENAI_API_KEY)
            .timeout(ofSeconds(60))
            .build();
    ////////////////// SIMPLE EXAMPLE //////////////////////
    static class Simple_AI_Service_Example {
        interface Assistant {
            String chat(String message);
        }
        public static void main(String[] args) {
            Assistant assistant = AiServices.create(Assistant.class, model);
            String userMessage = "Translate 'Plus-Values des cessions de
valeurs mobilières, de droits sociaux et gains assimilés'";
            String answer = assistant.chat(userMessage);
            System.out.println(answer);
        }
    }
    ////////////////// WITH MESSAGE AND VARIABLES //////////////////////
    static class AI_Service_with_System_Message_Example {
        interface Chef {
            @SystemMessage("You are a professional chef. You are friendly,
polite and concise.")
            String answer(String question);
        }
        public static void main(String[] args) {
            Chef chef = AiServices.create(Chef.class, model);
            String answer = chef.answer("How long should I grill chicken?");
            System.out.println(answer); // Grilling chicken usually takes
around 10-15 minutes per side ...
        }
    }
    static class AI_Service_with_System_and_User_Messages_Example {
        interface TextUtils {
            @SystemMessage("You are a professional translator into
{{language}}")
            @UserMessage("Translate the following text: {{text}}")
            String translate(@V("text") String text, @V("language") String
language);
```

```
            @SystemMessage("Summarize every message from user in {{n}} bullet
points. Provide only bullet points.")
            List<String> summarize(@UserMessage String text, @V("n") int n);
        }
        public static void main(String[] args) {
            TextUtils utils = AiServices.create(TextUtils.class, model);
            String translation = utils.translate("Hello, how are you?",
"italian");
            System.out.println(translation); // Ciao, come stai?
            String text = "AI, or artificial intelligence, is a branch of
computer science that aims to create "
                    + "machines that mimic human intelligence. This can range
from simple tasks such as recognizing "
                    + "patterns or speech to more complex tasks like making
decisions or predictions.";
            List<String> bulletPoints = utils.summarize(text, 3);
            System.out.println(bulletPoints);
            // [
            // "- AI is a branch of computer science",
            // "- It aims to create machines that mimic human intelligence",
            // "- It can perform simple or complex tasks"
            // ]
        }
    }
    ////////////////////// EXTRACTING DIFFERENT DATA TYPES //////////////////////
    static class Sentiment_Extracting_AI_Service_Example {
        enum Sentiment {
            POSITIVE, NEUTRAL, NEGATIVE;
        }
        interface SentimentAnalyzer {
            @UserMessage("Analyze sentiment of {{it}}")
            Sentiment analyzeSentimentOf(String text);
            @UserMessage("Does {{it}} have a positive sentiment?")
            boolean isPositive(String text);
        }
        public static void main(String[] args) {
            SentimentAnalyzer sentimentAnalyzer =
AiServices.create(SentimentAnalyzer.class, model);
            Sentiment sentiment = sentimentAnalyzer.analyzeSentimentOf("It is
good!");
            System.out.println(sentiment); // POSITIVE
            boolean positive = sentimentAnalyzer.isPositive("It is bad!");
            System.out.println(positive); // false
        }
    }
    static class Number_Extracting_AI_Service_Example {
        interface NumberExtractor {
            @UserMessage("Extract number from {{it}}")
            int extractInt(String text);
            @UserMessage("Extract number from {{it}}")
            long extractLong(String text);
            @UserMessage("Extract number from {{it}}")
            BigInteger extractBigInteger(String text);
            @UserMessage("Extract number from {{it}}")
            float extractFloat(String text);
            @UserMessage("Extract number from {{it}}")
            double extractDouble(String text);
            @UserMessage("Extract number from {{it}}")
            BigDecimal extractBigDecimal(String text);
        }
        public static void main(String[] args) {
```

```
            NumberExtractor extractor =
AiServices.create(NumberExtractor.class, model);
            String text = "After countless millennia of computation, the
supercomputer Deep Thought finally announced "
                    + "that the answer to the ultimate question of life, the
universe, and everything was forty two.";
            int intNumber = extractor.extractInt(text);
            System.out.println(intNumber); // 42
            long longNumber = extractor.extractLong(text);
            System.out.println(longNumber); // 42
            BigInteger bigIntegerNumber = extractor.extractBigInteger(text);
            System.out.println(bigIntegerNumber); // 42
            float floatNumber = extractor.extractFloat(text);
            System.out.println(floatNumber); // 42.0
            double doubleNumber = extractor.extractDouble(text);
            System.out.println(doubleNumber); // 42.0
            BigDecimal bigDecimalNumber = extractor.extractBigDecimal(text);
            System.out.println(bigDecimalNumber); // 42.0
        }
    }
    static class Date_and_Time_Extracting_AI_Service_Example {
        interface DateTimeExtractor {
            @UserMessage("Extract date from {{it}}")
            LocalDate extractDateFrom(String text);
            @UserMessage("Extract time from {{it}}")
            LocalTime extractTimeFrom(String text);
            @UserMessage("Extract date and time from {{it}}")
            LocalDateTime extractDateTimeFrom(String text);
        }
        public static void main(String[] args) {
            DateTimeExtractor extractor =
AiServices.create(DateTimeExtractor.class, model);
            String text = "The tranquility pervaded the evening of 1968, just
fifteen minutes shy of midnight,"
                    + " following the celebrations of Independence Day.";
            LocalDate date = extractor.extractDateFrom(text);
            System.out.println(date); // 1968-07-04
            LocalTime time = extractor.extractTimeFrom(text);
            System.out.println(time); // 23:45
            LocalDateTime dateTime = extractor.extractDateTimeFrom(text);
            System.out.println(dateTime); // 1968-07-04T23:45
        }
    }
    static class POJO_Extracting_AI_Service_Example {
        static class Person {
            private String firstName;
            private String lastName;
            private LocalDate birthDate;
            @Override
            public String toString() {
                return "Person {" +
                        " firstName = \"" + firstName + "\"" +
                        ", lastName = \"" + lastName + "\"" +
                        ", birthDate = " + birthDate +
                        " }";
            }
        }
        interface PersonExtractor {
            @UserMessage("Extract information about a person from {{it}}")
            Person extractPersonFrom(String text);
        }
```

```
        public static void main(String[] args) {
            PersonExtractor extractor =
AiServices.create(PersonExtractor.class, model);
            String text = "In 1968, amidst the fading echoes of Independence
Day, "
                    + "a child named John arrived under the calm evening sky.
"
                    + "This newborn, bearing the surname Doe, marked the
start of a new journey.";
            Person person = extractor.extractPersonFrom(text);
            System.out.println(person); // Person { firstName = "John",
lastName = "Doe", birthDate = 1968-07-04 }
        }
    }
    ////////////////////// DESCRIPTIONS ////////////////////////
    static class POJO_With_Descriptions_Extracting_AI_Service_Example {
        static class Recipe {
            @Description("short title, 3 words maximum")
            private String title;
            @Description("short description, 2 sentences maximum")
            private String description;
            @Description("each step should be described in 6 to 8 words,
steps should rhyme with each other")
            private List<String> steps;
            private Integer preparationTimeMinutes;
            @Override
            public String toString() {
                return "Recipe {" +
                        " title = \"" + title + "\"" +
                        ", description = \"" + description + "\"" +
                        ", steps = " + steps +
                        ", preparationTimeMinutes = " +
preparationTimeMinutes +
                        " }";
            }
        }
        @StructuredPrompt("Create a recipe of a {{dish}} that can be prepared
using only {{ingredients}}")
        static class CreateRecipePrompt {
            private String dish;
            private List<String> ingredients;
        }
        interface Chef {
            Recipe createRecipeFrom(String... ingredients);
            Recipe createRecipe(CreateRecipePrompt prompt);
        }
        public static void main(String[] args) {
            Chef chef = AiServices.create(Chef.class, model);
            Recipe recipe = chef.createRecipeFrom("cucumber", "tomato",
"feta", "onion", "olives", "lemon");
            System.out.println(recipe);
            // Recipe {
            // title = "Greek Salad",
            // description = "A refreshing mix of veggies and feta cheese in
a zesty
            // dressing.",
            // steps = [
            // "Chop cucumber and tomato",
            // "Add onion and olives",
            // "Crumble feta on top",
            // "Drizzle with dressing and enjoy!"
```

```
            // ],
            // preparationTimeMinutes = 10
            // }
            CreateRecipePrompt prompt = new CreateRecipePrompt();
            prompt.dish = "oven dish";
            prompt.ingredients = asList("cucumber", "tomato", "feta",
"onion", "olives", "potatoes");
            Recipe anotherRecipe = chef.createRecipe(prompt);
            System.out.println(anotherRecipe);
            // Recipe ...
        }
    }
    ////////////////////////// WITH MEMORY ////////////////////////
    static class ServiceWithMemoryExample {
        interface Assistant {
            String chat(String message);
        }
        public static void main(String[] args) {
            ChatMemory chatMemory =
MessageWindowChatMemory.withMaxMessages(10);
            Assistant assistant = AiServices.builder(Assistant.class)
                    .chatLanguageModel(model)
                    .chatMemory(chatMemory)
                    .build();
            String answer = assistant.chat("Hello! My name is Klaus.");
            System.out.println(answer); // Hello Klaus! How can I assist you
today?
            String answerWithName = assistant.chat("What is my name?");
            System.out.println(answerWithName); // Your name is Klaus.
        }
    }
    static class ServiceWithMemoryForEachUserExample {
        interface Assistant {
            String chat(@MemoryId int memoryId, @UserMessage String
userMessage);
        }
        public static void main(String[] args) {
            Assistant assistant = AiServices.builder(Assistant.class)
                    .chatLanguageModel(model)
                    .chatMemoryProvider(memoryId ->
MessageWindowChatMemory.withMaxMessages(10))
                    .build();
            System.out.println(assistant.chat(1, "Hello, my name is Klaus"));
            // Hi Klaus! How can I assist you today?
            System.out.println(assistant.chat(2, "Hello, my name is
Francine"));
            // Hello Francine! How can I assist you today?
            System.out.println(assistant.chat(1, "What is my name?"));
            // Your name is Klaus.
            System.out.println(assistant.chat(2, "What is my name?"));
            // Your name is Francine.
        }
    }
}
```

devoxx\src\main\java_09_ServiceWithPersistentMemoryForEachUserExample.java

```
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.memory.chat.ChatMemoryProvider;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
import dev.langchain4j.service.MemoryId;
import dev.langchain4j.service.UserMessage;
import dev.langchain4j.store.memory.chat.ChatMemoryStore;
import org.mapdb.DB;
import org.mapdb.DBMaker;
import java.util.List;
import java.util.Map;
import static
dev.langchain4j.data.message.ChatMessageDeserializer.messagesFromJson;
import static
dev.langchain4j.data.message.ChatMessageSerializer.messagesToJson;
import static org.mapdb.Serializer.INTEGER;
import static org.mapdb.Serializer.STRING;
public class _09_ServiceWithPersistentMemoryForEachUserExample {
    interface Assistant {
        String chat(@MemoryId int memoryId, @UserMessage String userMessage);
    }
    public static void main(String[] args) {
        PersistentChatMemoryStore store = new PersistentChatMemoryStore();
        ChatMemoryProvider chatMemoryProvider = memoryId ->
MessageWindowChatMemory.builder()
                .id(memoryId)
                .maxMessages(10)
                .chatMemoryStore(store)
                .build();
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPENAI_A
PI_KEY))
                .chatMemoryProvider(chatMemoryProvider)
                .build();
        System.out.println(assistant.chat(1, "Hello, my name is Klaus"));
        System.out.println(assistant.chat(2, "Hi, my name is Francine"));
        // Now, comment out the two lines above, uncomment the two lines
below, and run again.
        // System.out.println(assistant.chat(1, "What is my name?"));
        // System.out.println(assistant.chat(2, "What is my name?"));
    }
    // You can create your own implementation of ChatMemoryStore and store
chat memory whenever you'd like
    static class PersistentChatMemoryStore implements ChatMemoryStore {
        private final DB db = DBMaker.fileDB("multi-user-chat-
memory.db").transactionEnable().make();
        private final Map<Integer, String> map = db.hashMap("messages",
INTEGER, STRING).createOrOpen();
        @Override
        public List<ChatMessage> getMessages(Object memoryId) {
            String json = map.get((int) memoryId);
            return messagesFromJson(json);
        }
        @Override
        public void updateMessages(Object memoryId, List<ChatMessage>
messages) {
            String json = messagesToJson(messages);
```

```
            map.put((int) memoryId, json);
            db.commit();
        }
        @Override
        public void deleteMessages(Object memoryId) {
            map.remove((int) memoryId);
            db.commit();
        }
    }
}
```

devoxx\src\main\java_10_ServiceWithToolsExample.java

```
import dev.langchain4j.agent.tool.Tool;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
public class _10_ServiceWithToolsExample {
    // Please also check CustomerSupportApplication and
CustomerSupportApplicationTest
    // from spring-boot-example module
    static class Calculator {
        @Tool("Calculates the length of a string")
        int stringLength(String s) {
            return s.length();
        }
        @Tool("Calculates the sum of two numbers")
        int add(int a, int b) {
            return a + b;
        }
        @Tool("Calculates the square root of a number")
        double sqrt(int x) {
            return Math.sqrt(x);
        }
    }
    interface Assistant {
        String chat(String userMessage);
    }
    public static void main(String[] args) {
        ChatLanguageModel model = OpenAiChatModel.builder()
                .apiKey(ApiKeys.OPENAI_API_KEY)
                .logRequests(false)
                .build();
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(model)
                .tools(new Calculator())
                .chatMemory(MessageWindowChatMemory.withMaxMessages(10))
                .build();
        String question = "What is the square root of the sum of the numbers
of letters in the words \"hello\" and \"world\"?";
        String answer = assistant.chat(question);
        System.out.println(answer);
        // The square root of the sum of the number of letters in the words
"hello" and "world" is approximately 3.162.
    }
}
```

devoxx\src\main\java_11_ServiceWithDynamicToolsExample.java

```
import dev.langchain4j.code.Judge0JavaScriptExecutionTool;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
import static java.time.Duration.ofSeconds;
public class _11_ServiceWithDynamicToolsExample {
    interface Assistant {
        String chat(String message);
    }
    public static void main(String[] args) {
        Judge0JavaScriptExecutionTool judge0Tool = new
Judge0JavaScriptExecutionTool(ApiKeys.RAPID_API_KEY);
        ChatLanguageModel chatLanguageModel = OpenAiChatModel.builder()
                .apiKey(ApiKeys.OPENAI_API_KEY)
                .temperature(0.0)
                .timeout(ofSeconds(60))
                .build();
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(chatLanguageModel)
                .chatMemory(MessageWindowChatMemory.withMaxMessages(20))
                .tools(judge0Tool)
                .build();
        interact(assistant, "What is the square root of 49506838032859?");
        interact(assistant, "Capitalize every third letter: abcabc");
        interact(assistant, "What is the number of hours between 17:00 on 21
Feb 1988 and 04:00 on 12 Apr 2014?");
    }
    private static void interact(Assistant assistant, String userMessage) {
        System.out.println("[User]: " + userMessage);
        String answer = assistant.chat(userMessage);
        System.out.println("[Assistant]: " + answer);
        System.out.println();
        System.out.println();
    }
}
```

devoxx\src\main\java_12_ChatWithDocumentsExamples.java

```
import dev.langchain4j.chain.ConversationalRetrievalChain;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.document.splitter.DocumentSplitters;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.input.PromptTemplate;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import dev.langchain4j.retriever.EmbeddingStoreRetriever;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.EmbeddingStoreIngestor;
import dev.langchain4j.store.embedding.inmemory.InMemoryEmbeddingStore;
import java.net.URISyntaxException;
import java.net.URL;
import java.nio.file.Path;
import java.nio.file.Paths;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static
dev.langchain4j.data.document.FileSystemDocumentLoader.loadDocument;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static java.util.stream.Collectors.joining;
public class _12_ChatWithDocumentsExamples {
    static class IfYouNeedSimplicity {
        public static void main(String[] args) throws Exception {
            EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
            EmbeddingStore<TextSegment> embeddingStore = new
InMemoryEmbeddingStore<>();
            EmbeddingStoreIngestor ingestor = EmbeddingStoreIngestor.builder()
                    .documentSplitter(DocumentSplitters.recursive(500, 0))
                    .embeddingModel(embeddingModel)
                    .embeddingStore(embeddingStore)
                    .build();
            Document document = loadDocument(toPath("story-about-happy-
carrot.txt"));
            ingestor.ingest(document);
            ConversationalRetrievalChain chain =
ConversationalRetrievalChain.builder()
                    .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPEN
AI_API_KEY))
                    .retriever(EmbeddingStoreRetriever.from(embeddingStore,
embeddingModel))
                    // .chatMemory() // you can override default chat memory
                    // .promptTemplate() // you can override default prompt
template
                    .build();
            String answer = chain.execute("Who is Charlie?");
            System.out.println(answer); // Charlie is a cheerful carrot
living in VeggieVille...
        }
```

```
    }
    static class If_You_Need_More_Control {
        public static void main(String[] args) {
            // Load the document that includes the information you'd like to
"chat" about with the model.
            Document document = loadDocument(toPath("story-about-happy-
carrot.txt"));
            // Split document into segments 100 tokens each
            DocumentSplitter splitter = DocumentSplitters.recursive(
                    100,
                    0,
                    new OpenAiTokenizer(GPT_3_5_TURBO)
            );
            List<TextSegment> segments = splitter.split(document);
            // Embed segments (convert them into vectors that represent the
meaning) using embedding model
            EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
            List<Embedding> embeddings =
embeddingModel.embedAll(segments).content();
            // Store embeddings into embedding store for further search /
retrieval
            EmbeddingStore<TextSegment> embeddingStore = new
InMemoryEmbeddingStore<>();
            embeddingStore.addAll(embeddings, segments);
            // Specify the question you want to ask the model
            String question = "Who is Charlie?";
            // Embed the question
            Embedding questionEmbedding =
embeddingModel.embed(question).content();
            // Find relevant embeddings in embedding store by semantic
similarity
            // You can play with parameters below to find a sweet spot for
your specific use case
            int maxResults = 3;
            double minScore = 0.7;
            List<EmbeddingMatch<TextSegment>> relevantEmbeddings
                    = embeddingStore.findRelevant(questionEmbedding,
maxResults, minScore);
            // Create a prompt for the model that includes question and
relevant embeddings
            PromptTemplate promptTemplate = PromptTemplate.from(
                    "Answer the following question to the best of your
ability:\n"
                            + "\n"
                            + "Question:\n"
                            + "{{question}}\n"
                            + "\n"
                            + "Base your answer on the following information:
\n"
                            + "{{information}}");
            String information = relevantEmbeddings.stream()
                    .map(match -> match.embedded().text())
                    .collect(joining("\n\n"));
            Map<String, Object> variables = new HashMap<>();
            variables.put("question", question);
            variables.put("information", information);
            Prompt prompt = promptTemplate.apply(variables);
            // Send the prompt to the OpenAI chat model
            ChatLanguageModel chatModel =
OpenAiChatModel.withApiKey(ApiKeys.OPENAI_API_KEY);
            AiMessage aiMessage =
```

```
chatModel.generate(prompt.toUserMessage()).content();
            // See an answer from the model
            String answer = aiMessage.text();
            System.out.println(answer); // Charlie is a cheerful carrot
living in VeggieVille...
        }
    }
    private static Path toPath(String fileName) {
        try {
            URL fileUrl =
_12_ChatWithDocumentsExamples.class.getResource(fileName);
            return Paths.get(fileUrl.toURI());
        } catch (URISyntaxException e) {
            throw new RuntimeException(e);
        }
    }
}
```

devoxx\src\main\resources\story-about-happy-carrot.txt

Once upon a time in the town of VeggieVille, there lived a cheerful carrot named Charlie.
Charlie was a radiant carrot, always beaming with joy and positivity.
His vibrant orange skin and lush green top were a sight to behold, but it was his infectious laughter and warm personality that really set him apart.
Charlie had a diverse group of friends, each a vegetable with their own unique characteristics.
There was Bella the blushing beetroot, always ready with a riddle or two; Timmy the timid tomato, a gentle soul with a heart of gold; and Percy the prankster potato, whose jokes always brought a smile to everyone's faces.
Despite their differences, they shared a close bond, their friendship as robust as their natural goodness.
Their lives were filled with delightful adventures, from playing hide-and-seek amidst the leafy lettuce to swimming in the dewy droplets that pooled on the cabbage leaves.
Their favorite place, though, was the sunlit corner of the vegetable patch, where they would bask in the warmth of the sun, share stories, and have hearty laughs.
One day, a bunch of pesky caterpillars invaded VeggieVille.
The vegetables were terrified, fearing they would be nibbled to nothingness.
But Charlie, with his usual sunny disposition, had an idea.
He proposed they host a grand feast for the caterpillars, with the juiciest leaves from the outskirts of the town.
Charlie's optimism was contagious, and his friends eagerly joined in to prepare the feast.
When the caterpillars arrived, they were pleasantly surprised.
They enjoyed the feast and were so impressed with the vegetables' hospitality that they promised not to trouble VeggieVille again.
In return, they agreed to help pollinate the flowers, contributing to a more lush and vibrant VeggieVille.
Charlie's idea had saved the day, but he humbly attributed the success to their teamwork and friendship.
They celebrated their victory with a grand party, filled with laughter, dance, and merry games.
That night, under the twinkling stars, they made a pact to always stand by each other, come what may.
From then on, the story of the happy carrot and his friends spread far and wide, a tale of friendship, unity, and positivity.
Charlie, Bella, Timmy, and Percy continued to live their joyful lives, their laughter echoing through VeggieVille.
And so, the tale of the happy carrot and his friends serves as a reminder that no matter the challenge, with optimism, teamwork, and a bit of creativity, anything is possible.

devoxx\src\main\resources\tinylog.properties

```
writer.level = info
```

elasticsearch-example\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>elasticsearch-example</artifactId>
    <version>0.23.0</version>
    <properties>
        <maven.compiler.source>8</maven.compiler.source>
        <maven.compiler.target>8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-elasticsearch</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>${project.version}</version>
        </dependency>
    </dependencies>
</project>
```

elasticsearch-example\src\main\java\ElasticsearchEmbeddingStoreExample.java

```
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import
dev.langchain4j.store.embedding.elasticsearch.ElasticsearchEmbeddingStore;
import java.util.List;
public class ElasticsearchEmbeddingStoreExample {
    /**
     * To run this example, ensure you have Elasticsearch running locally. If
not, then:
     * - Execute "docker pull docker.elastic.co/elasticsearch/
elasticsearch:8.9.0"
     * - Execute "docker run -d -p 9200:9200 -p 9300:9300 -e
discovery.type=single-node -e xpack.security.enabled=false docker.elastic.co/
elasticsearch/elasticsearch:8.9.0"
     * - Wait until Elasticsearch is ready to serve (may take a few minutes)
     */
    public static void main(String[] args) throws InterruptedException {
        EmbeddingStore<TextSegment> embeddingStore =
ElasticsearchEmbeddingStore.builder()
                .serverUrl("http://localhost:9200")
                .build();
        EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
        TextSegment segment1 = TextSegment.from("I like football.");
        Embedding embedding1 = embeddingModel.embed(segment1).content();
        embeddingStore.add(embedding1, segment1);
        TextSegment segment2 = TextSegment.from("The weather is good today.");
        Embedding embedding2 = embeddingModel.embed(segment2).content();
        embeddingStore.add(embedding2, segment2);
        Thread.sleep(1000); // to be sure that embeddings were persisted
        Embedding queryEmbedding = embeddingModel.embed("What is your
favourite sport?").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(queryEmbedding, 1);
        EmbeddingMatch<TextSegment> embeddingMatch = relevant.get(0);
        System.out.println(embeddingMatch.score()); // 0.81442887
        System.out.println(embeddingMatch.embedded().text()); // I like
football.
    }
}
```

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   on Your own behalf and on Your sole responsibility, not on behalf
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   defend, and hold each Contributor harmless for any liability
   incurred by, or claims asserted against, such Contributor by reason
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   replaced with your own identifying information. (Don't include
   the brackets!) The text should be enclosed in the appropriate
   comment syntax for the file format. We also recommend that a
   file or class name and description of purpose be included on the
   same "printed page" as the copyright notice for easier
   identification within third-party archives.

milvus-example\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>milvus-example</artifactId>
    <version>0.23.0</version>
    <properties>
        <maven.compiler.source>8</maven.compiler.source>
        <maven.compiler.target>8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-milvus</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>${project.version}</version>
        </dependency>
    </dependencies>
</project>
```

milvus-example\src\main\java\MilvusEmbeddingStoreExample.java

```
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.milvus.MilvusEmbeddingStore;
import java.util.List;
public class MilvusEmbeddingStoreExample {
    /**
     * First run Milvus locally:
     * Run "docker compose up -d" inside "../resources" directory.
     * If you want to create a fresh Milvus instance, don't forget to remove
"../resources/volumes" directory.
     */
    public static void main(String[] args) {
        EmbeddingStore<TextSegment> embeddingStore =
MilvusEmbeddingStore.builder()
                .host("localhost")
                .port(19530)
                .dimension(384)
                .build();
        EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
        TextSegment segment1 = TextSegment.from("I like football.");
        Embedding embedding1 = embeddingModel.embed(segment1).content();
        embeddingStore.add(embedding1, segment1);
        TextSegment segment2 = TextSegment.from("The weather is good today.");
        Embedding embedding2 = embeddingModel.embed(segment2).content();
        embeddingStore.add(embedding2, segment2);
        Embedding queryEmbedding = embeddingModel.embed("What is your
favourite sport?").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(queryEmbedding, 1);
        EmbeddingMatch<TextSegment> embeddingMatch = relevant.get(0);
        System.out.println(embeddingMatch.score()); // 0.8144287765026093
        System.out.println(embeddingMatch.embedded().text()); // I like
football.
    }
}
```

other-examples\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>other-examples</artifactId>
    <version>0.23.0</version>
    <properties>
        <maven.compiler.source>8</maven.compiler.source>
        <maven.compiler.target>8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-open-ai</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-hugging-face</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-vertex-ai</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>org.mapdb</groupId>
            <artifactId>mapdb</artifactId>
            <version>3.0.9</version>
            <exclusions>
                <exclusion>
                    <groupId>org.jetbrains.kotlin</groupId>
                    <artifactId>kotlin-stdlib</artifactId>
                </exclusion>
            </exclusions>
        </dependency>
        <dependency>
            <groupId>org.tinylog</groupId>
```

```
            <artifactId>tinylog-impl</artifactId>
            <version>2.6.2</version>
        </dependency>
        <dependency>
            <groupId>org.tinylog</groupId>
            <artifactId>slf4j-tinylog</artifactId>
            <version>2.6.2</version>
        </dependency>
    </dependencies>
</project>
```

other-examples\src\main\java\ApiKeys.java

```
public class ApiKeys {
    // You can use "demo" api key for demonstration purposes.
    // You can get your own OpenAI API key here: https://platform.openai.com/
account/api-keys
    public static final String OPENAI_API_KEY = "demo";
    // You can get your own HuggingFace API key here: https://huggingface.co/
settings/tokens
    public static final String HF_API_KEY = System.getenv("HF_API_KEY");
    // You can get your own Judge0 RapidAPI key here: https://rapidapi.com/
judge0-official/api/judge0-ce
    public static final String RAPID_API_KEY = System.getenv("RAPID_API_KEY");
}
```

other-examples\src\main\java\ChatMemoryExamples.java

```
import dev.langchain4j.chain.ConversationalChain;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.TokenWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import java.io.IOException;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
public class ChatMemoryExamples {
    // See also ServiceWithMemoryExample and
ServiceWithMemoryForEachUserExample
    public static class ConversationalChain_Example {
        public static void main(String[] args) throws IOException {
            ConversationalChain chain = ConversationalChain.builder()
                    .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPEN
AI_API_KEY))
                    // .chatMemory() // you can override default chat memory
                    .build();
            String answer = chain.execute("Hello, my name is Klaus");
            System.out.println(answer); // Hello Klaus! How can I assist you
today?
            String answerWithName = chain.execute("What is my name?");
            System.out.println(answerWithName); // Your name is Klaus.
        }
    }
    public static class If_You_Need_More_Control {
        public static void main(String[] args) {
            ChatLanguageModel model =
OpenAiChatModel.withApiKey(ApiKeys.OPENAI_API_KEY);
            ChatMemory chatMemory = TokenWindowChatMemory.withMaxTokens(300,
new OpenAiTokenizer(GPT_3_5_TURBO));
            // You have full control over the chat memory.
            // You can decide if you want to add a particular message to the
memory
            // (e.g. you might not want to store few-shot examples to save on
tokens).
            // You can process/modify the message before saving if required.
            chatMemory.add(userMessage("Hello, my name is Klaus"));
            AiMessage answer =
model.generate(chatMemory.messages()).content();
            System.out.println(answer.text()); // Hello Klaus! How can I
assist you today?
            chatMemory.add(answer);
            chatMemory.add(userMessage("What is my name?"));
            AiMessage answerWithName =
model.generate(chatMemory.messages()).content();
            System.out.println(answerWithName.text()); // Your name is Klaus.
            chatMemory.add(answerWithName);
        }
    }
}
```

other-examples\src\main\java\ChatWithDocumentsExamples.java

```
import dev.langchain4j.chain.ConversationalRetrievalChain;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.document.splitter.DocumentSplitters;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.input.PromptTemplate;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import dev.langchain4j.retriever.EmbeddingStoreRetriever;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.EmbeddingStoreIngestor;
import dev.langchain4j.store.embedding.inmemory.InMemoryEmbeddingStore;
import java.net.URISyntaxException;
import java.net.URL;
import java.nio.file.Path;
import java.nio.file.Paths;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static
dev.langchain4j.data.document.FileSystemDocumentLoader.loadDocument;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
import static java.util.stream.Collectors.joining;
public class ChatWithDocumentsExamples {
    // Please also check ServiceWithRetrieverExample
    static class IfYouNeedSimplicity {
        public static void main(String[] args) throws Exception {
            EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
            EmbeddingStore<TextSegment> embeddingStore = new
InMemoryEmbeddingStore<>();
            EmbeddingStoreIngestor ingestor = EmbeddingStoreIngestor.builder()
                    .documentSplitter(DocumentSplitters.recursive(500, 0))
                    .embeddingModel(embeddingModel)
                    .embeddingStore(embeddingStore)
                    .build();
            Document document = loadDocument(toPath("example-files/story-
about-happy-carrot.txt"));
            ingestor.ingest(document);
            ConversationalRetrievalChain chain =
ConversationalRetrievalChain.builder()
                    .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPEN
AI_API_KEY))
                    .retriever(EmbeddingStoreRetriever.from(embeddingStore,
embeddingModel))
                    // .chatMemory() // you can override default chat memory
                    // .promptTemplate() // you can override default prompt
template
                    .build();
            String answer = chain.execute("Who is Charlie?");
            System.out.println(answer); // Charlie is a cheerful carrot
living in VeggieVille...
```

```
        }
    }
    static class If_You_Need_More_Control {
        public static void main(String[] args) {
            // Load the document that includes the information you'd like to
"chat" about with the model.
            Document document = loadDocument(toPath("example-files/story-
about-happy-carrot.txt"));
            // Split document into segments 100 tokens each
            DocumentSplitter splitter = DocumentSplitters.recursive(
                    100,
                    0,
                    new OpenAiTokenizer(GPT_3_5_TURBO)
            );
            List<TextSegment> segments = splitter.split(document);
            // Embed segments (convert them into vectors that represent the
meaning) using embedding model
            EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
            List<Embedding> embeddings =
embeddingModel.embedAll(segments).content();
            // Store embeddings into embedding store for further search /
retrieval
            EmbeddingStore<TextSegment> embeddingStore = new
InMemoryEmbeddingStore<>();
            embeddingStore.addAll(embeddings, segments);
            // Specify the question you want to ask the model
            String question = "Who is Charlie?";
            // Embed the question
            Embedding questionEmbedding =
embeddingModel.embed(question).content();
            // Find relevant embeddings in embedding store by semantic
similarity
            // You can play with parameters below to find a sweet spot for
your specific use case
            int maxResults = 3;
            double minScore = 0.7;
            List<EmbeddingMatch<TextSegment>> relevantEmbeddings
                    = embeddingStore.findRelevant(questionEmbedding,
maxResults, minScore);
            // Create a prompt for the model that includes question and
relevant embeddings
            PromptTemplate promptTemplate = PromptTemplate.from(
                    "Answer the following question to the best of your
ability:\n"
                            + "\n"
                            + "Question:\n"
                            + "{{question}}\n"
                            + "\n"
                            + "Base your answer on the following information:
\n"
                            + "{{information}}");
            String information = relevantEmbeddings.stream()
                    .map(match -> match.embedded().text())
                    .collect(joining("\n\n"));
            Map<String, Object> variables = new HashMap<>();
            variables.put("question", question);
            variables.put("information", information);
            Prompt prompt = promptTemplate.apply(variables);
            // Send the prompt to the OpenAI chat model
            ChatLanguageModel chatModel =
OpenAiChatModel.withApiKey(ApiKeys.OPENAI_API_KEY);
```

```
            AiMessage aiMessage =
chatModel.generate(prompt.toUserMessage()).content();
            // See an answer from the model
            String answer = aiMessage.text();
            System.out.println(answer); // Charlie is a cheerful carrot
living in VeggieVille...
        }
    }
    private static Path toPath(String fileName) {
        try {
            URL fileUrl =
ChatWithDocumentsExamples.class.getResource(fileName);
            return Paths.get(fileUrl.toURI());
        } catch (URISyntaxException e) {
            throw new RuntimeException(e);
        }
    }
}
```

other-examples\src\main\java\DocumentLoaderExamples.java

```
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.FileSystemDocumentLoader;
import java.net.URISyntaxException;
import java.net.URL;
import java.nio.file.Path;
import java.nio.file.Paths;
import java.util.List;
public class DocumentLoaderExamples {
    static class Load_Pdf_From_File_System_Example {
        public static void main(String[] args) {
            Path filePath = toPath("example-files/story-about-happy-
carrot.pdf");
            Document document =
FileSystemDocumentLoader.loadDocument(filePath);
            System.out.println(document);
        }
    }
    static class Load_Docx_From_File_System_Example {
        public static void main(String[] args) {
            Path filePath = toPath("example-files/story-about-happy-
carrot.docx");
            Document document =
FileSystemDocumentLoader.loadDocument(filePath);
            System.out.println(document);
        }
    }
    static class Load_The_Whole_Directory_Example {
        public static void main(String[] args) {
            Path directoryPath = toPath("example-files");
            List<Document> documents =
FileSystemDocumentLoader.loadDocuments(directoryPath);
            documents.forEach(System.out::println);
        }
    }
    private static Path toPath(String fileName) {
        try {
            URL fileUrl =
ChatWithDocumentsExamples.class.getResource(fileName);
            return Paths.get(fileUrl.toURI());
        } catch (URISyntaxException e) {
            throw new RuntimeException(e);
        }
    }
}
```

other-examples\src\main\java\embedding\classification\EmbeddingModelTextClassifierExample.java

```
package embedding.classification;
import dev.langchain4j.classification.EmbeddingModelTextClassifier;
import dev.langchain4j.classification.TextClassifier;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import java.util.HashMap;
import java.util.List;
import java.util.Map;
import static embedding.classification.EmbeddingModelTextClassifierExample.CustomerServiceCategory.*;
import static java.util.Arrays.asList;
public class EmbeddingModelTextClassifierExample {
    enum CustomerServiceCategory {
        BILLING_AND_PAYMENTS,
        TECHNICAL_SUPPORT,
        ACCOUNT_MANAGEMENT,
        PRODUCT_INFORMATION,
        ORDER_STATUS,
        RETURNS_AND_EXCHANGES,
        FEEDBACK_AND_COMPLAINTS
    }
    public static void main(String[] args) {
        Map<CustomerServiceCategory, List<String>> examples = new HashMap<>();
        examples.put(BILLING_AND_PAYMENTS, asList(
                "Can I pay using PayPal?",
                "Do you accept Bitcoin?",
                "Is it possible to pay via wire transfer?",
                "I keep getting an error message when I try to pay.",
                "My card was charged twice, can you help?",
                "Why was my payment declined?",
                "How can I request a refund?",
                "When will I get my refund?",
                "Can I get a refund if I cancel my subscription?",
                "Can you send me an invoice for my last order?",
                "I didn't receive a receipt for my purchase.",
                "Is the invoice sent to my email automatically?",
                "How do I upgrade my subscription?",
                "What are the differences between the Basic and Premium plans?",
                "How do I cancel my subscription?",
                "Can I switch to a monthly plan from an annual one?",
                "I want to downgrade my subscription, how do I go about it?",
                "Is there a penalty for downgrading my plan?"
        ));
        examples.put(TECHNICAL_SUPPORT, asList(
                "The app keeps crashing whenever I open it.",
                "I can't save changes in the settings.",
                "Why is the search function not working?",
                "The installer is stuck at 50%.",
                "I keep getting an ‘Installation Failed' message.",
                "How do I install this on a Mac?",
                "I can't connect to the server.",
                "Why am I constantly getting disconnected?",
                "My Wi-Fi works, but your app says no internet connection.",
                "Why is the app so slow?",
                "I'm experiencing lag during video calls.",
                "The website keeps freezing on my browser.",
```

```
            "I get a ‘404 Not Found' error.",
            "What does the ‘Permission Denied' error mean?",
            "Why am I seeing an ‘Insufficient Storage' warning?",
            "Is this compatible with Windows 11?",
            "The app doesn't work on my Android phone.",
            "Do you have a browser extension for Safari?"
    ));
    examples.put(ACCOUNT_MANAGEMENT, asList(
            "I forgot my password, how can I reset it?",
            "I didn't receive a password reset email.",
            "Is there a way to change my password from within the app?",
            "How do I set up two-factor authentication?",
            "I lost my phone, how can I log in now?",
            "Why am I not getting the 2FA code?",
            "My account has been locked, what do I do?",
            "Is there a limit on login attempts?",
            "I've been locked out for no reason, can you help?",
            "How do I change my email address?",
            "Can I update my profile picture?",
            "How do I edit my shipping address?",
            "Can I share my account with family?",
            "How do I give admin access to my team member?",
            "Is there a guest access feature?",
            "How do I delete my account?",
            "What happens to my data if I deactivate my account?",
            "Can I reactivate my account later?"
    ));
    examples.put(PRODUCT_INFORMATION, asList(
            "What does the ‘Sync' feature do?",
            "How does the privacy mode work?",
            "Can you explain the real-time tracking feature?",
            "When will the new model be in stock?",
            "Do you have this item in a size medium?",
            "Are you restocking the sold-out items soon?",
            "What's the difference between version 1.0 and 2.0?",
            "Is the Pro version worth the extra cost?",
            "Do older versions support the new update?",
            "Is this product compatible with iOS?",
            "Will this work with a 220V power supply?",
            "Do you have options for USB-C?",
            "Are there any accessories included?",
            "Do you sell protective cases for this model?",
            "What add-ons would you recommend?",
            "What does the warranty cover?",
            "How do I claim the warranty?",
            "Is the warranty international?"
    ));
    examples.put(ORDER_STATUS, asList(
            "Where is my order right now?",
            "Can you give me a tracking number?",
            "How do I know my order has been shipped?",
            "Can I change the shipping method?",
            "Do you offer overnight shipping?",
            "Is pickup from the store an option?",
            "When will my order arrive?",
            "Why is my delivery delayed?",
            "Can I specify a delivery date?",
            "It's past the delivery date, where is my order?",
            "Will I be notified if there's a delay?",
            "How long will the weather delay my shipment?",
            "I received my order, but an item is missing.",
```

```
                "The package was empty when it arrived.",
                "I got the wrong item, what should I do?",
                "Will all my items arrive at the same time?",
                "Why did I receive only part of my order?",
                "Is it possible to get the remaining items faster?"
        ));
        examples.put(RETURNS_AND_EXCHANGES, asList(
                "What's your return policy?",
                "Is the return shipping free?",
                "Do I need the original packaging to return?",
                "How do I get a return label?",
                "Do I need to call customer service for a return?",
                "Is an RMA number required?",
                "I need to exchange for a different size.",
                "Can I exchange a gift?",
                "How long does the exchange process take?",
                "My item arrived damaged, what do I do?",
                "The product doesn't work as described.",
                "There's a part missing, can you send it?",
                "I received the wrong item, how can I get it corrected?",
                "I didn't order this, why did I receive it?",
                "You sent me two of the same item by mistake.",
                "Is there a restocking fee for returns?",
                "Will I get a full refund?",
                "How much will be deducted for restocking?"
        ));
        examples.put(FEEDBACK_AND_COMPLAINTS, asList(
                "The material quality is not as advertised.",
                "The product broke after a week of use.",
                "The colors faded after the first wash.",
                "The representative was rude to me.",
                "I was on hold for 30 minutes, this is unacceptable.",
                "Your customer service resolved my issue quickly, thank you!",
                "Your website is hard to navigate.",
                "The app keeps crashing, it's frustrating.",
                "The checkout process is confusing.",
                "You should offer a chat feature for quicker help.",
                "Can you add a wishlist feature?",
                "Please make a mobile-friendly version of the website.",
                "I found a bug in your software.",
                "There's a typo on your homepage.",
                "The payment page has a glitch.",
                "Can you start offering this in a gluten-free option?",
                "Please add support for Linux.",
                "I wish you had more colors to choose from."
        ));
        EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
        TextClassifier<CustomerServiceCategory> classifier = new
EmbeddingModelTextClassifier<>(embeddingModel, examples);
        List<CustomerServiceCategory> categories = classifier.classify("Yo
where is my package?");
        System.out.println(categories); // [ORDER_STATUS]
    }
}
```

other-examples\src\main\java\embedding\model\HuggingFaceEmbeddingModelExample.java

```
package embedding.model;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.huggingface.HuggingFaceEmbeddingModel;
import dev.langchain4j.model.output.Response;
import static java.time.Duration.ofSeconds;
public class HuggingFaceEmbeddingModelExample {
    public static void main(String[] args) {
        EmbeddingModel embeddingModel = HuggingFaceEmbeddingModel.builder()
                .accessToken(System.getenv("HF_API_KEY"))
                .modelId("sentence-transformers/all-MiniLM-L6-v2")
                .waitForModel(true)
                .timeout(ofSeconds(60))
                .build();
        Response<Embedding> response = embeddingModel.embed("Hello, how are
you?");
        System.out.println(response);
    }
}
```

other-examples\src\main\java\embedding\model\InProcessEmbeddingModelExamples.java

```
package embedding.model;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.embedding.OnnxEmbeddingModel;
import java.io.IOException;
public class InProcessEmbeddingModelExamples {
    static class Pre_Packaged_In_Process_Embedding_Model_Example {
        public static void main(String[] args) throws IOException {
            String text = "Let's demonstrate that embedding can be done
within a Java process and entirely offline.";
            // requires "langchain4j-embeddings-all-minilm-l6-v2" Maven/
Gradle dependency, see pom.xml
            EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
            Embedding inProcessEmbedding =
embeddingModel.embed(text).content();
            System.out.println(inProcessEmbedding);
            // Uncomment to compare with embedding generated by HuggingFace
            // EmbeddingModel huggingFaceEmbeddingModel =
HuggingFaceEmbeddingModel.builder()
            //         .accessToken(System.getenv("HF_API_KEY"))
            //         .modelId("sentence-transformers/all-MiniLM-L6-v2")
            //         .build();
            //Embedding huggingFaceEmbedding =
huggingFaceEmbeddingModel.embed(text).content();
            //System.out.println(CosineSimilarity.between(inProcessEmbedding,
huggingFaceEmbedding));
            // 1.000000001963221 <- this indicates that the embedding created
by the offline in-process all-MiniLM-L6-v2 model
            // is practically identical to that generated using the
HuggingFace API.
        }
    }
    static class Custom_In_Process_Embedding_Model_Example {
        public static void main(String[] args) throws IOException {
            String text = "Let's demonstrate that embedding can be done
within a Java process and entirely offline.";
            // requires "langchain4j-embeddings" Maven/Gradle dependency, see
pom.xml
            EmbeddingModel embeddingModel = new OnnxEmbeddingModel("/home/me/
model.onnx");
            Embedding inProcessEmbedding =
embeddingModel.embed(text).content();
            System.out.println(inProcessEmbedding);
        }
    }
}
```

other-examples\src\main\java\embedding\model\OpenAiEmbeddingModelExample.java

```
package embedding.model;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.openai.OpenAiEmbeddingModel;
import dev.langchain4j.model.output.Response;
public class OpenAiEmbeddingModelExample {
    public static void main(String[] args) {
        EmbeddingModel embeddingModel =
OpenAiEmbeddingModel.withApiKey("demo");
        Response<Embedding> response = embeddingModel.embed("Hello, how are
you?");
        System.out.println(response);
    }
}
```

other-examples\src\main\java\embedding\model\VertexAiEmbeddingModelExample.java

```
package embedding.model;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.output.Response;
import dev.langchain4j.model.vertexai.VertexAiEmbeddingModel;
public class VertexAiEmbeddingModelExample {
    public static void main(String[] args) {
        EmbeddingModel embeddingModel = VertexAiEmbeddingModel.builder()
                .endpoint("us-central1-aiplatform.googleapis.com:443")
                .project("langchain4j")
                .location("us-central1")
                .publisher("google")
                .modelName("textembedding-gecko@001")
                .build();
        Response<Embedding> response = embeddingModel.embed("Hello, how are
you?");
        System.out.println(response);
    }
}
```

other-examples\src\main\java\embedding\store\InMemoryEmbeddingStoreExample.java

```
package embedding.store;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.inmemory.InMemoryEmbeddingStore;
import java.util.List;
public class InMemoryEmbeddingStoreExample {
    public static void main(String[] args) {
        InMemoryEmbeddingStore<TextSegment> embeddingStore = new
InMemoryEmbeddingStore<>();
        EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
        TextSegment segment1 = TextSegment.from("I like football.");
        Embedding embedding1 = embeddingModel.embed(segment1).content();
        embeddingStore.add(embedding1, segment1);
        TextSegment segment2 = TextSegment.from("The weather is good today.");
        Embedding embedding2 = embeddingModel.embed(segment2).content();
        embeddingStore.add(embedding2, segment2);
        Embedding queryEmbedding = embeddingModel.embed("What is your
favourite sport?").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(queryEmbedding, 1);
        EmbeddingMatch<TextSegment> embeddingMatch = relevant.get(0);
        System.out.println(embeddingMatch.score()); // 0.8144288515898701
        System.out.println(embeddingMatch.embedded().text()); // I like
football.
        // In-memory embedding store can be serialized and deserialized to/
from JSON
        // String serializedStore = embeddingStore.serializeToJson();
        // InMemoryEmbeddingStore<TextSegment> deserializedStore =
InMemoryEmbeddingStore.fromJson(serializedStore);
        // In-memory embedding store can be serialized and deserialized to/
from file
        // String filePath = "/home/me/embedding.store";
        // embeddingStore.serializeToFile(filePath);
        // InMemoryEmbeddingStore<TextSegment> deserializedStore =
InMemoryEmbeddingStore.fromFile(filePath);
    }
}
```

other-examples\src\main\java\HelloWorldExample.java

```
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
public class HelloWorldExample {
    public static void main(String[] args) {
        // Create an instance of a model
        ChatLanguageModel model =
OpenAiChatModel.withApiKey(ApiKeys.OPENAI_API_KEY);
        // Start interacting
        String answer = model.generate("Hello world!");
        System.out.println(answer); // Hello! How can I assist you today?
    }
}
```

other-examples\src\main\java\OtherServiceExamples.java

```
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.input.structured.StructuredPrompt;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.model.output.structured.Description;
import dev.langchain4j.service.*;
import java.math.BigDecimal;
import java.math.BigInteger;
import java.time.LocalDate;
import java.time.LocalDateTime;
import java.time.LocalTime;
import java.util.List;
import static java.util.Arrays.asList;
public class OtherServiceExamples {
    static ChatLanguageModel chatLanguageModel =
OpenAiChatModel.withApiKey(ApiKeys.OPENAI_API_KEY);
    static class Sentiment_Extracting_AI_Service_Example {
        enum Sentiment {
            POSITIVE, NEUTRAL, NEGATIVE;
        }
        interface SentimentAnalyzer {
            @UserMessage("Analyze sentiment of {{it}}")
            Sentiment analyzeSentimentOf(String text);
            @UserMessage("Does {{it}} have a positive sentiment?")
            boolean isPositive(String text);
        }
        public static void main(String[] args) {
            SentimentAnalyzer sentimentAnalyzer =
AiServices.create(SentimentAnalyzer.class, chatLanguageModel);
            Sentiment sentiment = sentimentAnalyzer.analyzeSentimentOf("It is
good!");
            System.out.println(sentiment); // POSITIVE
            boolean positive = sentimentAnalyzer.isPositive("It is bad!");
            System.out.println(positive); // false
        }
    }
    static class Number_Extracting_AI_Service_Example {
        interface NumberExtractor {
            @UserMessage("Extract number from {{it}}")
            int extractInt(String text);
            @UserMessage("Extract number from {{it}}")
            long extractLong(String text);
            @UserMessage("Extract number from {{it}}")
            BigInteger extractBigInteger(String text);
            @UserMessage("Extract number from {{it}}")
            float extractFloat(String text);
            @UserMessage("Extract number from {{it}}")
            double extractDouble(String text);
            @UserMessage("Extract number from {{it}}")
            BigDecimal extractBigDecimal(String text);
        }
        public static void main(String[] args) {
            NumberExtractor extractor =
AiServices.create(NumberExtractor.class, chatLanguageModel);
            String text = "After countless millennia of computation, the
supercomputer Deep Thought finally announced " +
                    "that the answer to the ultimate question of life, the
universe, and everything was forty two.";
            int intNumber = extractor.extractInt(text);
```

```
            System.out.println(intNumber); // 42
            long longNumber = extractor.extractLong(text);
            System.out.println(longNumber); // 42
            BigInteger bigIntegerNumber = extractor.extractBigInteger(text);
            System.out.println(bigIntegerNumber); // 42
            float floatNumber = extractor.extractFloat(text);
            System.out.println(floatNumber); // 42.0
            double doubleNumber = extractor.extractDouble(text);
            System.out.println(doubleNumber); // 42.0
            BigDecimal bigDecimalNumber = extractor.extractBigDecimal(text);
            System.out.println(bigDecimalNumber); // 42.0
        }
    }
    static class Date_and_Time_Extracting_AI_Service_Example {
        interface DateTimeExtractor {
            @UserMessage("Extract date from {{it}}")
            LocalDate extractDateFrom(String text);
            @UserMessage("Extract time from {{it}}")
            LocalTime extractTimeFrom(String text);
            @UserMessage("Extract date and time from {{it}}")
            LocalDateTime extractDateTimeFrom(String text);
        }
        public static void main(String[] args) {
            DateTimeExtractor extractor =
AiServices.create(DateTimeExtractor.class, chatLanguageModel);
            String text = "The tranquility pervaded the evening of 1968, just
fifteen minutes shy of midnight," +
                    " following the celebrations of Independence Day.";
            LocalDate date = extractor.extractDateFrom(text);
            System.out.println(date); // 1968-07-04
            LocalTime time = extractor.extractTimeFrom(text);
            System.out.println(time); // 23:45
            LocalDateTime dateTime = extractor.extractDateTimeFrom(text);
            System.out.println(dateTime); // 1968-07-04T23:45
        }
    }
    static class POJO_Extracting_AI_Service_Example {
        static class Person {
            private String firstName;
            private String lastName;
            private LocalDate birthDate;
            @Override
            public String toString() {
                return "Person {" +
                        " firstName = \"" + firstName + "\"" +
                        ", lastName = \"" + lastName + "\"" +
                        ", birthDate = " + birthDate +
                        " }";
            }
        }
        interface PersonExtractor {
            @UserMessage("Extract information about a person from {{it}}")
            Person extractPersonFrom(String text);
        }
        public static void main(String[] args) {
            PersonExtractor extractor =
AiServices.create(PersonExtractor.class, chatLanguageModel);
            String text = "In 1968, amidst the fading echoes of Independence
Day, "
                    + "a child named John arrived under the calm evening sky.
"
```

```
                    + "This newborn, bearing the surname Doe, marked the
start of a new journey.";
            Person person = extractor.extractPersonFrom(text);
            System.out.println(person); // Person { firstName = "John",
lastName = "Doe", birthDate = 1968-07-04 }
        }
    }
    static class POJO_With_Descriptions_Extracting_AI_Service_Example {
        static class Recipe {
            @Description("short title, 3 words maximum")
            private String title;
            @Description("short description, 2 sentences maximum")
            private String description;
            @Description("each step should be described in 4 words, steps
should rhyme")
            private List<String> steps;
            private Integer preparationTimeMinutes;
            @Override
            public String toString() {
                return "Recipe {" +
                        " title = \"" + title + "\"" +
                        ", description = \"" + description + "\"" +
                        ", steps = " + steps +
                        ", preparationTimeMinutes = " +
preparationTimeMinutes +
                        " }";
            }
        }
        @StructuredPrompt("Create a recipe of a {{dish}} that can be prepared
using only {{ingredients}}")
        static class CreateRecipePrompt {
            private String dish;
            private List<String> ingredients;
        }
        interface Chef {
            Recipe createRecipeFrom(String... ingredients);
            Recipe createRecipe(CreateRecipePrompt prompt);
        }
        public static void main(String[] args) {
            Chef chef = AiServices.create(Chef.class, chatLanguageModel);
            Recipe recipe = chef.createRecipeFrom("cucumber", "tomato",
"feta", "onion", "olives");
            System.out.println(recipe);
            // Recipe {
            //     title = "Greek Salad",
            //     description = "A refreshing mix of veggies and feta cheese
in a zesty dressing.",
            //     steps = [
            //         "Chop cucumber and tomato",
            //         "Add onion and olives",
            //         "Crumble feta on top",
            //         "Drizzle with dressing and enjoy!"
            //     ],
            //     preparationTimeMinutes = 10
            // }
            CreateRecipePrompt prompt = new CreateRecipePrompt();
            prompt.dish = "salad";
            prompt.ingredients = asList("cucumber", "tomato", "feta",
"onion", "olives");
            Recipe anotherRecipe = chef.createRecipe(prompt);
            System.out.println(anotherRecipe);
```

```
            // Recipe ...
        }
    }
    static class AI_Service_with_System_Message_Example {
        interface Chef {
            @SystemMessage("You are a professional chef. You are friendly,
polite and concise.")
            String answer(String question);
        }
        public static void main(String[] args) {
            Chef chef = AiServices.create(Chef.class, chatLanguageModel);
            String answer = chef.answer("How long should I grill chicken?");
            System.out.println(answer); // Grilling chicken usually takes
around 10-15 minutes per side, depending on ...
        }
    }
    static class AI_Service_with_System_and_User_Messages_Example {
        interface TextUtils {
            @SystemMessage("You are a professional translator into
{{language}}")
            @UserMessage("Translate the following text: {{text}}")
            String translate(@V("text") String text, @V("language") String
language);
            @SystemMessage("Summarize every message from user in {{n}} bullet
points. Provide only bullet points.")
            List<String> summarize(@UserMessage String text, @V("n") int n);
        }
        public static void main(String[] args) {
            TextUtils utils = AiServices.create(TextUtils.class,
chatLanguageModel);
            String translation = utils.translate("Hello, how are you?",
"italian");
            System.out.println(translation); // Ciao, come stai?
            String text = "AI, or artificial intelligence, is a branch of
computer science that aims to create " +
                    "machines that mimic human intelligence. This can range
from simple tasks such as recognizing " +
                    "patterns or speech to more complex tasks like making
decisions or predictions.";
            List<String> bulletPoints = utils.summarize(text, 3);
            System.out.println(bulletPoints);
            // [
            //     "- AI is a branch of computer science",
            //     "- It aims to create machines that mimic human
intelligence",
            //     "- It can perform simple or complex tasks"
            // ]
        }
    }
    static class AI_Service_with_UserName_Example {
        interface Assistant {
            String chat(@UserName String name, @UserMessage String message);
        }
        public static void main(String[] args) {
            Assistant assistant = AiServices.create(Assistant.class,
chatLanguageModel);
            String answer = assistant.chat("Klaus", "Hi, tell me my name if
you see it.");
            System.out.println(answer); // Hello! Your name is Klaus. How can
I assist you today?
        }
```

```
    }
}
```

other-examples\src\main\java\PromptTemplateExamples.java

```
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.input.PromptTemplate;
import java.util.HashMap;
import java.util.Map;
public class PromptTemplateExamples {
    static class PromptTemplate_with_One_Variable_Example {
        public static void main(String[] args) {
            PromptTemplate promptTemplate = PromptTemplate.from("Say 'hi' in
{{it}}.");
            Prompt prompt = promptTemplate.apply("German");
            System.out.println(prompt.text()); // Say 'hi' in German.
        }
    }
    static class PromptTemplate_With_Multiple_Variables_Example {
        public static void main(String[] args) {
            PromptTemplate promptTemplate = PromptTemplate.from("Say
'{{text}}' in {{language}}.");
            Map<String, Object> variables = new HashMap<>();
            variables.put("text", "hi");
            variables.put("language", "German");
            Prompt prompt = promptTemplate.apply(variables);
            System.out.println(prompt.text()); // Say 'hi' in German.
        }
    }
}
```

other-examples\src\main\java\ProxyExample.java

```
import dev.langchain4j.model.openai.OpenAiChatModel;
import java.net.InetSocketAddress;
import java.net.Proxy;
import static java.net.Proxy.Type.HTTP;
public class ProxyExample {
    public static void main(String[] args) {
        OpenAiChatModel model = OpenAiChatModel.builder()
                .apiKey(ApiKeys.OPENAI_API_KEY)
                .proxy(new Proxy(HTTP, new InetSocketAddress("39.175.77.7",
30001)))
                .build();
        String answer = model.generate("hello");
        System.out.println(answer);
    }
}
```

other-examples\src\main\java\ServiceWithAutoModerationExample.java

```
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.model.openai.OpenAiModerationModel;
import dev.langchain4j.service.AiServices;
import dev.langchain4j.service.Moderate;
import dev.langchain4j.service.ModerationException;
public class ServiceWithAutoModerationExample {
    interface Chat {
        @Moderate
        String chat(String text);
    }
    public static void main(String[] args) {
        OpenAiModerationModel moderationModel =
OpenAiModerationModel.withApiKey(ApiKeys.OPENAI_API_KEY);
        Chat chat = AiServices.builder(Chat.class)
                .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPENAI_A
PI_KEY))
                .moderationModel(moderationModel)
                .build();
        try {
            chat.chat("I WILL KILL YOU!!!");
        } catch (ModerationException e) {
            System.out.println(e.getMessage());
            // Text "I WILL KILL YOU!!!" violates content policy
        }
    }
}
```

other-examples\src\main\java\ServiceWithDynamicToolsExample.java

```
import dev.langchain4j.code.Judge0JavaScriptExecutionTool;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
import static java.time.Duration.ofSeconds;
public class ServiceWithDynamicToolsExample {
    interface Assistant {
        String chat(String message);
    }
    public static void main(String[] args) {
        Judge0JavaScriptExecutionTool judge0Tool = new
Judge0JavaScriptExecutionTool(ApiKeys.RAPID_API_KEY);
        ChatLanguageModel chatLanguageModel = OpenAiChatModel.builder()
                .apiKey(ApiKeys.OPENAI_API_KEY)
                .temperature(0.0)
                .timeout(ofSeconds(60))
                .build();
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(chatLanguageModel)
                .chatMemory(MessageWindowChatMemory.withMaxMessages(20))
                .tools(judge0Tool)
                .build();
        interact(assistant, "What is the square root of 49506838032859?");
        interact(assistant, "Capitalize every third letter: abcabc");
        interact(assistant, "What is the number of hours between 17:00 on 21
Feb 1988 and 04:00 on 12 Apr 2014?");
    }
    private static void interact(Assistant assistant, String userMessage) {
        System.out.println("[User]: " + userMessage);
        String answer = assistant.chat(userMessage);
        System.out.println("[Assistant]: " + answer);
        System.out.println();
        System.out.println();
    }
}
```

other-examples\src\main\java\ServiceWithMemoryExample.java

```
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
public class ServiceWithMemoryExample {
    interface Assistant {
        String chat(String message);
    }
    public static void main(String[] args) {
        ChatMemory chatMemory = MessageWindowChatMemory.withMaxMessages(10);
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPENAI_A
PI_KEY))
                .chatMemory(chatMemory)
                .build();
        String answer = assistant.chat("Hello! My name is Klaus.");
        System.out.println(answer); // Hello Klaus! How can I assist you
today?
        String answerWithName = assistant.chat("What is my name?");
        System.out.println(answerWithName); // Your name is Klaus.
    }
}
```

other-examples\src\main\java\ServiceWithMemoryForEachUserExample.java

```
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
import dev.langchain4j.service.MemoryId;
import dev.langchain4j.service.UserMessage;
public class ServiceWithMemoryForEachUserExample {
    interface Assistant {
        String chat(@MemoryId int memoryId, @UserMessage String userMessage);
    }
    public static void main(String[] args) {
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPENAI_A
PI_KEY))
                .chatMemoryProvider(memoryId ->
MessageWindowChatMemory.withMaxMessages(10))
                .build();
        System.out.println(assistant.chat(1, "Hello, my name is Klaus"));
        // Hi Klaus! How can I assist you today?
        System.out.println(assistant.chat(2, "Hello, my name is Francine"));
        // Hello Francine! How can I assist you today?
        System.out.println(assistant.chat(1, "What is my name?"));
        // Your name is Klaus.
        System.out.println(assistant.chat(2, "What is my name?"));
        // Your name is Francine.
    }
}
```

other-examples\src\main\java\ServiceWithPersistentMemoryExample.java

```
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.memory.ChatMemory;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
import dev.langchain4j.store.memory.chat.ChatMemoryStore;
import org.mapdb.DB;
import org.mapdb.DBMaker;
import java.util.List;
import java.util.Map;
import static
dev.langchain4j.data.message.ChatMessageDeserializer.messagesFromJson;
import static
dev.langchain4j.data.message.ChatMessageSerializer.messagesToJson;
import static org.mapdb.Serializer.STRING;
public class ServiceWithPersistentMemoryExample {
    interface Assistant {
        String chat(String message);
    }
    public static void main(String[] args) {
        ChatMemory chatMemory = MessageWindowChatMemory.builder()
                .maxMessages(10)
                .chatMemoryStore(new PersistentChatMemoryStore())
                .build();
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPENAI_A
PI_KEY))
                .chatMemory(chatMemory)
                .build();
        String answer = assistant.chat("Hello! My name is Klaus.");
        System.out.println(answer); // Hello Klaus! How can I assist you
today?
        // Now, comment out the two lines above, uncomment the two lines
below, and run again.
        // String answerWithName = assistant.chat("What is my name?");
        // System.out.println(answerWithName); // Your name is Klaus.
    }
    // You can create your own implementation of ChatMemoryStore and store
chat memory whenever you'd like
    static class PersistentChatMemoryStore implements ChatMemoryStore {
        private final DB db = DBMaker.fileDB("chat-
memory.db").transactionEnable().make();
        private final Map<String, String> map = db.hashMap("messages",
STRING, STRING).createOrOpen();
        @Override
        public List<ChatMessage> getMessages(Object memoryId) {
            String json = map.get((String) memoryId);
            return messagesFromJson(json);
        }
        @Override
        public void updateMessages(Object memoryId, List<ChatMessage>
messages) {
            String json = messagesToJson(messages);
            map.put((String) memoryId, json);
            db.commit();
        }
        @Override
        public void deleteMessages(Object memoryId) {
```

```
            map.remove((String) memoryId);
            db.commit();
        }
    }
}
```

other-examples\src\main\java\ServiceWithPersistentMemoryForEachUserExample.java

```
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.memory.chat.ChatMemoryProvider;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
import dev.langchain4j.service.MemoryId;
import dev.langchain4j.service.UserMessage;
import dev.langchain4j.store.memory.chat.ChatMemoryStore;
import org.mapdb.DB;
import org.mapdb.DBMaker;
import java.util.List;
import java.util.Map;
import static
dev.langchain4j.data.message.ChatMessageDeserializer.messagesFromJson;
import static
dev.langchain4j.data.message.ChatMessageSerializer.messagesToJson;
import static org.mapdb.Serializer.INTEGER;
import static org.mapdb.Serializer.STRING;
public class ServiceWithPersistentMemoryForEachUserExample {
    interface Assistant {
        String chat(@MemoryId int memoryId, @UserMessage String userMessage);
    }
    public static void main(String[] args) {
        PersistentChatMemoryStore store = new PersistentChatMemoryStore();
        ChatMemoryProvider chatMemoryProvider = memoryId ->
MessageWindowChatMemory.builder()
                .id(memoryId)
                .maxMessages(10)
                .chatMemoryStore(store)
                .build();
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPENAI_A
PI_KEY))
                .chatMemoryProvider(chatMemoryProvider)
                .build();
        System.out.println(assistant.chat(1, "Hello, my name is Klaus"));
        System.out.println(assistant.chat(2, "Hi, my name is Francine"));
        // Now, comment out the two lines above, uncomment the two lines
below, and run again.
        // System.out.println(assistant.chat(1, "What is my name?"));
        // System.out.println(assistant.chat(2, "What is my name?"));
    }
    // You can create your own implementation of ChatMemoryStore and store
chat memory whenever you'd like
    static class PersistentChatMemoryStore implements ChatMemoryStore {
        private final DB db = DBMaker.fileDB("multi-user-chat-
memory.db").transactionEnable().make();
        private final Map<Integer, String> map = db.hashMap("messages",
INTEGER, STRING).createOrOpen();
        @Override
        public List<ChatMessage> getMessages(Object memoryId) {
            String json = map.get((int) memoryId);
            return messagesFromJson(json);
        }
        @Override
        public void updateMessages(Object memoryId, List<ChatMessage>
messages) {
```

```
            String json = messagesToJson(messages);
            map.put((int) memoryId, json);
            db.commit();
        }
        @Override
        public void deleteMessages(Object memoryId) {
            map.remove((int) memoryId);
            db.commit();
        }
    }
}
```

other-examples\src\main\java\ServiceWithRetrieverExample.java

```
public class ServiceWithRetrieverExample {
    // Please check CustomerSupportApplication and
CustomerSupportApplicationTest
    // from spring-boot-example module
}
```

other-examples\src\main\java\ServiceWithStreamingExample.java

```
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiStreamingChatModel;
import dev.langchain4j.service.AiServices;
import dev.langchain4j.service.TokenStream;
public class ServiceWithStreamingExample {
    interface Assistant {
        TokenStream chat(String message);
    }
    public static void main(String[] args) {
        // Sorry, "demo" API key does not support streaming (yet). Please use
your own key.
        StreamingChatLanguageModel model =
OpenAiStreamingChatModel.withApiKey(System.getenv("OPENAI_API_KEY"));
        Assistant assistant = AiServices.create(Assistant.class, model);
        TokenStream tokenStream = assistant.chat("Tell me a joke");
        tokenStream.onNext(System.out::println)
                .onComplete(System.out::println)
                .onError(Throwable::printStackTrace)
                .start();
    }
}
```

other-examples\src\main\java\ServiceWithToolsExample.java

```
import dev.langchain4j.agent.tool.Tool;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
public class ServiceWithToolsExample {
    // Please also check CustomerSupportApplication and
CustomerSupportApplicationTest
    // from spring-boot-example module
    static class Calculator {
        @Tool("Calculates the length of a string")
        int stringLength(String s) {
            return s.length();
        }
        @Tool("Calculates the sum of two numbers")
        int add(int a, int b) {
            return a + b;
        }
        @Tool("Calculates the square root of a number")
        double sqrt(int x) {
            return Math.sqrt(x);
        }
    }
    interface Assistant {
        String chat(String userMessage);
    }
    public static void main(String[] args) {
        Assistant assistant = AiServices.builder(Assistant.class)
                .chatLanguageModel(OpenAiChatModel.withApiKey(ApiKeys.OPENAI_A
PI_KEY))
                .tools(new Calculator())
                .chatMemory(MessageWindowChatMemory.withMaxMessages(10))
                .build();
        String question = "What is the square root of the sum of the numbers
of letters in the words \"hello\" and \"world\"?";
        String answer = assistant.chat(question);
        System.out.println(answer);
        // The square root of the sum of the number of letters in the words
"hello" and "world" is approximately 3.162.
    }
}
```

other-examples\src\main\java\SimpleServiceExample.java

```
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.openai.OpenAiChatModel;
import dev.langchain4j.service.AiServices;
public class SimpleServiceExample {
    interface Assistant {
        String chat(String message);
    }
    public static void main(String[] args) {
        ChatLanguageModel chatLanguageModel =
OpenAiChatModel.withApiKey(ApiKeys.OPENAI_API_KEY);
        Assistant assistant = AiServices.create(Assistant.class,
chatLanguageModel);
        String answer = assistant.chat("Hello");
        System.out.println(answer); // Hello! How can I assist you today?
    }
}
```

other-examples\src\main\java\StreamingExamples.java

```
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.data.message.ChatMessage;
import dev.langchain4j.model.StreamingResponseHandler;
import dev.langchain4j.model.chat.StreamingChatLanguageModel;
import dev.langchain4j.model.language.StreamingLanguageModel;
import dev.langchain4j.model.openai.OpenAiStreamingChatModel;
import dev.langchain4j.model.openai.OpenAiStreamingLanguageModel;
import dev.langchain4j.model.output.Response;
import java.util.List;
import static dev.langchain4j.data.message.SystemMessage.systemMessage;
import static dev.langchain4j.data.message.UserMessage.userMessage;
import static java.util.Arrays.asList;
public class StreamingExamples {
    static class StreamingChatLanguageModel_Example {
        public static void main(String[] args) {
            // Sorry, "demo" API key does not support streaming (yet). Please
use your own key.
            StreamingChatLanguageModel model =
OpenAiStreamingChatModel.withApiKey(System.getenv("OPENAI_API_KEY"));
            List<ChatMessage> messages = asList(
                    systemMessage("You are a very sarcastic assistant"),
                    userMessage("Tell me a joke")
            );
            model.generate(messages, new
StreamingResponseHandler<AiMessage>() {
                @Override
                public void onNext(String token) {
                    System.out.println("New token: '" + token + "'");
                }
                @Override
                public void onComplete(Response<AiMessage> response) {
                    System.out.println("Streaming completed: " + response);
                }
                @Override
                public void onError(Throwable error) {
                    error.printStackTrace();
                }
            });
        }
    }
    static class StreamingLanguageModel_Example {
        public static void main(String[] args) {
            // Sorry, "demo" API key does not support streaming (yet). Please
use your own key.
            StreamingLanguageModel model =
OpenAiStreamingLanguageModel.withApiKey(System.getenv("OPENAI_API_KEY"));
            model.generate("Tell me a joke", new
StreamingResponseHandler<String>() {
                @Override
                public void onNext(String token) {
                    System.out.println("New token: '" + token + "'");
                }
                @Override
                public void onComplete(Response<String> response) {
                    System.out.println("Streaming completed: " + response);
                }
                @Override
                public void onError(Throwable error) {
```

```
                    error.printStackTrace();
                }
            });
        }
    }
}
```

other-examples\src\main\java\StructuredPromptTemplateExamples.java

```
import dev.langchain4j.data.message.AiMessage;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.input.Prompt;
import dev.langchain4j.model.input.structured.StructuredPrompt;
import dev.langchain4j.model.input.structured.StructuredPromptProcessor;
import dev.langchain4j.model.openai.OpenAiChatModel;
import java.util.List;
import static java.time.Duration.ofSeconds;
import static java.util.Arrays.asList;
public class StructuredPromptTemplateExamples {
    static ChatLanguageModel model = OpenAiChatModel.builder()
            .apiKey(ApiKeys.OPENAI_API_KEY)
            .timeout(ofSeconds(60))
            .build();
    static class Simple_Structured_Prompt_Example {
        @StructuredPrompt("Create a recipe of a {{dish}} that can be prepared
using only {{ingredients}}")
        static class CreateRecipePrompt {
            private String dish;
            private List<String> ingredients;
        }
        public static void main(String[] args) {
            CreateRecipePrompt createRecipePrompt = new CreateRecipePrompt();
            createRecipePrompt.dish = "salad";
            createRecipePrompt.ingredients = asList("cucumber", "tomato",
"feta", "onion", "olives");
            Prompt prompt =
StructuredPromptProcessor.toPrompt(createRecipePrompt);
            AiMessage aiMessage =
model.generate(prompt.toUserMessage()).content();
            System.out.println(aiMessage.text());
        }
    }
    static class Multi_Line_Structured_Prompt_Example {
        @StructuredPrompt({
                "Create a recipe of a {{dish}} that can be prepared using
only {{ingredients}}.",
                "Structure your answer in the following way:",
                "Recipe name: ...",
                "Description: ...",
                "Preparation time: ...",
                "Required ingredients:",
                "- ...",
                "- ...",
                "Instructions:",
                "- ...",
                "- ..."
        })
        static class CreateRecipePrompt {
            private String dish;
            private List<String> ingredients;
        }
        public static void main(String[] args) {
            CreateRecipePrompt createRecipePrompt = new CreateRecipePrompt();
            createRecipePrompt.dish = "salad";
            createRecipePrompt.ingredients = asList("cucumber", "tomato",
"feta", "onion", "olives");
            Prompt prompt =
```

```
StructuredPromptProcessor.toPrompt(createRecipePrompt);
            AiMessage aiMessage =
model.generate(prompt.toUserMessage()).content();
            System.out.println(aiMessage.text());
        }
    }
}
```

other-examples\src\main\resources\example-files\story-about-happy-carrot.docx

BASE64:

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other-examples\src\main\resources\example-files\story-about-happy-carrot.txt

Once upon a time in the town of VeggieVille, there lived a cheerful carrot named Charlie.
Charlie was a radiant carrot, always beaming with joy and positivity.
His vibrant orange skin and lush green top were a sight to behold, but it was his infectious laughter and warm personality that really set him apart.
Charlie had a diverse group of friends, each a vegetable with their own unique characteristics.
There was Bella the blushing beetroot, always ready with a riddle or two; Timmy the timid tomato, a gentle soul with a heart of gold; and Percy the prankster potato, whose jokes always brought a smile to everyone's faces.
Despite their differences, they shared a close bond, their friendship as robust as their natural goodness.
Their lives were filled with delightful adventures, from playing hide-and-seek amidst the leafy lettuce to swimming in the dewy droplets that pooled on the cabbage leaves.
Their favorite place, though, was the sunlit corner of the vegetable patch, where they would bask in the warmth of the sun, share stories, and have hearty laughs.
One day, a bunch of pesky caterpillars invaded VeggieVille.
The vegetables were terrified, fearing they would be nibbled to nothingness.
But Charlie, with his usual sunny disposition, had an idea.
He proposed they host a grand feast for the caterpillars, with the juiciest leaves from the outskirts of the town.
Charlie's optimism was contagious, and his friends eagerly joined in to prepare the feast.
When the caterpillars arrived, they were pleasantly surprised.
They enjoyed the feast and were so impressed with the vegetables' hospitality that they promised not to trouble VeggieVille again.
In return, they agreed to help pollinate the flowers, contributing to a more lush and vibrant VeggieVille.
Charlie's idea had saved the day, but he humbly attributed the success to their teamwork and friendship.
They celebrated their victory with a grand party, filled with laughter, dance, and merry games.
That night, under the twinkling stars, they made a pact to always stand by each other, come what may.
From then on, the story of the happy carrot and his friends spread far and wide, a tale of friendship, unity, and positivity.
Charlie, Bella, Timmy, and Percy continued to live their joyful lives, their laughter echoing through VeggieVille.
And so, the tale of the happy carrot and his friends serves as a reminder that no matter the challenge, with optimism, teamwork, and a bit of creativity, anything is possible.

other-examples\src\main\resources\tinylog.properties

```
writer.level = debug
```

pinecone-example\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>pinecone-example</artifactId>
    <version>0.23.0</version>
    <properties>
        <maven.compiler.source>8</maven.compiler.source>
        <maven.compiler.target>8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-pinecone</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>${project.version}</version>
        </dependency>
    </dependencies>
</project>
```

pinecone-example\src\main\java\PineconeEmbeddingStoreExample.java

```
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.pinecone.PineconeEmbeddingStore;
import java.util.List;
public class PineconeEmbeddingStoreExample {
    public static void main(String[] args) {
        EmbeddingStore<TextSegment> embeddingStore =
PineconeEmbeddingStore.builder()
                .apiKey(System.getenv("PINECONE_API_KEY"))
                .environment("asia-southeast1-gcp-free")
                // Project ID can be found in the Pinecone url:
                // https://app.pinecone.io/organizations/{organization}/
projects/{environment}:{projectId}/indexes
                .projectId("75dc67a")
                // Make sure the dimensions of the Pinecone index match the
dimensions of the embedding model
                // (384 for all-MiniLM-L6-v2, 1536 for text-embedding-
ada-002, etc.)
                .index("test")
                .build();
        EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
        TextSegment segment1 = TextSegment.from("I like football.");
        Embedding embedding1 = embeddingModel.embed(segment1).content();
        embeddingStore.add(embedding1, segment1);
        TextSegment segment2 = TextSegment.from("The weather is good today.");
        Embedding embedding2 = embeddingModel.embed(segment2).content();
        embeddingStore.add(embedding2, segment2);
        Embedding queryEmbedding = embeddingModel.embed("What is your
favourite sport?").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(queryEmbedding, 1);
        EmbeddingMatch<TextSegment> embeddingMatch = relevant.get(0);
        System.out.println(embeddingMatch.score()); // 0.8144288515898701
        System.out.println(embeddingMatch.embedded().text()); // I like
football.
    }
}
```

pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>langchain4j-examples</artifactId>
    <version>0.23.0</version>
    <packaging>pom</packaging>
    <modules>
        <module>devoxx</module>
        <module>chroma-example</module>
        <module>elasticsearch-example</module>
        <module>milvus-example</module>
        <module>pinecone-example</module>
        <module>other-examples</module>
        <module>redis-example</module>
        <module>spring-boot-example</module>
        <module>vespa-example</module>
        <module>weaviate-example</module>
    </modules>
</project>
```

redis-example\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>redis-example</artifactId>
    <version>0.23.0</version>
    <properties>
        <maven.compiler.source>8</maven.compiler.source>
        <maven.compiler.target>8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-redis</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>${project.version}</version>
        </dependency>
    </dependencies>
</project>
```

redis-example\src\main\java\RedisEmbeddingStoreExample.java

```
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.redis.RedisEmbeddingStore;
import java.util.List;
public class RedisEmbeddingStoreExample {
    /**
     * To run this example, ensure you have Redis running locally. If not,
then:
     * - Execute "docker pull redis/redis-stack:latest"
     * - Execute "docker run -d -p 6379:6379 -p 8001:8001 redis/redis-
stack:latest"
     * - Wait until Redis is ready to serve (may take a few minutes)
     */
    public static void main(String[] args) {
        EmbeddingStore<TextSegment> embeddingStore =
RedisEmbeddingStore.builder()
                .host("localhost")
                .port(6379)
                .dimension(384)
                .build();
        EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
        TextSegment segment1 = TextSegment.from("I like football.");
        Embedding embedding1 = embeddingModel.embed(segment1).content();
        embeddingStore.add(embedding1, segment1);
        TextSegment segment2 = TextSegment.from("The weather is good today.");
        Embedding embedding2 = embeddingModel.embed(segment2).content();
        embeddingStore.add(embedding2, segment2);
        Embedding queryEmbedding = embeddingModel.embed("What is your
favourite sport?").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(queryEmbedding, 1);
        EmbeddingMatch<TextSegment> embeddingMatch = relevant.get(0);
        System.out.println(embeddingMatch.score()); // 0.8144288659095
        System.out.println(embeddingMatch.embedded().text()); // I like
football.
    }
}
```

spring-boot-example\.mvn\wrapper\maven-wrapper.jar

BASE64:

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spring-boot-example\.mvn\wrapper\maven-wrapper.properties

```
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# software distributed under the License is distributed on an
# "AS IS" BASIS, WITHOUT WARRANTIES OR CONDITIONS OF ANY
# KIND, either express or implied.  See the License for the
# specific language governing permissions and limitations
# under the License.
distributionUrl=https://repo.maven.apache.org/maven2/org/apache/maven/apache-
maven/3.8.7/apache-maven-3.8.7-bin.zip
wrapperUrl=https://repo.maven.apache.org/maven2/org/apache/maven/wrapper/
maven-wrapper/3.1.1/maven-wrapper-3.1.1.jar
```

spring-boot-example\mvnw

```
#!/bin/sh
# ----------------------------------------------------------------------------
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# "AS IS" BASIS, WITHOUT WARRANTIES OR CONDITIONS OF ANY
# KIND, either express or implied.  See the License for the
# specific language governing permissions and limitations
# under the License.
# ----------------------------------------------------------------------------
# ----------------------------------------------------------------------------
# Maven Start Up Batch script
#
# Required ENV vars:
# ------------------
#   JAVA_HOME - location of a JDK home dir
#
# Optional ENV vars
# -----------------
#   M2_HOME - location of maven2's installed home dir
#   MAVEN_OPTS - parameters passed to the Java VM when running Maven
#     e.g. to debug Maven itself, use
#       set MAVEN_OPTS=-Xdebug -
Xrunjdwp:transport=dt_socket,server=y,suspend=y,address=8000
#   MAVEN_SKIP_RC - flag to disable loading of mavenrc files
# ----------------------------------------------------------------------------
if [ -z "$MAVEN_SKIP_RC" ] ; then
  if [ -f /usr/local/etc/mavenrc ] ; then
    . /usr/local/etc/mavenrc
  fi
  if [ -f /etc/mavenrc ] ; then
    . /etc/mavenrc
  fi
  if [ -f "$HOME/.mavenrc" ] ; then
    . "$HOME/.mavenrc"
  fi
fi
# OS specific support.  $var _must_ be set to either true or false.
cygwin=false;
darwin=false;
mingw=false
case "`uname`" in
  CYGWIN*) cygwin=true ;;
  MINGW*) mingw=true;;
  Darwin*) darwin=true
    # Use /usr/libexec/java_home if available, otherwise fall back to /
Library/Java/Home
    # See https://developer.apple.com/library/mac/qa/qa1170/_index.html
    if [ -z "$JAVA_HOME" ]; then
```

```
      if [ -x "/usr/libexec/java_home" ]; then
        export JAVA_HOME="`/usr/libexec/java_home`"
      else
        export JAVA_HOME="/Library/Java/Home"
      fi
    fi
    ;;
esac
if [ -z "$JAVA_HOME" ] ; then
  if [ -r /etc/gentoo-release ] ; then
    JAVA_HOME=`java-config --jre-home`
  fi
fi
if [ -z "$M2_HOME" ] ; then
  ## resolve links - $0 may be a link to maven's home
  PRG="$0"
  # need this for relative symlinks
  while [ -h "$PRG" ] ; do
    ls=`ls -ld "$PRG"`
    link=`expr "$ls" : '.*-> \(.*\)$'`
    if expr "$link" : '/.*' > /dev/null; then
      PRG="$link"
    else
      PRG="`dirname "$PRG"`/$link"
    fi
  done
  saveddir=`pwd`
  M2_HOME=`dirname "$PRG"`/..
  # make it fully qualified
  M2_HOME=`cd "$M2_HOME" && pwd`
  cd "$saveddir"
  # echo Using m2 at $M2_HOME
fi
# For Cygwin, ensure paths are in UNIX format before anything is touched
if $cygwin ; then
  [ -n "$M2_HOME" ] &&
    M2_HOME=`cygpath --unix "$M2_HOME"`
  [ -n "$JAVA_HOME" ] &&
    JAVA_HOME=`cygpath --unix "$JAVA_HOME"`
  [ -n "$CLASSPATH" ] &&
    CLASSPATH=`cygpath --path --unix "$CLASSPATH"`
fi
# For Mingw, ensure paths are in UNIX format before anything is touched
if $mingw ; then
  [ -n "$M2_HOME" ] &&
    M2_HOME="`(cd "$M2_HOME"; pwd)`"
  [ -n "$JAVA_HOME" ] &&
    JAVA_HOME="`(cd "$JAVA_HOME"; pwd)`"
fi
if [ -z "$JAVA_HOME" ]; then
  javaExecutable="`which javac`"
  if [ -n "$javaExecutable" ] && ! [ "`expr \"$javaExecutable\" :
'\([^ ]*\)'`" = "no" ]; then
    # readlink(1) is not available as standard on Solaris 10.
    readLink=`which readlink`
    if [ ! `expr "$readLink" : '\([^ ]*\)'` = "no" ]; then
      if $darwin ; then
        javaHome="`dirname \"$javaExecutable\"`"
        javaExecutable="`cd \"$javaHome\" && pwd -P`/javac"
      else
        javaExecutable="`readlink -f \"$javaExecutable\"`"
```

```
      fi
      javaHome="`dirname \"$javaExecutable\"`"
      javaHome=`expr "$javaHome" : '\(.*\)/bin'`
      JAVA_HOME="$javaHome"
      export JAVA_HOME
    fi
  fi
fi
if [ -z "$JAVACMD" ] ; then
  if [ -n "$JAVA_HOME"  ] ; then
    if [ -x "$JAVA_HOME/jre/sh/java" ] ; then
      # IBM's JDK on AIX uses strange locations for the executables
      JAVACMD="$JAVA_HOME/jre/sh/java"
    else
      JAVACMD="$JAVA_HOME/bin/java"
    fi
  else
    JAVACMD="`\\unset -f command; \\command -v java`"
  fi
fi
if [ ! -x "$JAVACMD" ] ; then
  echo "Error: JAVA_HOME is not defined correctly." >&2
  echo "  We cannot execute $JAVACMD" >&2
  exit 1
fi
if [ -z "$JAVA_HOME" ] ; then
  echo "Warning: JAVA_HOME environment variable is not set."
fi
CLASSWORLDS_LAUNCHER=org.codehaus.plexus.classworlds.launcher.Launcher
# traverses directory structure from process work directory to filesystem root
# first directory with .mvn subdirectory is considered project base directory
find_maven_basedir() {
  if [ -z "$1" ]
  then
    echo "Path not specified to find_maven_basedir"
    return 1
  fi
  basedir="$1"
  wdir="$1"
  while [ "$wdir" != '/' ] ; do
    if [ -d "$wdir"/.mvn ] ; then
      basedir=$wdir
      break
    fi
    # workaround for JBEAP-8937 (on Solaris 10/Sparc)
    if [ -d "${wdir}" ]; then
      wdir=`cd "$wdir/.."; pwd`
    fi
    # end of workaround
  done
  echo "${basedir}"
}
# concatenates all lines of a file
concat_lines() {
  if [ -f "$1" ]; then
    echo "$(tr -s '\n' ' ' < "$1")"
  fi
}
BASE_DIR=`find_maven_basedir "$(pwd)"`
if [ -z "$BASE_DIR" ]; then
  exit 1;
```

```
fi
##############################################################################
############
# Extension to allow automatically downloading the maven-wrapper.jar from
Maven-central
# This allows using the maven wrapper in projects that prohibit checking in
binary data.
##############################################################################
############
if [ -r "$BASE_DIR/.mvn/wrapper/maven-wrapper.jar" ]; then
    if [ "$MVNW_VERBOSE" = true ]; then
      echo "Found .mvn/wrapper/maven-wrapper.jar"
    fi
else
    if [ "$MVNW_VERBOSE" = true ]; then
      echo "Couldn't find .mvn/wrapper/maven-wrapper.jar, downloading it ..."
    fi
    if [ -n "$MVNW_REPOURL" ]; then
      jarUrl="$MVNW_REPOURL/org/apache/maven/wrapper/maven-wrapper/3.1.0/
maven-wrapper-3.1.0.jar"
    else
      jarUrl="https://repo.maven.apache.org/maven2/org/apache/maven/wrapper/
maven-wrapper/3.1.0/maven-wrapper-3.1.0.jar"
    fi
    while IFS="=" read key value; do
      case "$key" in (wrapperUrl) jarUrl="$value"; break ;;
      esac
    done < "$BASE_DIR/.mvn/wrapper/maven-wrapper.properties"
    if [ "$MVNW_VERBOSE" = true ]; then
      echo "Downloading from: $jarUrl"
    fi
    wrapperJarPath="$BASE_DIR/.mvn/wrapper/maven-wrapper.jar"
    if $cygwin; then
      wrapperJarPath=`cygpath --path --windows "$wrapperJarPath"`
    fi
    if command -v wget > /dev/null; then
        if [ "$MVNW_VERBOSE" = true ]; then
          echo "Found wget ... using wget"
        fi
        if [ -z "$MVNW_USERNAME" ] || [ -z "$MVNW_PASSWORD" ]; then
            wget "$jarUrl" -O "$wrapperJarPath" || rm -f "$wrapperJarPath"
        else
            wget --http-user=$MVNW_USERNAME --http-password=$MVNW_PASSWORD
"$jarUrl" -O "$wrapperJarPath" || rm -f "$wrapperJarPath"
        fi
    elif command -v curl > /dev/null; then
        if [ "$MVNW_VERBOSE" = true ]; then
          echo "Found curl ... using curl"
        fi
        if [ -z "$MVNW_USERNAME" ] || [ -z "$MVNW_PASSWORD" ]; then
            curl -o "$wrapperJarPath" "$jarUrl" -f
        else
            curl --user $MVNW_USERNAME:$MVNW_PASSWORD -o "$wrapperJarPath"
"$jarUrl" -f
        fi
    else
        if [ "$MVNW_VERBOSE" = true ]; then
          echo "Falling back to using Java to download"
        fi
        javaClass="$BASE_DIR/.mvn/wrapper/MavenWrapperDownloader.java"
        # For Cygwin, switch paths to Windows format before running javac
```

```
        if $cygwin; then
          javaClass=`cygpath --path --windows "$javaClass"`
        fi
        if [ -e "$javaClass" ]; then
            if [ ! -e "$BASE_DIR/.mvn/wrapper/
MavenWrapperDownloader.class" ]; then
                if [ "$MVNW_VERBOSE" = true ]; then
                  echo " - Compiling MavenWrapperDownloader.java ..."
                fi
                # Compiling the Java class
                ("$JAVA_HOME/bin/javac" "$javaClass")
            fi
            if [ -e "$BASE_DIR/.mvn/wrapper/MavenWrapperDownloader.class" ];
then
                # Running the downloader
                if [ "$MVNW_VERBOSE" = true ]; then
                  echo " - Running MavenWrapperDownloader.java ..."
                fi
                ("$JAVA_HOME/bin/java" -cp .mvn/wrapper
MavenWrapperDownloader "$MAVEN_PROJECTBASEDIR")
            fi
        fi
    fi
fi
##########################################################################################
#############
# End of extension
##########################################################################################
#############
export MAVEN_PROJECTBASEDIR=${MAVEN_BASEDIR:-"$BASE_DIR"}
if [ "$MVNW_VERBOSE" = true ]; then
  echo $MAVEN_PROJECTBASEDIR
fi
MAVEN_OPTS="$(concat_lines "$MAVEN_PROJECTBASEDIR/.mvn/jvm.config")
$MAVEN_OPTS"
# For Cygwin, switch paths to Windows format before running java
if $cygwin; then
  [ -n "$M2_HOME" ] &&
    M2_HOME=`cygpath --path --windows "$M2_HOME"`
  [ -n "$JAVA_HOME" ] &&
    JAVA_HOME=`cygpath --path --windows "$JAVA_HOME"`
  [ -n "$CLASSPATH" ] &&
    CLASSPATH=`cygpath --path --windows "$CLASSPATH"`
  [ -n "$MAVEN_PROJECTBASEDIR" ] &&
    MAVEN_PROJECTBASEDIR=`cygpath --path --windows "$MAVEN_PROJECTBASEDIR"`
fi
# Provide a "standardized" way to retrieve the CLI args that will
# work with both Windows and non-Windows executions.
MAVEN_CMD_LINE_ARGS="$MAVEN_CONFIG $@"
export MAVEN_CMD_LINE_ARGS
WRAPPER_LAUNCHER=org.apache.maven.wrapper.MavenWrapperMain
exec "$JAVACMD" \
  $MAVEN_OPTS \
  $MAVEN_DEBUG_OPTS \
  -classpath "$MAVEN_PROJECTBASEDIR/.mvn/wrapper/maven-wrapper.jar" \
  "-Dmaven.home=${M2_HOME}" \
  "-Dmaven.multiModuleProjectDirectory=${MAVEN_PROJECTBASEDIR}" \
  ${WRAPPER_LAUNCHER} $MAVEN_CONFIG "$@"
```

spring-boot-example\mvnw.cmd

```
@REM
----------------------------------------------------------------------------
@REM Licensed to the Apache Software Foundation (ASF) under one
@REM or more contributor license agreements.  See the NOTICE file
@REM distributed with this work for additional information
@REM regarding copyright ownership.  The ASF licenses this file
@REM to you under the Apache License, Version 2.0 (the
@REM "License"); you may not use this file except in compliance
@REM with the License.  You may obtain a copy of the License at
@REM
@REM    https://www.apache.org/licenses/LICENSE-2.0
@REM
@REM Unless required by applicable law or agreed to in writing,
@REM software distributed under the License is distributed on an
@REM "AS IS" BASIS, WITHOUT WARRANTIES OR CONDITIONS OF ANY
@REM KIND, either express or implied.  See the License for the
@REM specific language governing permissions and limitations
@REM under the License.
@REM
----------------------------------------------------------------------------
@REM
----------------------------------------------------------------------------
@REM Maven Start Up Batch script
@REM
@REM Required ENV vars:
@REM JAVA_HOME - location of a JDK home dir
@REM
@REM Optional ENV vars
@REM M2_HOME - location of maven2's installed home dir
@REM MAVEN_BATCH_ECHO - set to 'on' to enable the echoing of the batch
commands
@REM MAVEN_BATCH_PAUSE - set to 'on' to wait for a keystroke before ending
@REM MAVEN_OPTS - parameters passed to the Java VM when running Maven
@REM     e.g. to debug Maven itself, use
@REM set MAVEN_OPTS=-Xdebug -
Xrunjdwp:transport=dt_socket,server=y,suspend=y,address=8000
@REM MAVEN_SKIP_RC - flag to disable loading of mavenrc files
@REM
----------------------------------------------------------------------------
@REM Begin all REM lines with '@' in case MAVEN_BATCH_ECHO is 'on'
@echo off
@REM set title of command window
title %0
@REM enable echoing by setting MAVEN_BATCH_ECHO to 'on'
@if "%MAVEN_BATCH_ECHO%" == "on"  echo %MAVEN_BATCH_ECHO%
@REM set %HOME% to equivalent of $HOME
if "%HOME%" == "" (set "HOME=%HOMEDRIVE%%HOMEPATH%")
@REM Execute a user defined script before this one
if not "%MAVEN_SKIP_RC%" == "" goto skipRcPre
@REM check for pre script, once with legacy .bat ending and once with .cmd
ending
if exist "%USERPROFILE%\mavenrc_pre.bat" call "%USERPROFILE%\mavenrc_pre.bat"
%*
if exist "%USERPROFILE%\mavenrc_pre.cmd" call "%USERPROFILE%\mavenrc_pre.cmd"
%*
:skipRcPre
@setlocal
set ERROR_CODE=0
```

```
@REM To isolate internal variables from possible post scripts, we use another
setlocal
@setlocal
@REM ==== START VALIDATION ====
if not "%JAVA_HOME%" == "" goto OkJHome
echo.
echo Error: JAVA_HOME not found in your environment. >&2
echo Please set the JAVA_HOME variable in your environment to match the >&2
echo location of your Java installation. >&2
echo.
goto error
:OkJHome
if exist "%JAVA_HOME%\bin\java.exe" goto init
echo.
echo Error: JAVA_HOME is set to an invalid directory. >&2
echo JAVA_HOME = "%JAVA_HOME%" >&2
echo Please set the JAVA_HOME variable in your environment to match the >&2
echo location of your Java installation. >&2
echo.
goto error
@REM ==== END VALIDATION ====
:init
@REM Find the project base dir, i.e. the directory that contains the folder
".mvn".
@REM Fallback to current working directory if not found.
set MAVEN_PROJECTBASEDIR=%MAVEN_BASEDIR%
IF NOT "%MAVEN_PROJECTBASEDIR%"=="" goto endDetectBaseDir
set EXEC_DIR=%CD%
set WDIR=%EXEC_DIR%
:findBaseDir
IF EXIST "%WDIR%"\.mvn goto baseDirFound
cd ..
IF "%WDIR%"=="%CD%" goto baseDirNotFound
set WDIR=%CD%
goto findBaseDir
:baseDirFound
set MAVEN_PROJECTBASEDIR=%WDIR%
cd "%EXEC_DIR%"
goto endDetectBaseDir
:baseDirNotFound
set MAVEN_PROJECTBASEDIR=%EXEC_DIR%
cd "%EXEC_DIR%"
:endDetectBaseDir
IF NOT EXIST "%MAVEN_PROJECTBASEDIR%\.mvn\jvm.config" goto
endReadAdditionalConfig
@setlocal EnableExtensions EnableDelayedExpansion
for /F "usebackq delims=" %%a in ("%MAVEN_PROJECTBASEDIR%\.mvn\jvm.config")
do set JVM_CONFIG_MAVEN_PROPS=!JVM_CONFIG_MAVEN_PROPS! %%a
@endlocal & set JVM_CONFIG_MAVEN_PROPS=%JVM_CONFIG_MAVEN_PROPS%
:endReadAdditionalConfig
SET MAVEN_JAVA_EXE="%JAVA_HOME%\bin\java.exe"
set WRAPPER_JAR="%MAVEN_PROJECTBASEDIR%\.mvn\wrapper\maven-wrapper.jar"
set WRAPPER_LAUNCHER=org.apache.maven.wrapper.MavenWrapperMain
set DOWNLOAD_URL="https://repo.maven.apache.org/maven2/org/apache/maven/
wrapper/maven-wrapper/3.1.0/maven-wrapper-3.1.0.jar"
FOR /F "usebackq tokens=1,2 delims==" %%A IN ("%MAVEN_PROJECTBASEDIR%
\.mvn\wrapper\maven-wrapper.properties") DO (
    IF "%%A"=="wrapperUrl" SET DOWNLOAD_URL=%%B
)
@REM Extension to allow automatically downloading the maven-wrapper.jar from
Maven-central
```

```
@REM This allows using the maven wrapper in projects that prohibit checking
in binary data.
if exist %WRAPPER_JAR% (
    if "%MVNW_VERBOSE%" == "true" (
        echo Found %WRAPPER_JAR%
    )
) else (
    if not "%MVNW_REPOURL%" == "" (
        SET DOWNLOAD_URL="%MVNW_REPOURL%/org/apache/maven/wrapper/maven-
wrapper/3.1.0/maven-wrapper-3.1.0.jar"
    )
    if "%MVNW_VERBOSE%" == "true" (
        echo Couldn't find %WRAPPER_JAR%, downloading it ...
        echo Downloading from: %DOWNLOAD_URL%
    )
    powershell -Command "&{"^
™"$webclient = new-object System.Net.WebClient;"^
™"if (-not ([string]::IsNullOrEmpty('%MVNW_USERNAME%') -and
[string]::IsNullOrEmpty('%MVNW_PASSWORD%'))) {"^
™"$webclient.Credentials = new-object
System.Net.NetworkCredential('%MVNW_USERNAME%', '%MVNW_PASSWORD%');"^
™"}"^
™"[Net.ServicePointManager]::SecurityProtocol =
[Net.SecurityProtocolType]::Tls12; $webclient.DownloadFile('%DOWNLOAD_URL%',
'%WRAPPER_JAR%')"^
™"}"
    if "%MVNW_VERBOSE%" == "true" (
        echo Finished downloading %WRAPPER_JAR%
    )
)
@REM End of extension
@REM Provide a "standardized" way to retrieve the CLI args that will
@REM work with both Windows and non-Windows executions.
set MAVEN_CMD_LINE_ARGS=%*
%MAVEN_JAVA_EXE% ^
  %JVM_CONFIG_MAVEN_PROPS% ^
  %MAVEN_OPTS% ^
  %MAVEN_DEBUG_OPTS% ^
  -classpath %WRAPPER_JAR% ^
  "-Dmaven.multiModuleProjectDirectory=%MAVEN_PROJECTBASEDIR%" ^
  %WRAPPER_LAUNCHER% %MAVEN_CONFIG% %*
if ERRORLEVEL 1 goto error
goto end
:error
set ERROR_CODE=1
:end
@endlocal & set ERROR_CODE=%ERROR_CODE%
if not "%MAVEN_SKIP_RC%"=="" goto skipRcPost
@REM check for post script, once with legacy .bat ending and once with .cmd
ending
if exist "%USERPROFILE%\mavenrc_post.bat" call "%USERPROFILE%
\mavenrc_post.bat"
if exist "%USERPROFILE%\mavenrc_post.cmd" call "%USERPROFILE%
\mavenrc_post.cmd"
:skipRcPost
@REM pause the script if MAVEN_BATCH_PAUSE is set to 'on'
if "%MAVEN_BATCH_PAUSE%"=="on" pause
if "%MAVEN_TERMINATE_CMD%"=="on" exit %ERROR_CODE%
cmd /C exit /B %ERROR_CODE%
```

spring-boot-example\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://
www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 https://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <parent>
        <groupId>org.springframework.boot</groupId>
        <artifactId>spring-boot-starter-parent</artifactId>
        <version>2.7.14</version>
        <relativePath/>
    </parent>
    <groupId>dev.langchain4j</groupId>
    <artifactId>spring-boot-example</artifactId>
    <version>0.23.0</version>
    <properties>
        <java.version>1.8</java.version>
        <!-- due to vulnerabilities in version 1.X (transitive dependency of
spring boot) -->
        <snakeyaml.version>2.1</snakeyaml.version>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-spring-boot-starter</artifactId>
            <version>0.23.0</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>0.23.0</version>
        </dependency>
        <dependency>
            <groupId>org.springframework.boot</groupId>
            <artifactId>spring-boot-starter-test</artifactId>
            <scope>test</scope>
        </dependency>
    </dependencies>
    <build>
        <plugins>
            <plugin>
                <groupId>org.springframework.boot</groupId>
                <artifactId>spring-boot-maven-plugin</artifactId>
            </plugin>
        </plugins>
    </build>
</project>
```

spring-boot-example\src\main\java\dev\example\Booking.java

```
package dev.example;
import java.time.LocalDate;
public class Booking {
    private String bookingNumber;
    private LocalDate bookingFrom;
    private LocalDate bookingTo;
    private Customer customer;
    public Booking(String bookingNumber, LocalDate bookingFrom, LocalDate
bookingTo, Customer customer) {
        this.bookingNumber = bookingNumber;
        this.bookingFrom = bookingFrom;
        this.bookingTo = bookingTo;
        this.customer = customer;
    }
}
```

spring-boot-example\src\main\java\dev\example\BookingCannotBeCancelledException.java

```
package dev.example;
public class BookingCannotBeCancelledException extends RuntimeException {
    public BookingCannotBeCancelledException(String bookingNumber) {
        super("Booking " + bookingNumber + " cannot be canceled");
    }
}
```

spring-boot-example\src\main\java\dev\example\BookingNotFoundException.java

```
package dev.example;
public class BookingNotFoundException extends RuntimeException {
    public BookingNotFoundException(String bookingNumber) {
        super("Booking " + bookingNumber + " not found");
    }
}
```

spring-boot-example\src\main\java\dev\example\BookingService.java

```
package dev.example;
import org.springframework.stereotype.Component;
import java.time.LocalDate;
@Component
public class BookingService {
    public Booking getBookingDetails(String bookingNumber, String
customerName, String customerSurname) {
        ensureExists(bookingNumber, customerName, customerSurname);
        // Imitating retrieval from DB
        LocalDate bookingFrom = LocalDate.now().plusDays(1);
        LocalDate bookingTo = LocalDate.now().plusDays(3);
        Customer customer = new Customer(customerName, customerSurname);
        return new Booking(bookingNumber, bookingFrom, bookingTo, customer);
    }
    public void cancelBooking(String bookingNumber, String customerName,
String customerSurname) {
        ensureExists(bookingNumber, customerName, customerSurname);
        // Imitating cancellation
        throw new BookingCannotBeCancelledException(bookingNumber);
    }
    private void ensureExists(String bookingNumber, String customerName,
String customerSurname) {
        // Imitating check
        if (!(bookingNumber.equals("123-456")
                && customerName.equals("Klaus")
                && customerSurname.equals("Heisler"))) {
            throw new BookingNotFoundException(bookingNumber);
        }
    }
}
```

spring-boot-example\src\main\java\dev\example\BookingTools.java

```
package dev.example;
import dev.langchain4j.agent.tool.Tool;
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.stereotype.Component;
@Component
public class BookingTools {
    @Autowired
    private BookingService bookingService;
    @Tool
    public Booking getBookingDetails(String bookingNumber, String
customerName, String customerSurname) {
        System.out.println("==========================================
======================================");
        System.out.printf("[Tool]: Getting details for booking %s for %s %s...
%n", bookingNumber, customerName, customerSurname);
        System.out.println("==========================================
======================================");
        return bookingService.getBookingDetails(bookingNumber, customerName,
customerSurname);
    }
    @Tool
    public void cancelBooking(String bookingNumber, String customerName,
String customerSurname) {
        System.out.println("==========================================
======================================");
        System.out.printf("[Tool]: Cancelling booking %s for %s %s...%n",
bookingNumber, customerName, customerSurname);
        System.out.println("==========================================
======================================");
        bookingService.cancelBooking(bookingNumber, customerName,
customerSurname);
    }
}
```

spring-boot-example\src\main\java\dev\example\Customer.java

```
package dev.example;
public class Customer {
    private String name;
    private String surname;
    public Customer(String name, String surname) {
        this.name = name;
        this.surname = surname;
    }
}
```

spring-boot-example\src\main\java\dev\example\CustomerSupportAgent.java

```
package dev.example;
import dev.langchain4j.service.SystemMessage;
interface CustomerSupportAgent {
    @SystemMessage({
            "You are a customer support agent of a car rental company named
'Miles of Smiles'.",
            "Before providing information about booking or cancelling
booking, you MUST always check:",
            "booking number, customer name and surname.",
            "Today is {{current_date}}."
    })
    String chat(String userMessage);
}
```

spring-boot-example\src\main\java\dev\example\CustomerSupportApplication.java

```
package dev.example;
import dev.langchain4j.data.document.Document;
import dev.langchain4j.data.document.DocumentSplitter;
import dev.langchain4j.data.document.splitter.DocumentSplitters;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.memory.chat.MessageWindowChatMemory;
import dev.langchain4j.model.chat.ChatLanguageModel;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.model.openai.OpenAiTokenizer;
import dev.langchain4j.retriever.EmbeddingStoreRetriever;
import dev.langchain4j.retriever.Retriever;
import dev.langchain4j.service.AiServices;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.EmbeddingStoreIngestor;
import dev.langchain4j.store.embedding.inmemory.InMemoryEmbeddingStore;
import org.springframework.boot.SpringApplication;
import org.springframework.boot.autoconfigure.SpringBootApplication;
import org.springframework.context.annotation.Bean;
import org.springframework.core.io.Resource;
import org.springframework.core.io.ResourceLoader;
import java.io.IOException;
import static
dev.langchain4j.data.document.FileSystemDocumentLoader.loadDocument;
import static dev.langchain4j.model.openai.OpenAiModelName.GPT_3_5_TURBO;
@SpringBootApplication
public class CustomerSupportApplication {
    @Bean
    CustomerSupportAgent customerSupportAgent(ChatLanguageModel
chatLanguageModel,
                                              BookingTools bookingTools,
                                              Retriever<TextSegment>
retriever) {
        return AiServices.builder(CustomerSupportAgent.class)
                .chatLanguageModel(chatLanguageModel)
                .chatMemory(MessageWindowChatMemory.withMaxMessages(20))
                .tools(bookingTools)
                .retriever(retriever)
                .build();
    }
    @Bean
    Retriever<TextSegment> retriever(EmbeddingStore<TextSegment>
embeddingStore, EmbeddingModel embeddingModel) {
        // You will need to adjust these parameters to find the optimal
setting, which will depend on two main factors:
        // - The nature of your data
        // - The embedding model you are using
        int maxResultsRetrieved = 1;
        double minScore = 0.6;
        return EmbeddingStoreRetriever.from(embeddingStore, embeddingModel,
maxResultsRetrieved, minScore);
    }
    @Bean
    EmbeddingModel embeddingModel() {
        return new AllMiniLmL6V2EmbeddingModel();
    }
    @Bean
    EmbeddingStore<TextSegment> embeddingStore(EmbeddingModel embeddingModel,
```

```
ResourceLoader resourceLoader) throws IOException {
        // Normally, you would already have your embedding store filled with
your data.
        // However, for the purpose of this demonstration, we will:
        // 1. Create an in-memory embedding store
        EmbeddingStore<TextSegment> embeddingStore = new
InMemoryEmbeddingStore<>();
        // 2. Load an example document ("Miles of Smiles" terms of use)
        Resource resource = resourceLoader.getResource("classpath:miles-of-
smiles-terms-of-use.txt");
        Document document = loadDocument(resource.getFile().toPath());
        // 3. Split the document into segments 100 tokens each
        // 4. Convert segments into embeddings
        // 5. Store embeddings into embedding store
        // All this can be done manually, but we will use
EmbeddingStoreIngestor to automate this:
        DocumentSplitter documentSplitter = DocumentSplitters.recursive(100,
0, new OpenAiTokenizer(GPT_3_5_TURBO));
        EmbeddingStoreIngestor ingestor = EmbeddingStoreIngestor.builder()
                .documentSplitter(documentSplitter)
                .embeddingModel(embeddingModel)
                .embeddingStore(embeddingStore)
                .build();
        ingestor.ingest(document);
        return embeddingStore;
    }
    public static void main(String[] args) {
        SpringApplication.run(CustomerSupportApplication.class, args);
    }
}
```

spring-boot-example\src\main\resources\application.properties

```
langchain4j.chat-model.provider=openai
langchain4j.chat-model.openai.api-key=demo
langchain4j.chat-model.openai.model-name=gpt-3.5-turbo
langchain4j.chat-model.openai.temperature=0.0
#langchain4j.chat-model.openai.top-p=1.0
#langchain4j.chat-model.openai.max-tokens=100
#langchain4j.chat-model.openai.presence-penalty=0.0
#langchain4j.chat-model.openai.frequency-penalty=0.0
langchain4j.chat-model.openai.timeout=PT60S
#langchain4j.chat-model.openai.max-retries=3
#langchain4j.chat-model.openai.log-requests=true
#langchain4j.chat-model.openai.log-responses=true
logging.level.dev.langchain4j=DEBUG
logging.level.dev.ai4j.openai4j=DEBUG
```

spring-boot-example\src\main\resources\miles-of-smiles-terms-of-use.txt

Miles of Smiles Car Rental Services Terms of Use

1. Introduction

These Terms of Service (“Terms”) govern the access or use by you, an individual, from within any country in the world, of applications, websites, content, products, and services (“Services”) made available by Miles of Smiles Car Rental Services, a company registered in the United States of America.

2. The Services

Miles of Smiles rents out vehicles to the end user. We reserve the right to temporarily or permanently discontinue the Services at any time and are not liable for any modification, suspension or discontinuation of the Services.

3. Bookings

3.1 Users may make a booking through our website or mobile application.

3.2 You must provide accurate, current and complete information during the reservation process. You are responsible for all charges incurred under your account.

3.3 All bookings are subject to vehicle availability.

4. Cancellation Policy

4.1 Reservations can be cancelled up to 7 days prior to the start of the booking period.

4.2 If the booking period is less than 3 days, cancellations are not permitted.

5. Use of Vehicle

5.1 All cars rented from Miles of Smiles must not be used:

for any illegal purpose or in connection with any criminal offense.

for teaching someone to drive.

in any race, rally or contest.

while under the influence of alcohol or drugs.

6. Liability

6.1 Users will be held liable for any damage, loss, or theft that occurs during the rental period.

6.2 We do not accept liability for any indirect or consequential loss, damage, or expense including but not limited to loss of profits.

7. Governing Law

These terms will be governed by and construed in accordance with the laws of the United States of America, and any disputes relating to these terms will be subject to the exclusive jurisdiction of the courts of United States.

8. Changes to These Terms

We may revise these terms of use at any time by amending this page. You are expected to check this page from time to time to take notice of any changes we made.

9. Acceptance of These Terms

By using the Services, you acknowledge that you have read and understand these Terms and agree to be bound by them.

If you do not agree to these Terms, please do not use or access our Services.

spring-boot-example\src\test\java\dev\example\CustomerSupportApplicationTest.java

```
package dev.example;
import org.junit.jupiter.api.Test;
import org.springframework.beans.factory.annotation.Autowired;
import org.springframework.boot.test.context.SpringBootTest;
@SpringBootTest
class CustomerSupportApplicationTest {
    @Autowired
    CustomerSupportAgent agent;
    @Test
    void
should_provide_booking_details_and_explain_why_cancellation_is_not_possible()
{
        // Please define API keys in application.properties before running
this test.
        // Tip: Use gpt-4 for this example, as gpt-3.5-turbo tends to
hallucinate often and invent name and surname.
        interact(agent, "Hi, I forgot when my booking is.");
        interact(agent, "123-457");
        interact(agent, "I'm sorry I'm so inattentive today. Klaus Heisler.");
        interact(agent, "My bad, it's 123-456");
        // Here, information about the cancellation policy is automatically
retrieved and injected into the prompt.
        // Although the LLM sometimes attempts to cancel the booking, it
fails to do so and will explain
        // the reason why the booking cannot be cancelled, based on the
injected cancellation policy.
        interact(agent, "My plans have changed, can I cancel my booking?");
    }
    private static void interact(CustomerSupportAgent agent, String
userMessage) {
        System.out.println("================================================
========================================");
        System.out.println("[User]: " + userMessage);
        System.out.println("================================================
========================================");
        String agentAnswer = agent.chat(userMessage);
        System.out.println("================================================
========================================");
        System.out.println("[Agent]: " + agentAnswer);
        System.out.println("================================================
========================================");
    }
}
```

vespa-example\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>vespa-example</artifactId>
    <version>0.23.0</version>
    <properties>
        <maven.compiler.source>8</maven.compiler.source>
        <maven.compiler.target>8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-vespa</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>${project.version}</version>
        </dependency>
    </dependencies>
</project>
```

vespa-example\src\main\java\README.md

````
# Server side setup with Maven to run example on Vespa Cloud
1. Do steps 1 - 4 from https://cloud.vespa.ai/en/getting-started-java.html
2. Create new Maven Java application and go to it
3. Add following dependency to `pom.xml`, so the latest Vespa release is used
on each build:
```xml
<parent>
    <groupId>com.yahoo.vespa</groupId>
    <artifactId>cloud-tenant-base</artifactId>
    <version>[8,9)</version>
    <relativePath/>
</parent>
```
4. Create `src/main/application/schemas/langchain4j.sd` with following
content:
```sd
schema langchain4j {
  document langchain4j {
    field text_segment type string {
      indexing: summary | index
    }
    field vector type tensor<float>(x[384]) {
      indexing: summary | attribute
      attribute {
        distance-metric: prenormalized-angular
      }
    }
  }
  rank-profile cosine_similarity {
    inputs {
      query(q) tensor<float>(x[384])
    }
    function cosine() {
      expression: 1.0 - distance(field, vector)
    }
    first-phase {
      expression: if (cosine() < query(threshold), -1, cosine())
      rank-score-drop-limit: 0.0
    }
  }
}
```
5. Create `src/main/application/services.xml` with following content:
```xml
<?xml version="1.0" encoding="utf-8" ?>
<services version="1.0">
    <container version="1.0" id="default">
        <document-api/>
        <search/>
    </container>
    <content id="langchain4j" version="1.0">
        <redundancy>1</redundancy>
        <documents>
            <document type="langchain4j" mode="index"/>
        </documents>
    </content>
</services>
```
````

6. Do steps 6 from https://cloud.vespa.ai/en/getting-started-java.html. This will generate SSL private key and
   public certificate and store them locally. Their path will be used in client example. Certificate will be added
   to the project under `src/main/application/security/clients.pem`.
7. Now you can build (you need Java > 17 for this) and deploy your application: do steps 7 & 8 from
   https://cloud.vespa.ai/en/getting-started.html.
   Alternatively you can deploy your build application by using [Cloud UI](https://console.vespa-cloud.com) and
   uploading `target/application.zip` there.

vespa-example\src\main\java\VespaEmbeddingStoreExample.java

```
import static java.util.Arrays.asList;
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.vespa.VespaEmbeddingStore;
import java.util.List;
/**
 * Example of integration with Vespa. You need to configure Vespa server side first, instructions are
 * inside of README.md file.
 */
public class VespaEmbeddingStoreExample {
  public static void main(String[] args) {
    EmbeddingStore<TextSegment> embeddingStore = VespaEmbeddingStore
      .builder()
      // server url, e.g. https://alexey-heezer.langchain4j.mytenant346.aws-us-east-1c.dev.z.vespa-app.cloud
      .url("url")
      // local path to the SSL private key file,
      // e.g. /Users/user/.vespa/mytenant346.langchain4j.alexey-heezer/data-plane-private-key.pem
      .keyPath("keyPath")
      // local path to the SSL certificate file,
      // e.g. /Users/user/.vespa/mytenant346.langchain4j.alexey-heezer/data-plane-public-cert.pem
      .certPath("certPath")
      .build();
    EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
    TextSegment segment1 = TextSegment.from("I like football.");
    Embedding embedding1 = embeddingModel.embed(segment1).content();
    embeddingStore.add(embedding1, segment1);
    TextSegment segment2 = TextSegment.from("I've never been to New York.");
    Embedding embedding2 = embeddingModel.embed(segment2).content();
    embeddingStore.add(embedding2, segment2);
    TextSegment segment3 = TextSegment.from(
      "But actually we tried our new swimming pool yesterday and it was awesome!"
    );
    Embedding embedding3 = embeddingModel.embed(segment3).content();
    embeddingStore.add(embedding3, segment3);
    List<String> ids = embeddingStore.addAll(
      asList(embedding1, embedding2, embedding3),
      asList(segment1, segment2, segment3)
    );
    System.out.println("added/updated records count: " + ids.size()); // 3
    TextSegment segment4 = TextSegment.from(
      "John Lennon was a very cool person."
    );
    Embedding embedding4 = embeddingModel.embed(segment4).content();
    String s4id = embeddingStore.add(embedding4, segment4);
    System.out.println("segment 4 id: " + s4id);
    Embedding queryEmbedding = embeddingModel.embed(
      "What is your favorite sport?"
    ).content();
```

```
    List<EmbeddingMatch<TextSegment>> relevant = embeddingStore.findRelevant(
      queryEmbedding,
      2
    );
    System.out.println(
      "relevant results count for sport question: " + relevant.size()
    ); // 2
    System.out.println(relevant.get(0).score()); // 0.639...
    System.out.println(relevant.get(0).embedded().text()); // football
    System.out.println(relevant.get(1).score()); // 0.232...
    System.out.println(relevant.get(1).embedded().text()); // swimming pool
    queryEmbedding = embeddingModel.embed("And what about
musicians?").content();
    relevant = embeddingStore.findRelevant(queryEmbedding, 5, 0.3);
    System.out.println(
      "relevant results count for music question: " + relevant.size()
    ); // 1
    System.out.println(relevant.get(0).score()); // 0.359...
    System.out.println(relevant.get(0).embedded().text()); // John Lennon
  }
}
```

weaviate-example\pom.xml

```
<?xml version="1.0" encoding="UTF-8"?>
<project xmlns="http://maven.apache.org/POM/4.0.0"
         xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://
maven.apache.org/xsd/maven-4.0.0.xsd">
    <modelVersion>4.0.0</modelVersion>
    <groupId>dev.langchain4j</groupId>
    <artifactId>weaviate-example</artifactId>
    <version>0.23.0</version>
    <properties>
        <maven.compiler.source>8</maven.compiler.source>
        <maven.compiler.target>8</maven.compiler.target>
        <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    </properties>
    <dependencies>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-weaviate</artifactId>
            <version>${project.version}</version>
        </dependency>
        <dependency>
            <groupId>dev.langchain4j</groupId>
            <artifactId>langchain4j-embeddings-all-minilm-l6-v2</artifactId>
            <version>${project.version}</version>
        </dependency>
    </dependencies>
</project>
```

weaviate-example\src\main\java\WeaviateEmbeddingStoreExample.java

```
import dev.langchain4j.data.embedding.Embedding;
import dev.langchain4j.data.segment.TextSegment;
import dev.langchain4j.model.embedding.AllMiniLmL6V2EmbeddingModel;
import dev.langchain4j.model.embedding.EmbeddingModel;
import dev.langchain4j.store.embedding.EmbeddingMatch;
import dev.langchain4j.store.embedding.EmbeddingStore;
import dev.langchain4j.store.embedding.weaviate.WeaviateEmbeddingStore;
import java.util.List;
public class WeaviateEmbeddingStoreExample {
    public static void main(String[] args) {
        EmbeddingStore<TextSegment> embeddingStore =
WeaviateEmbeddingStore.builder()
                // Find it under "Show API keys" of your Weaviate cluster.
                .apiKey(System.getenv("WEAVIATE_API_KEY"))
                // The scheme, e.g. "https" of cluster URL. Find in under
Details of your Weaviate cluster.
                .scheme("https")
                // The host, e.g. "test-o1gvgnp4.weaviate.network" of cluster
URL.
                // Find in under Details of your Weaviate cluster.
                .host("test3-bwsieg9y.weaviate.network")
                // "Default" class is used if not specified. Must start from
an uppercase letter!
                .objectClass("Test")
                // If true (default), then WeaviateEmbeddingStore will
generate a hashed ID based on provided
                // text segment, which avoids duplicated entries in DB. If
false, then random ID will be generated.
                .avoidDups(true)
                // Consistency level: ONE, QUORUM (default) or ALL.
                .consistencyLevel("ALL")
                .build();
        EmbeddingModel embeddingModel = new AllMiniLmL6V2EmbeddingModel();
        TextSegment segment1 = TextSegment.from("I like football.");
        Embedding embedding1 = embeddingModel.embed(segment1).content();
        embeddingStore.add(embedding1, segment1);
        TextSegment segment2 = TextSegment.from("The weather is good today.");
        Embedding embedding2 = embeddingModel.embed(segment2).content();
        embeddingStore.add(embedding2, segment2);
        Embedding queryEmbedding = embeddingModel.embed("What is your
favourite sport?").content();
        List<EmbeddingMatch<TextSegment>> relevant =
embeddingStore.findRelevant(queryEmbedding, 1);
        EmbeddingMatch<TextSegment> embeddingMatch = relevant.get(0);
        System.out.println(embeddingMatch.score()); // 0.8144288063049316
        System.out.println(embeddingMatch.embedded().text()); // I like
football.
    }
}
```