AI Java Labs: Building Intelligent Java Applications

From HTTP fundamentals to advanced RAG systems →

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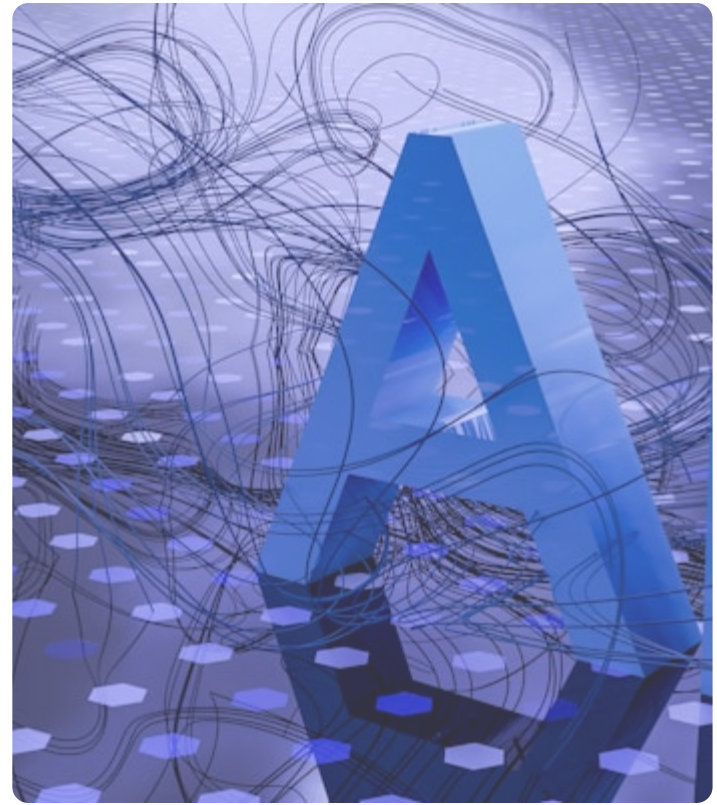
- *Tales from the jar side* (free newsletter)
  - https://kenkousen.substack.com
  - https://youtube.com/@talesfromthejarside

What You'll Learn



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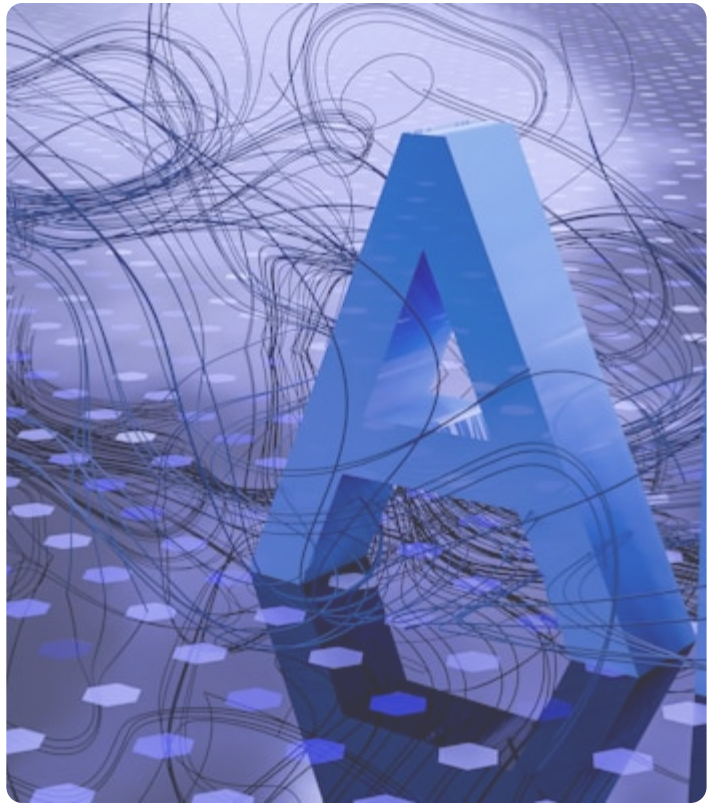

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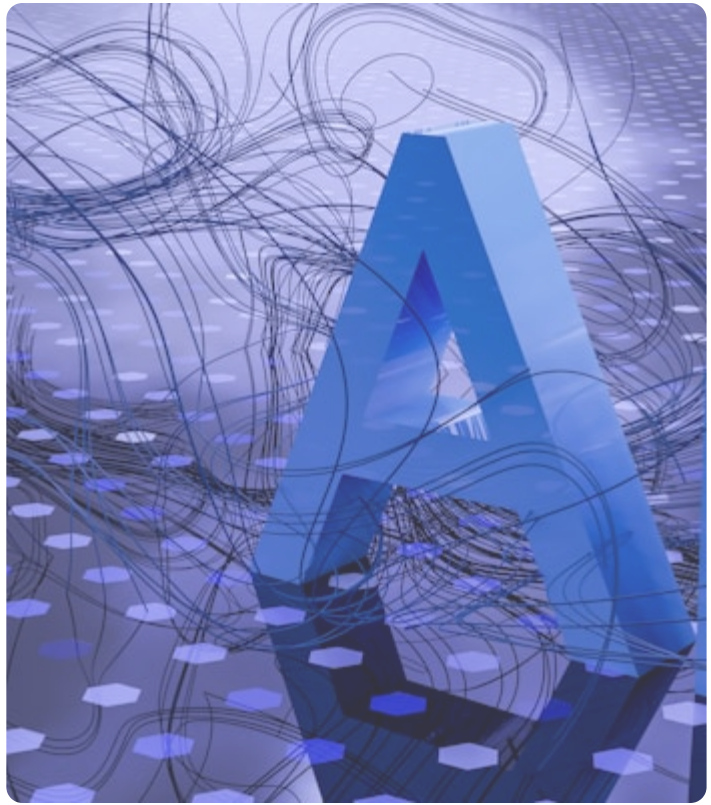

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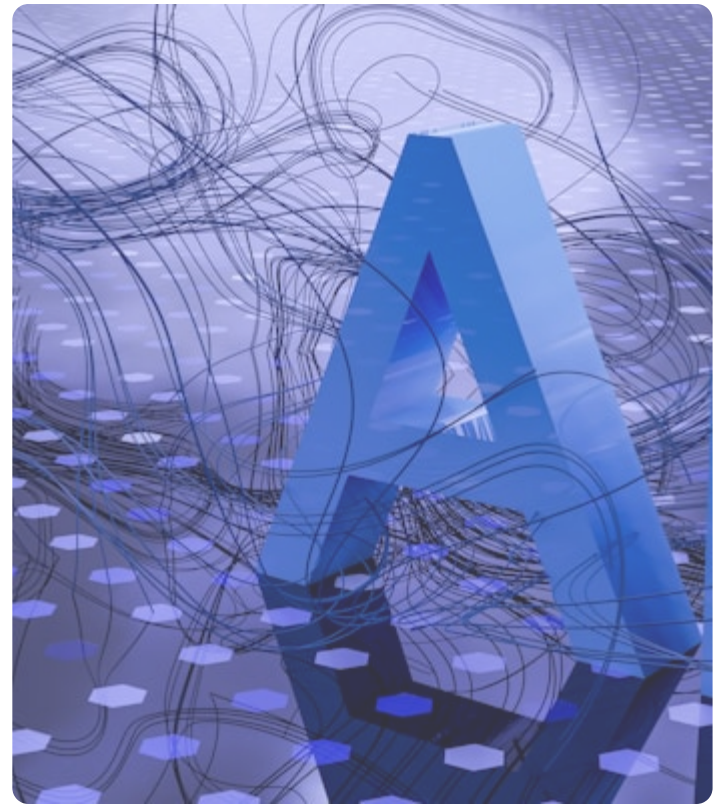

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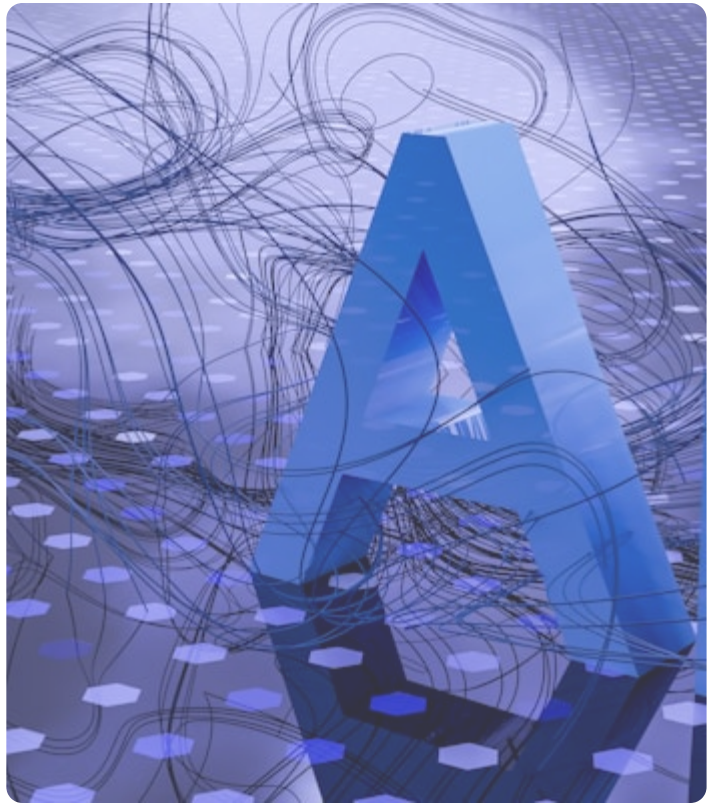

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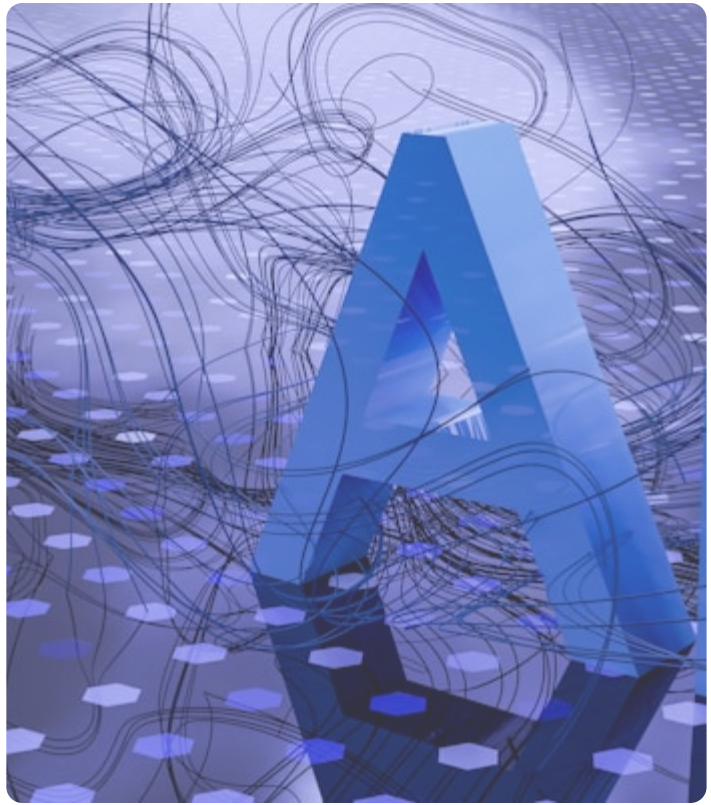

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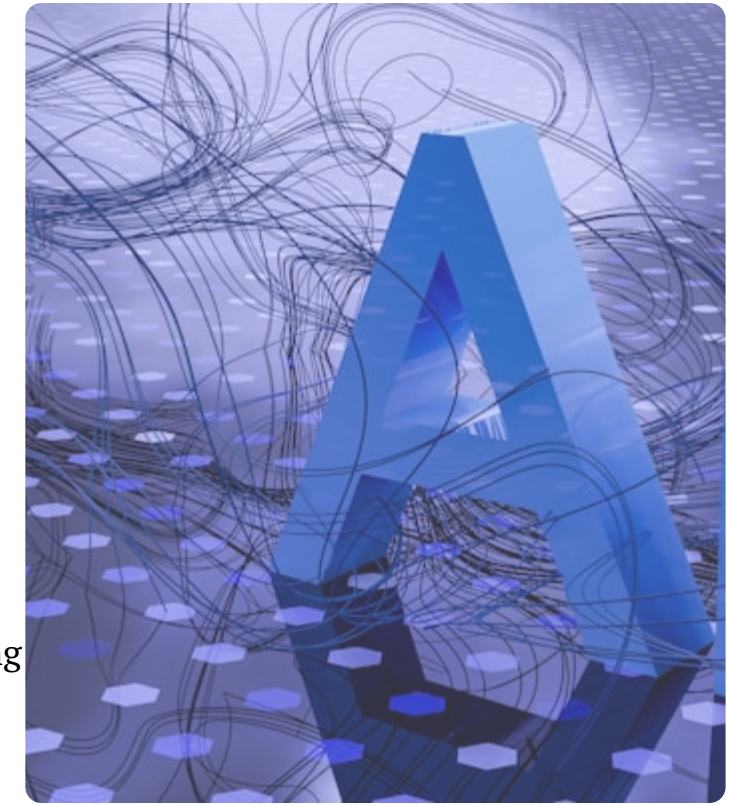

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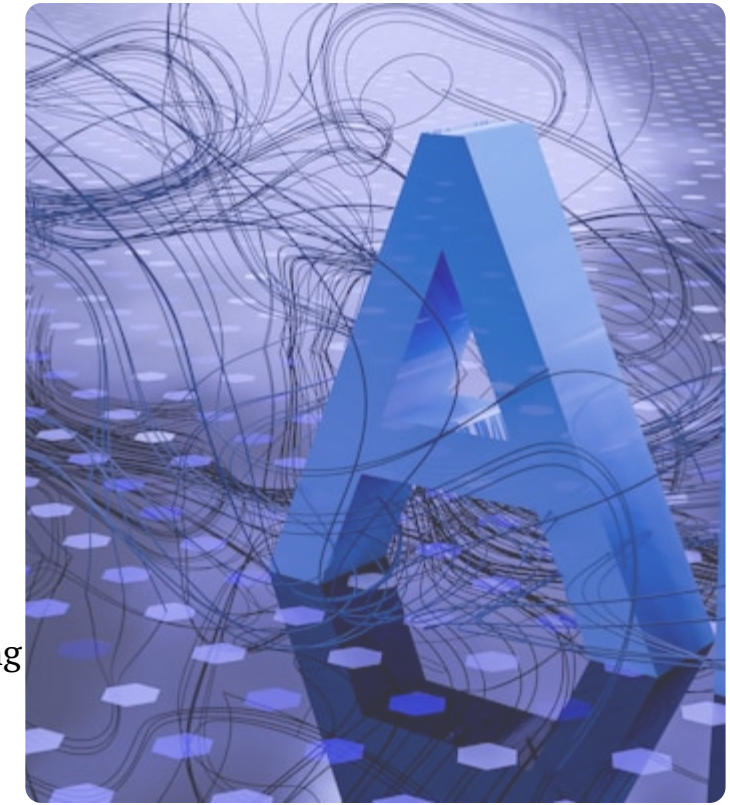

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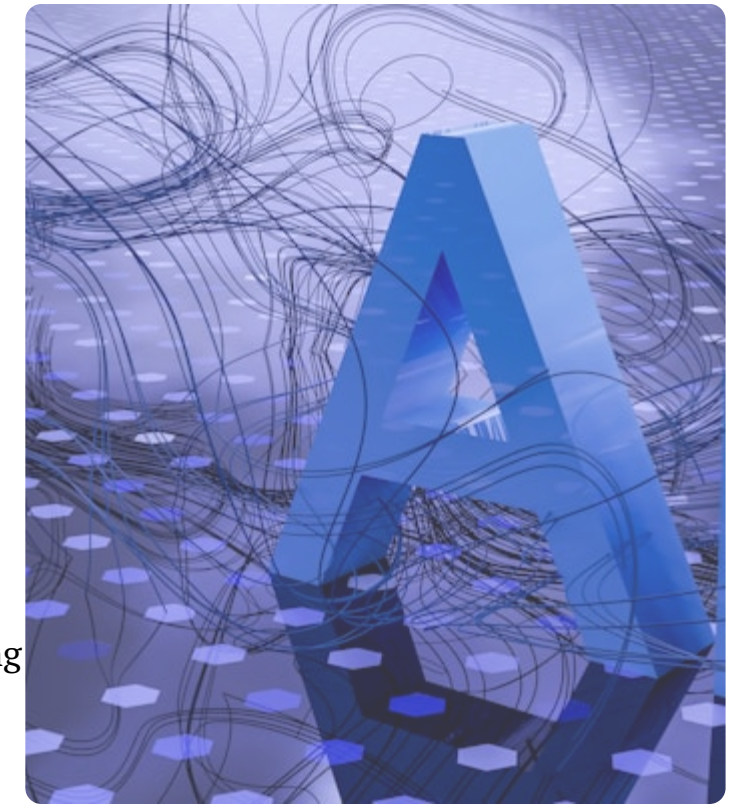

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Why Learn Raw HTTP First? **Then Master Frameworks**

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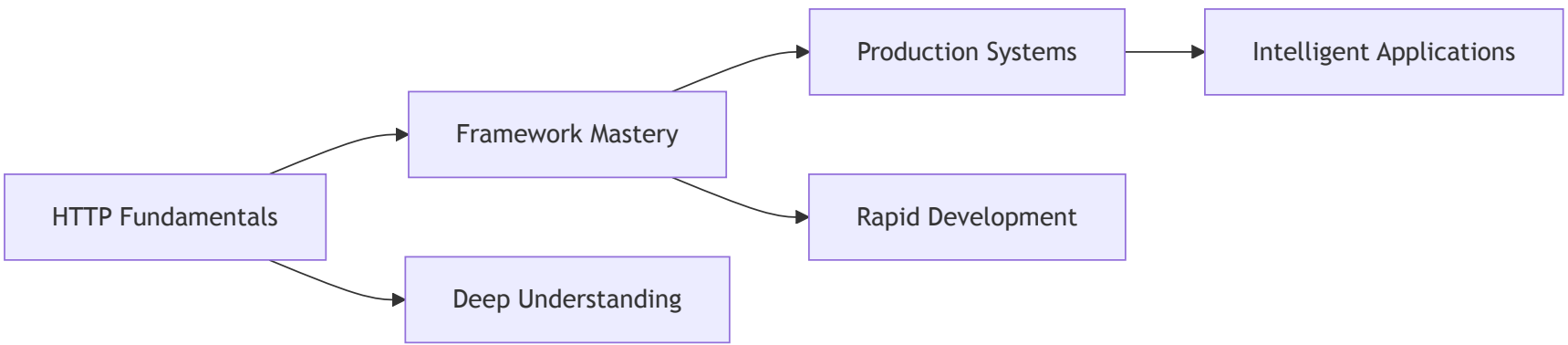

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Environment Setup

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# Optional: Local AI models
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ollama pull gemma3
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Cost Management Strategy

Test Categories

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Cost Management Strategy

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Smart Strategy: Develop with free local models, deploy with optimal cloud models

Demo 1-2: HTTP Fundamentals

Understanding Raw API Integration

Demo 1: Text-to-Speech with Raw HTTP

```java
// Raw HTTP approach - Understanding the fundamentals
public class TextToSpeechService {
    private static final String OPENAI_API_KEY = System.getenv("OPENAI_API_KEY");
    private static final HttpClient client = HttpClient.newHttpClient();

    public Path generateMp3(String model, String input, String voice) {
        // TODO: How do we construct the request?
    }
}
```

Demo 1: Text-to-Speech with Raw HTTP

```
// Step 1: Create JSON payload manually
String payload = """
    {
        "model": "%s",
        "input": "%s",
        "voice": "%s"
    }
    """.formatted(model, input.replaceAll("\\s+", " ").trim(), voice);
```

Demo 1: Text-to-Speech with Raw HTTP

```
// Step 2: Build HTTP request with proper headers
HttpRequest request = HttpRequest.newBuilder()
    .uri(URI.create("https://api.openai.com/v1/audio/speech"))
    .header("Authorization", "Bearer %s".formatted(OPENAI_API_KEY))
    .header("Content-Type", "application/json")
    .header("Accept", "audio/mpeg")
    .POST(HttpRequest.BodyPublishers.ofString(payload))
    .build();
```

Demo 1: Text-to-Speech with Raw HTTP

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// Step 3: Complete implementation with file handling
public Path generateMp3(String model, String input, String voice) {
    String payload = """
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            "model": "%s",
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    HttpRequest request = HttpRequest.newBuilder()
        .uri(URI.create("https://api.openai.com/v1/audio/speech"))
        .header("Authorization", "Bearer %s".formatted(OPENAI_API_KEY))
        .header("Content-Type", "application/json")
        .header("Accept", "audio/mpeg")
        .POST(HttpRequest.BodyPublishers.ofString(payload))
        .build();

    try {
        HttpResponse<Path> response =
            client.send(request, HttpResponse.BodyHandlers.ofFile(getFilePath()));
        return response.body();
    } catch (IOException | InterruptedException e) {
        throw new RuntimeException(e);
```

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```
// Step 3: Complete implementation with file handling
public Path generateMp3(String model, String input, String voice) {
    String payload = """
        {
            "model": "%s",
            "input": "%s",
            "voice": "%s"
        }
        """.formatted(model, input.replaceAll("\\s+", " ").trim(), voice);

    HttpRequest request = HttpRequest.newBuilder()
        .uri(URI.create("https://api.openai.com/v1/audio/speech"))
        .header("Authorization", "Bearer %s".formatted(OPENAI_API_KEY))
        .header("Content-Type", "application/json")
        .header("Accept", "audio/mpeg")
        .POST(HttpRequest.BodyPublishers.ofString(payload))
        .build();

    try {
        HttpResponse<Path> response =
            client.send(request, HttpResponse.BodyHandlers.ofFile(getFilePath()));
        return response.body();
    } catch (IOException | InterruptedException e) {
        throw new RuntimeException(e);
```

Demo 2: Model Discovery & JSON Parsing

```java
// Understanding API responses with Java records
public class OpenAiRecords {
    public record ModelList(List<Model> data) {
        public record Model(
                String id,
                long created,
                @SerializedName("owned_by") String ownedBy) {
        }
    }
}
```

Demo 2: Model Discovery & JSON Parsing

```java
// Service implementation with Gson parsing
public class OpenAiService {
    private static final HttpClient client = HttpClient.newHttpClient();
    private final Gson gson = new GsonBuilder()
            .setFieldNamingPolicy(FieldNamingPolicy.LOWER_CASE_WITH_UNDERSCORES)
            .create();

    public ModelList listModels() throws IOException, InterruptedException {
        HttpRequest request = HttpRequest.newBuilder()
            .uri(URI.create("https://api.openai.com/v1/models"))
            .header("Authorization", "Bearer " + System.getenv("OPENAI_API_KEY"))
            .GET()
            .build();

        HttpResponse<String> response = client.send(request,
                HttpResponse.BodyHandlers.ofString());
        return gson.fromJson(response.body(), ModelList.class);
    }
}
            .build();

        try {
            HttpResponse<String> response =
                client.send(request, HttpResponse.BodyHandlers.ofString());
```

Demo 2: Model Discovery & JSON Parsing

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            .header("Authorization", "Bearer " + System.getenv("OPENAI_API_KEY"))
            .GET()
            .build();

        HttpResponse<String> response = client.send(request,
                HttpResponse.BodyHandlers.ofString());
        return gson.fromJson(response.body(), ModelList.class);
    }
}
            .build();

        try {
            HttpResponse<String> response =
                client.send(request, HttpResponse.BodyHandlers.ofString());
```

HTTP vs Framework Comparison

Raw HTTP Approach

```
// Manual request construction
HttpRequest request = HttpRequest.newBuilder()
    .uri(URI.create(url))
    .header("Authorization", "Bearer " + key)
    .header("Content-Type", "application/json")
    .POST(HttpRequest.BodyPublishers.ofString(
        gson.toJson(payload)))
    .build();

// Manual response handling
HttpResponse<String> response =
    client.send(request, HttpResponse.BodyHandlers.
return gson.fromJson(response.body(), ResponseClass
```

LangChain4j Framework

```
// High-level abstraction
ChatModel model = OpenAiChatModel.builder()
    .apiKey(System.getenv("OPENAI_API_KEY"))
    .modelName("gpt-4.1-nano")
    .build();

// Simple method call
String response = model.chat("Hello, world!");
```

HTTP vs Framework Comparison

Raw HTTP Approach

```
// Manual request construction
HttpRequest request = HttpRequest.newBuilder()
    .uri(URI.create(url))
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    .build();

// Simple method call
String response = model.chat("Hello, world!");
```

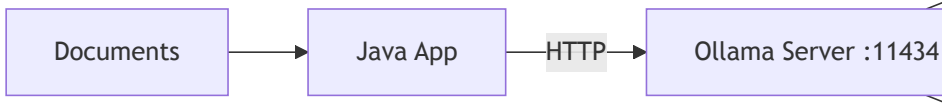
Both are valuable: Raw HTTP for understanding, frameworks for productivity

Demo 3-4: Local AI with Ollama

Privacy-First AI Integration

Demo 3: Ollama Setup and Architecture

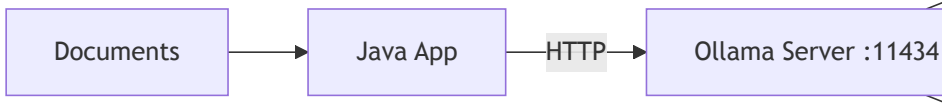
Why Ollama?



Demo 3: Ollama Setup and Architecture

Why Ollama?

- **Privacy**: No data leaves your machine



Demo 3: Ollama Setup and Architecture

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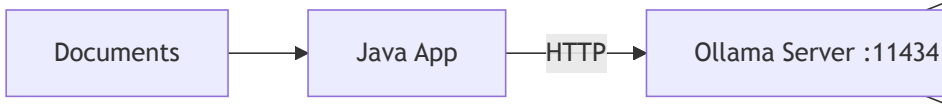
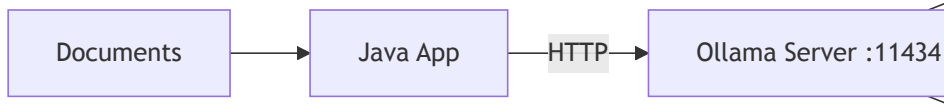
- **Privacy**: No data leaves your machine
- **Cost**: Zero API costs after setup



Demo 3: Ollama Setup and Architecture

Why Ollama?

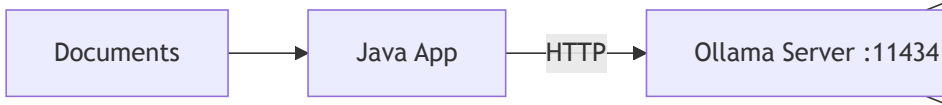
- **Privacy**: No data leaves your machine
- **Cost**: Zero API costs after setup
- **Control**: Full model customization



Demo 3: Ollama Setup and Architecture

Why Ollama?

- **Privacy**: No data leaves your machine
- **Cost**: Zero API costs after setup
- **Control**: Full model customization
- **Speed**: Local inference, no network delays



Demo 3: Ollama Setup and Architecture

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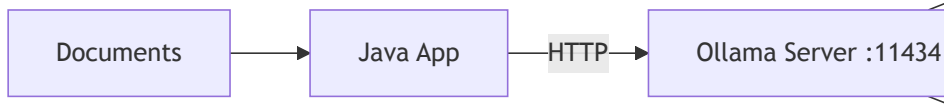

Setup Commands:

```
ollama pull gemma3        # Text generation
ollama pull moondream     # Vision analysis
ollama serve              # Start server (automatic on install)
```

Demo 4: Modern Java with Sealed Interfaces

```java
// Step 1: Model different request types with records
public class OllamaRecords {
    public record OllamaTextRequest(
            String model,
            String prompt,
            boolean stream) {}

    public record OllamaVisionRequest(
            String model,
            String prompt,
            boolean stream,
            List<String> images) {}
}
```

Demo 4: Modern Java with Sealed Interfaces

```java
// Step 2: Use sealed interfaces for type safety (Java 17+)
public sealed interface OllamaRequest
    permits OllamaTextRequest, OllamaVisionRequest {}

public record OllamaTextRequest(
        String model, String prompt, boolean stream)
        implements OllamaRequest {}

public record OllamaVisionRequest(
        String model, String prompt, boolean stream, List<String> images)
        implements OllamaRequest {

    // Compact constructor with Base64 encoding
    public OllamaVisionRequest {
        images = images.stream()
                .map(this::encodeImage)
                .collect(Collectors.toList());
    }
}
```

Demo 4: Modern Java with Sealed Interfaces

```java
// Step 3: Pattern matching with switch expressions (Java 21)
public OllamaResponse generate(OllamaRequest request) {
    switch (request) {
        case OllamaTextRequest textRequest -> {
            logger.log(INFO, "Text request: {0}", textRequest.prompt());
        }
        case OllamaVisionRequest visionRequest -> {
            logger.log(INFO, "Vision request with {0} images",
                visionRequest.images().size());
        }
        // Exhaustive - no default needed with sealed types!
    }

    // Same HTTP logic for both request types
    return sendRequest(request);
}
```

Demo 4: Modern Java with Sealed Interfaces

```java
// Step 3: Pattern matching with switch expressions (Java 21)
public OllamaResponse generate(OllamaRequest request) {
    switch (request) {
        case OllamaTextRequest textRequest -> {
            logger.log(INFO, "Text request: {0}", textRequest.prompt());
        }
        case OllamaVisionRequest visionRequest -> {
            logger.log(INFO, "Vision request with {0} images",
                visionRequest.images().size());
        }
        // Exhaustive - no default needed with sealed types!
    }

    // Same HTTP logic for both request types
    return sendRequest(request);
}
```

Modern Java Benefits: Type safety, exhaustive pattern matching, compact constructors

Demo 5-6: Framework Integration

LangChain4j Power and Simplicity

Demo 5: Quick Chat with LangChain4j

```java
// From 50+ lines of HTTP code to this:
import dev.langchain4j.model.chat.ChatModel;
import dev.langchain4j.model.openai.OpenAiChatModel;

public class QuickChatDemo {
    public static void main(String[] args) {
        // TODO: How do we create a chat model?
    }
}
```

Demo 5: Quick Chat with LangChain4j

```
// Step 1: Build the model with fluent API
ChatModel model = OpenAiChatModel.builder()
        .apiKey(System.getenv("OPENAI_API_KEY"))
        .modelName("gpt-4.1-nano")
        .logRequests(false)  // Toggle for debugging
        .logResponses(false) // Toggle for debugging
        .build();
```

Demo 5: Quick Chat with LangChain4j

```java
// Step 2: Complete implementation - just one method call!
public class QuickChatDemo {
    public static void main(String[] args) {
        ChatModel model = OpenAiChatModel.builder()
                .apiKey(System.getenv("OPENAI_API_KEY"))
                .modelName("gpt-4.1-nano")
                .build();

        String prompt = "Explain what LangChain4j is in 2-3 sentences.";
        System.out.println("Answer: " + model.chat(prompt));
    }
}
```

Demo 5: Quick Chat with LangChain4j

```java
// Step 2: Complete implementation - just one method call!
public class QuickChatDemo {
    public static void main(String[] args) {
        ChatModel model = OpenAiChatModel.builder()
                .apiKey(System.getenv("OPENAI_API_KEY"))
                .modelName("gpt-4.1-nano")
                .build();

        String prompt = "Explain what LangChain4j is in 2-3 sentences.";
        System.out.println("Answer: " + model.chat(prompt));
    }
}
```

Live Demo: Run `QuickChatDemo.java` - from complex HTTP to simple method call!

Demo 6: Multi-Model Provider Support

```
// Step 1: OpenAI implementation
ChatModel openai = OpenAiChatModel.builder()
        .apiKey(System.getenv("OPENAI_API_KEY"))
        .modelName("gpt-4.1-nano")
        .build();

String response = openai.chat("What is the capital of France?");
System.out.println("OpenAI: " + response);
```

Demo 6: Multi-Model Provider Support

```
// Step 2: Switch to Google Gemini - same interface!
ChatModel gemini = GoogleAiGeminiChatModel.builder()
        .apiKey(System.getenv("GOOGLEAI_API_KEY"))
        .modelName("gemini-2.0-flash-exp")
        .build();

String response = gemini.chat("What is the capital of France?");
System.out.println("Gemini: " + response);
```

Demo 6: Multi-Model Provider Support

```
// Step 3: Or use local Ollama - still same interface!
ChatModel ollama = OllamaChatModel.builder()
        .baseUrl("http://localhost:11434")
        .modelName("gemma3")
        .build();

String response = ollama.chat("What is the capital of France?");
System.out.println("Ollama: " + response);
```

Demo 6: Multi-Model Provider Support

```java
// Step 3: Or use local Ollama - still same interface!
ChatModel ollama = OllamaChatModel.builder()
        .baseUrl("http://localhost:11434")
        .modelName("gemma3")
        .build();

String response = ollama.chat("What is the capital of France?");
System.out.println("Ollama: " + response);
```

Key Insight: Same `ChatModel` interface = vendor-agnostic code!

Provider Ecosystem

Cloud Providers

Local Models

Specialized Services

Provider Ecosystem

Cloud Providers

- **OpenAI** • GPT-4.1-nano, DALL-E 3

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- **Code** • CodeLlama, StarCoder

LangChain4j **Advantage**: Switch providers with just configuration changes!

Demo 7: Streaming Responses

Real-Time AI Interactions

Demo 7: Clean Streaming with Lambda Handlers

```
// Old way: Complex anonymous inner classes
public void oldStreamingApproach() {
    model.chat("Tell me a story", new StreamingChatResponseHandler() {
        @Override
        public void onPartialResponse(String token) {
            System.out.print(token);
        }

        @Override
        public void onError(Throwable error) {
            System.err.println("Error: " + error);
        }

        @Override
        public void onCompleted() {
            System.out.println("\nDone!");
        }
    });
}
```

Demo 7: Clean Streaming with Lambda Handlers

```java
// LangChain4j utilities: Clean lambda approach
import static dev.langchain4j.model.LambdaStreamingResponseHandler.*;

public class StreamingDemo {
    public static void main(String[] args) {
        var ollama = OllamaStreamingChatModel.builder()
                .baseUrl("http://localhost:11434")
                .modelName("gemma3")
                .build();

        // One-liner for simple streaming
        ollama.chat("Tell me a haiku about Java",
            onPartialResponse(System.out::print));
    }
}
```

Demo 7: Clean Streaming with Lambda Handlers

```
// With error handling - still clean and functional
var openai = OpenAiStreamingChatModel.builder()
        .apiKey(System.getenv("OPENAI_API_KEY"))
        .modelName("gpt-4o-mini")
        .build();

// Handle both tokens and errors elegantly
openai.chat("Why is the sky blue?",
    onPartialResponseAndError(
        System.out::print,  // Handle each token
        error -> System.err.println("Error: " + error.getMessage())
    ));
```

Demo 7: Clean Streaming with Lambda Handlers

```
// With error handling - still clean and functional
var openai = OpenAiStreamingChatModel.builder()
        .apiKey(System.getenv("OPENAI_API_KEY"))
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openai.chat("Why is the sky blue?",
    onPartialResponseAndError(
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        error -> System.err.println("Error: " + error.getMessage())
    ));
```
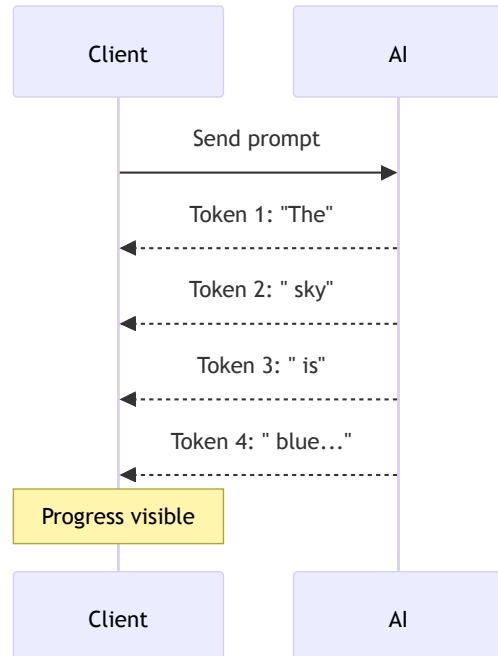

Live Demo: Run `StreamingDemo.java` to see tokens appear in real-time!

Streaming Architecture Benefits

User Experience

Technical Benefits

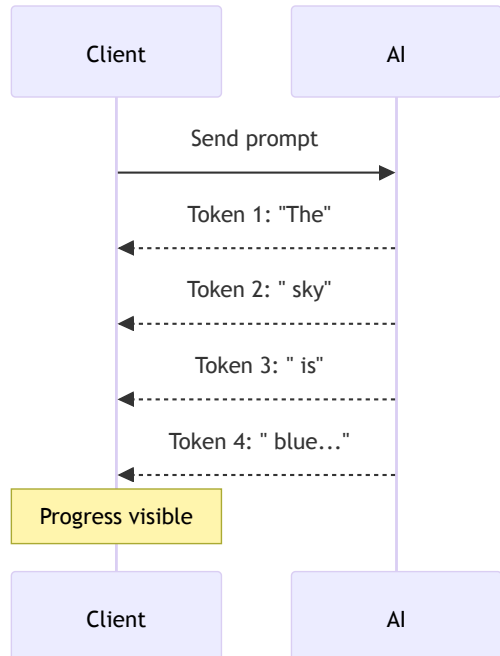


Streaming Architecture Benefits

User Experience

- **Immediate Feedback**: See progress instantly

Technical Benefits

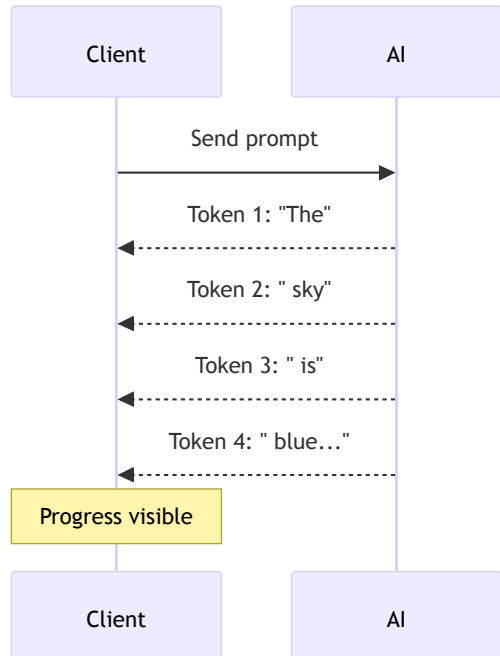


Streaming Architecture Benefits

User Experience

- **Immediate Feedback**: See progress instantly
- **Perceived Speed**: Feels faster

Technical Benefits



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- **Interruptible**: Stop generation early

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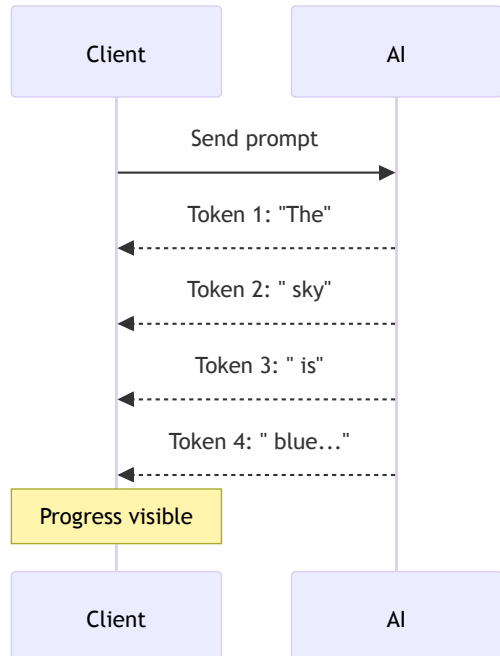

Streaming Architecture Benefits

User Experience

- **Immediate Feedback**: See progress instantly
- **Perceived Speed**: Feels faster
- **Interruptible**: Stop generation early
- **Engaging**: Watch AI "think"

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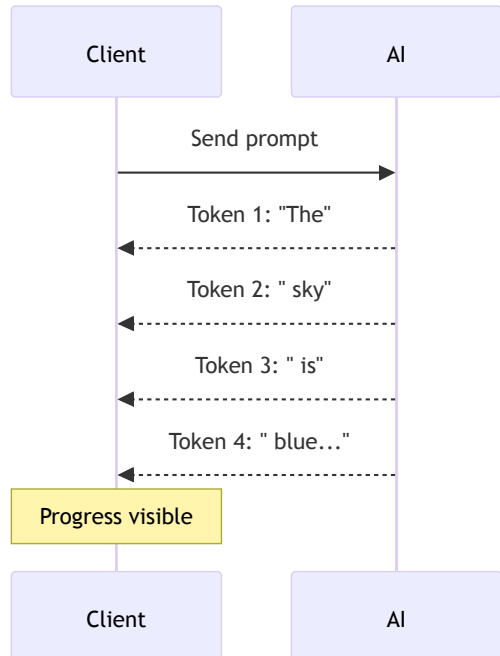

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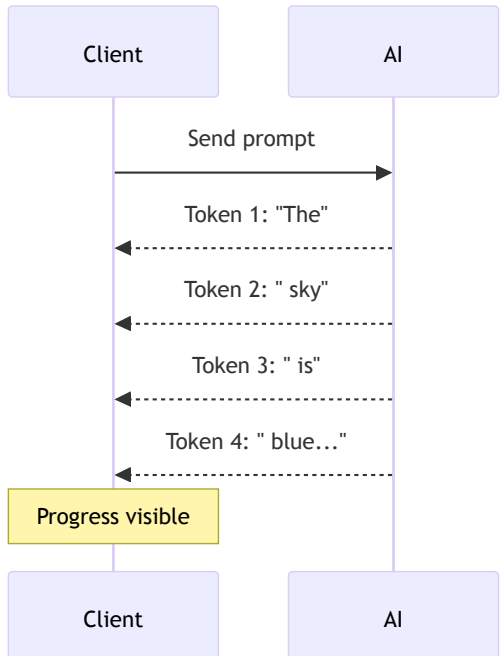
User Experience

- **Immediate Feedback**: See progress instantly
- **Perceived Speed**: Feels faster
- **Interruptible**: Stop generation early
- **Engaging**: Watch AI "think"

Technical Benefits

- **Lower Latency**: First token quickly



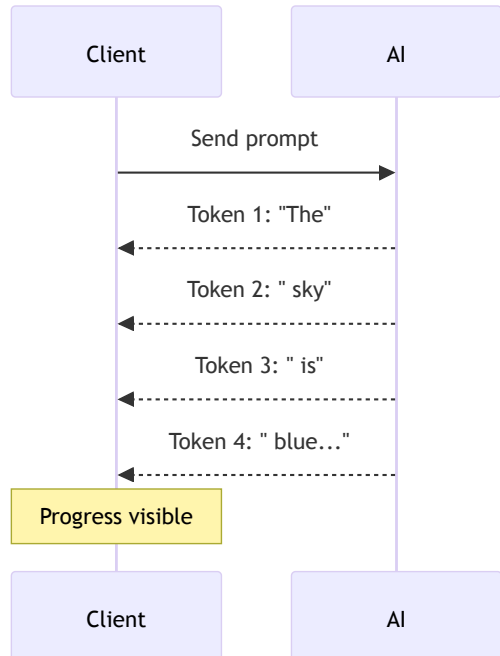
Streaming Architecture Benefits

User Experience

- **Immediate Feedback**: See progress instantly
- **Perceived Speed**: Feels faster
- **Interruptible**: Stop generation early
- **Engaging**: Watch AI "think"

Technical Benefits

- **Lower Latency**: First token quickly
- **Better Resources**: Process as arriving



Streaming Architecture Benefits

User Experience

- **Immediate Feedback**: See progress instantly
- **Perceived Speed**: Feels faster
- **Interruptible**: Stop generation early
- **Engaging**: Watch AI "think"

Technical Benefits

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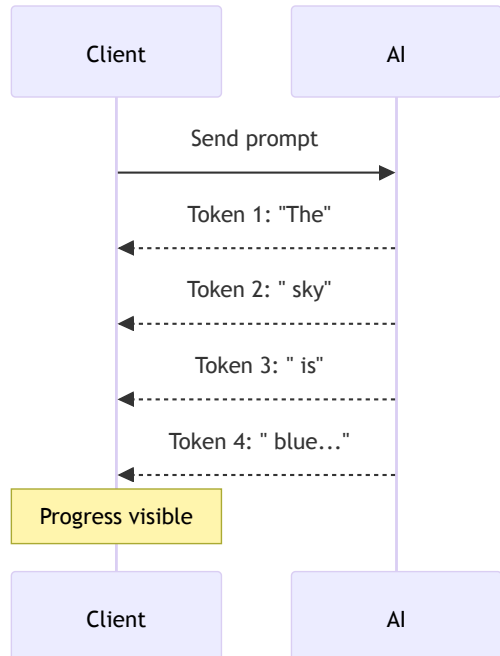

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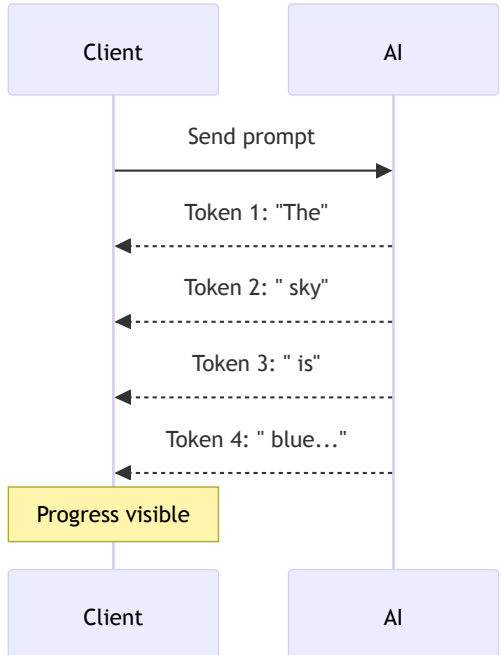

Demo 8: Retrieval-Augmented Generation

Document-Powered AI

RAG: The Knowledge Problem

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RAG: The Knowledge Problem

RAG Implementation with LangChain4j

```java
// Step 1: Load and process documents
import static dev.langchain4j.data.document.loader.FileSystemDocumentLoader.loadDocuments;

List<Document> documents = loadDocuments(
    toPath("documents/"),
    glob("*.txt")
);
```

RAG Implementation with LangChain4j

```
// Step 2: Create vector store and ingest documents
InMemoryEmbeddingStore<TextSegment> embeddingStore =
    new InMemoryEmbeddingStore<>();

// Magic happens here - documents become searchable vectors
EmbeddingStoreIngestor.ingest(documents, embeddingStore);

ContentRetriever retriever =
    EmbeddingStoreContentRetriever.from(embeddingStore);
```

RAG Implementation with LangChain4j

```java
// Step 3: Create AI assistant with document access
public interface Assistant {
    String chat(String userMessage);
}

Assistant assistant = AiServices.builder(Assistant.class)
        .chatModel(chatModel)
        .chatMemory(MessageWindowChatMemory.withMaxMessages(10))
        .contentRetriever(retriever)  // The magic ingredient!
         .build();
```

RAG Implementation with LangChain4j

```java
// Step 4: Complete EasyRAGDemo implementation
public class EasyRAGDemo {
    public static void main(String[] args) {
        List<Document> documents = loadDocuments(toPath("documents/"), glob("*.txt"));

        ChatModel chatModel = OpenAiChatModel.builder()
                .apiKey(System.getenv("OPENAI_API_KEY"))
                .modelName("gpt-4.1-nano")
                .build();

        Assistant assistant = AiServices.builder(Assistant.class)
                .chatModel(chatModel)
                .chatMemory(MessageWindowChatMemory.withMaxMessages(10))
                .contentRetriever(createContentRetriever(documents))
                .build();

        // AI can now answer questions about your documents!
        startConversationWith(assistant);
    }
}
```

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                .contentRetriever(createContentRetriever(documents))
                .build();

        // AI can now answer questions about your documents!
        startConversationWith(assistant);
    }
}
```

Live Demo: Run `EasyRAGDemo.java` - AI answers questions about YOUR documents!

RAG Deep Dive: How It Works

Vector Embeddings

Document Processing

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Vector Embeddings

- **Numerical Representation**: Text → vectors (1536+ dimensions)

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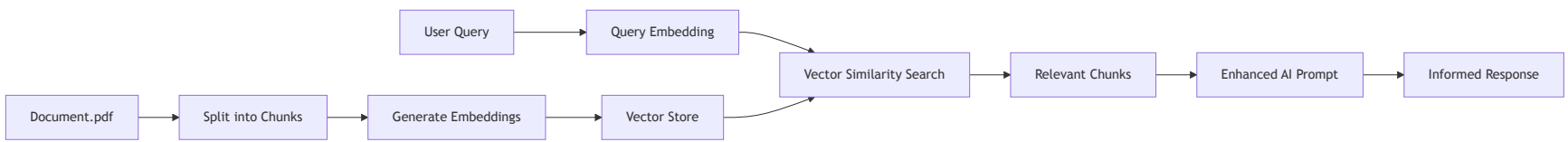

Advanced Topics Overview

Production Considerations

Integration Patterns

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- **Vector Databases**: Redis, Pinecone, Weaviate

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- **Security**: Access control, data privacy

Testing Strategy

Smart Cost Control and Quality Assurance

Test Categories for Cost Control

Test Tags

```java
@Test
@Tag("local")  // Free
void testOllama() {
    // $0 cost
}

@Test
@Tag("cheap")  // Low cost
void testNano() {
    // ~$0.001
}

@Test
@Tag("demo")   // Fast
void quickDemo() {
    // Optimized
}
```

Gradle Commands

```bash
# Free tests only
./gradlew testLocal

# Low-cost tests
./gradlew testCheap

# Demo tests
./gradlew testDemo

# Exclude expensive
./gradlew testNotExpensive
```

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```

Strategy: Develop with `testLocal`, validate with `testCheap`

Gradle Test Tasks

Cost-Controlled Testing

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./gradlew testLocal

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# Exclude expensive tests
./gradlew testNotExpensive

# Quick live demos
./gradlew testDemo
```

Provider-Specific Testing

```
# OpenAI API tests only
./gradlew testOpenAI

# All tests (including expensive)
./gradlew test

# Custom test selection
./gradlew test --tests "*OpenAi*"
```

Gradle Test Tasks

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./gradlew testLocal

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# Custom test selection
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Smart Development: Use free local models for TDD, validate with cloud models before deployment

Testing Patterns for AI Applications

Unit Testing Approaches

```java
@Test
void shouldParseModelList() {
    String json = """
        {"data": [
            {"id": "gpt-4", "created": 123}
        ]}
        """;
    ModelList result = gson.fromJson(json, ModelList
    assertThat(result.data()).hasSize(1);
}

@Test
void shouldHandleApiError() {
    // Test error scenarios
    assertThrows(RuntimeException.class,
        () -> service.generateWithInvalidKey());
}
```

Integration Testing

```java
@Test
@Tag("local")
void shouldStreamTokens() {
    List<String> tokens = new ArrayList<>();

    ollamaService.generateStreaming("gemma3",
        "Count to 5",
        token -> tokens.add(token)
    );

    assertThat(tokens).isNotEmpty();
    assertThat(String.join("", tokens))
        .containsPattern("1.*2.*3.*4.*5");
}
```

Quality Assurance for Non-Deterministic Systems

```java
@Test
@Tag("cheap")
void shouldAnswerSkyColorQuestion() {
    String response = chatModel.chat("Why is the sky blue?");

    // Flexible content assertion
    assertThat(response.toLowerCase())
        .containsAnyOf("scattering", "wavelength", "atmosphere", "light");

    // Structural assertion
    assertThat(response).hasSizeGreaterThan(10);
    assertThat(response).doesNotContain("I don't know");
}
```

Quality Assurance for Non-Deterministic Systems

- **Content Assertions**: Check for key concepts, not exact strings

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Course Summary

From HTTP to Intelligent Applications

Your AI Java Journey

Foundation Built

Advanced Capabilities

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- **HTTP Fundamentals**: Raw API integration patterns

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Result: You can build intelligent Java applications with confidence! 🚀

Demo Classes Mastered

Core Demos

- **QuickChatDemo** - Fast OpenAI integration
- **TextToSpeechDemo** - Audio generation
- **LocalOllamaDemo** - Privacy-first AI
- **MultiModelDemo** - Provider comparison

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All Ready for Live Demonstration: Each demo is optimized for training delivery

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Hands-On Practice

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Resources:

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- Course Repository
- Ollama Models

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Thank You!

Questions?

Kenneth Kousen
Java Champion, Author, Speaker

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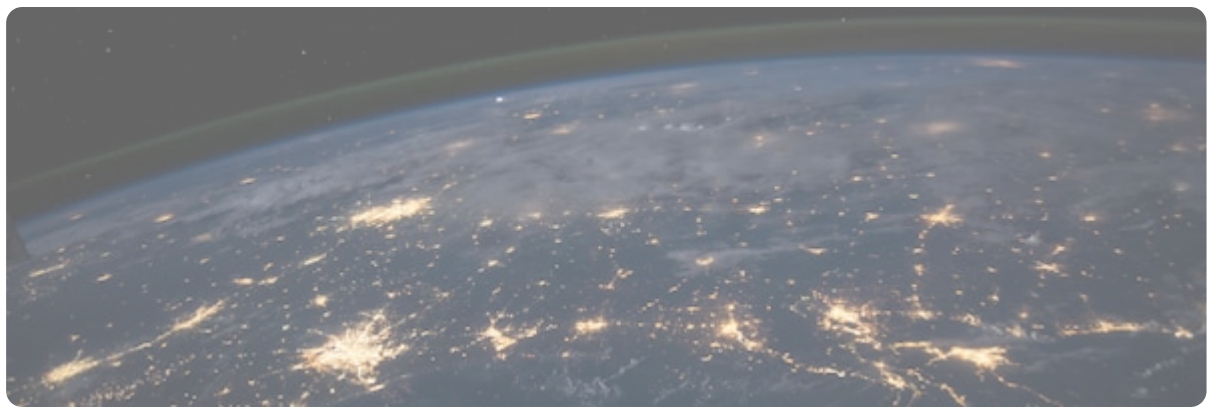

Ready to build intelligent Java applications!