

ПРАВИТЕЛЬСТВО РОССИЙСКОЙ ФЕДЕРАЦИИ
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АНАЛИЗ ПОВЕДЕНИЯ ВРЕМЕННЫХ СИСТЕМ С
ПОМОЩЬЮ ДИНАМИЧЕСКИХ МЕТРИЧЕСКИХ ГРАФОВ.

Текст программы

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1. Текст программы

1.1. TapaalHeadlessService.java

```
package com.github.zinoviy23.tapaal;

import java.awt.*;
import java.util.function.Supplier;

public class TapaalHeadlessService {
    public static boolean isHeadless() {
        return GraphicsEnvironment.isHeadless();
    }

    public static void handleHeadless(Runnable runnable) {
        if (!isHeadless()) {
            runnable.run();
        }
    }

    public static <T> T computeIfNotHeadless(Supplier<T> supplier) {
        if (!isHeadless()) {
            return supplier.get();
        }
        return null;
    }
}
```

1.2. ExtensionException.java

```
package com.github.zinoviy23.tapaal.extenstions;

public class ExtensionException extends RuntimeException {
    public ExtensionException(String message) {
        super(message);
    }

    public ExtensionException(String message, Throwable cause) {
        super(message, cause);
    }
}
```

1.3. ExtensionPoint.java

```
package com.github.zinoviy23.tapaal.extenstions;

import java.lang.reflect.Constructor;
import java.lang.reflect.InvocationTargetException;
import java.util.*;
import java.util.stream.Collectors;
```

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```

public final class ExtensionPoint<T> {
    private final Class<T> interfaceType;
    private final List<Class<?>> extensionClasses = new ArrayList<>();

    private final Map<Class<?>, Object> extensionCache = new HashMap<>();

    public ExtensionPoint(Class<T> interfaceType) {
        this.interfaceType = interfaceType;
    }

    public Class<T> getInterfaceType() {
        return interfaceType;
    }

    public synchronized List<T> getExtensions() {
        return extensionClasses.stream()
            .map(ext -> {
                @SuppressWarnings("unchecked")
                T instance = (T) extensionCache.computeIfAbsent(ext, ExtensionPoint::instantiate)
                ;
                return instance;
            })
            .collect(Collectors.toList());
    }

    public synchronized void addExtension(Class<?> extension) {
        if (!interfaceType.isAssignableFrom(extension)) {
            throw new ExtensionException("Adding extension of wrong type. Expected " +
                interfaceType.getName());
        }

        extensionClasses.add(extension);
    }

    private static Object instantiate(Class<?> clazz) {
        try {
            Constructor<?> constructor = clazz.getConstructor();
            return constructor.newInstance();
        } catch (NoSuchMethodException | IllegalAccessException | InstantiationException |
            InvocationTargetException e) {
            throw new ExtensionException("Extension must have default constructor", e);
        }
    }
}

```

1.4. ExtensionManager.java

```

package com.github.zinoviy23.tapaal.extenstions;

import java.util.HashMap;
import java.util.Map;
import java.util.Objects;

```

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```

public class ExtensionManager {
    private static ExtensionManager instance;

    private final Map<String, ExtensionPoint<?>> extensionPoints = new HashMap<>();

    private ExtensionManager() {
    }

    public static ExtensionManager getInstance() {
        if (instance == null) {
            synchronized (ExtensionManager.class) {
                if (instance == null) {
                    instance = new ExtensionManager();
                }
            }
        }
        return instance;
    }

    public synchronized <T> void registerExtensionPoint(String name, Class<T> interfaceType)
    {
        Objects.requireNonNull(name, "name");
        Objects.requireNonNull(interfaceType, "interfaceType");

        if (extensionPoints.containsKey(name)) {
            throw new ExtensionException("Already contains extension point" + name);
        }
        extensionPoints.put(name, new ExtensionPoint<>(interfaceType));
    }

    public synchronized void registerExtension(String name, Class<?> extensionImpl) {
        Objects.requireNonNull(name, "name");
        Objects.requireNonNull(extensionImpl, "extension");
        if (!extensionPoints.containsKey(name)) {
            throw new ExtensionException("There isn't any extension point" + name);
        }

        extensionPoints.get(name).addExtension(extensionImpl);
    }

    public synchronized <T> ExtensionPoint<T> getExtensionPoint(String name) {
        //noinspection unchecked
        return (ExtensionPoint<T>) extensionPoints.get(name);
    }
}

```

1.5. TapnFilesTest.java

```

package com.github.zinoviy23;

import dk.aau.cs.io.LoadedModel;

```

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```

import dk.aau.cs.io.TapnXmlLoader;
import dk.aau.cs.io.TimedArcPetriNetNetworkWriter;
import dk.aau.cs.model.tapn.*;
import dk.aau.cs.util.FormatException;
import org.junit.Test;

import javax.xml.parsers.ParserConfigurationException;
import javax.xml.transform.TransformerException;
import java.io.File;
import java.io.FileInputStream;
import java.io.IOException;
import java.io.InputStream;
import java.util.Collections;

import static org.assertj.core.api.Assertions.assertThat;

public class TapnFilesTest {
    @Test
    public void readFileWebserver() throws FormatException {
        InputStream resource = getClass().getClassLoader().getResourceAsStream("Example_
            nets/webserver.tapn");
        assertThat(resource).isNotNull();

        assertWebserver(resource);
    }

    @Test
    public void writeFileWebserver() throws FormatException, ParserConfigurationException,
        TransformerException, IOException {
        TapnXmlLoader loader = new TapnXmlLoader();
        InputStream resource = getClass().getClassLoader().getResourceAsStream("Example_
            nets/webserver.tapn");
        assertThat(resource).isNotNull();

        LoadedModel model = loader.load(resource);
        TimedArcPetriNetNetwork network = model.network();

        TimedArcPetriNetNetworkWriter writer = new TimedArcPetriNetNetworkWriter(network,
            model.templates(), Collections.emptyList(), network.constants());
        File file = File.createTempFile("myFile", ".xml");
        writer.savePNML(file);

        try (InputStream stream = new FileInputStream(file)) {
            assertWebserver(stream);
        }

        assertThat(file.delete()).isTrue();
    }

    private void assertWebserver(InputStream resource) throws FormatException {
        TapnXmlLoader loader = new TapnXmlLoader();

```

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```

LoadedModel model = loader.load(resource);
TimedArcPetriNetNetwork network = model.network();
TimedArcPetriNet webServer = network.getTAPNByName("WebServer");
assertThat(webServer).isNotNull();

TimedPlace userA = webServer.getPlaceByName("UserA");
TimedPlace userB = webServer.getPlaceByName("UserB");
TimedTransition drop = webServer.getTransitionByName("Drop");
assertThat(userA).isNotNull();
assertThat(userB).isNotNull();
assertThat(drop).isNotNull();
    }
}

```

1.6. ConversionException.java

```

package com.github.zinoviy23.tapnToMg.converters;

public class ConversionException extends RuntimeException {
    public ConversionException(Throwable cause) {
        super(cause);
    }
}

```

1.7. Converter.java

```

package com.github.zinoviy23.tapnToMg.converters;

import org.jetbrains.annotations.NotNull;

import java.util.function.Function;

public interface Converter<TFrom, TTo> extends Function<TFrom, TTo> {
    @NotNull TTo convert(@NotNull TFrom from);

    @Override
    default TTo apply(TFrom from) {
        if (from == null) {
            return null;
        }
        return convert(from);
    }
}

```

1.8. ConvertersFactory.java

```

package com.github.zinoviy23.tapnToMg.converters;

import com.github.zinoviy23.metricGraphs.MetricGraph;
import com.github.zinoviy23.metricGraphs.io.MetricGraphReadingException;
import com.github.zinoviy23.metricGraphs.io.ValidatedMetricGraphJsonReader;
import com.github.zinoviy23.metricGraphs.util.ContainerUtil;

```

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```

import com.github.zinoviy23.tapnToMg.converters.mgToTapn.ConvertedTimedArcPetriNet;
import com.github.zinoviy23.tapnToMg.converters.mgToTapn.
    MetricGraphToTimedArcPetriNetConverter;
import dk.aau.cs.io.ModelLoader;
import dk.aau.cs.io.TimedArcPetriNetNetworkWriter;
import dk.aau.cs.model.tapn.TimedArcPetriNet;
import org.jetbrains.annotations.NotNull;

import javax.xml.parsers.ParserConfigurationException;
import javax.xml.transform.TransformerException;
import java.io.File;
import java.io.IOException;
import java.util.Collections;
import java.util.List;
import java.util.function.Function;

public class ConvertersFactory {
    public static @NotNull Function<File, File> createMetricGraphToTimedArcPetriNetConverter
        () {
        return createFileToMetricGraphConverter()
            .andThen(new MetricGraphToTimedArcPetriNetConverter())
            .andThen(createTimedArcPetriNetToFileConverter());
    }

    public static @NotNull Function<File, MetricGraph> createFileToMetricGraphConverter() {
        return file -> {
            try (var reader = new ValidatedMetricGraphJsonReader(file).getReader()) {
                return reader.read();
            } catch (IOException | MetricGraphReadingException e) {
                throw new ConversionException(e);
            }
        };
    }

    public static @NotNull Function<ConvertedTimedArcPetriNet, File>
        createTimedArcPetriNetToFileConverter() {
        return petriNet -> {
            var writer = new TimedArcPetriNetNetworkWriter(
                petriNet.getNetwork(),
                List.of(petriNet.getTemplate()),
                Collections.emptyList(),
                petriNet.getNetwork().constants()
            );
            try {
                File file = File.createTempFile("convertedTapn", ".tapn");
                writer.savePNML(file);
                return file;
            } catch (TransformerException | IOException | ParserConfigurationException e) {
                throw new ConversionException(e);
            }
        };
    }
}

```

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```

}

public static @NotNull Function<File, TimedArcPetriNet>
    createFileToTimedArcPetriNetConverter() {
    return file -> {
        ModelLoader loader = new ModelLoader();
        try {
            var load = loader.load(file);
            var network = load.network();
            var net = ContainerUtil.first(network.allTemplates());
            if (net == null) {
                throw new RuntimeException("Network_must_have_at_least_one_template");
            }
            return net;
        } catch (Exception e) {
            throw new ConversionException(e);
        }
    };
}

private ConvertersFactory() {
}
}

```

1.9. MgMetadataUtil.java

```

package com.github.zinoviy23.tapnToMg.converters.tapnToMg;

import com.github.zinoviy23.metricGraphs.MetricGraph;
import com.github.zinoviy23.metricGraphs.util.Ref;
import dk.aau.cs.model.tapn.*;
import org.jetbrains.annotations.NotNull;
import org.jgrapht.alg.util.Pair;
import org.jgrapht.alg.util.Triple;

final class MgMetadataUtil {
    private MgMetadataUtil() {
    }

    static @NotNull String getNodeName(@NotNull TimedTransition transition) {
        return "n_" + transition.name();
    }

    static @NotNull String getNodeComment(@NotNull TimedTransition transition) {
        return "Generated_from_transition_" + transition.name();
    }

    static @NotNull String getArcName(@NotNull TimedTransition transitionSource,
                                      @NotNull TimedPlace place,
                                      @NotNull TimedTransition transitionTarget) {
        return "a_" + transitionSource.name() + "_" + place.name() + "_" + transitionTarget.name();
    }
}

```

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```

}

static @NotNull String getNameForReversal(@NotNull String arcName) {
    return "rev_" + arcName;
}

static @NotNull String getTokenName(@NotNull Ref<Integer> currentId) {
    return "t_" + currentId.update(i -> i + 1);
}

static @NotNull String getLeadName(@NotNull TimedOutputArc outputArc) {
    return "l_" + outputArc.source().name() + "_" + outputArc.destination().name();
}

static @NotNull String getLeadName(@NotNull TimedInputArc inputArc) {
    return "l_" + inputArc.source().name() + "_" + inputArc.destination().name();
}

static @NotNull String getInfName(@NotNull TimedInputArc inputArc) {
    return "inf_" + inputArc.source().name() + "_" + inputArc.destination().name();
}

static @NotNull String getInfName(@NotNull TimedOutputArc outputArc) {
    return "inf_" + outputArc.source().name() + "_" + outputArc.destination().name();
}

static @NotNull String getGraphName(@NotNull TimedArcPetriNet tapn) {
    return "mg_" + tapn.name();
}

static @NotNull String getMultiedgeHandlerNodeName(@NotNull String name) {
    return "br_n_" + name;
}

static @NotNull Pair<String, String> getMultiedgeHandlerArcsNames(@NotNull String name)
{
    return Pair.of("br_" + name + "_part1", "br_" + name + "_part2");
}

static @NotNull Triple<String, String, String> getSelfLoopHandleArcsNames(@NotNull
    String name) {
    return Triple.of("br_" + name + "_part1", "br_" + name + "_part2", "br_" + name + "
        _part3");
}

static @NotNull String getComment(@NotNull String name, @NotNull TimedArcPetriNet
    petriNet) {
    return String.format("Metric_graph_%s_generated_from_corresponding_Timed_Arc_Petri_Net
        %s.\n" +
            "n_*_nodes_generated_from_transitions.\n" +
            "a_*_*_*_arc_generated_from_transition_place_and_transition.\n" +

```

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```

        "rev_*_reversal_arc.Arc+_reversal_arc=edge_in_metric_graph.\n" +
        "t_*_point_generated_from_token.\n" +
        "l_*_lead_generated_from_place,which_has_only_incoming_or_only_outgoing_arcs\n" +
        ".\n" +
        "inf_*_node_representing_infinity_node,which_isn't_exist.\n" +
        "br_*_additional_node,to_break_self_loop_or_multiple_edges_between_to_nodes.\n",
        name, petriNet.name()
    );
}
}

```

1.10. TapnPlacesArcs.java

```

package com.github.zinoviy23.tapnToMg.converters.tapnToMg;

import dk.aau.cs.model.tapn.*;
import org.jetbrains.annotations.NotNull;

import java.util.*;

final class TapnPlacesArcs {
    private final Map<TimedPlace, List<TimedInputArc>> outputArcs = new HashMap<>();
    private final Map<TimedPlace, List<TimedOutputArc>> inputArcs = new HashMap<>();

    public TapnPlacesArcs(@NotNull TimedArcPetriNet petriNet) {
        for (TimedTransition transition : petriNet.transitions()) {
            for (TimedOutputArc outputArc : transition.getOutputArcs()) {
                inputArcs.computeIfAbsent(outputArc.destination(), __ -> new ArrayList<>()).add(
                    outputArc);
            }
            for (TimedInputArc inputArc : transition.getInputArcs()) {
                assertInputArc(inputArc);
                outputArcs.computeIfAbsent(inputArc.source(), __ -> new ArrayList<>()).add(inputArc);
            }
        }
    }

    public List<TimedInputArc> getOutputArcs(@NotNull TimedPlace place) {
        var list = outputArcs.get(place);
        return list != null ? Collections.unmodifiableList(list) : Collections.emptyList();
    }

    public List<TimedOutputArc> getInputArcs(@NotNull TimedPlace place) {
        var list = inputArcs.get(place);
        return list != null ? Collections.unmodifiableList(list) : Collections.emptyList();
    }

    private static void assertInputArc(@NotNull TimedInputArc arc) {
        var interval = arc.interval();
        if (!interval.IsLowerBoundNonStrict() || !interval.IsUpperBoundNonStrict()) {

```

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```

        throw new TimedArcPetriNetToMetricGraphConversionException(
            String.format("Time interval %s in %s must be closed!", interval, arc)
        );
    }

    if (interval.lowerBound().value() != interval.upperBound().value()) {
        throw new TimedArcPetriNetToMetricGraphConversionException(
            String.format("Time interval %s in %s must be zero length!", interval, arc)
        );
    }
}
}
}

```

1.11. TimedArcPetriNetToMetricGraphConversionException.java

```

package com.github.zinoviy23.tapnToMg.converters.tapnToMg;

public final class TimedArcPetriNetToMetricGraphConversionException extends
    RuntimeException {
    public TimedArcPetriNetToMetricGraphConversionException(String message) {
        super(message);
    }
}

```

1.12. TimedArcPetriNetToMetricGraphConverter.java

```

package com.github.zinoviy23.tapnToMg.converters.tapnToMg;

import com.github.zinoviy23.metricGraphs.Arc;
import com.github.zinoviy23.metricGraphs.MetricGraph;
import com.github.zinoviy23.metricGraphs.MovingPoint;
import com.github.zinoviy23.metricGraphs.Node;
import com.github.zinoviy23.metricGraphs.util.DoubleUtil;
import com.github.zinoviy23.metricGraphs.util.Ref;
import com.github.zinoviy23.tapnToMg.converters.Converter;
import dk.aau.cs.model.tapn.*;
import org.jetbrains.annotations.NotNull;
import org.jgrapht.alg.util.Pair;

import java.util.HashMap;
import java.util.List;
import java.util.Map;
import java.util.stream.Collectors;

public final class TimedArcPetriNetToMetricGraphConverter implements Converter<
    TimedArcPetriNet, MetricGraph> {
    @Override
    public @NotNull MetricGraph convert(@NotNull TimedArcPetriNet petriNet) {
        var graphName = MgMetadataUtil.getGraphName(petriNet);
        var graphBuilder = MetricGraph.createBuilder()
            .setId(graphName)
            .setComment(MgMetadataUtil.getComment(graphName, petriNet));
    }
}

```

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```

var transitionNodes = addNodes(graphBuilder, petriNet);
var placesArcs = new TapnPlacesArcs(petriNet);
var tokenId = addEdges(graphBuilder, petriNet, transitionNodes, placesArcs);
addLeads(graphBuilder, petriNet, transitionNodes, placesArcs, tokenId);

return graphBuilder.buildGraph();
}

private @NotNull Map<TimedTransition, Node> addNodes(@NotNull MetricGraph.
    MetricGraphBuilder builder,
                                @NotNull TimedArcPetriNet petriNet) {
    var result = new HashMap<TimedTransition, Node>();

    for (TimedTransition transition : petriNet.transitions()) {
        assertTransition(transition);

        var id = MgMetadataUtil.getNodeName(transition);
        var comment = MgMetadataUtil.getNodeComment(transition);
        var node = Node.createNode(id, id, comment);
        builder.addNode(node);
        result.put(transition, node);
    }

    return result;
}

private Ref<Integer> addEdges(@NotNull MetricGraph.MetricGraphBuilder builder,
    @NotNull TimedArcPetriNet petriNet,
    @NotNull Map<TimedTransition, Node> transitionNodes,
    @NotNull TapnPlacesArcs arcs) {
    var tokenId = new Ref<>(0);
    for (TimedTransition transition : petriNet.transitions()) {
        var source = transitionNodes.get(transition);
        for (TimedOutputArc outputArc : transition.getOutputArcs()) {
            var place = outputArc.destination();
            for (TimedInputArc arc : arcs.getOutputArcs(place)) {
                var target = transitionNodes.get(arc.destination());
                String name = addEdge(builder, transition, source, place, arc, target);

                var points = getPointsFromPlace(tokenId, place);
                builder.addPoints(name, points);
            }
        }
    }
    return tokenId;
}

private @NotNull String addEdge(@NotNull MetricGraph.MetricGraphBuilder builder,
    @NotNull TimedTransition transition,
    @NotNull Node source,

```

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```

        @NotNull TimedPlace place,
        @NotNull TimedInputArc arc,
        @NotNull Node target) {
String name = MgMetadataUtil.getArcName(transition, place, arc.destination());
if (!builder.containsEdge(source, target) && !source.equals(target)) {
    var resultArc = Arc.createBuilder()
        .setSource(source)
        .setTarget(target)
        .setLength(fixLength(arc.interval().upperBound().value()))
        .setId(name);

    builder.addArc(resultArc).withReversal(MgMetadataUtil.getNameForReversal(name));
} else if (!source.equals(target)) {
    var handlerNode = Node.createMultiEdgeHandler(MgMetadataUtil.
        getMultiedgeHandlerNodeName(name), source, target);
    var edgesNames = MgMetadataUtil.getMultiedgeHandlerArcsNames(name);
    var length = fixLength(arc.interval().upperBound().value()) / 2.0;
    builder
        .addNode(handlerNode)
        .addArc(Arc.createBuilder()
            .setSource(source)
            .setTarget(handlerNode)
            .setId(edgesNames.getFirst())
            .setLength(length)
        ).withReversal(MgMetadataUtil.getNameForReversal(edgesNames.getFirst()))
        .addArc(Arc.createBuilder()
            .setSource(handlerNode)
            .setTarget(target)
            .setId(edgesNames.getSecond())
            .setLength(length)
        ).withReversal(MgMetadataUtil.getNameForReversal(edgesNames.getSecond())));

    name = edgesNames.getFirst();
} else {
    var edgesNames = MgMetadataUtil.getSelfLoopHandleArcsNames(name);
    var loopFixes = fixSelfLoop(name, source, target);
    var length = fixLength(arc.interval().upperBound().value()) / 3.0;
    builder
        .addNode(loopFixes.getFirst())
        .addNode(loopFixes.getSecond())
        .addArc(Arc.createBuilder()
            .setSource(source)
            .setTarget(loopFixes.getFirst())
            .setId(edgesNames.getFirst())
            .setLength(length)
        ).withReversal(MgMetadataUtil.getNameForReversal(edgesNames.getFirst()))
        .addArc(Arc.createBuilder()
            .setSource(loopFixes.getFirst())
            .setTarget(loopFixes.getSecond())
            .setId(edgesNames.getSecond())
            .setLength(length)

```

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```

        ).withReversal(MgMetadataUtil.getNameForReversal(edgesNames.getSecond()))
        .addArc(Arc.createBuilder()
            .setSource(loopFixes.getSecond())
            .setTarget(target)
            .setId(edgesNames.getThird())
            .setLength(length)
        ).withReversal(MgMetadataUtil.getNameForReversal(edgesNames.getThird())));
        name = edgesNames.getFirst();
    }

    return name;
}

private double fixLength(int length) {
    return length != 0 ? length : DoubleUtil.DELTA;
}

private Pair<Node, Node> fixSelfLoop(@NotNull String name, @NotNull Node source,
    @NotNull Node target) {
    var handlerNode1 = Node.createMultiEdgeHandler(MgMetadataUtil.
        getMultiedgeHandlerNodeName(name) + "_1", source, target);
    var handlerNode2 = Node.createMultiEdgeHandler(MgMetadataUtil.
        getMultiedgeHandlerNodeName(name) + "_2", source, target);
    return Pair.of(handlerNode1, handlerNode2);
}

private @NotNull List<MovingPoint> getPointsFromPlace(Ref<Integer> tokenId, TimedPlace
    place) {
    // TODO: in paper points should be at the beginning of arc, but it isn't intuitive
    return place.tokens().stream()
        .map(token -> new MovingPoint(MgMetadataUtil.getTokenName(tokenId), 0))
        .collect(Collectors.toList());
}

private void addLeads(@NotNull MetricGraph.MetricGraphBuilder builder,
    @NotNull TimedArcPetriNet petriNet,
    @NotNull Map<TimedTransition, Node> transitionNodes,
    @NotNull TapnPlacesArcs arcs,
    @NotNull Ref<Integer> tokenId) {
    for (TimedPlace place : petriNet.places()) {
        var outputArcs = arcs.getOutputArcs(place);
        var inputArcs = arcs.getInputArcs(place);
        if (!inputArcs.isEmpty() && outputArcs.isEmpty()) {
            for (TimedOutputArc inputArc : inputArcs) {
                var node = transitionNodes.get(inputArc.source());
                var leadName = MgMetadataUtil.getLeadName(inputArc);
                var infinity = Node.createInfinity(MgMetadataUtil.getInfName(inputArc));
                builder
                    .addNode(infinity)
                    .addArc(Arc.createBuilder()
                        .setSource(node)

```

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```

        .setTarget(infinity)
        .setLength(Double.POSITIVE_INFINITY)
        .setId(leadName)
        .createArc()
    )
    .withReversal(MgMetadataUtil.getNameForReversal(leadName));
}
}
if (inputArcs.isEmpty() && !outputArcs.isEmpty()) {
    for (TimedInputArc outputArc : outputArcs) {
        var node = transitionNodes.get(outputArc.destination());
        var leadName = MgMetadataUtil.getLeadName(outputArc);
        var infinity = Node.createInfinity(MgMetadataUtil.getInfName(outputArc));
        builder
            .addNode(infinity)
            .addArc(Arc.createBuilder()
                .setId(leadName)
                .setSource(infinity)
                .setTarget(node)
                .setLength(Double.POSITIVE_INFINITY)
                .setPoints(getPointsFromInputArc(tokenId, outputArc))
                .createArc()
            )
            .withReversal(MgMetadataUtil.getNameForReversal(leadName));
    }
}
}
}

private @NotNull List<MovingPoint> getPointsFromInputArc(Ref<Integer> tokenId,
    TimedInputArc arc) {
    return arc.source().tokens().stream()
        .map(token -> new MovingPoint(MgMetadataUtil.getTokenName(tokenId), arc.interval().
            upperBound().value()))
        .collect(Collectors.toList());
}

private static void assertTransition(@NotNull TimedTransition transition) {
    if (transition.isUrgent()) {
        throw new TimedArcPetriNetToMetricGraphConversionException(
            String.format("Transition_%s_must_be_non-urgent", transition.name())
        );
    }
}
}
}
}

```

1.13. MinMax.java

```
package com.github.zinoviy23.tapnToMg.converters.mgToTapn;
```

```
final class MinMax {
    static final MinMax NEUTRAL = new MinMax(Double.POSITIVE_INFINITY, Double.
```

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```
        NEGATIVE_INFINITY);  
double min;  
double max;  
  
MinMax(double min, double max) {  
    this.min = min;  
    this.max = max;  
}  
  
static MinMax reduce(MinMax minMax, double d) {  
    return new MinMax(Math.min(minMax.min, d), Math.max(minMax.max, d));  
}  
  
static MinMax combine(MinMax a, MinMax b) {  
    return new MinMax(Math.min(a.min, b.min), Math.max(a.max, b.max));  
}  
  
double avg() {  
    return (min + max) / 2;  
}  
}
```

1.14. MetricGraphToTimedArcPetriNetConverter.java

```
package com.github.zinoviy23.tapnToMg.converters.mgToTapn;  
  
import com.github.zinoviy23.metricGraphs.Arc;  
import com.github.zinoviy23.metricGraphs.MetricGraph;  
import com.github.zinoviy23.metricGraphs.MovingPoint;  
import com.github.zinoviy23.metricGraphs.Node;  
import com.github.zinoviy23.tapnToMg.converters.Converter;  
import dk.aau.cs.model.tapn.*;  
import org.jetbrains.annotations.NotNull;  
import org.jgrapht.Graph;  
import org.jgrapht.graph.SimpleDirectedWeightedGraph;  
  
import java.math.BigDecimal;  
import java.util.ArrayList;  
import java.util.HashMap;  
import java.util.Map;  
  
public final class MetricGraphToTimedArcPetriNetConverter implements Converter<MetricGraph  
    , ConvertedTimedArcPetriNet> {  
    @Override  
    public @NotNull ConvertedTimedArcPetriNet convert(@NotNull MetricGraph graph) {  
        var petriNet = new TimedArcPetriNet(TapnNamingUtil.getTapnName(graph.getId()));  
  
        var layoutGraph = new SimpleDirectedWeightedGraph<>(null, null);  
        var mapping = addPlacesForEachArc(graph, petriNet, layoutGraph);  
  
        for (Arc arc : graph.getGraph().edgeSet()) {  
            processArc(graph, arc, petriNet, mapping, layoutGraph);  
        }  
    }  
}
```

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```

}

var result = new TimedArcPetriNetNetwork();
result.add(petriNet);

var layoutMaker = new TapnLayoutMaker(graph.getId(), layoutGraph);

return new ConvertedTimedArcPetriNet(result, petriNet, layoutMaker.createDataLayer());
}

private @NotNull Map<Arc, TimedPlace> addPlacesForEachArc(@NotNull MetricGraph graph,
                                                         @NotNull TimedArcPetriNet petriNet,
                                                         @NotNull Graph<Object, Object>
                                                         layoutGraph) {
    var arcToPlaceMapping = new HashMap<Arc, TimedPlace>();
    for (Arc arc : graph.getGraph().edgeSet()) {
        if (Node.isInfinity(arc.getSource())) continue;

        var placeSourceTarget = new LocalTimedPlace(TapnNamingUtil.nameForPlace(arc));
        arcToPlaceMapping.put(arc, placeSourceTarget);
        petriNet.add(placeSourceTarget);
        layoutGraph.addVertex(placeSourceTarget);

        //TODO: tokens cannot be serialized
        arc.getPoints().stream()
            .map(point -> new TimedToken(placeSourceTarget, BigDecimal.valueOf(point.
                getPosition())))
            .forEach(placeSourceTarget::addToken);
    }

    return arcToPlaceMapping;
}

private void processArc(@NotNull MetricGraph graph,
                       @NotNull Arc arc,
                       @NotNull TimedArcPetriNet petriNet,
                       @NotNull Map<Arc, TimedPlace> mapping,
                       @NotNull SimpleDirectedWeightedGraph<Object, Object> graphToDraw) {
    if (Node.isInfinity(arc.getSource())) {
        handleInfinity(graph, arc, petriNet, mapping, graphToDraw);
        return;
    }

    var placeSourceTarget = mapping.get(arc);

    //TODO make rational
    var timedTransition = new TimedTransition(TapnNamingUtil.nameForTransition(arc), false
    );
    var arcLength = new IntBound(Double.isInfinite(arc.getLength()) ? 0 : (int) arc.
        getLength());
    var timedInputArc = new TimedInputArc(placeSourceTarget, timedTransition,

```

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        new TimeInterval(
            true, arcLength, arcLength.copy(), true
        )
    );
    petriNet.add(timedTransition);
    petriNet.add(timedInputArc);

    graphToDraw.addVertex(timedTransition);
    graphToDraw.addEdge(placeSourceTarget, timedTransition, timedInputArc);

    addArcForNeighbours(graph, arc, petriNet, mapping, graphToDraw, timedTransition);

    var collapsingTransition = new TimedTransition(TapnNamingUtil.
        nameForCollapsingTransition(arc), false);
    var collapsingInputArc = new TimedInputArc(placeSourceTarget, collapsingTransition,
        new TimeInterval(
            true, new IntBound(0), new IntBound(0), true
        ),
        new IntWeight(2)
    );

    var collapsingOutputArc = new TimedOutputArc(collapsingTransition, placeSourceTarget);

    petriNet.add(collapsingTransition);
    petriNet.add(collapsingInputArc);
    petriNet.add(collapsingOutputArc);

    graphToDraw.addVertex(collapsingTransition);
    graphToDraw.addEdge(placeSourceTarget, collapsingTransition, collapsingInputArc);
    graphToDraw.setEdgeWeight(collapsingInputArc, 2);
    graphToDraw.addEdge(collapsingTransition, placeSourceTarget, collapsingOutputArc);
}

private void addArcForNeighbours(@NotNull MetricGraph graph,
                                @NotNull Arc arc,
                                @NotNull TimedArcPetriNet petriNet,
                                @NotNull Map<Arc, TimedPlace> mapping,
                                @NotNull SimpleDirectedWeightedGraph<Object, Object>
                                    graphToDraw,
                                @NotNull TimedTransition timedTransition) {
    if (!Node.isInfinity(arc.getTarget())) {
        for (Arc outgoingArc : graph.getGraph().outgoingEdgesOf(arc.getTarget())) {
            var destination = mapping.get(outgoingArc);
            var timedOutputArc = new TimedOutputArc(timedTransition, destination);
            petriNet.add(timedOutputArc);
            graphToDraw.addEdge(timedTransition, destination, timedOutputArc);
        }
    }
}

private void handleInfinity(@NotNull MetricGraph graph,

```

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```

        @NotNull Arc arc,
        @NotNull TimedArcPetriNet petriNet,
        @NotNull Map<Arc, TimedPlace> mapping,
        @NotNull SimpleDirectedWeightedGraph<Object, Object>
            graphToDraw) {
    if (arc.getPoints().isEmpty()) {
        return;
    }

    var timedTransition = new TimedTransition(TapnNamingUtil.nameForTransition(arc), false
    );
    petriNet.add(timedTransition);
    var name = TapnNamingUtil.nameForPlace(arc);
    var arcs = new ArrayList<TimedInputArc>();
    for (MovingPoint point : arc.getPoints()) {
        var placeName = TapnNamingUtil.nameForInfinitePlace(name, point);
        var place = new LocalTimedPlace(placeName);
        var length = (int) point.getPosition();
        var inputArc = new TimedInputArc(place, timedTransition, new TimeInterval(
            true, new IntBound(length), new IntBound(length), true
        ));
        petriNet.add(place);
        var token = new TimedToken(place);
        place.addToken(token);
        petriNet.add(inputArc);
        graphToDraw.addVertex(place);
        arcs.add(inputArc);
    }

    graphToDraw.addVertex(timedTransition);
    for (TimedInputArc timedInputArc : arcs) {
        graphToDraw.addEdge(timedInputArc.source(), timedInputArc.destination(),
            timedInputArc);
    }

    addArcForNeighbours(graph, arc, petriNet, mapping, graphToDraw, timedTransition);
}
}

```

1.15. TapnNamingUtil.java

```

package com.github.zinoviy23.tapnToMg.converters.mgToTapn;

import com.github.zinoviy23.metricGraphs.Arc;
import com.github.zinoviy23.metricGraphs.MovingPoint;
import org.jetbrains.annotations.NotNull;

final class TapnNamingUtil {
    private TapnNamingUtil() {
    }

    static @NotNull String getTapnName(@NotNull String id) {

```

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```

    return "TAPN_" + id;
}

static @NotNull String nameForPlace(@NotNull Arc arc) {
    return "p_" + arc.getId();
}

static @NotNull String nameForTransition(@NotNull Arc arc) {
    return "t_" + arc.getId();
}

static @NotNull String nameForCollapsingTransition(@NotNull Arc arc) {
    return "ct_" + arc.getId();
}

static @NotNull String nameForInfinitePlace(@NotNull String name, @NotNull MovingPoint
    point) {
    return name + "_" + point.getId();
}
}

```

1.16. ConvertedTimedArcPetriNet.java

```

package com.github.zinoviy23.tapnToMg.converters.mgToTapn;

import dk.aau.cs.model.tapn.TimedArcPetriNet;
import dk.aau.cs.model.tapn.TimedArcPetriNetNetwork;
import org.jetbrains.annotations.NotNull;
import pipe.dataLayer.DataLayer;
import pipe.dataLayer.Template;

public final class ConvertedTimedArcPetriNet {
    private final TimedArcPetriNetNetwork network;
    private final Template template;

    public ConvertedTimedArcPetriNet(@NotNull TimedArcPetriNetNetwork network,
                                     @NotNull TimedArcPetriNet petriNet,
                                     @NotNull DataLayer dataLayer) {
        this.network = network;
        this.template = new Template(petriNet, dataLayer, null);
    }

    public TimedArcPetriNetNetwork getNetwork() {
        return network;
    }

    public Template getTemplate() {
        return template;
    }
}

```

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1.17. TapnLayoutMaker.java

```

package com.github.zinoviy23.tapnToMg.converters.mgToTapn;

import com.github.zinoviy23.metricGraphs.util.GraphLayout;
import dk.aau.cs.model.tapn.TimedInputArc;
import dk.aau.cs.model.tapn.TimedOutputArc;
import dk.aau.cs.model.tapn.TimedPlace;
import dk.aau.cs.model.tapn.TimedTransition;
import org.jetbrains.annotations.NotNull;
import org.jgrapht.Graph;
import org.jgrapht.alg.drawing.FRLayoutAlgorithm2D;
import org.jgrapht.alg.drawing.IndexedFRLayoutAlgorithm2D;
import org.jgrapht.alg.drawing.model.Box2D;
import org.jgrapht.alg.drawing.model.LayoutModel2D;
import org.jgrapht.alg.drawing.model.MapLayoutModel2D;
import pipe.dataLayer.DataLayer;
import pipe.gui.graphicElements.AnnotationNote;
import pipe.gui.graphicElements.PetriNetObject;
import pipe.gui.graphicElements.PlaceTransitionObject;
import pipe.gui.graphicElements.tapn.TimedInputArcComponent;
import pipe.gui.graphicElements.tapn.TimedOutputArcComponent;
import pipe.gui.graphicElements.tapn.TimedPlaceComponent;
import pipe.gui.graphicElements.tapn.TimedTransitionComponent;

import java.util.HashMap;
import java.util.Map;
import java.util.Random;

final class TapnLayoutMaker {
    public static final int ITERATIONS = 200;
    private static final double X_OFFSET = 100;
    private static final double Y_OFFSET = 100;
    private static final int NOTE_OFFSET = 50;
    private static final String HEADER = "'%s' - Timed Arc Petri Net automatically generated
        from Dynamic Metric Graph '%s'";
    private static final String DESCRIPTION_TEXT = "Places p_* - generated from
        corresponding arc in metric graph\n" +
        "Transitions t_* - generated from corresponding arc in metric graph\n" +
        "Transitions ct_* - generated for simulated collapsing of two points on corresponding
        arc.";
    private static final int NOTE_WIDTH = 500;
    private static final int NODE_HEIGHT = 200;
    private static final int VERTEX_SIZE = 130;
    private static final int SIZE_OFFSET = 300;

    private final String graphId;
    private final Graph<Object, Object> graph;
    private final LayoutModel2D<Object> layoutModel;

    private final Map<Object, PlaceTransitionObject> visualComponents = new HashMap<>();

```

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```

TapnLayoutMaker(@NotNull String graphId, @NotNull Graph<Object, Object> graph) {
    this.graphId = graphId;
    this.graph = graph;
    layoutModel = new GraphLayout().createLayout(graph, VERTEX_SIZE, SIZE_OFFSET);
}

private static String getTextFromId(@NotNull String id) {
    return String.format(HEADER, TapnNamingUtil.getTapnName(id), id) + "\n" +
        DESCRIPTION_TEXT;
}

public @NotNull DataLayer createDataLayer() {
    var dataLayer = new DataLayer();

    for (Object vertex : graph.vertexSet()) {
        dataLayer.addPetriNetObject(createPetriNetObject(vertex, layoutModel));
    }

    for (Object edge : graph.edgeSet()) {
        dataLayer.addPetriNetObject(createPetriNetObject(edge, layoutModel));
    }

    AnnotationNote note = createNote();
    dataLayer.addPetriNetObject(note);

    return dataLayer;
}

private @NotNull AnnotationNote createNote() {
    var maxX = (int) visualComponents.values().stream()
        .mapToDouble(PlaceTransitionObject::getPositionX)
        .max()
        .orElse(0) + NOTE_OFFSET;
    var maxY = (int) visualComponents.values().stream()
        .map(PlaceTransitionObject::getPositionY)
        .reduce(MinMax.NEUTRAL, MinMax::reduce, MinMax::combine)
        .avg();
    return new AnnotationNote(
        getTextFromId(graphId),
        maxX,
        maxY,
        NOTE_WIDTH,
        NODE_HEIGHT,
        true,
        true
    );
}

private @NotNull PetriNetObject createPetriNetObject(@NotNull Object object,
    @NotNull LayoutModel2D<Object> model) {

```

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```

if (object instanceof TimedPlace) {
    var point2D = model.get(object);
    var timedPlaceComponent = new TimedPlaceComponent(
        point2D.getX() + X_OFFSET,
        point2D.getY() + Y_OFFSET,
        (TimedPlace) object
    );
    visualComponents.put(object, timedPlaceComponent);
    return timedPlaceComponent;
}

if (object instanceof TimedTransition) {
    var point2D = model.get(object);
    var timedTransitionComponent = new TimedTransitionComponent(
        point2D.getX() + X_OFFSET,
        point2D.getY() + Y_OFFSET,
        (TimedTransition) object
    );
    visualComponents.put(object, timedTransitionComponent);
    return timedTransitionComponent;
}

if (object instanceof TimedInputArc) {
    var source = visualComponents.get(((TimedInputArc) object).source());
    var target = visualComponents.get(((TimedInputArc) object).destination());

    var arc = new TimedOutputArcComponent(
        source.getPositionX() + X_OFFSET,
        source.getPositionY() + Y_OFFSET,
        target.getPositionX() + X_OFFSET,
        target.getPositionY() + Y_OFFSET,
        source,
        target,
        0,
        "arc",
        false
    );
    var resultArc = new TimedInputArcComponent(arc);
    resultArc.setUnderlyingArc((TimedInputArc) object);

    return resultArc;
}

if (object instanceof TimedOutputArc) {
    var source = visualComponents.get(((TimedOutputArc) object).source());
    var target = visualComponents.get(((TimedOutputArc) object).destination());

    var arc = new TimedOutputArcComponent(
        source.getPositionX() + X_OFFSET,
        source.getPositionY() + Y_OFFSET,
        target.getPositionX() + X_OFFSET,

```

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```

        target.getPositionY() + Y_OFFSET,
        source,
        target,
        0,
        "arc",
        false
    );
    arc.setUnderlyingArc((TimedOutputArc) object);

    return arc;
}

throw new AssertionError("Cannot be here");
}
}

```

1.18. ExtendedTapaal.java

```

package com.github.zinoviy23.tapaal.extended;

import com.github.zinoviy23.tapaal.extensions.ExtensionManager;
import net.tapaal.TAPAAL;

import java.io.IOException;
import java.io.InputStream;
import java.util.Map;
import java.util.Properties;
import java.util.regex.Pattern;

public class ExtendedTapaal {
    private static final Pattern extensionPattern = Pattern.compile("(.)\\.\\.\\.\\d+");

    public static void main(String[] args) {
        initializeExtensionPoints();
        initializeExtensions();
        TAPAAL.main(args);
    }

    private static void initializeExtensionPoints() {
        try (InputStream config = TAPAAL.class.getResourceAsStream("/resources/Plugins/tapaal.
            ext.properties")) {
            Properties properties = new Properties();
            properties.load(config);
            addExtensionPoints(properties);
        } catch (IOException | ClassNotFoundException e) {
            e.printStackTrace();
        }
    }

    private static void addExtensionPoints(Properties properties) throws
        ClassNotFoundException {
        ExtensionManager instance = ExtensionManager.getInstance();
    }

```

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```

    for (Map.Entry<Object, Object> extensionPoint : properties.entrySet()) {
        Class<?> extensionInterface = Class.forName((String) extensionPoint.getValue());
        instance.registerExtensionPoint((String) extensionPoint.getKey(), extensionInterface)
        ;
    }
}

private static void initializeExtensions() {
    try (InputStream config = TAPAAL.class.getResourceAsStream("/extensions.properties"))
    {
        Properties properties = new Properties();
        properties.load(config);
        addExtensions(properties);
    } catch (IOException | ClassNotFoundException e) {
        e.printStackTrace();
    }
}

private static void addExtensions(Properties properties) throws ClassNotFoundException {
    ExtensionManager instance = ExtensionManager.getInstance();
    for (Map.Entry<Object, Object> extension : properties.entrySet()) {
        Class<?> extensionInterface = Class.forName((String) extension.getValue());
        String key;
        var matcher = extensionPattern.matcher((String) extension.getKey());
        if (matcher.matches()) {
            key = matcher.group(1);
        } else {
            key = (String) extension.getKey();
        }
        instance.registerExtension(key, extensionInterface);
    }
}
}

```

1.19. MyGuiAction.java

```

package com.github.zinoviy23.tapaal.extended.extensions;

import pipe.gui.action.GuiAction;

import java.awt.event.ActionEvent;

public class MyGuiAction extends GuiAction {
    public MyGuiAction() {
        super("kek", "lol");
    }

    @Override
    public void actionPerformed(ActionEvent e) {
        System.out.println("clicked");
    }
}

```

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1.20. ConvertTapnToJsonMgAction.java

```
package com.github.zinoviy23.tapaal.extended.extensions;

import com.github.zinoviy23.metricGraphs.MetricGraph;
import com.github.zinoviy23.metricGraphs.io.MetricGraphJsonWriter;
import pipe.gui.CreateGui;

import javax.swing.*;
import java.io.*;

public class ConvertTapnToJsonMgAction extends ConvertTapnToMgAction {
    public ConvertTapnToJsonMgAction() {
        super("Convert_то_Json_Metric_Graph", "Convert_сurrent_Timed_Arc_Petri_Net_то_Metric_Graph_in_JSON_format");
    }

    @Override
    protected String getFileExt() {
        return "json";
    }

    @Override
    protected boolean save(MetricGraph graph, String path) {
        try (var writer = new FileWriter(path); MetricGraphJsonWriter gw = new MetricGraphJsonWriter(writer, true)) {
            gw.write(graph);
            return true;
        } catch (IOException e) {
            JOptionPane.showMessageDialog(CreateGui.getAppGui(), e.getMessage(), "Error",
                JOptionPane.ERROR_MESSAGE);
        }

        return false;
    }
}
```

1.21. ConvertTapnToYedMgAction.java

```
package com.github.zinoviy23.tapaal.extended.extensions;

import com.github.zinoviy23.metricGraphs.MetricGraph;
import com.github.zinoviy23.metricGraphs.io.graphml.MetricGraphYedWriter;
import pipe.gui.CreateGui;

import javax.swing.*;
import java.io.*;

public class ConvertTapnToYedMgAction extends ConvertTapnToMgAction {
    public ConvertTapnToYedMgAction() {
```

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```

        super("Convert_to_YEd_Metric_Graph", "Convert_current_Timed_Arc_Petri_Net_to_Metric_Graph_in_YEd_format");
    }

    @Override
    protected String getFileExt() {
        return "graphml";
    }

    @Override
    protected boolean save(MetricGraph graph, String path) {
        try (var fileWriter = new FileWriter(path); var graphWriter = new MetricGraphYedWriter(
            fileWriter, true)) {
            graphWriter.write(graph);
            return true;
        } catch (IOException e) {
            JOptionPane.showMessageDialog(CreateGui.getAppGui(), e.getMessage(), "Error",
                JOptionPane.ERROR_MESSAGE);
        }
        return false;
    }
}

```

1.22. ConvertTapnToMgAction.java

```

package com.github.zinoviy23.tapaal.extended.extensions;

import com.github.zinoviy23.metricGraphs.MetricGraph;
import com.github.zinoviy23.metricGraphs.util.ContainerUtil;
import com.github.zinoviy23.tapnToMg.converters.tapnToMg.
    TimedArcPetriNetToMetricGraphConversionException;
import com.github.zinoviy23.tapnToMg.converters.tapnToMg.
    TimedArcPetriNetToMetricGraphConverter;
import pipe.gui.CreateGui;
import pipe.gui.action.GuiAction;
import pipe.gui.widgets.filebrowser.FileBrowser;

import javax.swing.*;
import java.awt.event.ActionEvent;

public abstract class ConvertTapnToMgAction extends GuiAction {
    protected ConvertTapnToMgAction(String name, String tooltip) {
        super(name, tooltip);
    }

    protected abstract String getFileExt();

    @Override
    public void actionPerformed(ActionEvent e) {
        if (CreateGui.getAppGui().getSelectedTabIndex() < 0) {
            return;
        }
    }
}

```

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```

var currentTab = CreateGui.getCurrentTab();

var path = FileBrowser.constructor("Metric_Graph", getFileExt(), FileBrowser.userPath)
    .saveFile("graph");

SwingWorker<Void, Void> worker = new SwingWorker<>() {
    @Override
    protected Void doInBackground() {
        var network = currentTab.network();
        if (network.allTemplates().size() > 1) {
            JOptionPane.showMessageDialog(CreateGui.getAppGui(), "There_is_too_may_templates.
                _Will_use_only_first", "Warning", JOptionPane.WARNING_MESSAGE);
        }
        var net = ContainerUtil.first(network.allTemplates());
        if (net == null) {
            JOptionPane.showMessageDialog(CreateGui.getAppGui(), "There_isn't_any_template_in
                _network!", "Error", JOptionPane.ERROR_MESSAGE);
            return null;
        }

        var converter = new TimedArcPetriNetToMetricGraphConverter();
        try {
            var graph = converter.convert(net);
            if (save(graph, path)) {
                JOptionPane.showMessageDialog(CreateGui.getAppGui(), "Graph_saved!");
            }
        } catch (TimedArcPetriNetToMetricGraphConversionException e) {
            JOptionPane.showMessageDialog(CreateGui.getAppGui(), e.getMessage(), "Error",
                JOptionPane.ERROR_MESSAGE);
            return null;
        }
        return null;
    }
};

worker.execute();
}

```

```

protected abstract boolean save(MetricGraph graph, String path);
}

```

1.23. ConvertMgToTapnAction.java

```

package com.github.zinoviy23.tapaal.extended.extensions;

import com.github.zinoviy23.tapnToMg.converters.ConversionException;
import com.github.zinoviy23.tapnToMg.converters.ConvertersFactory;
import pipe.gui.CreateGui;
import pipe.gui.action.GuiAction;
import pipe.gui.widgets.filebrowser.FileBrowser;

import javax.swing.*;

```

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```
import java.awt.*;
import java.awt.event.ActionEvent;

public class ConvertMgToTapnAction extends GuiAction {
    public ConvertMgToTapnAction() {
        super("Convert от Metric Graph", "Open Metric Graph file as Timed Arc Petri Net");
    }

    @Override
    public void actionPerformed(ActionEvent event) {
        var mgFile = FileBrowser.constructor("Metric Graph", "json", FileBrowser.userPath).
            openFile();
        var converter = ConvertersFactory.createMetricGraphToTimedArcPetriNetConverter();

        CreateGui.getAppGui().setCursor(Cursor.getPredefinedCursor(Cursor.WAIT_CURSOR));
        SwingWorker<Void, Void> worker = new SwingWorker<>() {
            @Override
            protected Void doInBackground() throws Exception {
                try {
                    var resultFile = converter.apply(mgFile);
                    FileBrowser.userPath = mgFile.getParent();
                    CreateGui.getAppGui().createNewTabFromFile(resultFile);
                } catch (ConversionException e) {
                    JOptionPane.showMessageDialog(CreateGui.getAppGui(), e.getCause().getMessage(), "
                        Error", JOptionPane.ERROR_MESSAGE);
                }
                return null;
            }
        };

        @Override
        protected void done() {
            try {
                CreateGui.getAppGui().setCursor(Cursor.getPredefinedCursor(Cursor.DEFAULT_CURSOR));
                get();
                JOptionPane.showMessageDialog(CreateGui.getAppGui(), "For save TAPN use Save as
                    action");
            } catch (Exception e) {
                JOptionPane.showMessageDialog(CreateGui.getAppGui(),
                    e.getMessage(),
                    "Error loading file",
                    JOptionPane.ERROR_MESSAGE);
            }
        }
    };

    worker.execute();
}
```

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1.24. Node.java

```
package com.github.zinoviy23.metricGraphs;

import com.github.zinoviy23.metricGraphs.api.Identity;
import com.github.zinoviy23.metricGraphs.api.ObjectWithComment;
import org.jetbrains.annotations.Contract;
import org.jetbrains.annotations.NotNull;
import org.jetbrains.annotations.Nullable;

import java.util.Objects;

public abstract class Node implements Identity, ObjectWithComment {
    public static final String INFINITY_NODE_LABEL = "Infinity_node";
    private final String id;
    private final String label;
    private final String comment;

    private Node(@NotNull String id) {
        this(id, id);
    }

    private Node(@NotNull String id, @Nullable String label) {
        this(id, label, null);
    }

    private Node(@NotNull String id, @Nullable String label, @Nullable String comment) {
        this.id = Objects.requireNonNull(id, "id");
        this.label = Objects.requireNonNull(label, "label");
        this.comment = comment;
    }

    @Contract("_->_new")
    public static @NotNull Node createNode(@NotNull String id) {
        return new NodeImpl(id);
    }

    @Contract("_, _->_new")
    public static @NotNull Node createNode(@NotNull String id, @Nullable String label) {
        return new NodeImpl(id, label);
    }

    @Contract("_, _, _->_new")
    public static @NotNull Node createNode(@NotNull String id, @Nullable String label,
        @Nullable String comment) {
        return new NodeImpl(id, label, comment);
    }

    @Contract("_->_new")
    public static @NotNull Node createInfinity(@NotNull String id) {
        return new InfinityNode(id);
    }
}
```

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```

}

public static @NotNull Node createMultiEdgeHandler(@NotNull String id, @NotNull Node
    source, @NotNull Node target) {
    return new MultiEdgeHandleNode(id, source, target);
}

@Override
public @NotNull String getId() {
    return id;
}

public @NotNull String getLabel() {
    return label;
}

@Override
public @Nullable String getComment() {
    return comment;
}

@Override
public boolean equals(Object o) {
    if (this == o) return true;
    if (o == null || getClass() != o.getClass()) return false;
    Node node = (Node) o;
    return id.equals(node.id);
}

@Override
public int hashCode() {
    return Objects.hash(id);
}

@Override
public String toString() {
    return "Node{" +
        "id='" + id + '\'' +
        ", label='" + label + '\'' +
        '}';
}

public static boolean isInfinity(@Nullable Node node) {
    return node instanceof InfinityNode;
}

static class NodeImpl extends Node {
    private NodeImpl(@NotNull String id) {
        super(id);
    }

    private NodeImpl(@NotNull String id, @Nullable String label) {

```

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```

        super(id, label);
    }

    private NodeImpl(@NotNull String id, @Nullable String label, @Nullable String comment)
    {
        super(id, label, comment);
    }
}

static class InfinityNode extends Node {
    private InfinityNode(@NotNull String id) {
        super(id, INFINITY_NODE_LABEL, "This_node_placed_on_infinity_distance_from_graph.");
    }
}

static class MultiEdgeHandleNode extends Node {
    private MultiEdgeHandleNode(@NotNull String id, @NotNull Node source, @NotNull Node
        target) {
        super(id, id, "Handles_multiedges_between_" + source.getId() + "and_" + target.getId
            ());
    }
}
}

```

1.25. MetricGraphStructureException.java

```

package com.github.zinoviy23.metricGraphs;

public class MetricGraphStructureException extends RuntimeException {
    public MetricGraphStructureException(String message) {
        super(message);
    }

    public MetricGraphStructureException(String message, Throwable cause) {
        super(message, cause);
    }
}

```

1.26. MovingPoint.java

```

package com.github.zinoviy23.metricGraphs;

import com.github.zinoviy23.metricGraphs.api.Identity;
import com.github.zinoviy23.metricGraphs.api.ObjectWithComment;
import org.jetbrains.annotations.NotNull;
import org.jetbrains.annotations.Nullable;

import java.util.Objects;

public final class MovingPoint implements Identity, ObjectWithComment {
    private final String id;
    private final double position;
}

```

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```

private final String comment;

public MovingPoint(@NotNull String id, double position) {
    this(id, position, null);
}

public MovingPoint(@NotNull String id, double position, @Nullable String comment) {
    this.id = Objects.requireNonNull(id, "id");
    this.position = position;
    this.comment = comment;
}

@Override
public @NotNull String getId() {
    return id;
}

public double getPosition() {
    return position;
}

@Override
public @Nullable String getComment() {
    return comment;
}

@Override
public boolean equals(Object o) {
    if (this == o) return true;
    if (o == null || getClass() != o.getClass()) return false;
    MovingPoint movingPoint = (MovingPoint) o;
    return id.equals(movingPoint.id);
}

@Override
public int hashCode() {
    return Objects.hash(id);
}

@Override
public String toString() {
    return "MovingPoint{" +
        "id='" + id + '\'' +
        ", position=" + position +
        '}';
}
}

```

1.27. Arc.java

```
package com.github.zinoviy23.metricGraphs;
```

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```

import com.github.zinoviy23.metricGraphs.api.Identity;
import com.github.zinoviy23.metricGraphs.api.ObjectWithComment;
import org.jetbrains.annotations.Contract;
import org.jetbrains.annotations.NotNull;
import org.jetbrains.annotations.Nullable;

import java.util.ArrayList;
import java.util.Collections;
import java.util.List;
import java.util.Objects;

import static com.github.zinoviy23.metricGraphs.util.ObjectUtil.*;

public final class Arc implements Identity, ObjectWithComment {
    private static final String POINT_MUST_BE_ON_ARC_ERROR = "Point_%s isn't on arc. [0, %f] is not contains it";
    private static final String POINT_ID_ALREADY_ASSIGNED_TO_NODE = "Points_id_%s already assigned to node";

    private final String id;
    private final String label;
    private final Node source;
    private final Node target;
    private final String comment;
    private final double length;
    private final List<MovingPoint> points;
    private final boolean distanceToTarget;

    private Arc(@NotNull String id,
                @Nullable String label,
                @NotNull Node source,
                @NotNull Node target,
                @Nullable String comment,
                double length,
                @NotNull List<MovingPoint> points) {
        this.id = Objects.requireNonNull(id, "id");
        this.label = Objects.requireNonNullElse(label, id);
        this.source = Objects.requireNonNull(source, "source");
        this.target = Objects.requireNonNull(target, "target");
        this.comment = comment;
        this.length = length;
        this.points = List.copyOf(checkPointsOnArc(length, Objects.requireNonNull(points, "points")));

        if (Node.isInfinity(source) && Node.isInfinity(target)) {
            throw new MetricGraphStructureException(String.format("%s and %s both are infinity nodes", source, target));
        }

        distanceToTarget = Node.isInfinity(source);
    }

```

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```

@Contract(value = "↪new", pure = true)
public static @NotNull ArcBuilder createBuilder() {
    return new ArcBuilderImpl();
}

private static double verifyLength(double length) {
    if (length <= 0) throw new MetricGraphStructureException("length_must_be_greater_than_0");
    return length;
}

static @NotNull List<MovingPoint> checkPointsOnArc(double arcLength, @NotNull List<
    MovingPoint> points) {
    points.stream()
        .filter(point -> point.getPosition() < 0 || point.getPosition() > arcLength)
        .findAny()
        .ifPresent(point -> {
            throw new MetricGraphStructureException(String.format(POINT_MUST_BE_ON_ARC_ERROR,
                point, arcLength));
        });
    return points;
}

@Override
public @NotNull String getId() {
    return id;
}

public @NotNull String getLabel() {
    return label;
}

public @NotNull Node getSource() {
    return source;
}

public @NotNull Node getTarget() {
    return target;
}

@Override
public @Nullable String getComment() {
    return comment;
}

public double getLength() {
    return length;
}

public @NotNull List<MovingPoint> getPoints() {

```

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```

    return points;
}

/**
 * Direction for points movement. <br>
 * If this is true, it means that points positions are relative to arc's target, not
 * source. <br>
 * If this is false, which is regular situation, it means, that points positions are
 * relative to arc's source.
 * @return true, only if this arc is lead, with infinity source, otherwise false
 */
public boolean isDistanceToTarget() {
    return distanceToTarget;
}

@Override
public boolean equals(Object o) {
    if (this == o) return true;
    if (o == null || getClass() != o.getClass()) return false;
    Arc arc = (Arc) o;
    return id.equals(arc.id);
}

@Override
public int hashCode() {
    return Objects.hash(id);
}

@Override
public String toString() {
    return "Arc{" +
        "id='" + id + '\'' +
        ", label='" + label + '\'' +
        ", length=" + length +
        '}';
}

/**
 * Too support lazy creation of graphs and allow adding built arcs to graph builder
 * @return wrapper builder, that "builds" this arc
 */
@Contract("↪→↪new")
@NotNull ArcBuilder toBuilder() {
    return new ExactArcBuilder(this);
}

/**
 * Class, because currently java do not support sealed interfaces
 */
public abstract static class ArcBuilder implements Identity {
    private ArcBuilder() {

```

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```

}

public abstract @NotNull ArcBuilder setSource(@NotNull Node source);

public abstract @Nullable Node getSource();

public abstract @NotNull ArcBuilder setTarget(@NotNull Node target);

public abstract @Nullable Node getTarget();

public abstract @NotNull ArcBuilder setLength(double length);

public abstract @Nullable Double getLength();

public abstract @NotNull ArcBuilder addPoint(@NotNull MovingPoint point);

public abstract @NotNull Arc createArc();

public abstract @NotNull String getId();

public abstract @NotNull ArcBuilder setId(@NotNull String id);

public abstract @NotNull List<MovingPoint> getPoints();

public abstract @NotNull ArcBuilder setPoints(@NotNull List<MovingPoint> points);

public abstract @Nullable String getLabel();

public abstract @NotNull ArcBuilder setLabel(@Nullable String label);

public abstract @Nullable String getComment();

public abstract @NotNull ArcBuilder setComment(@Nullable String comment);

public abstract @NotNull ArcBuilder copy();

@Override
public final boolean equals(Object o) {
    if (this == o) return true;
    if (!(o instanceof ArcBuilder)) return false;
    ArcBuilder that = (ArcBuilder) o;
    return Objects.equals(getId(), that.getId());
}

@Override
public final int hashCode() {
    return Objects.hash(getId());
}

protected static @NotNull String makeString(@Nullable String id, @Nullable String
    label, @Nullable Double length) {

```

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```

    var beginning = "RawArc{";
    StringBuilder sb = new StringBuilder(beginning);
    if (id != null) {
        sb.append("id=").append(id).append(", ");
    }
    if (label != null) {
        sb.append("label=").append(label).append(", ");
    }
    if (length != null) {
        sb.append("length=").append(length).append(", ");
    }
    if (sb.length() != beginning.length()) {
        sb.delete(sb.length() - 2, sb.length());
    }

    return sb.append("}").toString();
}
}

private static final class ArcBuilderImpl extends ArcBuilder {
    private String id;
    private String label;
    private Node source;
    private Node target;
    private String comment;
    private Double length;
    private List<MovingPoint> points = new ArrayList<>();

    private ArcBuilderImpl() {
    }

    public @NotNull ArcBuilderImpl setSource(@NotNull Node source) {
        this.source = Objects.requireNonNull(source, "source");
        return this;
    }

    @Override
    public @Nullable Node getSource() {
        return source;
    }

    public @NotNull ArcBuilderImpl setTarget(@NotNull Node target) {
        this.target = Objects.requireNonNull(target, "target");
        return this;
    }

    @Override
    public @Nullable Node getTarget() {
        return target;
    }
}

```

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```

public @NotNull ArcBuilderImpl setLength(double length) {
    this.length = verifyLength(length);
    return this;
}

@Override
public @Nullable Double getLength() {
    return length;
}

public @NotNull ArcBuilderImpl addPoint(@NotNull MovingPoint point) {
    points.add(verifyPointId(Objects.requireNonNull(point, "point"), id));
    return this;
}

@Contract("_,->_new")
public @NotNull Arc createArc() {
    return new Arc(id, label, source, target, comment, Objects.requireNonNull(length, "length"), points);
}

private @NotNull MovingPoint verifyPointId(@NotNull MovingPoint movingPoint, @NotNull String id) {
    if (movingPoint.getId().equals(id)) {
        throw new MetricGraphStructureException(String.format(
            POINT_ID_ALREADY_ASSIGNED_TO_NODE, id));
    }
    return movingPoint;
}

public @NotNull String getId() {
    if (id != null) {
        return id;
    }

    throw new IllegalStateException("ArcBuilder has not id");
}

public @NotNull ArcBuilderImpl setId(@NotNull String id) {
    Objects.requireNonNull(id, "id");
    for (var point : points) {
        verifyPointId(point, id);
    }
    this.id = id;
    return this;
}

public @NotNull List<MovingPoint> getPoints() {
    return Collections.unmodifiableList(points);
}

```

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```

public @NotNull ArcBuilderImpl setPoints(@NotNull List<MovingPoint> points) {
    for (var point : Objects.requireNonNull(points, "points")) {
        verifyPointId(Objects.requireNonNull(point, "point_in_points"), id);
    }
    this.points = new ArrayList<>(points);
    return this;
}

public @Nullable String getLabel() {
    return label;
}

public @NotNull ArcBuilderImpl setLabel(@Nullable String label) {
    this.label = label;
    return this;
}

public @Nullable String getComment() {
    return comment;
}

public @NotNull ArcBuilderImpl setComment(@Nullable String comment) {
    this.comment = comment;
    return this;
}

@Override
public @NotNull ArcBuilder copy() {
    var builder = createBuilder();
    doIfNotNull(id, builder::setId);
    doIfNotNull(label, builder::setLabel);
    doIfNotNull(source, builder::setSource);
    doIfNotNull(target, builder::setTarget);
    doIfNotNull(length, builder::setLength);
    builder.setComment(comment);
    builder.setPoints(points);
    return builder;
}

@Override
public String toString() {
    return makeString(id, label, length);
}
}

private static final class ExactArcBuilder extends ArcBuilder {
    private final Arc arc;

    private ExactArcBuilder(Arc arc) {
        this.arc = arc;
    }
}

```

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```

@Override
public @NotNull ArcBuilder setSource(@NotNull Node source) {
    throw new UnsupportedOperationException();
}

@Override
public @NotNull Node getSource() {
    return arc.getSource();
}

@Override
public @NotNull ArcBuilder setTarget(@NotNull Node target) {
    throw new UnsupportedOperationException();
}

@Override
public @NotNull Node getTarget() {
    return arc.getTarget();
}

@Override
public @NotNull ArcBuilder setLength(double length) {
    throw new UnsupportedOperationException();
}

@Override
public @NotNull Double getLength() {
    return arc.getLength();
}

@Override
public @NotNull ArcBuilder addPoint(@NotNull MovingPoint point) {
    throw new UnsupportedOperationException();
}

@Override
public @NotNull Arc createArc() {
    return arc;
}

@Override
public @NotNull String getId() {
    return arc.getId();
}

@Override
public @NotNull ArcBuilder setId(@NotNull String id) {
    throw new UnsupportedOperationException();
}

```

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```

@Override
public @NotNull List<MovingPoint> getPoints() {
    return arc.getPoints();
}

@Override
public @NotNull ArcBuilder setPoints(@NotNull List<MovingPoint> points) {
    throw new UnsupportedOperationException();
}

@Override
public @NotNull String getLabel() {
    return arc.getLabel();
}

@Override
public @NotNull ArcBuilder setLabel(@Nullable String label) {
    throw new UnsupportedOperationException();
}

@Override
public @Nullable String getComment() {
    return arc.getComment();
}

@Override
public @NotNull ArcBuilder setComment(@Nullable String comment) {
    throw new UnsupportedOperationException();
}

/**
 * Do not create any new object, because it is immutable, so it can be shared
 * @return {@code this} instance
 */
@Override
public @NotNull ArcBuilder copy() {
    return this;
}

@Override
public String toString() {
    return makeString(arc.getId(), arc.getLabel(), arc.getLength());
}
}
}

```

1.28. MetricGraph.java

```

package com.github.zinoviy23.metricGraphs;

import com.github.zinoviy23.metricGraphs.api.Identity;
import com.github.zinoviy23.metricGraphs.api.ObjectWithComment;

```

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```

import com.github.zinoviy23.metricGraphs.util.DoubleUtil;
import org.jetbrains.annotations.Contract;
import org.jetbrains.annotations.NotNull;
import org.jetbrains.annotations.Nullable;
import org.jgrapht.Graph;
import org.jgrapht.graph.AsUnmodifiableGraph;
import org.jgrapht.graph.SimpleDirectedWeightedGraph;

import java.util.*;

public final class MetricGraph implements Identity, ObjectWithComment {
    private final String id;
    private final String label;
    private final String comment;
    private final Graph<Node, Arc> graph;
    private final Map<String, Identity> ids;

    private MetricGraph(@NotNull String id,
                        @Nullable String label,
                        @Nullable String comment,
                        @NotNull Graph<Node, Arc> graph,
                        @NotNull Map<String, Identity> ids) {
        this.id = Objects.requireNonNull(id, "id");
        this.comment = comment;
        this.label = Objects.requireNonNullElse(label, id);
        this.graph = Objects.requireNonNull(graph, "graph");
        this.ids = new HashMap<>(ids);
    }

    @Contract("┐->┐new")
    public static @NotNull MetricGraphBuilder createBuilder() {
        return new MetricGraphBuilder();
    }

    @Override
    public @NotNull String getId() {
        return id;
    }

    public @NotNull Graph<Node, Arc> getGraph() {
        return graph;
    }

    public @NotNull String getLabel() {
        return label;
    }

    @Override
    public @Nullable String getComment() {
        return comment;
    }
}

```

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```

public @Nullable Arc getReversal(@NotNull Arc arc) {
    Objects.requireNonNull(arc, "arc");

    return graph.getEdge(arc.getTarget(), arc.getSource());
}

public @Nullable Node getNode(@NotNull String id) {
    Objects.requireNonNull(id);

    var identity = ids.get(id);
    return identity instanceof Node ? ((Node) identity) : null;
}

public @Nullable Arc getArc(@NotNull String id) {
    Objects.requireNonNull(id);

    var identity = ids.get(id);
    return identity instanceof Arc ? ((Arc) identity) : null;
}

@Override
public boolean equals(Object o) {
    if (this == o) return true;
    if (o == null || getClass() != o.getClass()) return false;
    MetricGraph that = (MetricGraph) o;
    return id.equals(that.id);
}

@Override
public int hashCode() {
    return Objects.hash(id);
}

@Override
public String toString() {
    return "MetricGraph{" +
        "id='" + id + '\'' +
        '}';
}

public static final class MetricGraphBuilder {
    private static final String ALREADY_EXISTS_IN_GRAPH_MESSAGE = "already exists in graph";
    private static final String ID_ALREADY_EXISTS_MESSAGE = "Id %s already assigned to %s";
    ;

    private final Graph<Node, Arc.ArcBuilder> graph = new SimpleDirectedWeightedGraph<>(
        null, null);

    private final Map<MovingPoint, Arc.ArcBuilder> containingPoints = new HashMap<>();

```

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```

private final Map<String, Identity> ids = new HashMap<>();

private String id;
private String label;
private String comment;

private MetricGraphBuilder() {
}

@Contract(value = "□->□new", pure = true)
public @NotNull MetricGraph buildGraph() {
    var resultGraph = new SimpleDirectedWeightedGraph<Node, Arc>(null, null);
    for (Node node : graph.vertexSet()) {
        resultGraph.addVertex(node);
    }
    Map<String, Arc> arcIds = new HashMap<>();
    graph.edgeSet().stream()
        .map(Arc.ArcBuilder::createArc)
        .forEach(arc -> {
            resultGraph.addEdge(arc.getSource(), arc.getTarget(), arc);
            resultGraph.setEdgeWeight(arc, arc.getLength());
            arcIds.put(arc.getId(), arc);
        });
    var newIds = new HashMap<>(ids);
    newIds.putAll(arcIds);
    return new MetricGraph(id, label, comment, new AsUnmodifiableGraph<>(resultGraph),
        newIds);
}

public @NotNull MetricGraphBuilder addNode(@NotNull Node node) {
    verifyId(node);
    if (!graph.addVertex(Objects.requireNonNull(node, "node"))) {
        failAlreadyExists(node);
    }
    addId(node);
    return this;
}

public @NotNull ArcWithReversalBuilder addArc(@NotNull Arc.ArcBuilder arcBuilder) {
    Objects.requireNonNull(arcBuilder, "arcBuilder");
    return new ArcWithReversalBuilder(arcBuilder.copy());
}

public @NotNull ArcWithReversalBuilder addArc(@NotNull Arc arc) {
    Objects.requireNonNull(arc, "arc");
    return new ArcWithReversalBuilder(arc.toBuilder());
}

public @NotNull MetricGraphBuilder setLabel(@Nullable String label) {
    this.label = label;
    return this;
}

```

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```

}

public @NotNull MetricGraphBuilder setComment(@Nullable String comment) {
    this.comment = comment;
    return this;
}

public @NotNull MetricGraphBuilder setId(@NotNull String id) {
    Identity identity = new Identity() {
        @Override
        public @NotNull String getId() {
            return id;
        }

        @Override
        public String toString() {
            return "CURRENT_GRAPH";
        }
    };
    verifyId(identity);

    this.id = id;
    ids.put(id, identity);
    return this;
}

public @NotNull MetricGraphBuilder addPoints(@NotNull String arcId, @NotNull List<
    MovingPoint> points) {
    var arc = ids.get(arcId);
    if (!(arc instanceof Arc.ArcBuilder)) {
        throw new MetricGraphStructureException("Graph_is_not_contain_arc_with_id=" + arcId
        );
    }
    verifyPoints(((Arc.ArcBuilder) arc), points);
    //noinspection ConstantConditions verified while adding arc
    Arc.checkPointsOnArc(((Arc.ArcBuilder) arc).getLength(), points);
    for (MovingPoint point : points) {
        ((Arc.ArcBuilder) arc).addPoint(point);
    }
    addPoints(((Arc.ArcBuilder) arc), points);
    return this;
}

public boolean containsEdge(Node source, Node target) {
    return graph.containsEdge(source, target);
}

private void verifyPoints(@NotNull Arc.ArcBuilder arc, @NotNull List<MovingPoint>
    points) {
    for (var point : points) {
        verifyId(point);
    }
}

```

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```

        if (containingPoints.containsKey(point)) {
            throw new MetricGraphStructureException(point + ALREADY_EXISTS_IN_GRAPH_MESSAGE +
                id + "in node" + arc);
        }
    }
}

private void addPoints(@NotNull Arc.ArcBuilder arc, @NotNull List<MovingPoint> points)
{
    for (var point : points) {
        addId(point);
        containingPoints.put(point, arc);
    }
}

private void verifyId(@NotNull Identity identity) {
    if (ids.containsKey(identity.getId())) {
        throw new MetricGraphStructureException(
            String.format(ID_ALREADY_EXISTS_MESSAGE, identity.getId(), ids.get(identity.
                getId()))
        );
    }
}

private void addId(@NotNull Identity identity) {
    ids.put(identity.getId(), identity);
}

@Contract("_->fail")
private void failAlreadyExists(Object o) {
    throw new MetricGraphStructureException(o + ALREADY_EXISTS_IN_GRAPH_MESSAGE + id);
}

public class ArcWithReversalBuilder {
    private final Arc.ArcBuilder currentArc;

    private String comment;
    private String label;

    private ArcWithReversalBuilder(@NotNull Arc.ArcBuilder currentArc) {
        this.currentArc = currentArc;
        verifyArcBuilder(currentArc, "currentArc");
    }

    public @NotNull ArcWithReversalBuilder setReversalComment(@Nullable String comment) {
        this.comment = comment;
        return this;
    }

    public @NotNull ArcWithReversalBuilder setReversalLabel(@Nullable String label) {
        this.label = label;
    }
}

```

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```

    return this;
}

public @NotNull MetricGraphBuilder withReversal(@NotNull String id, MovingPoint
    @NotNull ... points) {
    return withReversal(id, List.of(points));
}

public @NotNull MetricGraphBuilder withReversal(@NotNull String id, @NotNull List<
    MovingPoint> points) {
    //noinspection ConstantConditions verified in class ctor
    return internalWithReversal(Arc.createBuilder()
        .setId(id)
        .setLength(currentArc.getLength())
        .setSource(currentArc.getTarget())
        .setTarget(currentArc.getSource())
        .setLabel(label)
        .setComment(comment)
        .setPoints(points)
    );
}

public @NotNull MetricGraphBuilder withReversal(@NotNull Arc reversalArc) {
    return withReversal(reversalArc.toBuilder());
}

public @NotNull MetricGraphBuilder withReversal(@NotNull Arc.ArcBuilder reversalArc)
{
    return internalWithReversal(reversalArc.copy());
}

private @NotNull MetricGraphBuilder internalWithReversal(@NotNull Arc.ArcBuilder
    reversalArc) {
    verifyArcBuilder(reversalArc, "reversalArc");

    //noinspection ConstantConditions verified in verifyArcBuilder and ctor
    if (!reversalArc.getTarget().equals(currentArc.getSource()) ||
        !reversalArc.getSource().equals(currentArc.getTarget())) {
        throw new MetricGraphStructureException(String.format("Reversal_of_%s_must_have_
            wrong_source=%s_and_target=%s",
                currentArc,
                reversalArc.getSource(),
                reversalArc.getTarget()
            ));
    }
}

verifyId(currentArc);
verifyPoints(currentArc, currentArc.getPoints());
verifyId(reversalArc);
verifyPoints(reversalArc, reversalArc.getPoints());

```

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```
//noinspection ConstantConditions verified in verifyArcBuilder and ctor
if (!DoubleUtil.equals(currentArc.getLength(), reversalArc.getLength())) {
    throw new MetricGraphStructureException(
        String.format("Reversal edge %s of %s must have length %f", reversalArc,
            currentArc, currentArc.getLength())
    );
}

if (currentArc.getId().equals(reversalArc.getId())) {
    throw new MetricGraphStructureException(String.format(ID_ALREADY_EXISTS_MESSAGE,
        currentArc.getId(), currentArc));
}

if (graph.containsEdge(currentArc) || graph.containsEdge(currentArc.getSource(),
    currentArc.getTarget())) {
    failAlreadyExists(currentArc);
}
if (graph.containsEdge(reversalArc) || graph.containsEdge(reversalArc.getSource(),
    reversalArc.getTarget())) {
    failAlreadyExists(reversalArc);
}
graph.addEdge(currentArc.getSource(), currentArc.getTarget(), currentArc);
graph.setEdgeWeight(currentArc, currentArc.getLength());
graph.addEdge(reversalArc.getSource(), reversalArc.getTarget(), reversalArc);
graph.setEdgeWeight(reversalArc, reversalArc.getLength());

addId(currentArc);
addPoints(currentArc, currentArc.getPoints());
addId(reversalArc);
addPoints(reversalArc, reversalArc.getPoints());

return MetricGraphBuilder.this;
}

private void verifyArcBuilder(Arc.@NotNull ArcBuilder arcBuilder, final String
    fieldName) {
    Objects.requireNonNull(arcBuilder, fieldName);
    Objects.requireNonNull(arcBuilder.getSource(), fieldName + "_must_have_source");
    Objects.requireNonNull(arcBuilder.getTarget(), fieldName + "_must_have_target");
    Objects.requireNonNull(arcBuilder.getLength(), fieldName + "_must_have_length");
}
}
}
}
```

1.29. GraphLayout.java

```
package com.github.zinoviy23.metricGraphs.util;

import org.jetbrains.annotations.NotNull;
import org.jgrapht.Graph;
import org.jgrapht.alg.drawing.FRLayoutAlgorithm2D;
```

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```

import org.jgrapht.alg.drawing.IndexedFRLayoutAlgorithm2D;
import org.jgrapht.alg.drawing.model.Box2D;
import org.jgrapht.alg.drawing.model.LayoutModel2D;
import org.jgrapht.alg.drawing.model.MapLayoutModel2D;

import java.util.Random;

public class GraphLayout {
    private final long randomSeed;
    private final int iterations;
    private final double thetaFactor;
    private final double normalizationFactor;

    public GraphLayout() {
        this(11);
    }

    public GraphLayout(long randomSeed) {
        this(randomSeed, 200);
    }

    public GraphLayout(long randomSeed, int iterations) {
        this(randomSeed, iterations, IndexedFRLayoutAlgorithm2D.DEFAULT_THETA_FACTOR);
    }

    public GraphLayout(long randomSeed, int iterations, double thetaFactor) {
        this(randomSeed, iterations, thetaFactor, FRLayoutAlgorithm2D.
            DEFAULT_NORMALIZATION_FACTOR);
    }

    public GraphLayout(long randomSeed, int iterations, double thetaFactor, double
        normalizationFactor) {
        this.randomSeed = randomSeed;
        this.iterations = iterations;
        this.thetaFactor = thetaFactor;
        this.normalizationFactor = normalizationFactor;
    }

    public <V, E> @NotNull LayoutModel2D<V> createLayout(Graph<V, E> graph, int vertexSize,
        int sizeOffset) {
        Random random = new Random(randomSeed);

        var layoutAlgorithm2D = new IndexedFRLayoutAlgorithm2D<V, E>(
            iterations,
            thetaFactor,
            normalizationFactor,
            random
        );

        var size = calcSize(graph.vertexSet().size(), vertexSize, sizeOffset);
        MapLayoutModel2D<V> layoutModel2D = new MapLayoutModel2D<>(new Box2D(size, size));

```

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```

    layoutAlgorithm2D.layout(graph, layoutModel2D);

    return layoutModel2D;
}

private static int calcSize(int vertexCount, int vertexSize, int sizeOffset) {
    return (int) Math.ceil(Math.sqrt(vertexCount) * vertexSize) + sizeOffset;
}
}

```

1.30. ContainerUtil.java

```

package com.github.zinoviy23.metricGraphs.util;

import org.jetbrains.annotations.NotNull;
import org.jetbrains.annotations.Nullable;

import java.util.Iterator;
import java.util.Map;
import java.util.stream.Stream;

public class ContainerUtil {
    public static <T> @Nullable T first(@NotNull Iterable<T> iterable) {
        Iterator<T> iterator = iterable.iterator();
        if (iterator.hasNext()) {
            return iterator.next();
        }
        return null;
    }

    public static <T> @Nullable T second(@NotNull Iterable<T> iterable) {
        Iterator<T> iterator = iterable.iterator();
        if (!iterator.hasNext()) {
            return null;
        }
        iterator.next();
        if (!iterator.hasNext()) {
            return null;
        }
        return iterator.next();
    }

    public static <T1, T2, T3> @Nullable T3 getFromTable(Map<T1, Map<T2, T3>> table, T1 row,
        T2 column) {
        var tmpRow = table.get(row);
        if (tmpRow == null) return null;

        return tmpRow.get(column);
    }

    /**
     * Should be used once. You should close given stream by your own, after iteration

```

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```

*
* @return iterable, wrapping this stream.
*/
public static <T> @NotNull Iterable<T> iterate(Stream<T> stream) {
    return stream::iterator;
}
}

```

1.31. Ref.java

```

package com.github.zinoviy23.metricGraphs.util;

import org.jetbrains.annotations.NotNull;

import java.util.function.UnaryOperator;

public class Ref<T> {
    private T data;

    public Ref(T data) {
        this.data = data;
    }

    public Ref() {
    }

    public T getData() {
        return data;
    }

    public void setData(T data) {
        this.data = data;
    }

    /**
     * Updates containing value
     * @param updateOperator operator for updating value
     * @return previous value
     */
    public T update(@NotNull UnaryOperator<T> updateOperator) {
        T prev = data;
        data = updateOperator.apply(data);
        return prev;
    }
}

```

1.32. ObjectUtil.java

```

package com.github.zinoviy23.metricGraphs.util;

import org.jetbrains.annotations.NotNull;
import org.jetbrains.annotations.Nullable;

```

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```
import java.util.function.Consumer;

public class ObjectUtil {
    private ObjectUtil() {
    }

    public static <T> void doIfNotNull(@Nullable T t, Consumer<@NotNull T> consumer) {
        if (t != null) {
            consumer.accept(t);
        }
    }
}
```

1.33. DoubleUtil.java

```
package com.github.zinoviy23.metricGraphs.util;

public class DoubleUtil {
    public static final double DELTA = 1e-5;

    public static boolean equals(double a, double b) {
        // Check infinities
        if (Double.isInfinite(a) && Double.isInfinite(b) && a > 0 && b > 0) return true;

        return Math.abs(a - b) < DELTA;
    }
}
```

1.34. ThrowableBiConsumer.java

```
package com.github.zinoviy23.metricGraphs.util;

@FunctionalInterface
public interface ThrowableBiConsumer<T, E, TExp extends Throwable> {
    void consume(T t, E e) throws TExp;
}
```

1.35. MetricGraphWriter.java

```
package com.github.zinoviy23.metricGraphs.io;

import com.github.zinoviy23.metricGraphs.MetricGraph;
import org.jetbrains.annotations.NotNull;

import java.io.Closeable;

public interface MetricGraphWriter<T extends Throwable> extends AutoCloseable, Closeable {
    void write(@NotNull MetricGraph graph) throws T;
}
```

1.36. IoUtils.java

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```

package com.github.zinoviy23.metricGraphs.io;

import com.fasterxml.jackson.core.JsonFactory;

final class IoUtils {
    static final JsonFactory factory = new JsonFactory();

    static final String LENGTH = "length";
    static final String DIRECTED = "directed";
    static final String ID = "id";
    static final String GRAPH = "graph";
    static final String ALREADY_WRITE_GRAPH_TO_STREAM_MESSAGE = "Already_write_graph_to_stream!";
    static final String ALREADY_READ_GRAPH_FROM_STREAM_MESSAGE = "Already_read_graph_from_stream";
    static final String TYPE = "type";
    static final String METRIC_GRAPH = "metric_graph";
    static final String LABEL = "label";
    static final String NODES = "nodes";
    static final String EDGES = "edges";
    static final String SOURCE = "source";
    static final String TARGET = "target";
    static final String RELATION = "relation";
    static final String NODES_CONNECTION = "nodes_connection";
    static final String METADATA = "metadata";
    static final String POINTS = "points";
    static final String POSITION = "position";
    static final String COMMENT = "comment";

    private IoUtils() {
    }
}

```

1.37. MetricGraphJsonReader.java

```

package com.github.zinoviy23.metricGraphs.io;

import com.fasterxml.jackson.core.JsonLocation;
import com.fasterxml.jackson.core.JsonParseException;
import com.fasterxml.jackson.core.JsonParser;
import com.fasterxml.jackson.core.JsonToken;
import com.github.zinoviy23.metricGraphs.Arc;
import com.github.zinoviy23.metricGraphs.MetricGraph;
import com.github.zinoviy23.metricGraphs.MovingPoint;
import com.github.zinoviy23.metricGraphs.Node;
import com.github.zinoviy23.metricGraphs.util.ContainerUtil;
import com.github.zinoviy23.metricGraphs.util.Ref;
import com.github.zinoviy23.metricGraphs.util.ThrowableBiConsumer;
import org.apache.logging.log4j.LogManager;
import org.apache.logging.log4j.Logger;
import org.jetbrains.annotations.NotNull;
import org.jetbrains.annotations.Nullable;

```

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```

import org.jgrapht.alg.util.Pair;
import org.jgrapht.alg.util.Triple;

import java.io.*;
import java.util.*;

public final class MetricGraphJsonReader implements AutoCloseable, Closeable {
    private static final Logger LOG = LogManager.getLogger(MetricGraphJsonReader.class);

    private static final String GRAPH_HAS_EDGES_BUT_HASN_T_NODES_MESSAGE = "Graph_has_edges,
        but_hasn't_nodes";
    private static final String HASN_T_ANY_NODES_WITH_ID_MESSAGE = "Hasn't_any_nodes_with_id
        =";
    private static final String ARC_S_MUST_HAVE_REVERSAL_EDGE = "Arc_%s_must_have_reversal_
        edge!";

    private final JsonParser parser;
    private boolean isRead;
    private boolean errorOccurred;

    public MetricGraphJsonReader(@NotNull Reader reader) throws IOException {
        parser = IoUtils.factory.createParser(reader);
    }

    public MetricGraphJsonReader(@NotNull InputStream inputStream) throws IOException {
        parser = IoUtils.factory.createParser(inputStream);
    }

    public MetricGraphJsonReader(@NotNull File file) throws IOException {
        parser = IoUtils.factory.createParser(file);
    }

    public MetricGraphJsonReader(@NotNull String source) throws IOException {
        parser = IoUtils.factory.createParser(source);
    }

    public @Nullable MetricGraph read() throws IOException {
        if (isRead || errorOccurred) {
            throw new IllegalStateException(IoUtils.ALREADY_READ_GRAPH_FROM_STREAM_MESSAGE);
        }

        try {
            var graph = internalRead();
            isRead = true;
            return graph;
        } catch (JsonParseException e) {
            errorOccurred = true;
            throw new MetricGraphReadingException(e.getMessage());
        } catch (IOException e) {
            errorOccurred = true;
            throw new IOException(e);
        }
    }

```

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```

    }
}

private @Nullable MetricGraph internalRead() throws IOException {
    while (parser.nextToken() != JsonToken.END_OBJECT) {
        String currentName = parser.getCurrentName();
        if (IoUtils.GRAPH.equals(currentName)) {
            return readGraph();
        }
    }

    return null;
}

private @NotNull MetricGraph readGraph() throws IOException {
    var graphBuilder = MetricGraph.createBuilder();
    Map<String, Node> nodes = null;
    Map<String, Map<String, Arc.ArcBuilder>> edgesInfo = null;
    while (parser.nextToken() != JsonToken.END_OBJECT) {
        var currentName = parser.getCurrentName();
        if (IoUtils.ID.equals(currentName)) {
            parser.nextToken();
            graphBuilder.setId(parser.getValueAsString());
        }

        if (IoUtils.LABEL.equals(currentName)) {
            parser.nextToken();
            graphBuilder.setLabel(parser.getValueAsString());
        }

        if (IoUtils.NODES.equals(currentName)) {
            parser.nextToken();
            nodes = readNodes(graphBuilder);
        }

        if (IoUtils.EDGES.equals(currentName)) {
            parser.nextToken();
            edgesInfo = readEdges();
        }

        if (IoUtils.METADATA.equals(currentName)) {
            fetchMetadata((name, balance) -> {
                if (IoUtils.COMMENT.equals(name) && balance == 1) {
                    parser.nextToken();
                    graphBuilder.setComment(parser.getValueAsString());
                }
            });
        }
    }

    if (edgesInfo != null && nodes != null) {

```

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Set<String> processedArcs = new HashSet<>();

var edgesStream = edgesInfo.entrySet().stream()
    .flatMap(mapEntry ->
        mapEntry.getValue().entrySet().stream()
            .map(targetAndBuilder -> Triple.of(mapEntry.getKey(),
                targetAndBuilder.getKey(),
                targetAndBuilder.getValue())
            )
        )
    );

for (var triple : ContainerUtil.iterate(edgesStream)) {
    if (processedArcs.contains(triple.getThird().getId())) continue;

    var stringStringPair = addArcAndReversal(graphBuilder, nodes, edgesInfo, triple);
    processedArcs.add(stringStringPair.getFirst());
    processedArcs.add(stringStringPair.getSecond());
}
} else if (edgesInfo != null) {
    throw new MetricGraphReadingException(GRAPH_HAS_EDGES_BUT_HASN_T_NODES_MESSAGE);
}

return graphBuilder.buildGraph();
}

private @NotNull Pair<String, String> addArcAndReversal(@NotNull MetricGraph.
    MetricGraphBuilder graphBuilder,
                                @NotNull Map<String, Node> finalNodes,
                                @NotNull Map<String, Map<String, Arc.
                                    ArcBuilder>> finalEdgesInfo,
                                @NotNull Triple<String, String, Arc.
                                    ArcBuilder> triple) {

    var source = finalNodes.get(triple.getFirst());
    var target = finalNodes.get(triple.getSecond());
    if (source == null) {
        throw new MetricGraphReadingException(HASN_T_ANY_NODES_WITH_ID_MESSAGE + triple.
            getFirst());
    }
    if (target == null) {
        throw new MetricGraphReadingException(HASN_T_ANY_NODES_WITH_ID_MESSAGE + triple.
            getSecond());
    }

    var arcBuilder = triple.getThird();
    var reversal = ContainerUtil.getFromTable(finalEdgesInfo, triple.getSecond(), triple.
        getFirst());
    if (reversal == null) {
        throw new MetricGraphReadingException(String.format(ARC_S_MUST_HAVE_REVERSAL_EDGE,
            arcBuilder.getId()));
    }
}

```

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var arc = arcBuilder
    .setSource(source)
    .setTarget(target)
    .createArc();
graphBuilder
    .addArc(arc)
    .setReversalComment(reversal.getComment())
    .setReversalLabel(reversal.getLabel())
    .withReversal(reversal.getId(), reversal.getPoints());

return Pair.of(arc.getId(), reversal.getId());
}

private @NotNull Map<String, Map<String, Arc.ArcBuilder>> readEdges() throws IOException
{
    var result = new HashMap<String, Map<String, Arc.ArcBuilder>>();
    while (parser.nextToken() != JsonToken.END_ARRAY) {
        if (parser.currentToken() == JsonToken.START_OBJECT) {
            var edgeInfo = readEdge();
            result.computeIfAbsent(edgeInfo.getFirst(), (k) -> new HashMap<>())
                .put(edgeInfo.getSecond(), edgeInfo.getThird());
        }
    }
    return result;
}

private @NotNull Triple<String, String, Arc.ArcBuilder> readEdge() throws IOException {
    var arcBuilder = Arc.createBuilder();
    String source = null;
    String target = null;

    while (parser.nextToken() != JsonToken.END_OBJECT) {
        var currentName = parser.getCurrentName();
        if (IoUtils.LABEL.equals(currentName)) {
            parser.nextToken();
            arcBuilder.setLabel(parser.getValueAsString());
        }
        if (IoUtils.SOURCE.equals(currentName)) {
            parser.nextToken();
            source = parser.getValueAsString();
        }
        if (IoUtils.TARGET.equals(currentName)) {
            parser.nextToken();
            target = parser.getValueAsString();
        }
        if (IoUtils.ID.equals(currentName)) {
            parser.nextToken();
            var valueAsString = parser.getValueAsString();
            arcBuilder.setId(valueAsString);
            LOG.debug(() -> "readEdge_" + valueAsString);
        }
    }
}

```

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    }
    if (IoUtils.METADATA.equals(currentName)) {
        readArcMetadata(arcBuilder);
    }
}

return Triple.of(source, target, arcBuilder);
}

private void readArcMetadata(@NotNull Arc.ArcBuilder arcBuilder) throws IOException {
    fetchMetadata((name, balance) -> {
        if (IoUtils.COMMENT.equals(name) && balance == 1) {
            parser.nextToken();
            arcBuilder.setComment(parser.getValueAsString());
        }
        if (IoUtils.POINTS.equals(name) && balance == 1) {
            parser.nextToken();
            readPoints(arcBuilder);
        }
        if (IoUtils.LENGTH.equals(name) && balance == 1) {
            parser.nextToken();
            if (parser.getCurrentToken().isNumeric()) {
                arcBuilder.setLength(parser.getNumberValue().doubleValue());
            } else if ("Infinity".equals(parser.getValueAsString())) {
                arcBuilder.setLength(Double.POSITIVE_INFINITY);
            } else {
                throw new MetricGraphReadingException("Unexpected value: " + parser.
                    getValueAsString());
            }
        }
    });
}

private void readPoints(@NotNull Arc.ArcBuilder arcBuilder) throws IOException {
    while (parser.nextToken() != JsonToken.END_ARRAY) {
        if (parser.getCurrentToken() == JsonToken.START_OBJECT) {
            arcBuilder.addPoint(readPoint());
        }
    }
}

private MovingPoint readPoint() throws IOException {
    String id = null;
    Double position = null;
    Ref<String> comment = new Ref<>();

    while (parser.nextToken() != JsonToken.END_OBJECT) {
        var currentName = parser.getCurrentName();
        if (IoUtils.ID.equals(currentName)) {
            parser.nextToken();
            id = parser.getValueAsString();
        }
    }
}

```

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        String finalId = id;
        LOG.debug(() -> "read_point_" + finalId);
    }
    if (IoUtils.POSITION.equals(currentName)) {
        parser.nextToken();
        position = parser.getNumberValue().doubleValue();
    }
    if (IoUtils.METADATA.equals(currentName)) {
        fetchMetadata((name, balance) -> {
            // comment must be property of metadata obj, not its child
            if (IoUtils.COMMENT.equals(name) && balance == 1) {
                parser.nextToken();
                comment.setData(parser.getValueAsString());
            }
        });
    }
}

//noinspection ConstantConditions
return new MovingPoint(id, position, comment.getData());
}

private @NotNull Map<String, Node> readNodes(@NotNull MetricGraph.MetricGraphBuilder
    graphBuilder) throws IOException {
    Map<String, Node> nodes = new HashMap<>();
    while (parser.nextToken() != JsonToken.END_OBJECT) {
        LOG.debug(() -> "read_nodes");
        String id = parser.getCurrentName();
        if (id != null) {
            var node = readNode(id);
            graphBuilder.addNode(node);
            nodes.put(id, node);
        }
    }
    return nodes;
}

private @NotNull Node readNode(@NotNull String id) throws IOException {
    String label = null;
    Ref<String> comment = new Ref<>();
    while (parser.nextToken() != JsonToken.END_OBJECT) {
        if (IoUtils.LABEL.equals(parser.getCurrentName())) {
            LOG.debug(() -> "read_node_" + id);
            parser.nextToken();
            label = parser.getValueAsString();
        }
        if (IoUtils.METADATA.equals(parser.getCurrentName())) {
            fetchMetadata((name, balance) -> {
                // comment must be property of metadata obj, not its child
                if (IoUtils.COMMENT.equals(name) && balance == 1) {
                    parser.nextToken();
                }
            });
        }
    }
}

```

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        comment.setData(parser.getValueAsString());
    }
    });
}
}
if (Node.INFINITY_NODE_LABEL.equals(label)) {
    return Node.createInfinity(id);
}
return Node.createNode(id, label, comment.getData());
}

private void fetchMetadata(ThrowablesBiConsumer<String, Integer, IOException> fetcher)
    throws IOException {
    parser.nextToken();
    if (parser.currentToken() != JsonToken.START_OBJECT) {
        parser.nextToken();
        return;
    }
    int balance = 1;
    while (balance != 0) {
        parser.nextToken();
        if (parser.currentToken() == JsonToken.START_OBJECT) {
            balance++;
        }
        if (parser.currentToken() == JsonToken.END_OBJECT) {
            balance--;
        }
        fetcher.consume(parser.getCurrentName(), balance);
    }
}

public @NotNull JsonLocation lastLocation() {
    return parser.getCurrentLocation();
}

@Override
public void close() throws IOException {
    parser.close();
}
}

```

1.38. MetricGraphReadingException.java

```

package com.github.zinoviy23.metricGraphs.io;

public class MetricGraphReadingException extends RuntimeException {
    public MetricGraphReadingException(String message) {
        super(message);
    }

    public MetricGraphReadingException(String message, Throwable cause) {
        super(message, cause);
    }
}

```

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```
}  
}
```

1.39. ValidatedMetricGraphJsonReader.java

```
package com.github.zinoviy23.metricGraphs.io;  
  
import org.everit.json.schema.ValidationException;  
import org.everit.json.schema.loader.SchemaLoader;  
import org.jetbrains.annotations.NotNull;  
import org.json.JSONObject;  
import org.json.JSONTokener;  
  
import java.io.*;  
  
public class ValidatedMetricGraphJsonReader {  
    public static final String JSON_GRAPH_SCHEMA_JSON = "/json-graph-schema.json";  
    private final MetricGraphJsonReader reader;  
  
    public ValidatedMetricGraphJsonReader(@NotNull File file) throws IOException {  
        try (var bufferedReader = new BufferedReader(new FileReader(file))) {  
            validate(bufferedReader);  
        } catch (ValidationException e) {  
            throw new IOException(String.join("\n", e.getAllMessages()));  
        }  
        reader = new MetricGraphJsonReader(file);  
    }  
  
    public ValidatedMetricGraphJsonReader(@NotNull String string) throws IOException {  
        validate(new StringReader(string));  
        reader = new MetricGraphJsonReader(string);  
    }  
  
    private static void validate(@NotNull Reader reader) {  
        JSONObject jsonSchema = new JSONObject(new JSONTokener(  
            ValidatedMetricGraphJsonReader.class.getResourceAsStream(JSON_GRAPH_SCHEMA_JSON)  
        ));  
        JSONObject jsonGraph = new JSONObject(new JSONTokener(reader));  
        var schema = SchemaLoader.load(jsonSchema);  
        schema.validate(jsonGraph);  
    }  
  
    public @NotNull MetricGraphJsonReader getReader() {  
        return reader;  
    }  
}
```

1.40. MetricGraphJsonWriter.java

```
package com.github.zinoviy23.metricGraphs.io;  
  
import com.fasterxml.jackson.core.JsonGenerator;
```

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```

import com.github.zinoviy23.metricGraphs.Arc;
import com.github.zinoviy23.metricGraphs.MetricGraph;
import com.github.zinoviy23.metricGraphs.api.ObjectWithComment;
import org.jetbrains.annotations.NotNull;

import java.io.IOException;
import java.io.OutputStream;
import java.io.Writer;

public final class MetricGraphJsonWriter implements MetricGraphWriter<IOException> {

    private final JsonGenerator generator;
    private boolean isWritten;
    private boolean errorOccurred;

    public MetricGraphJsonWriter(@NotNull OutputStream outputStream, boolean
        usePrettyPrinter) throws IOException {
        this(IoUtils.factory.createGenerator(outputStream), usePrettyPrinter);
    }

    public MetricGraphJsonWriter(@NotNull Writer writer, boolean usePrettyPrinter) throws
        IOException {
        this(IoUtils.factory.createGenerator(writer), usePrettyPrinter);
    }

    private MetricGraphJsonWriter(@NotNull JsonGenerator generator, boolean usePrettyPrint)
    {
        this.generator = generator;
        if (usePrettyPrint) {
            this.generator.useDefaultPrettyPrinter();
        }
    }

    public void write(@NotNull MetricGraph graph) throws IOException {
        if (isWritten || errorOccurred) throw new IllegalStateException(IoUtils.
            ALREADY_WRITE_GRAPH_TO_STREAM_MESSAGE);

        try {
            internalWrite(graph);
        } catch (IOException e) {
            errorOccurred = true;
            throw new IOException(e);
        }

        isWritten = true;
    }

    private void internalWrite(@NotNull MetricGraph graph) throws IOException {
        generator.writeStartObject();
        generator.writeObjectFieldStart(IoUtils.GRAPH);
    }

```

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```

writeGraphInfo(graph);
writeNodes(graph);
writeEdges(graph);
writeComment(graph);

generator.writeEndObject();
generator.writeEndObject();
}

private void writeGraphInfo(@NotNull MetricGraph graph) throws IOException {
    generator.writeBooleanField(IoUtils.DIRECTED, true);
    generator.writeStringField(IoUtils.ID, graph.getId());
    generator.writeStringField(IoUtils.TYPE, IoUtils.METRIC_GRAPH);
    generator.writeStringField(IoUtils.LABEL, graph.getLabel());
}

private void writeNodes(@NotNull MetricGraph graph) throws IOException {
    generator.writeObjectFieldStart(IoUtils.NODES);

    for (var node : graph.getGraph().vertexSet()) {
        generator.writeObjectFieldStart(node.getId());
        generator.writeStringField(IoUtils.LABEL, node.getLabel());
        writeComment(node);
        generator.writeEndObject();
    }
    generator.writeEndObject();
}

private void writeEdges(@NotNull MetricGraph graph) throws IOException {
    generator.writeArrayFieldStart(IoUtils.EDGES);

    for (var arc : graph.getGraph().edgeSet()) {
        generator.writeStartObject();
        generator.writeStringField(IoUtils.ID, arc.getId());
        generator.writeStringField(IoUtils.SOURCE, arc.getSource().getId());
        generator.writeStringField(IoUtils.TARGET, arc.getTarget().getId());
        generator.writeStringField(IoUtils.RELATION, IoUtils.NODES_CONNECTION);
        generator.writeStringField(IoUtils.LABEL, arc.getLabel());
        writeArcMetadata(arc);
        generator.writeEndObject();
    }

    generator.writeEndArray();
}

private void writeArcMetadata(@NotNull Arc arc) throws IOException {
    generator.writeObjectFieldStart(IoUtils.METADATA);

    generator.writeArrayFieldStart(IoUtils.POINTS);
    for (var point : arc.getPoints()) {
        generator.writeStartObject();

```

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        generator.writeStringField(IoUtils.ID, point.getId());
        generator.writeNumberField(IoUtils.POSITION, point.getPosition());
        writeComment(point);
        generator.writeEndObject();
    }
    generator.writeEndArray();

    if (arc.getComment() != null) {
        generator.writeStringField(IoUtils.COMMENT, arc.getComment());
    }

    generator.writeNumberField(IoUtils.LENGTH, arc.getLength());

    generator.writeEndObject();
}

private void writeComment(@NotNull ObjectWithComment objectWithComment) throws
    IOException {
    if (objectWithComment.getComment() == null) return;

    generator.writeObjectFieldStart(IoUtils.METADATA);
    generator.writeStringField(IoUtils.COMMENT, objectWithComment.getComment());

    generator.writeEndObject();
}

@Override
public void close() throws IOException {
    generator.close();
}
}

```

1.41. XmlUtils.java

```

package com.github.zinoviy23.metricGraphs.io.graphml;

import javax.xml.stream.XMLOutputFactory;
import javax.xml.transform.TransformerFactory;

class XmlUtils {
    static final XMLOutputFactory xmlOutputFactory = XMLOutputFactory.newFactory();
    static final TransformerFactory transformerFactory = TransformerFactory.newInstance();

    static final String ALREADY_WRITE_GRAPH_TO_STREAM_MESSAGE = "Already write graph to stream!";
}

```

1.42. MetricGraphYedWriter.java

```

package com.github.zinoviy23.metricGraphs.io.graphml;

```

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```

import com.github.zinoviy23.metricGraphs.Arc;
import com.github.zinoviy23.metricGraphs.MetricGraph;
import com.github.zinoviy23.metricGraphs.MovingPoint;
import com.github.zinoviy23.metricGraphs.Node;
import com.github.zinoviy23.metricGraphs.io.MetricGraphWriter;
import com.github.zinoviy23.metricGraphs.util.GraphLayout;
import org.jetbrains.annotations.NotNull;
import org.jetbrains.annotations.Nullable;
import org.jgrapht.alg.drawing.model.LayoutModel2D;

import javax.xml.stream.XMLStreamException;
import javax.xml.stream.XMLStreamWriter;
import javax.xml.transform.OutputKeys;
import javax.xml.transform.TransformerException;
import javax.xml.transform.stream.StreamResult;
import javax.xml.transform.stream.StreamSource;
import java.io.*;
import java.util.HashSet;
import java.util.Set;

public final class MetricGraphYedWriter implements MetricGraphWriter<IOException> {
    private boolean isWritten;
    private boolean errorOccurred;
    private final Writer resultWriter;
    private final File currentFile;
    private final boolean applyLayout;

    public MetricGraphYedWriter(@NotNull Writer writer, boolean applyLayout) throws
        IOException {
        currentFile = File.createTempFile("result", ".xml");
        resultWriter = writer;
        this.applyLayout = applyLayout;
    }

    public void write(@NotNull MetricGraph graph) throws IOException {
        if (isWritten || errorOccurred) {
            throw new IllegalStateException(XmlUtils.ALREADY_WRITE_GRAPH_TO_STREAM_MESSAGE);
        }

        try (var fileWriter = new FileWriter(currentFile); var writer = new YedWriter(
            fileWriter, applyLayout)) {
            writer.write(graph);
        } catch (XMLStreamException e) {
            errorOccurred = true;
            throw new IOException(e);
        }

        try (var fileReader = new FileReader(currentFile)) {
            addIndents(fileReader);
        } catch (TransformerException e) {
            errorOccurred = true;
            throw new IOException(e);
        }
    }

```

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    }
    isWritten = true;
}

private void addIndents(@NotNull Reader reader) throws TransformerException {
    var transformer = XmlUtils.transformerFactory.newTransformer();
    transformer.setOutputProperty(OutputKeys.INDENT, "yes");
    transformer.setOutputProperty("{http://xml.apache.org/xslt}indent-amount", "2");
    transformer.transform(new StreamSource(reader), new StreamResult(resultWriter));
}

@Override
public void close() throws IOException {
    if (!currentFile.delete()) {
        throw new IOException("Cannot delete cache file!");
    }
}

private static final class YedWriter implements MetricGraphWriter<XMLStreamException> {
    public static final String EDGE_POINTS = "d12";
    private static final String GRAPH_DESCR = "d0";
    private static final String NODE_DESCR = "d5";
    private static final String EDGE_DESCR = "d9";
    private static final String NODE_GRAPHICS = "d6";
    private static final String Y = "http://www.yworks.com/xml/graphml";
    private static final String EDGE_GRAPHICS = "d10";
    public static final String EDGE_LENGTH = "d11";

    private final XMLStreamWriter writer;
    private final boolean applyLayout;

    private final Set<Arc> drawnArc = new HashSet<>();

    private YedWriter(Writer writer, boolean applyLayout) throws XMLStreamException {
        this.writer = XmlUtils.xmlOutputFactory.createXMLStreamWriter(writer);
        this.applyLayout = applyLayout;
    }

    public void write(@NotNull MetricGraph graph) throws XMLStreamException {
        writer.writeStartDocument();
        writer.writeStartElement("graphml");
        writeYedSchemes();
        writeDataElements();
        writeGraph(graph);
        writer.writeEndDocument();
    }

    private void writeYedSchemes() throws XMLStreamException {
        writer.writeNamespace("xmlns", "http://graphml.graphdrawing.org/xmlns");
        writer.writeNamespace("java", "http://www.yworks.com/xml/yfiles-common/1.0/java");
        writer.writeNamespace("sys", "http://www.yworks.com/xml/yfiles-common/markup/");
    }
}

```

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        primitives/2.0");
writer.writeNamespace( "x", "http://www.yworks.com/xml/yfiles-common/markup/2.0");
var xsi = "http://www.w3.org/2001/XMLSchema-instance";
writer.writeNamespace( "xsi", xsi);
writer.writeNamespace( "y", Y);
writer.writeNamespace( "yed", "http://www.yworks.com/xml/yed/3");
writer.writeAttribute(xsi, "schemaLocation", "http://graphml.graphdrawing.org/xmlns_
    http://www.yworks.com/xml/schema/graphml/1.1/ygraphml.xsd");
}

private void writeDataElements() throws XMLStreamException {
    writeDataDef(GRAPH_DESCR, "graph", "Description", "string", null);
    writeDataDef("d1", "port", null, null, "portgraphics");
    writeDataDef("d2", "port", null, null, "portgeometry");
    writeDataDef("d3", "port", null, null, "portuserdata");
    writeDataDef("d4", "node", "url", "string", null);
    writeDataDef(NODE_DESCR, "node", "description", "string", null);
    writeDataDef(NODE_GRAPHICS, "node", null, null, "nodegraphics");
    writeDataDef("d7", "graphml", null, null, "resources");
    writeDataDef("d8", "edge", "url", "string", null);
    writeDataDef(EDGE_DESCR, "edge", "description", "string", null);
    writeDataDef(EDGE_GRAPHICS, "edge", null, null, "edgegraphics");
    writeDataDef(EDGE_LENGTH, "edge", "length", "double", null);
    writeDataDef(EDGE_POINTS, "edge", "points", null, null);
}

private void writeDataDef(@NotNull String id,
    @NotNull String forAttr,
    @Nullable String name,
    @Nullable String type,
    @Nullable String yfilesType) throws XMLStreamException {
    writer.writeStartElement("key");
    writer.writeAttribute("id", id);
    writer.writeAttribute("for", forAttr);
    if (name != null) {
        writer.writeAttribute("attr.name", name);
    }
    if (type != null) {
        writer.writeAttribute("attr.type", type);
    }
    if (yfilesType != null) {
        writer.writeAttribute("yfiles.type", yfilesType);
    }
    writer.writeEndElement();
}

private void writeGraph(MetricGraph graph) throws XMLStreamException {
    writer.writeStartElement("graph");
    writer.writeAttribute("edgedefault", "directed");
    writer.writeAttribute("id", graph.getId());
    writer.writeStartElement("data");

```

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writer.writeAttribute("key", GRAPH_DESCR);
writer.writeCharacters(graph.getComment());
writer.writeEndElement();

LayoutModel2D<Node> layoutModel2D = applyLayout
    ? new GraphLayout().createLayout(graph.getGraph(), 200, 300)
    : null;

for (Node node : graph.getGraph().vertexSet()) {
    writeNode(node, layoutModel2D);
}

for (Arc arc : graph.getGraph().edgeSet()) {
    writeArc(arc, graph);
}
}

private void writeArc(@NotNull Arc arc, @NotNull MetricGraph graph) throws
    XMLStreamException {
    writer.writeStartElement("edge");
    writer.writeAttribute("id", arc.getId());
    writer.writeAttribute("source", arc.getSource().getId());
    writer.writeAttribute("target", arc.getTarget().getId());

    writeComment(arc.getComment(), EDGE_DESCR);

    writeArcGraphics(arc, drownArc.contains(graph.getReversal(arc)));

    writer.writeStartElement("data");
    writer.writeAttribute("key", EDGE_LENGTH);
    writer.writeCharacters(Double.toString(arc.getLength()));
    writer.writeEndElement();

    writer.writeStartElement("data");
    writer.writeAttribute("key", EDGE_POINTS);
    for (MovingPoint point : arc.getPoints()) {
        writePoint(point);
    }
    writer.writeEndElement();

    writer.writeEndElement();

    drownArc.add(arc);
}

private void writePoint(@NotNull MovingPoint point) throws XMLStreamException {
    writer.writeStartElement("point");
    writer.writeAttribute("id", point.getId());
    writer.writeAttribute("position", Double.toString(point.getPosition()));
    if (point.getComment() != null) {
        writer.writeCharacters(point.getComment());
    }
}

```

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    }
    writer.writeEndElement();
}

private void writeArcGraphics(@NotNull Arc arc, boolean hide) throws
    XMLStreamException {
    writer.writeStartElement("data");
    writer.writeAttribute("key", EDGE_GRAPHICS);
    writer.writeStartElement(Y, "PolyLineEdge");

    writer.writeStartElement(Y, "EdgeLabel");
    if (hide) {
        writer.writeAttribute("visible", "false");
    }
    writer.writeCharacters(arc.getLabel() + ",□" + arc.getLength());
    writer.writeEndElement();

    writer.writeStartElement(Y, "Path");
    writer.writeAttribute("sx", !hide ? "0.0" : "10.0");
    writer.writeAttribute("sy", "0.0");
    writer.writeAttribute("tx", !hide ? "0.0" : "10.0");
    writer.writeAttribute("ty", "0.0");
    writer.writeEndElement();

    writer.writeStartElement(Y, "LineStyle");
    writer.writeAttribute("color", hide ? "#00000000" : "#000000");
    writer.writeAttribute("width", "1.0");
    writer.writeEndElement();

    writer.writeStartElement(Y, "Arrows");
    writer.writeAttribute("source", "none");
    writer.writeAttribute("target", "none");
    writer.writeEndElement();

    writer.writeStartElement(Y, "BendElement");
    writer.writeAttribute("smoothed", "false");
    writer.writeEndElement();

    writer.writeEndElement();
    writer.writeEndElement();
}

private void writeComment(String comment, String descr) throws XMLStreamException {
    if (comment != null) {
        writer.writeStartElement("data");
        writer.writeAttribute("key", descr);
        writer.writeCharacters(comment);
        writer.writeEndElement();
    }
}
}

```

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```

private void writeNode(@NotNull Node node, @Nullable LayoutModel2D<Node> layoutModel2D
    ) throws XMLStreamException {
    writer.writeStartElement("node");
    writer.writeAttribute("id", node.getId());
    writeComment(node.getComment(), NODE_DESCR);
    writeNodeGraphics(node, layoutModel2D);
    writer.writeEndElement();
}

private void writeNodeGraphics(@NotNull Node node, @Nullable LayoutModel2D<Node>
    layoutModel2D) throws XMLStreamException {
    writer.writeStartElement("data");
    writer.writeAttribute("key", NODE_GRAPHICS);
    writer.writeStartElement(Y, "ShapeNode");

    writer.writeStartElement(Y, "NodeLabel");
    writer.writeCharacters(node.getLabel());
    writer.writeEndElement();

    writer.writeStartElement(Y, "Geometry");
    writer.writeAttribute("height", "30");
    writer.writeAttribute("width", "30");
    if (layoutModel2D != null) {
        var point = layoutModel2D.get(node);
        writer.writeAttribute("x", Double.toString(point.getX()));
        writer.writeAttribute("y", Double.toString(point.getY()));
    }
    writer.writeEndElement();

    writer.writeStartElement(Y, "Fill");
    writer.writeAttribute("color", "#FFCC00");
    writer.writeAttribute("transparent", "false");
    writer.writeEndElement();

    writer.writeStartElement(Y, "Shape");
    writer.writeAttribute("type", "ellipse");
    writer.writeEndElement();

    writer.writeEndElement();
    writer.writeEndElement();
}

@Override
public void close() throws IOException {
    try {
        writer.close();
    } catch (XMLStreamException e) {
        throw new IOException(e);
    }
}
}

```

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```
}
```

1.43. ObjectWithComment.java

```
package com.github.zinoviy23.metricGraphs.api;

import org.jetbrains.annotations.Nullable;

public interface ObjectWithComment {
    @Nullable String getComment();
}
```

1.44. Identity.java

```
package com.github.zinoviy23.metricGraphs.api;

import org.jetbrains.annotations.NotNull;

public interface Identity {
    @NotNull String getId();
}
```

1.45. TapnToMgApp.java

```
package com.github.zinoviy23;

import com.github.zinoviy23.metricGraphs.io.MetricGraphJsonWriter;
import com.github.zinoviy23.metricGraphs.io.graphml.MetricGraphYedWriter;
import com.github.zinoviy23.tapaal.TapaalHeadlessService;
import com.github.zinoviy23.tapaal.extended.ExtendedTapaal;
import com.github.zinoviy23.tapnToMg.converters.ConversionException;
import com.github.zinoviy23.tapnToMg.converters.ConvertersFactory;
import com.github.zinoviy23.tapnToMg.converters.mgToTapn.
    MetricGraphToTimedArcPetriNetConverter;
import com.github.zinoviy23.tapnToMg.converters.tapnToMg.
    TimedArcPetriNetToMetricGraphConverter;
import dk.aau.cs.io.TimedArcPetriNetNetworkWriter;
import picocli.CommandLine;

import java.io.File;
import java.io.FileWriter;
import java.io.IOException;
import java.util.Collections;
import java.util.List;
import java.util.concurrent.Callable;

@CommandLine.Command(
    name = "tapn-to-mg",
    description = "Converts Timed Arc Petri Net to Metric Graph and vice versa.",
    version = "tapn-to-mg 0.0",
    mixinStandardHelpOptions = true
)
```

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```

public class TapnToMgApp implements Callable<Integer> {
    @SuppressWarnings("unused")
    @CommandLine.Option(names = {"-f", "--from"}, description = "Source_file")
    private File sourceFile;

    @SuppressWarnings("unused")
    @CommandLine.Option(names = "--to-mg", description = "Target_metric_graph_file")
    private File mgFile;

    @SuppressWarnings({"FieldMayBeFinal", "FieldCanBeLocal"})
    @CommandLine.Option(names = "--format", description = "JSON,yEd")
    private String mgFileFormat = "json";

    @SuppressWarnings("unused")
    @CommandLine.Option(names = "--to-tapn", description = "Target_Timed_Arc_Petri_Net")
    private File tapnFile;

    @SuppressWarnings("unused")
    @CommandLine.Option(names = {"-g", "--gui"}, description = "Run_extended_TAPAAL_
        application")
    private boolean useGui;

    private static Runnable resultRunnable;

    public static void main(String[] args) {
        var exitCode = new CommandLine(new TapnToMgApp()).execute(args);
        if (exitCode == 0 && resultRunnable != null) {
            resultRunnable.run();
        } else {
            System.exit(exitCode);
        }
    }

    @Override
    public Integer call() throws Exception {
        if (useGui && TapaalHeadlessService.isHeadless()) {
            System.err.println("Cannot_use_GUI_in_headless_mode");
            return -1;
        } else if (useGui) {
            String[] args;
            if (sourceFile != null) {
                args = new String[]{sourceFile.getAbsolutePath()};
            } else {
                args = new String[0];
            }
            resultRunnable = () -> ExtendedTapaal.main(args);
            return 0;
        }

        if (mgFile != null && tapnFile != null) {
            System.err.println("Provided_both_mg_and_tapn_destinations");
        }
    }
}

```

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    return -1;
}

if (sourceFile == null || !sourceFile.exists()) {
    System.err.println("Please, provide existing source file");
    return -1;
}

if (mgFile != null) {
    if (!"json".equals(mgFileFormat.toLowerCase()) && !"yed".equals(mgFileFormat.
        toLowerCase())) {
        System.err.println("Unknown format" + mgFileFormat);
        return -1;
    }

    var converter = ConvertersFactory.createFileToTimedArcPetriNetConverter()
        .andThen(new TimedArcPetriNetToMetricGraphConverter());

    try {
        var graph = converter.apply(sourceFile);
        try (var fileWriter = new FileWriter(mgFile)) {
            try (var graphWriter = "yed".equals(mgFileFormat.toLowerCase())
                ? new MetricGraphYedWriter(fileWriter, true)
                : new MetricGraphJsonWriter(fileWriter, true)
            ) {
                graphWriter.write(graph);
            }
            return 0;
        } catch (IOException e) {
            if (e.getCause() != null) {
                System.err.println(e.getCause().getMessage());
            } else {
                System.err.println(e.getMessage());
            }
            return -1;
        }
    } catch (ConversionException e) {
        System.err.println(e.getCause().getMessage());
        return -1;
    }
}

if (tapnFile != null) {
    var converter = ConvertersFactory.createFileToMetricGraphConverter()
        .andThen(new MetricGraphToTimedArcPetriNetConverter());

    try {
        var network = converter.apply(sourceFile);
        TimedArcPetriNetNetworkWriter writer = new TimedArcPetriNetNetworkWriter(
            network.getNetwork(),
            List.of(network.getTemplate()),

```

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```

        Collections.emptyList(),
        network.getNetwork().constants()
    );
    writer.savePNML(tapnFile);
    return 0;
} catch (ConversionException e) {
    System.err.println(e.getCause().getMessage());
    return -1;
} catch (IOException e) {
    System.err.println(e.getMessage());
    return -1;
}
}
return 0;
}
}

```

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