# Introduction to mRUBiS

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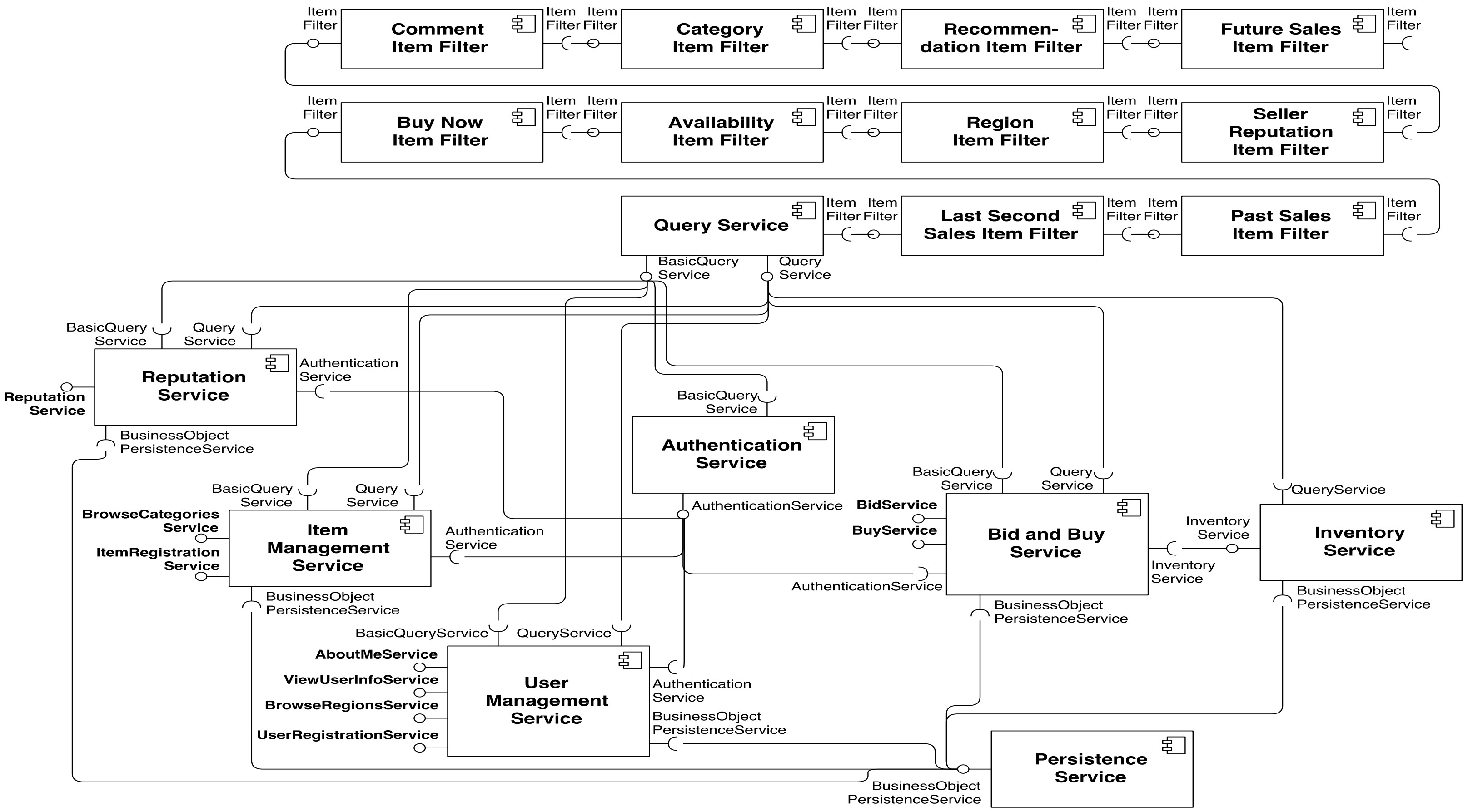
# mRUBiS

- mRUBiS is a marketplace modelled after eBay on which users sell or auction items
- Derived from RUBiS (Rice University Bidding System), a popular case study to evaluate control theoretic algorithms
- modularized RUBiS
- A marketplace that hosts arbitrarily many shops

https://www.hpi.uni-potsdam.de/giese/public/mdelab/mdelab-projects/case-studies/mrubis/

*Thomas Vogel. 2018. MRUBiS: an exemplar for model-based architectural self-healing and self-optimization. In Proceedings of the 13th International Conference on Software Engineering for Adaptive and Self-Managing Systems (SEAMS '18). Association for Computing Machinery, New York, NY, USA, 101–107. DOI:https://doi.org/10.1145/3194133.3194161*

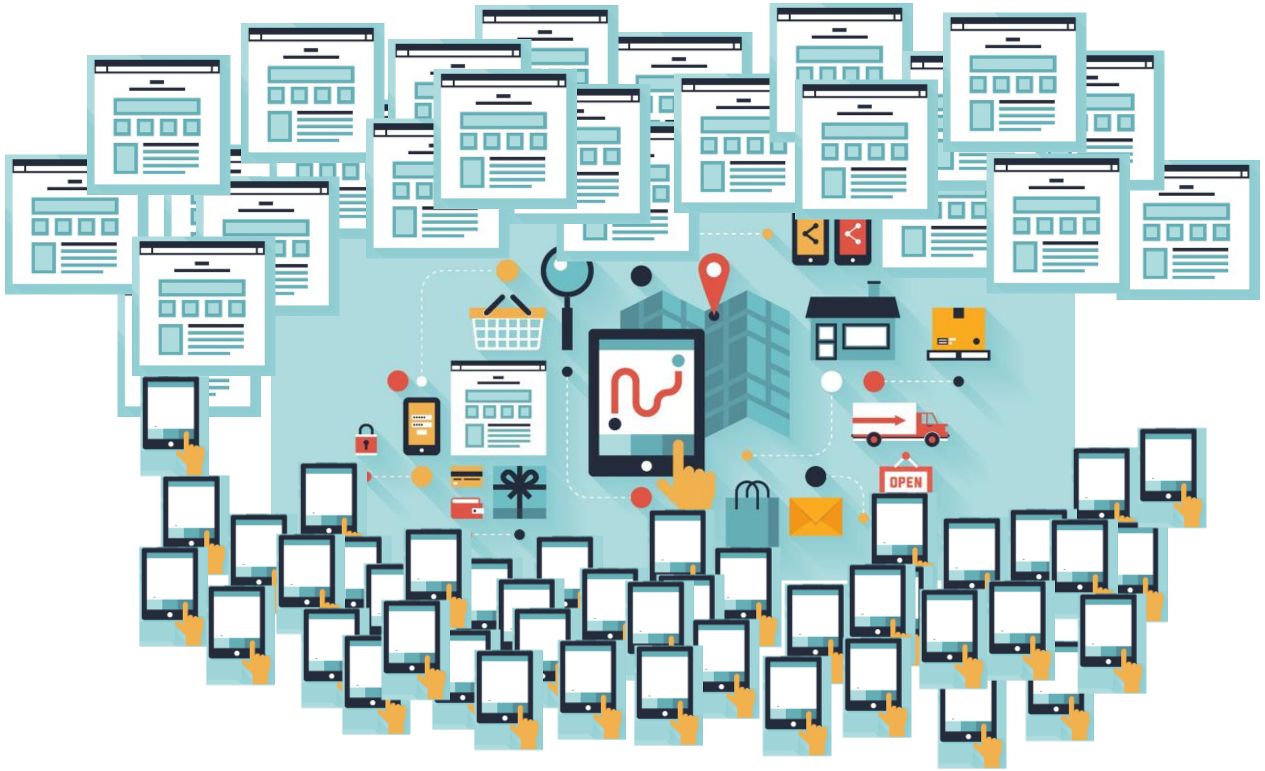
# Architecture of a single shop in mRUBiS



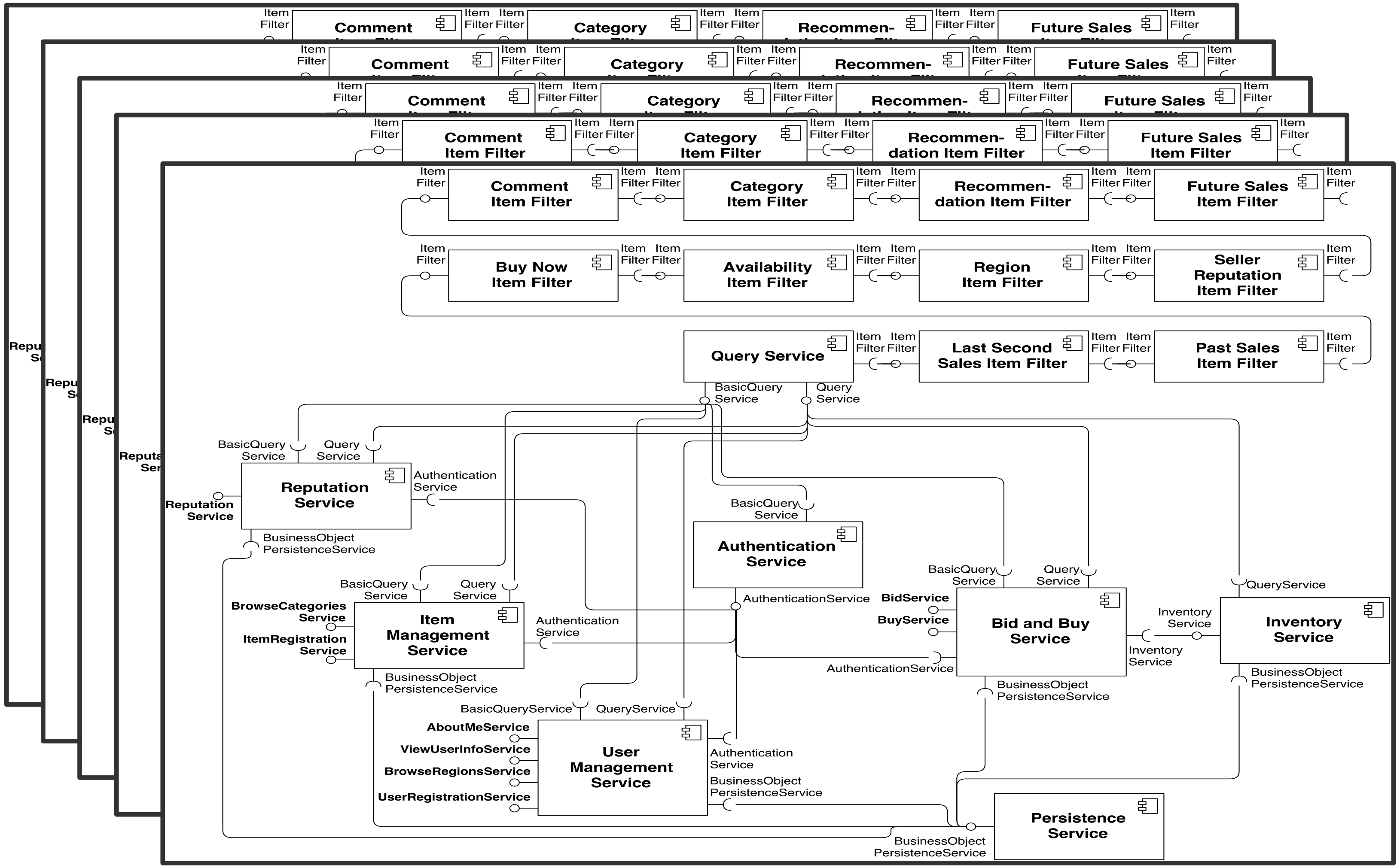
- Each shop consists of 18 components and belongs to a tenant
- All shops share the same *component types* but each shop has its own, individually configured components

- Architecture of each shop is isolated from the architectures of the other shops (cf. multi-tenancy)
- Multi-tenancy setting enables scaling up the system

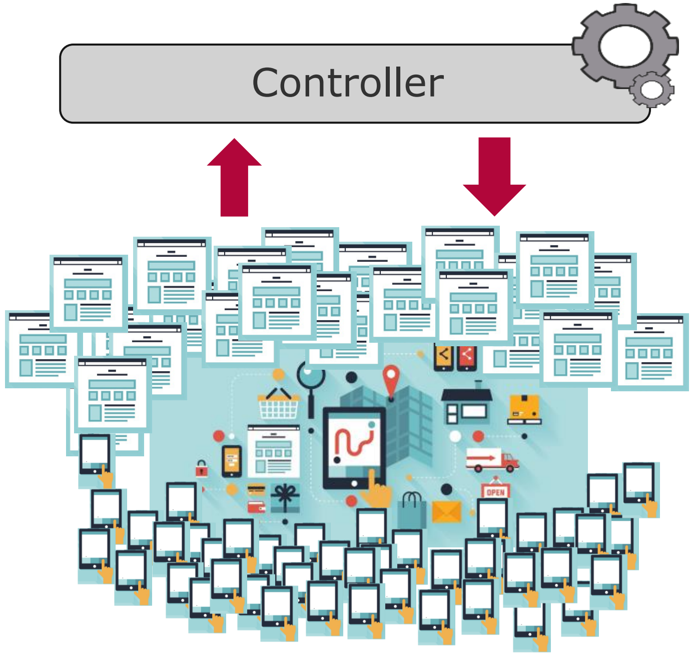
# mRUBiS as a Large Market Place



# Architecture of the Market Place

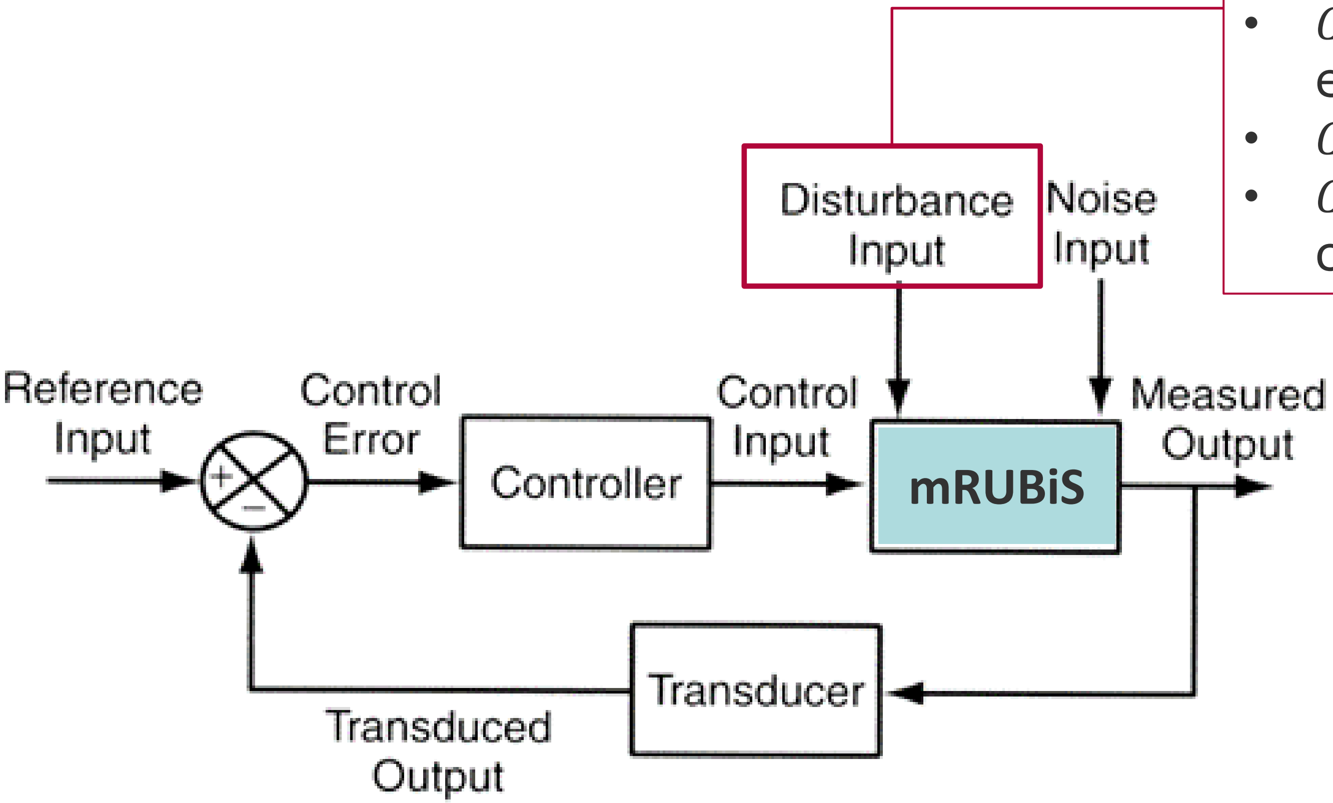


- A single controller controls all mRUBiS instances.

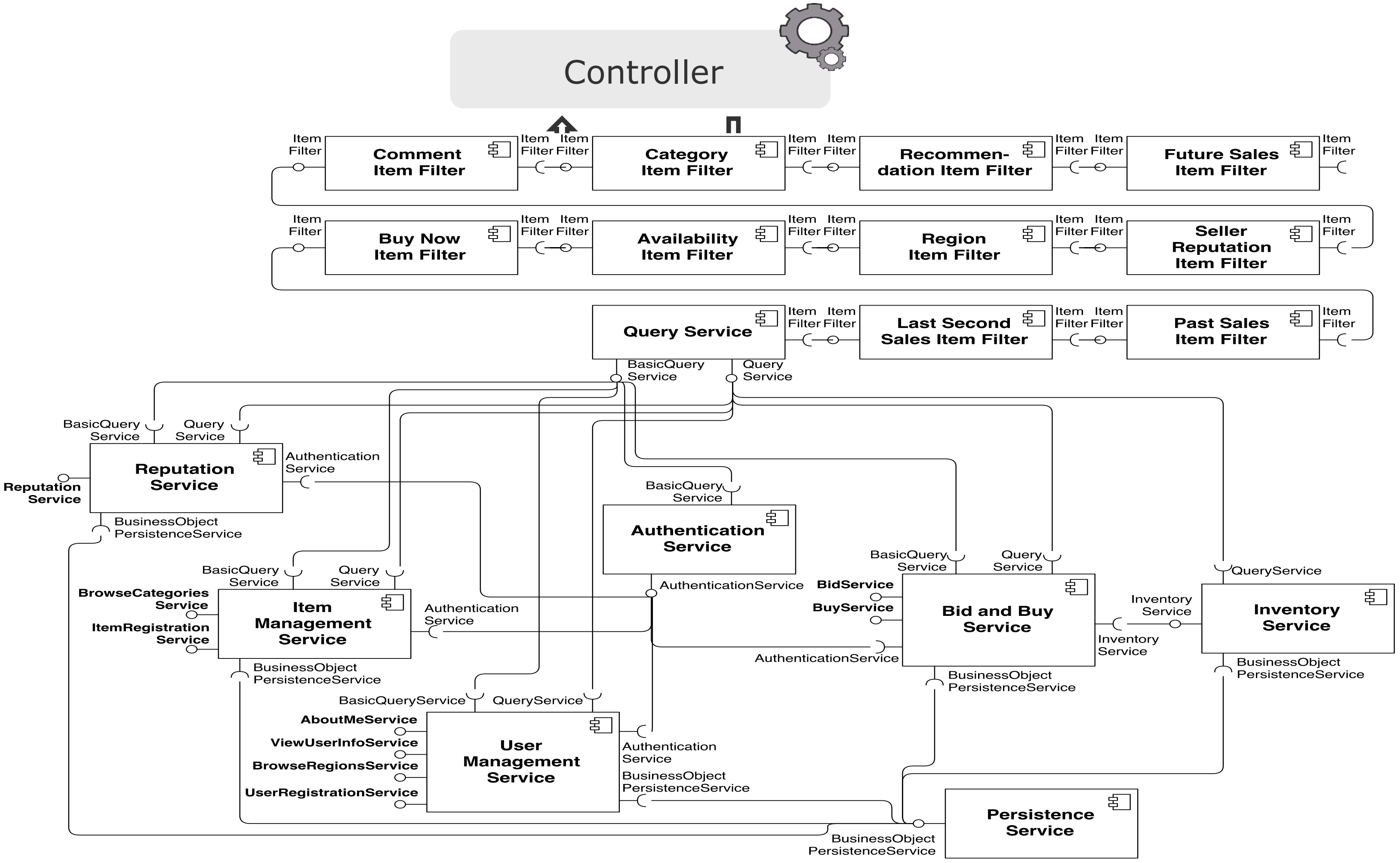


# Disturabance in mRUBiS

- $CF_1$ = Component crashed
- $CF_2$ = Component throws exceptions
- $CF_3$ = Component is undeployed
- $CF_5$ = Change in the system load causing sub-optimal performance



# Failures and Affected Components



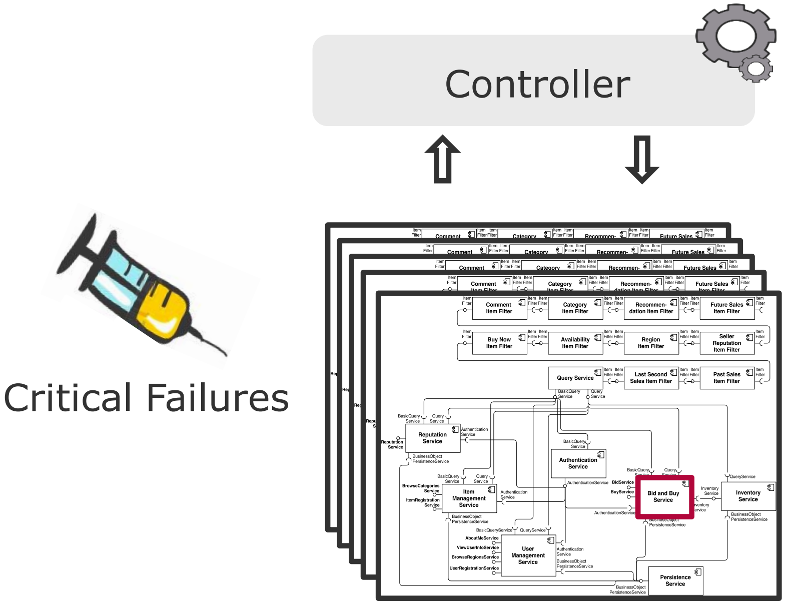
Affected Component

Bid and Buy Service

Affected Component Uid:
(_SEu7n-cdEeet0YmmfbMwkw )

Affected Component :
(Shop#,Component_type)

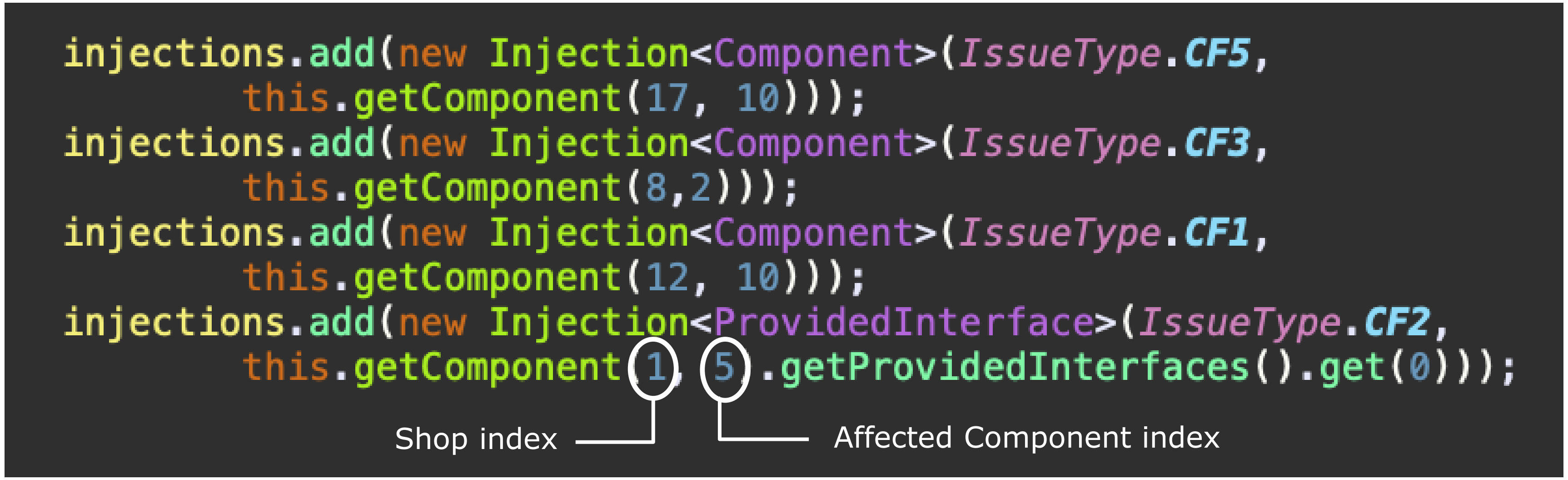
# Input Failure Traces in mRUBiS



Affected Component

Affected Component Uid:
(_SEu7n-cdEeet0YmmfbMwkw )

Affected Component :
(Shop#,Component_type)

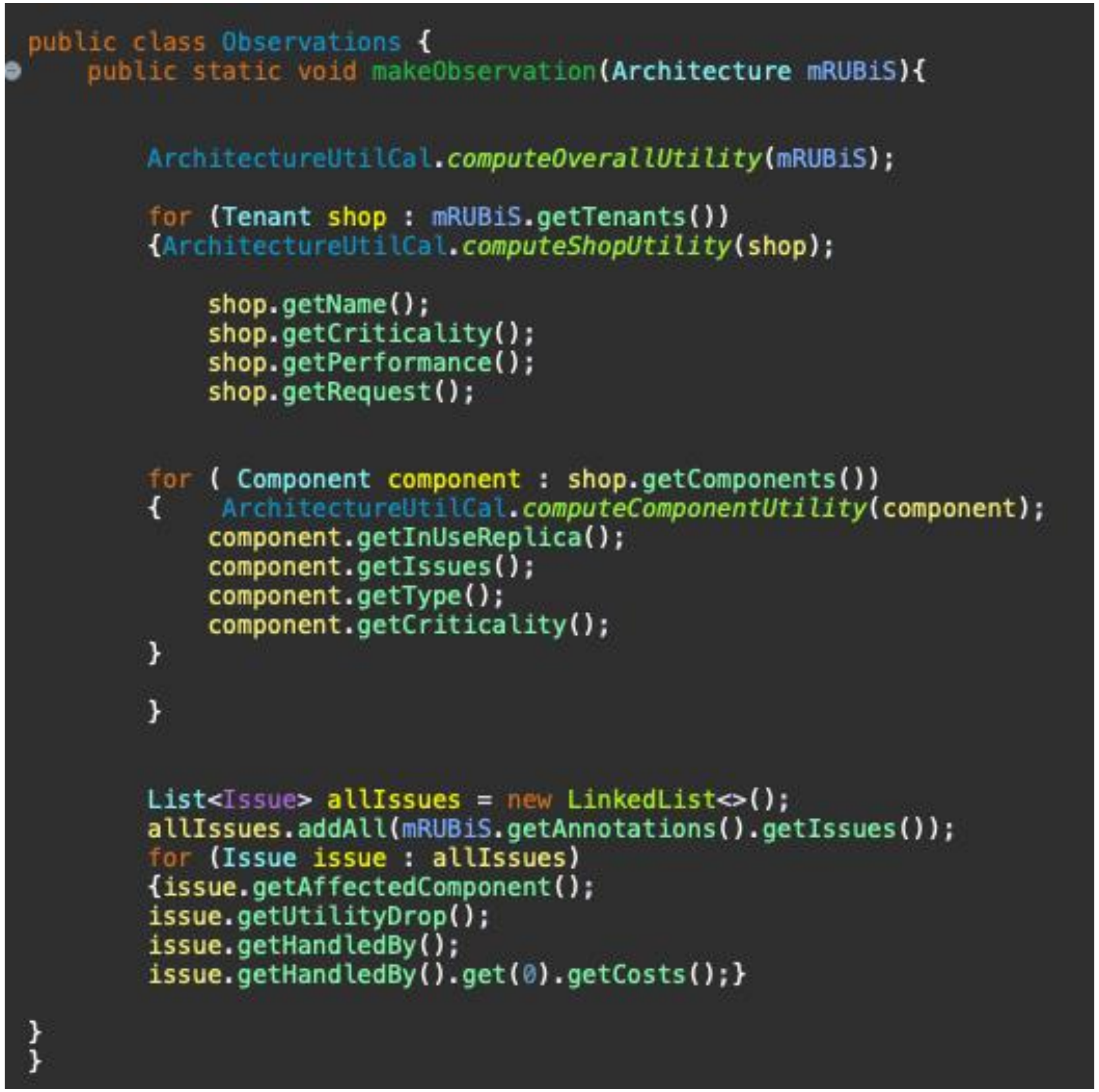


```
injections.add(new Injection<Component>(IssueType.CF5,
        this.getComponent(17, 10)));
injections.add(new Injection<Component>(IssueType.CF3,
        this.getComponent(8,2)));
injections.add(new Injection<Component>(IssueType.CF1,
        this.getComponent(12, 10)));
injections.add(new Injection<ProvidedInterface>(IssueType.CF2,
        this.getComponent(1, 5).getProvidedInterfaces().get(0)));
```

# Possible Observations (Outputs) in mRUBiS

- Output 1: list of all components and their corresponding CF status (CF0 to CF5): <Shop_id, Component_type, CF_x>
- Output 2: for each component, the current values of their parameters and the corresponding utility <Param_1,...,Param_N, Component_utility>
- Output 3: the list of <Compoment_type, CF_x, Action, Cost>
- Output 4: system current *Overall Utility, Shop Utility or, Component Utility*

# Instance of mRUBiS for Sampling



```
public class Observations {
    public static void makeObservation(Architecture mRUBiS){


        ArchitectureUtilCal.computeOverallUtility(mRUBiS);

        for (Tenant shop : mRUBiS.getTenants())
        {ArchitectureUtilCal.computeShopUtility(shop);

            shop.getName();
            shop.getCriticality();
            shop.getPerformance();
            shop.getRequest();


        for ( Component component : shop.getComponents())
        {    ArchitectureUtilCal.computeComponentUtility(component);
            component.getInUseReplica();
            component.getIssues();
            component.getType();
            component.getCriticality();
        }

        }


        List<Issue> allIssues = new LinkedList<>();
        allIssues.addAll(mRUBiS.getAnnotations().getIssues());
        for (Issue issue : allIssues)
        {issue.getAffectedComponent();
        issue.getUtilityDrop();
        issue.getHandledBy();
        issue.getHandledBy().get(0).getCosts();}

}
}
```

- Output 1: list of all components and their corresponding CF status (CF0 to CF5): <Shop_id, Component_type, CF_x>

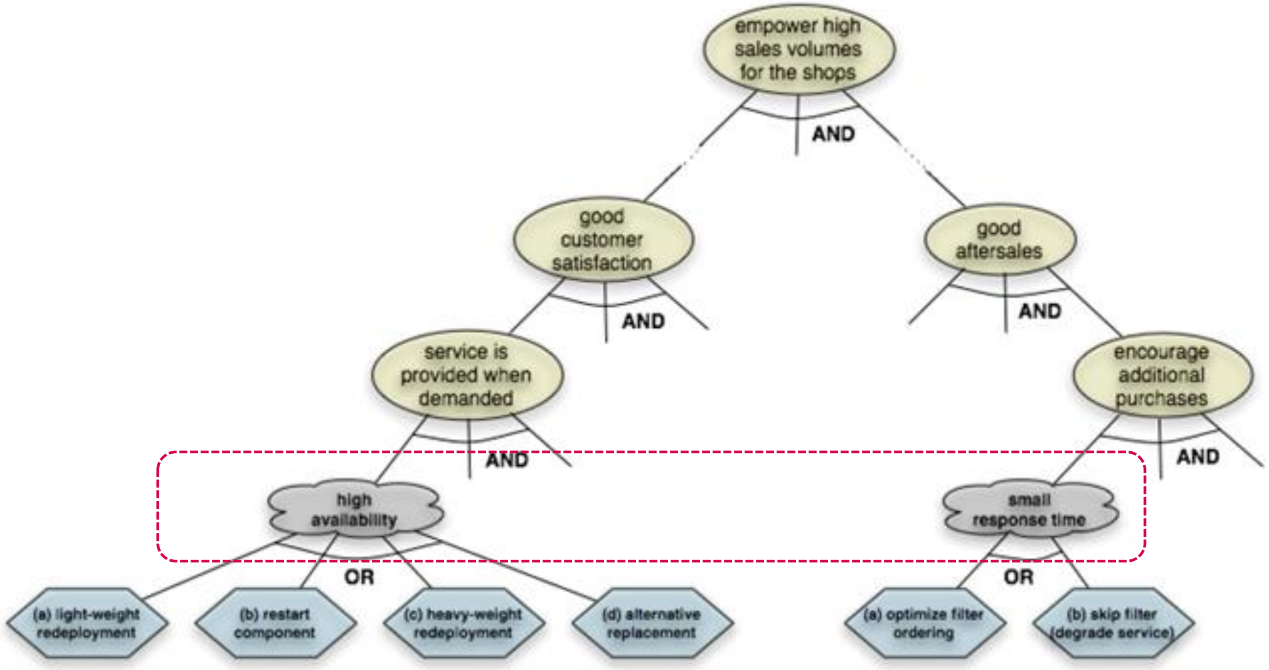
- Output 2: for each component, the current values of their parameters and the corresponding utility <Param_1,…,Param_N, Component_utility>

- Output 3: the list of <Compoment_type, CF_x, Action, cost>

- Output 4: system current *Overall Utility*

# mRUBiS Goal Model

- The controller follows a goal-based approach focused on fulfilling the soft goals of *High availability* and *Low response time* for the shops.
- Disturbances are addressed via two sets of actions:
  - □ Repair Action
  - □ Optimization Actions


empower high sales volumes for the shops
AND
good customer satisfaction
good aftersales
AND
AND
service is provided when demanded
encourage additional purchases
AND
AND
high availability
small response time
OR
OR
(a) light-weight redeployment
(b) restart component
(c) heavy-weight redeployment
(d) alternative replacement
(a) optimize filter ordering
(b) skip filter (degrade service)

# Possible Actions in mRUBiS

- Repair Action
  - Restart Component
  - Heavy Weight Redeployment
  - Light weight Redeployment
  - Replace Component (if an alternative component is available)

- Optimization Actions
  - Add Replica
  - Remove Replica

# Mapping Actions to CFs

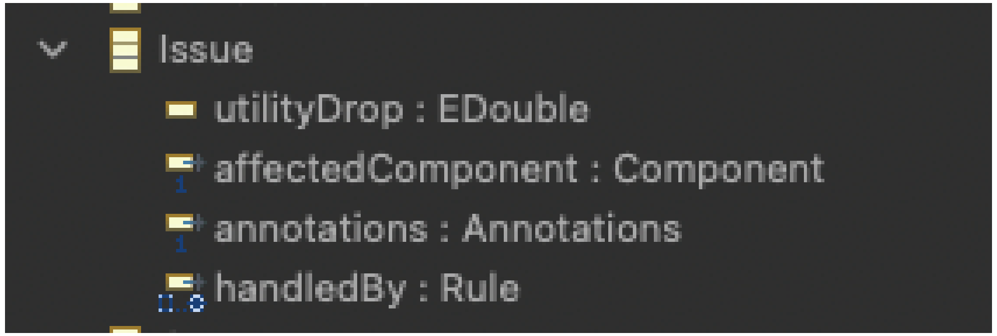
- CF1,CF2,CF3 can be addressed by:
  - Restart Component
  - Heavy Weight Redeployment
  - Light Weight Redeployment
  - Replace Component (if an alternative component is available)

- CF5 can be addressed by:
  - Add Replica
  - Remove Replica

Action: <Reward, Cost>
Reward (Affected_Component , CF_type)

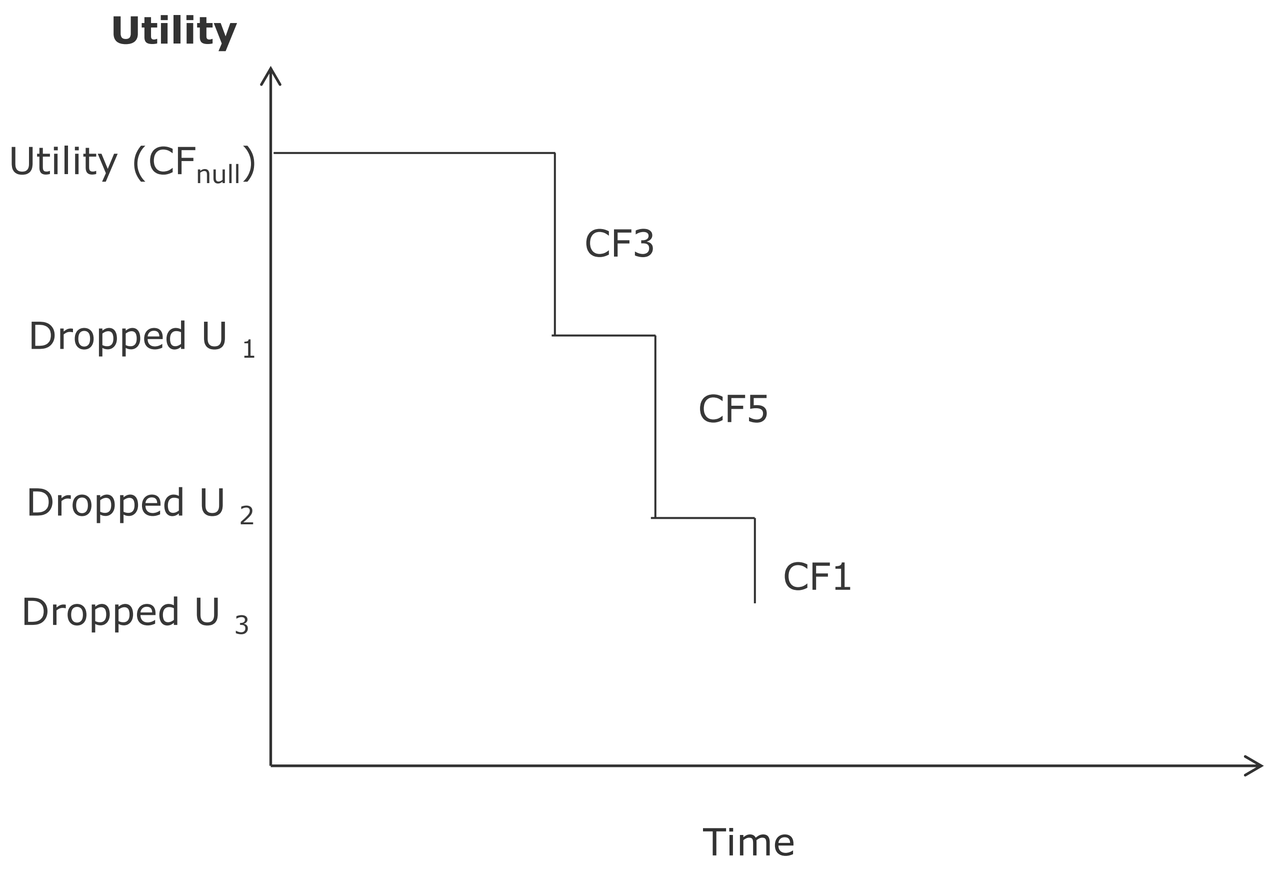
# CFs (issues) in mRUBiS

- For each CF_x
  - Affected Component
    - Component parameters can be observed!
  - Utility Drop
  - Possible Actions to Resolve
    - Action: <Reward, Cost>
    - Reward is the Utility Increase or Delta

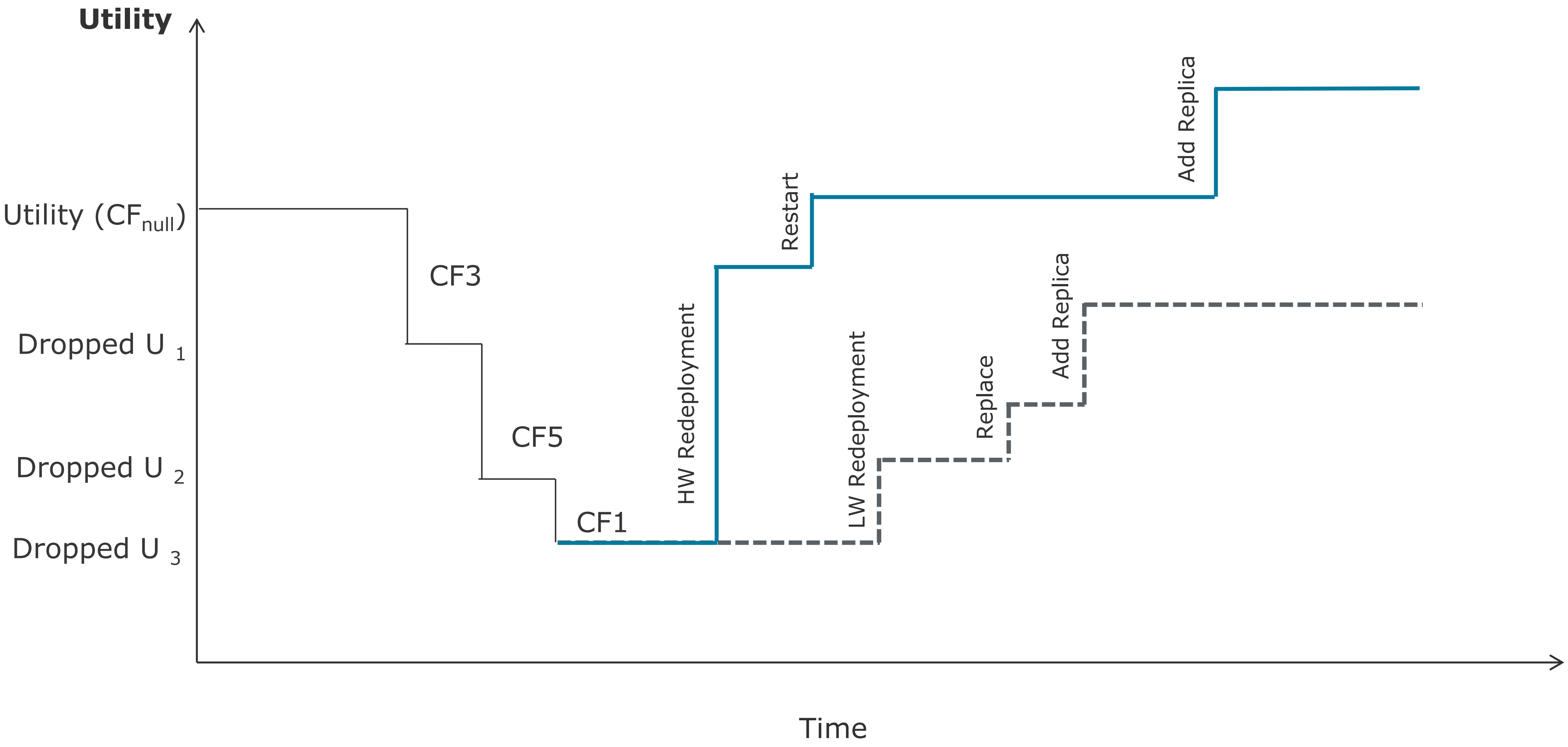


```
Issue
  utilityDrop : EDouble
  affectedComponent : Component
  annotations : Annotations
  handledBy : Rule
```

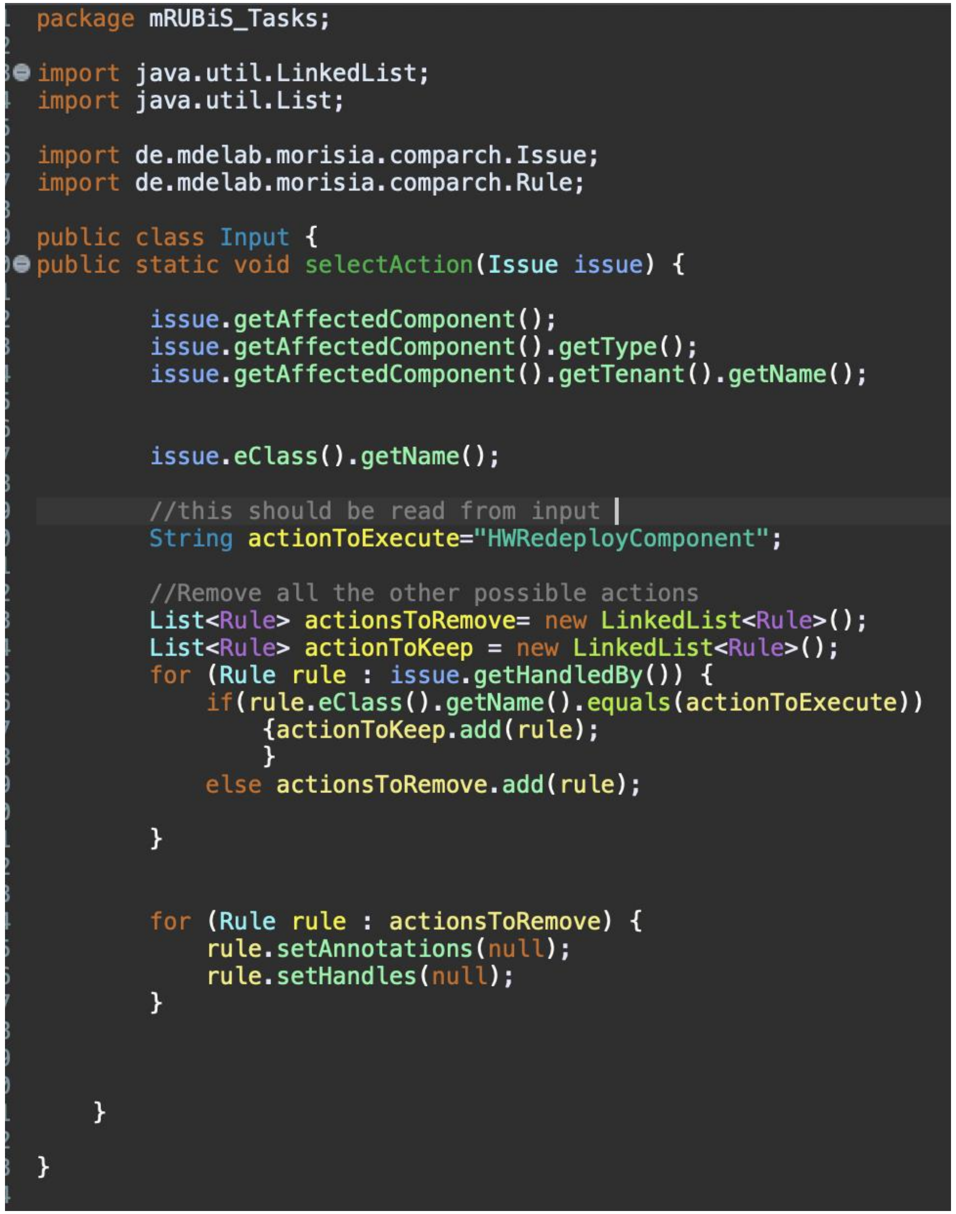
# Utility Drop



# Which Actions to Take? -→ You tell mRUBiS

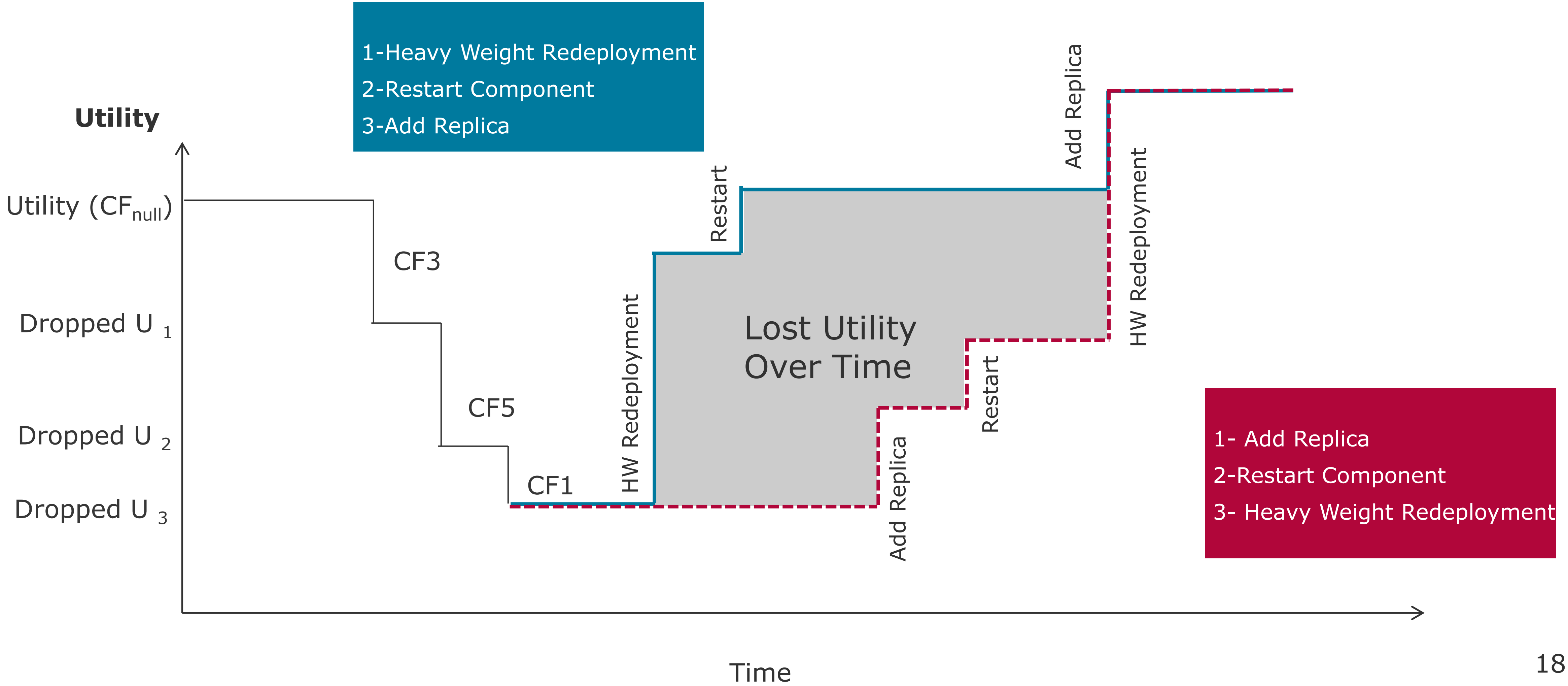


# Which Actions to Take? -→ You tell mRUBiS

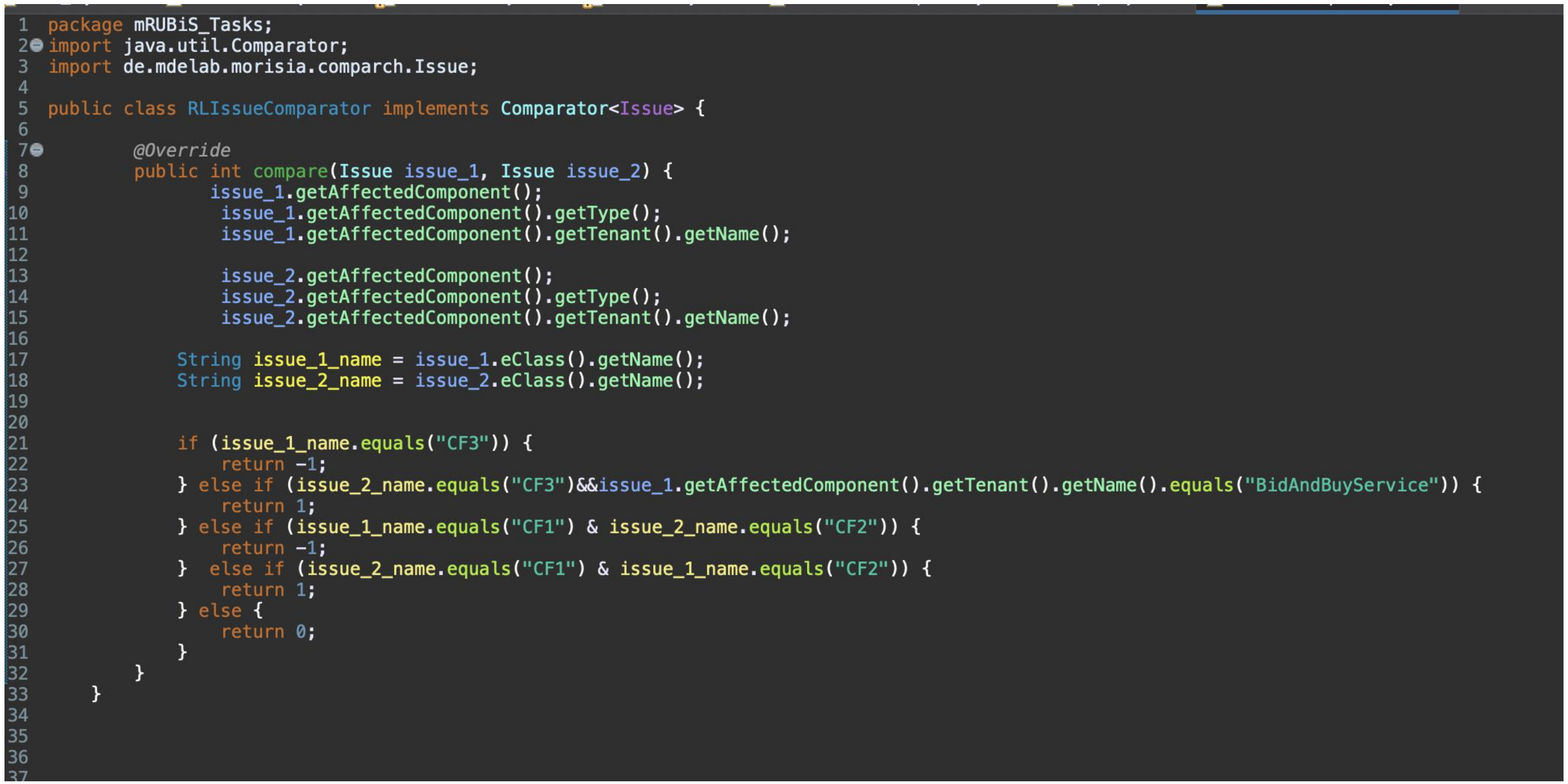


```
package mRUBiS_Tasks;

import java.util.LinkedList;
import java.util.List;

import de.mdelab.morisia.comparch.Issue;
import de.mdelab.morisia.comparch.Rule;

public class Input {
public static void selectAction(Issue issue) {

        issue.getAffectedComponent();
        issue.getAffectedComponent().getType();
        issue.getAffectedComponent().getTenant().getName();


        issue.eClass().getName();

        //this should be read from input
        String actionToExecute="HWRedeployComponent";

        //Remove all the other possible actions
        List<Rule> actionsToRemove= new LinkedList<Rule>();
        List<Rule> actionToKeep = new LinkedList<Rule>();
        for (Rule rule : issue.getHandledBy()) {
            if(rule.eClass().getName().equals(actionToExecute))
                {actionToKeep.add(rule);
                }
            else actionsToRemove.add(rule);

        }


        for (Rule rule : actionsToRemove) {
            rule.setAnnotations(null);
            rule.setHandles(null);
        }



    }

}
```

# And in Which Order?



# And in Which Order?



```java
package mRUBiS_Tasks;
import java.util.Comparator;
import de.mdelab.morisia.comparch.Issue;

public class RLIssueComparator implements Comparator<Issue> {

        @Override
        public int compare(Issue issue_1, Issue issue_2) {
               issue_1.getAffectedComponent();
                issue_1.getAffectedComponent().getType();
                issue_1.getAffectedComponent().getTenant().getName();

                issue_2.getAffectedComponent();
                issue_2.getAffectedComponent().getType();
                issue_2.getAffectedComponent().getTenant().getName();

            String issue_1_name = issue_1.eClass().getName();
            String issue_2_name = issue_2.eClass().getName();


            if (issue_1_name.equals("CF3")) {
                return -1;
            } else if (issue_2_name.equals("CF3")&&issue_1.getAffectedComponent().getTenant().getName().equals("BidAndBuyService")) {
                return 1;
            } else if (issue_1_name.equals("CF1") & issue_2_name.equals("CF2")) {
                return -1;
            }  else if (issue_2_name.equals("CF1") & issue_1_name.equals("CF2")) {
                return 1;
            } else {
                return 0;
            }
        }
    }
```

- Input: ordered list of <component ,  action>

Or Input: ordered list of <component ,  CF_x>

# Back-end

*Thomas Vogel. 2018. mRUBiS: an exemplar for model-based architectural self-healing and self-optimization. In Proceedings of the 13th International Conference on Software Engineering for Adaptive and Self-Managing Systems (SEAMS ’18). Association for Computing Machinery, New York, NY, USA, 101–107. DOI:https://doi.org/10.1145/3194133.3194161*

# Eclipse Modeling Framework

- The mRUBiS Simulator maintains a model of mRUBiS that simulates the real system.
- This model is an instance of a metamodel developed with the Eclipse Modeling Framework (EMF).
  - □ Framework and code-generation tool for building Java applications based on models (*model-driven development*).
- To use the simulator a *Java installation* and the *Eclipse Modelling Tools* edition of Eclipse Download here:

http://www.eclipse.org/downloads/packages/release/2021-03/r/eclipse-modeling-tools

# SDM

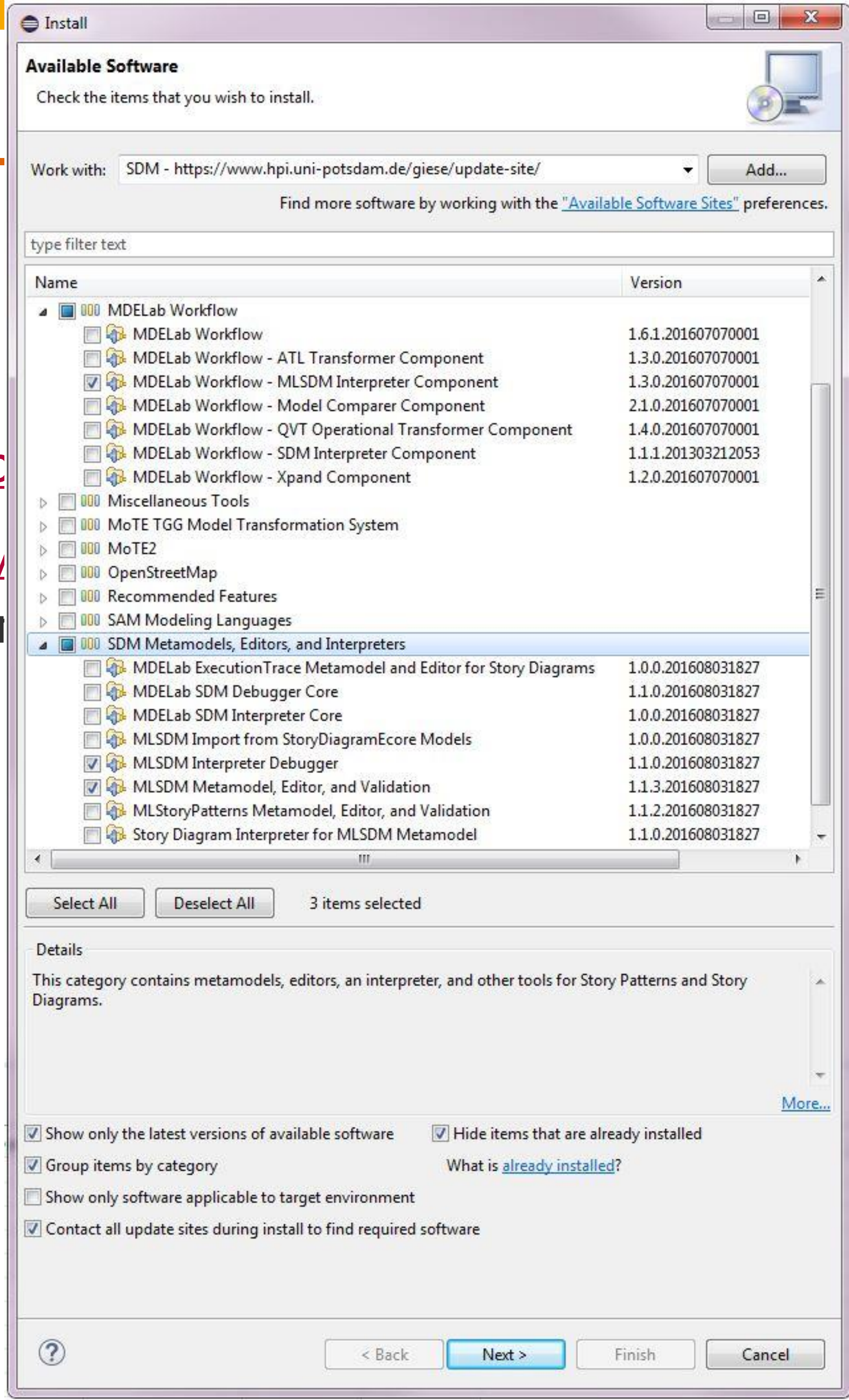
Download the Eclipse Modeling Tools package

Add the following update sites to the Eclipse update manager:

MDELab update site: https://www.hpi.uni-potsdam.de/giese/up

Eclipse Neon update site: http://download.eclipse.org/releases/
latest Eclipse releases no longer include GMF (Graphical Modeli
by the SDM graphical editors).

Select the following features:



Install

**Available Software**

Check the items that you wish to install.

Work with: SDM - https://www.hpi.uni-potsdam.de/giese/update-site/

Find more software by working with the "Available Software Sites" preferences.

type filter text

| Name | Version |
|---|---|
| ▣ MDELab Workflow | |
| □ MDELab Workflow | 1.6.1.201607070001 |
| □ MDELab Workflow - ATL Transformer Component | 1.3.0.201607070001 |
| ☑ MDELab Workflow - MLSDM Interpreter Component | 1.3.0.201607070001 |
| □ MDELab Workflow - Model Comparer Component | 2.1.0.201607070001 |
| □ MDELab Workflow - QVT Operational Transformer Component | 1.4.0.201607070001 |
| □ MDELab Workflow - SDM Interpreter Component | 1.1.1.201303212053 |
| □ MDELab Workflow - Xpand Component | 1.2.0.201607070001 |
| □ Miscellaneous Tools | |
| □ MoTE TGG Model Transformation System | |
| □ MoTE2 | |
| □ OpenStreetMap | |
| □ Recommended Features | |
| □ SAM Modeling Languages | |
| ▣ SDM Metamodels, Editors, and Interpreters | |
| □ MDELab ExecutionTrace Metamodel and Editor for Story Diagrams | 1.0.0.201608031827 |
| □ MDELab SDM Debugger Core | 1.1.0.201608031827 |
| □ MDELab SDM Interpreter Core | 1.0.0.201608031827 |
| □ MLSDM Import from StoryDiagramEcore Models | 1.0.0.201608031827 |
| ☑ MLSDM Interpreter Debugger | 1.1.0.201608031827 |
| ☑ MLSDM Metamodel, Editor, and Validation | 1.1.3.201608031827 |
| □ MLStoryPatterns Metamodel, Editor, and Validation | 1.1.2.201608031827 |
| □ Story Diagram Interpreter for MLSDM Metamodel | 1.1.0.201608031827 |

3 items selected

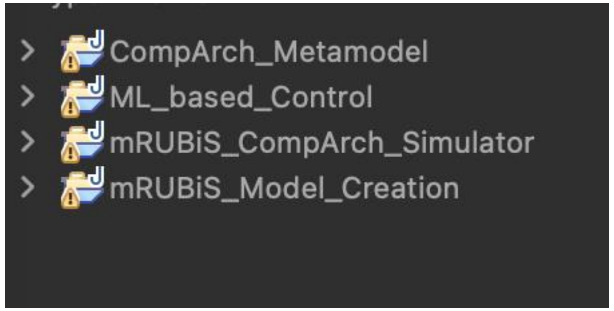
Details

This category contains metamodels, editors, an interpreter, and other tools for Story Patterns and Story Diagrams.

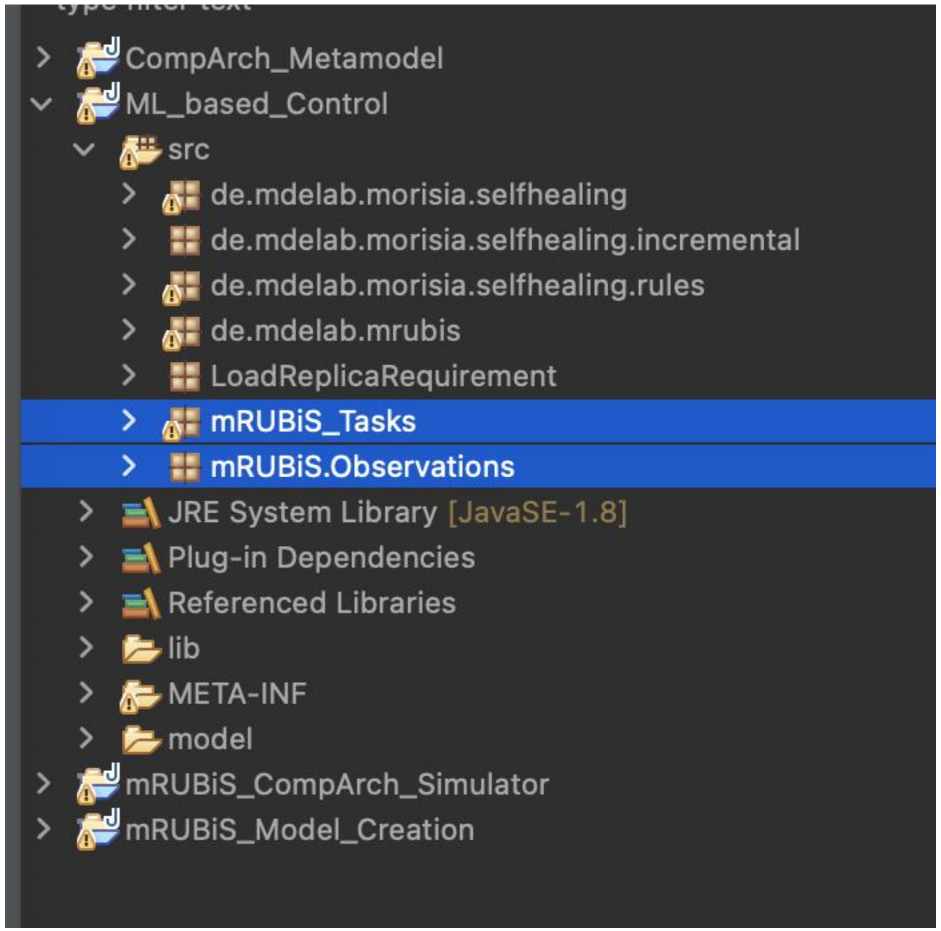
☑ Show only the latest versions of available software
☑ Hide items that are already installed
☑ Group items by category
What is already installed?
□ Show only software applicable to target environment
☑ Contact all update sites during install to find required software

# Project Files

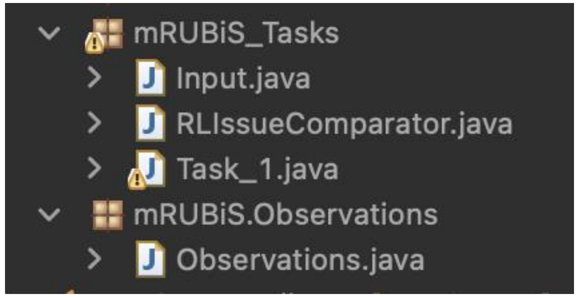
- Will be uploaded on GitHub



```
> CompArch_Metamodel
> ML_based_Control
> mRUBiS_CompArch_Simulator
> mRUBiS_Model_Creation
```



```
type filter text
> CompArch_Metamodel
v ML_based_Control
  v src
    > de.mdelab.morisia.selfhealing
    > de.mdelab.morisia.selfhealing.incremental
    > de.mdelab.morisia.selfhealing.rules
    > de.mdelab.mrubis
    > LoadReplicaRequirement
    > mRUBiS_Tasks
    > mRUBiS.Observations
  > JRE System Library [JavaSE-1.8]
  > Plug-in Dependencies
  > Referenced Libraries
  > lib
  > META-INF
  > model
> mRUBiS_CompArch_Simulator
> mRUBiS_Model_Creation
```



```
v mRUBiS_Tasks
  > Input.java
  > RLIssueComparator.java
  > Task_1.java
v mRUBiS.Observations
  > Observations.java
```

# End