



**Workshop “Cooperation at Academic Informatics Education across Balkan
DAAD Countries and Beyond: The Impact of Informatics to Society”
Hvar, 1st – 7th September 2019.**

AMADEOS – An Online System for Automated Model-driven Database Design

**D. Banjac, D. Brdjanin, G. Banjac, S. Maric
University of Banja Luka, Bosnia & Herzegovina**

Introduction

- Different surveys show that only a **small number of papers present implemented automatic model-driven generator of data models**
- **AMADEOS** - the first online two-phase business process model-driven generator of the conceptual database model (CDM)
- **AMADEOS** enables automatic generation of the target data model based on business process models (BPM) represented by two concrete notations: **BPMN** and **UML activity diagram** (UML AD)
- Target model is represented by a **UML class diagram**

Research context



<http://m-lab.etf.unibl.org>

M-lab long-term research project:
**Automatic database design
driven by business process models**

Main project achievements:

2010: the first ideas and prototype UML AD→UML CD

2012: identified semantic capacity of BPM for automatic CDM synthesis

2014: ATL-based generator BPMN→UML CD

2017: controlled experiment with database professionals

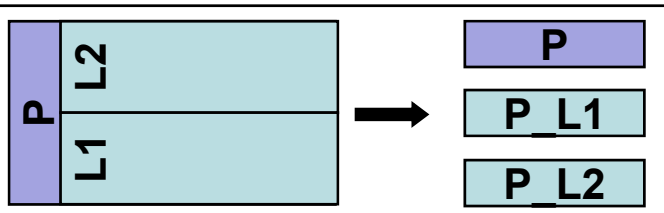
2017: two-phase approach to automatic BPM-driven CDM synthesis

2018: online BPM-driven CDM generator service

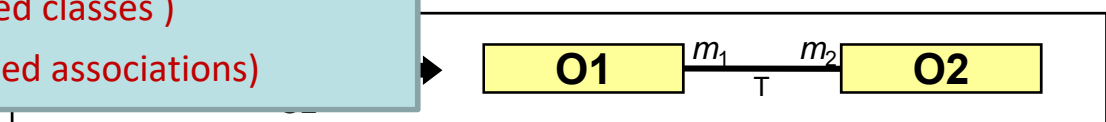
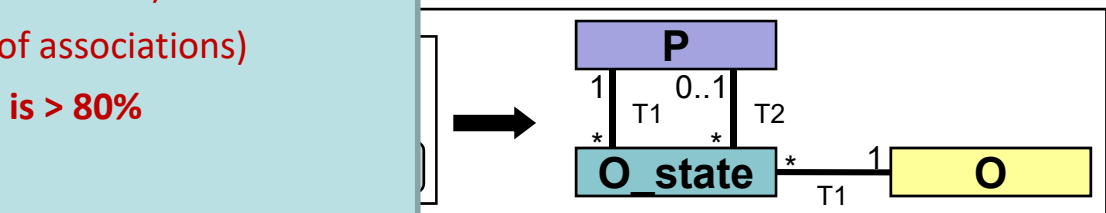
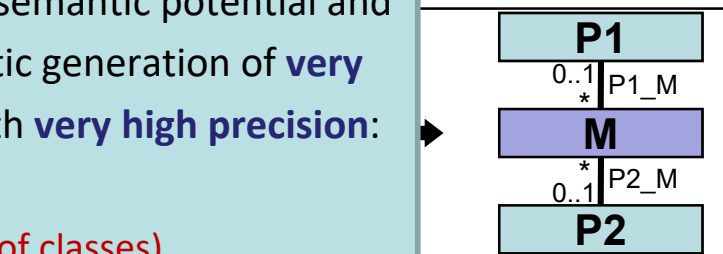
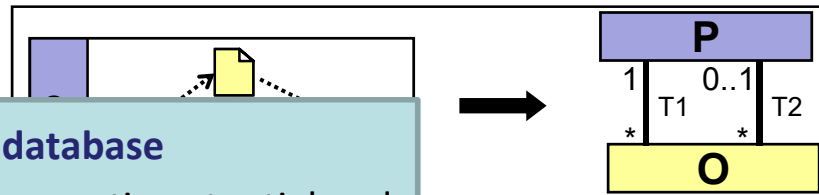
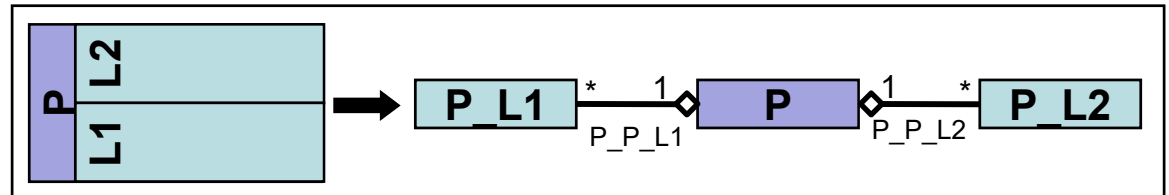
2019: AMADEOS – the first online web-based system for BPM-driven CDM synthesis

BPM-driven CDM synthesis

Classes



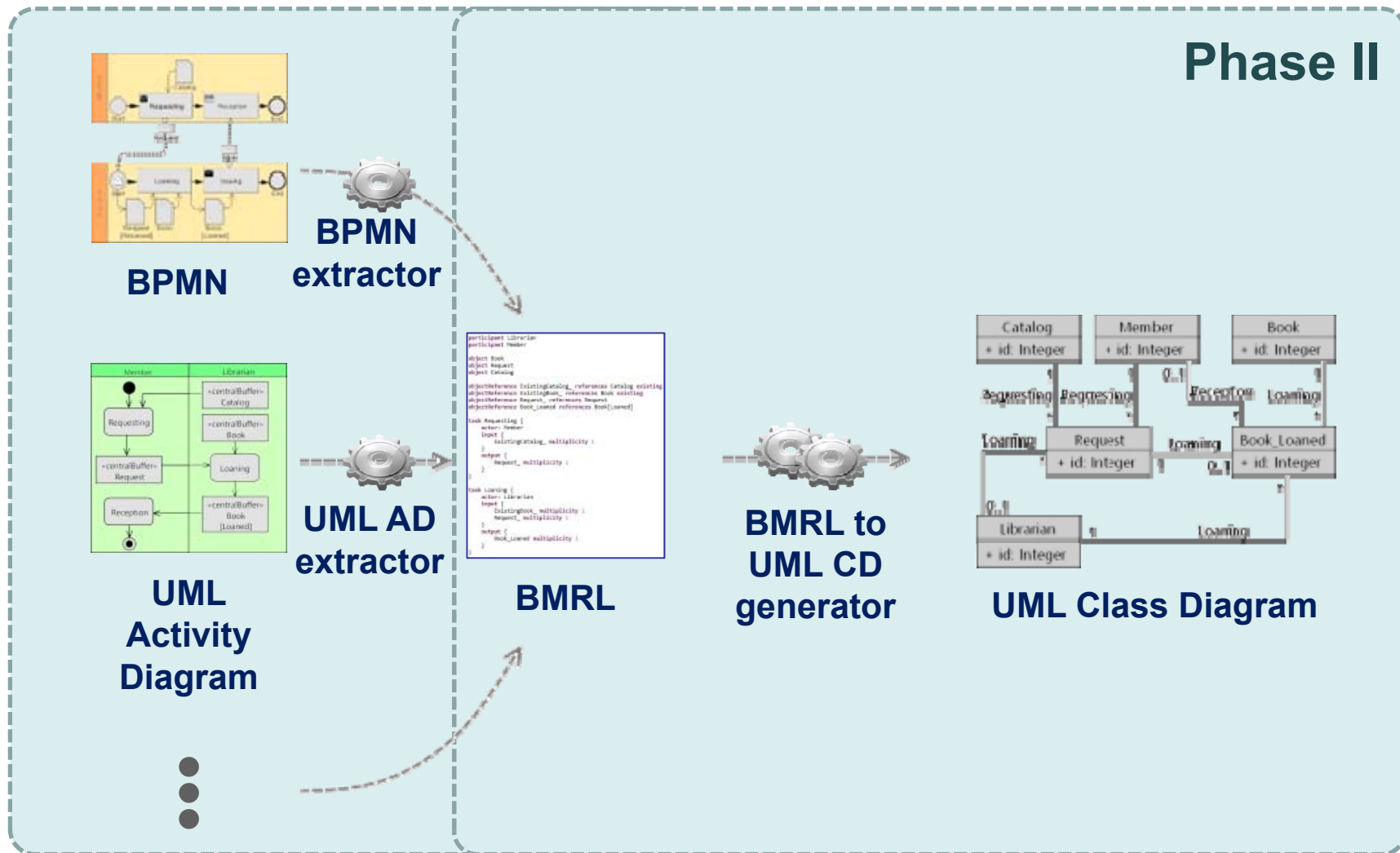
Associations



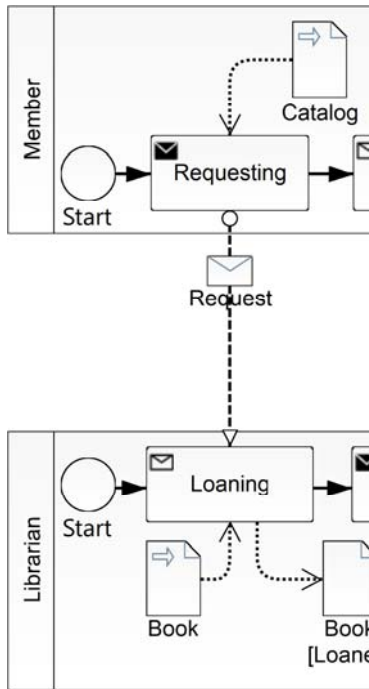
Our recent **experiment conducted with database professionals** confirmed that identified semantic potential and implemented generator enable automatic generation of **very high percentage** of the target model with **very high precision**:

- **Average effectiveness:**
 - ~ 78% (for automatic generation of classes)
 - ~ 85% (for automatic generation of associations)
- **Average recall of the generated model is > 80%**
- **Average precision:**
 - ~ 75% (for automatically generated classes)
 - ~ 90% (for automatically generated associations)

Two-phase synthesis of the target model

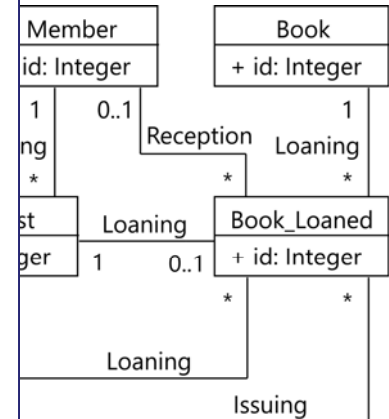


Illustrative example



```

participant Librarian
participant Member
object Book
object Request
object Catalog
objectReference ExistingBook_ references Book existing
objectReference ExistingCatalog_ references Catalog existing
objectReference Book_ references Book
objectReference Request_ references Request
objectReference Book_Loaned references Book[Loaned]
task Reception {
  actor: Member
  input { Book_ multiplicity 1 }
  output { } }
task Issuing {
  actor: Librarian
  input { Book_Loaned multiplicity 1 }
  output { Book_ multiplicity 1 } }
task Requesting {
  actor: Member
  input { ExistingCatalog_ multiplicity 1 }
  output { Request_ multiplicity 1 } }
task Loaning {
  actor: Librarian
  input { ExistingBook_ multiplicity 1
    Request_ multiplicity 1 }
  output { Book_Loaned multiplicity 1 } }
  
```



Previously implemented tools

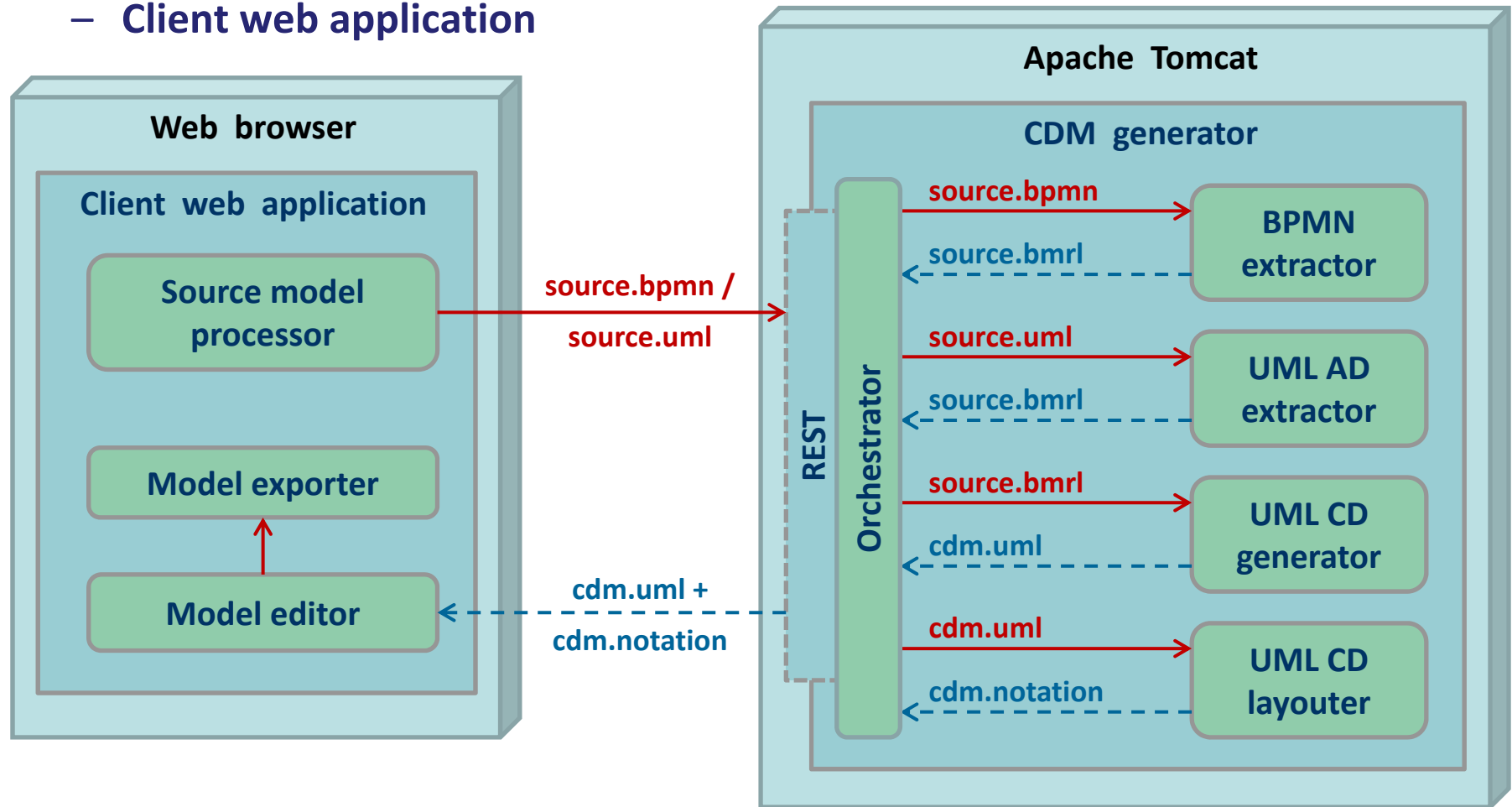
- During the last several years of research, we implemented a set of tools for the automatic CDM synthesis:
 - ATL-based CDM generator based on the single source UML AD
 - ATL-based CDM generator based on the single source collaborative BPMN model
 - Java-based CDM generator taking a collection of the source UML AD models
- This set of tools, like all existing tool-supported MDSDM approaches, is platform-dependent – all tools are implemented as Eclipse plug-ins

AMADEOS

- In order to obtain a **platform independent and publicly available tool** for the BPM-driven CDM synthesis, we performed the migration of these tools into a **SOA application**
- The result of the migration is the **AMADEOS** – an online tool for the automatic BPM-driven CDM synthesis
- AMADEOS currently enables automatic generation of the target database model, based on BPMs represented by:
 - **BPMN**
 - **UML AD**
- The target database model is represented by **UML class diagram**
- AMADEOS GitLab:
<https://gitlab.com/m-lab-research/amadeos>

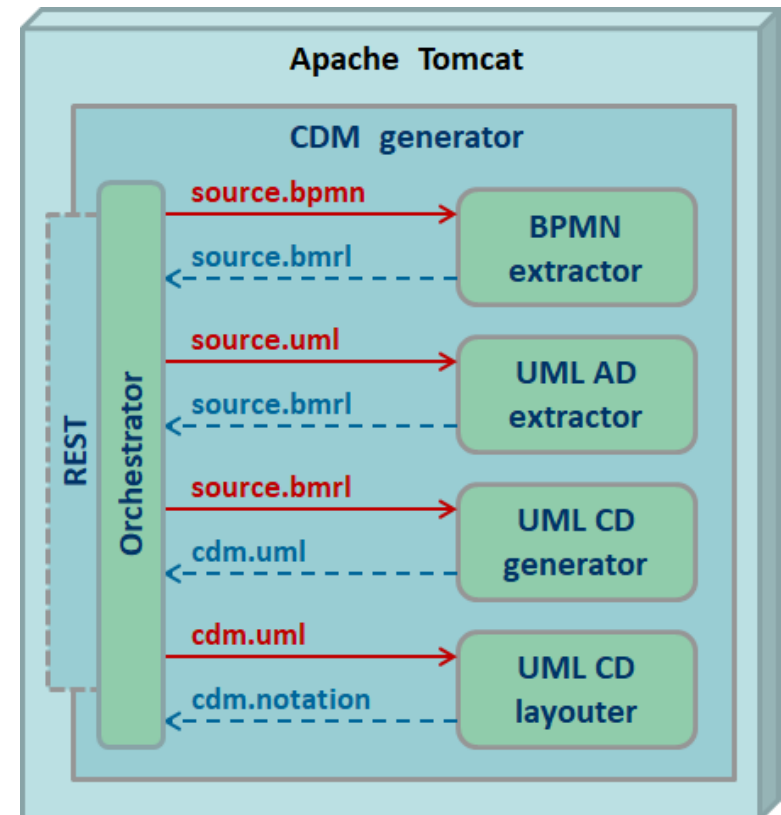
AMADEOS architecture

- AMADEOS consists of two main components:
 - CDM generator
 - Client web application



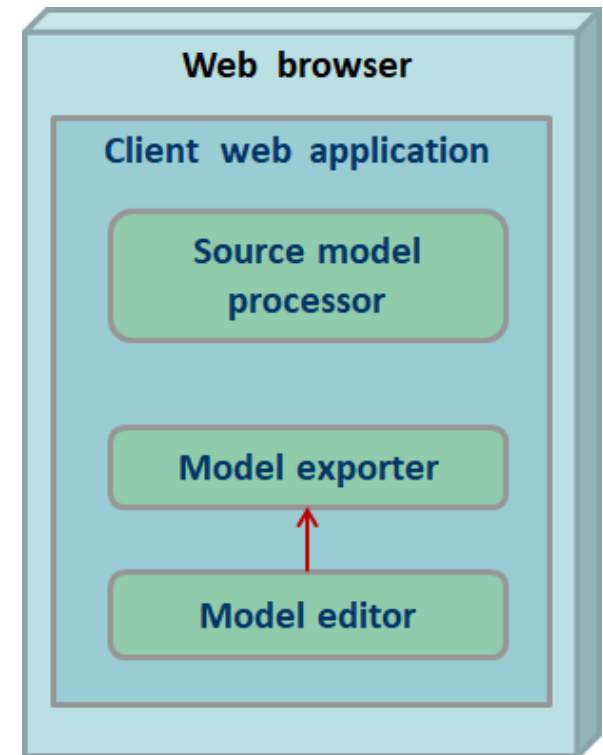
AMADEOS CDM generator

- Services are exposed as **RESTful** web services
- CDM generator receives a source BPM represented by BPMN or UML AD
- **Orchestrator** service orchestrates the two-phase BPM-driven CDM synthesis:
 - Invokes the corresponding **BPM extractor**
 - Invokes the **UML CD generator service**
- Orchestrator forwards the generated model to the **UML CD Layouter service** that generates layout of the diagram
- Orchestrator merges model and diagram and returns response



AMADEOS Client web application

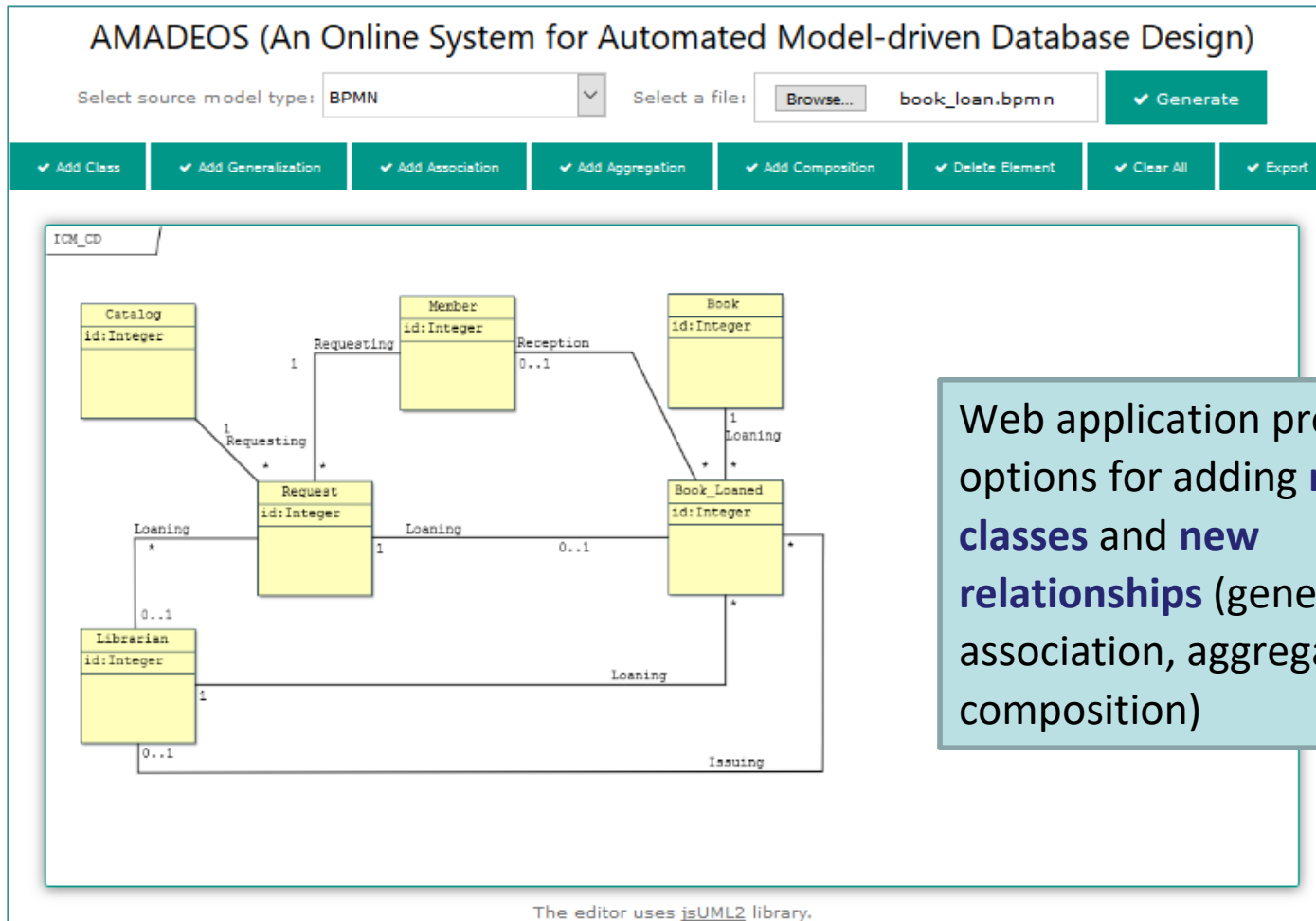
- Client web application is available at: <http://m-lab.etf.unibl.org:8080/amadeos/>
- User selects a source UML AD or BPMN model
- **Source model processor** invokes the remote **CDM generator service** and submits the source BPM
- Client web application processes the JSON response and visualizes the corresponding **UML class diagram in the browser**
- jsUML2* library is used for web visualization
- Diagram and model can be exported in native jsUML2 format



* <http://www.jrromero.net/tools/jsUML2>

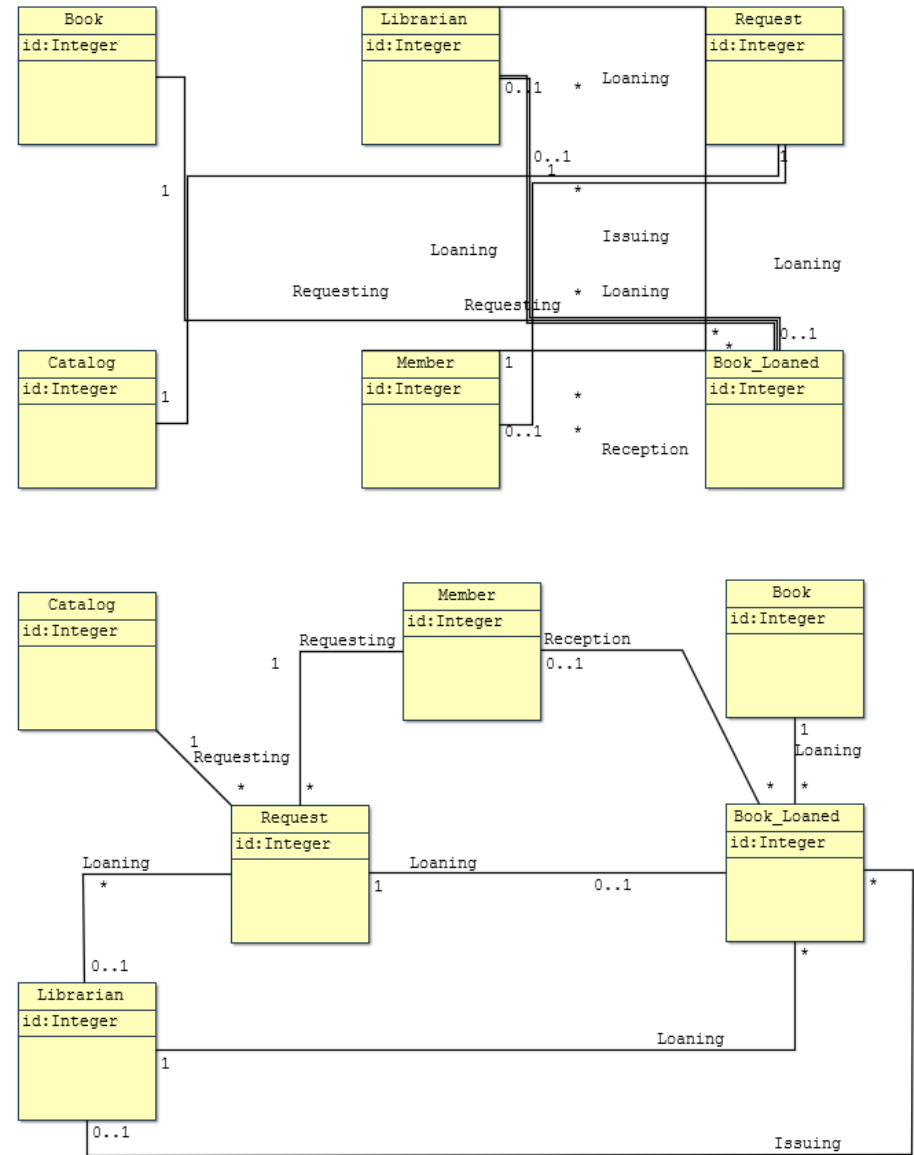
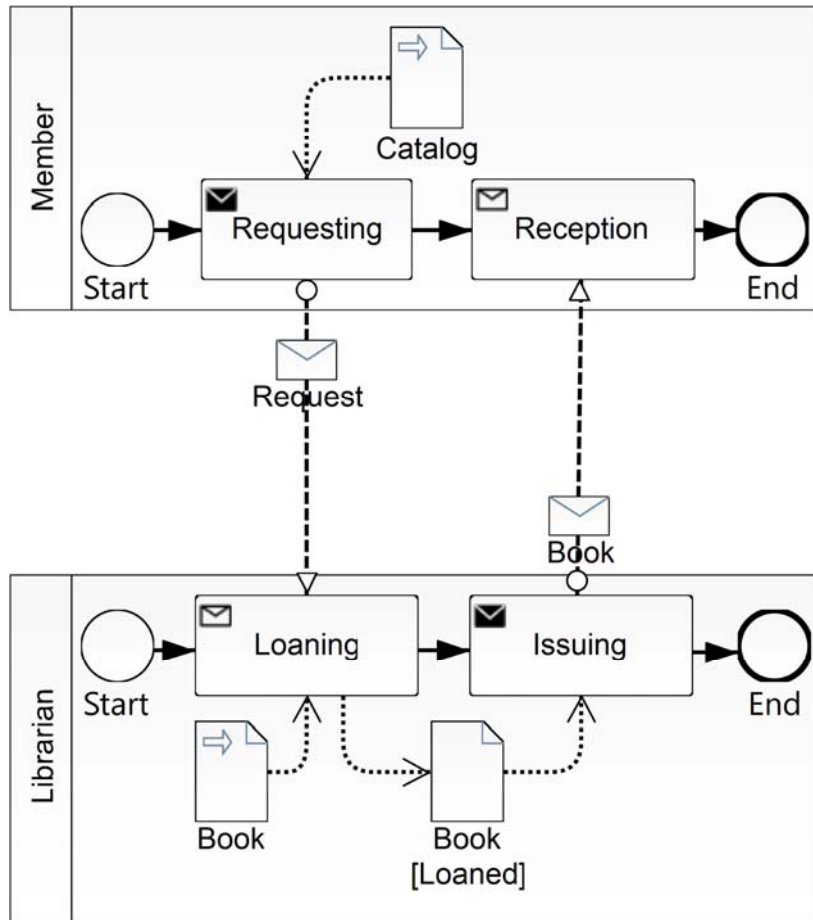
AMADEOS Client web application

- AMADEOS enables web-based **visualization** and **editing functionalities** of automatically generated database models



Web application provides options for adding **new classes** and **new relationships** (generalization, association, aggregation and composition)

Illustrative example



Usage of the AMADEOS CDM generator

- AMADEOS CDM generator can be used from **independent client application** which consumes the exposed REST service for generation of the target database model
- Example of the Web service client (Java):

```
FileDataBodyPart filePart = new FileDataBodyPart("input", new File("path_to_source_model"));

FormDataMultiPart multipart = new FormDataMultiPart();
multipart.field("source_model_type", "AD").bodyPart(filePart);
// For BPMN: multipart.field("source_model_type", "BPMN").bodyPart(filePart);

ClientConfig clientConfig = new ClientConfig().register(MultiPartFeature.class);
Client client = ClientBuilder.newClient(clientConfig);
WebTarget target = client.target("http://m-
lab.etf.unibl.org:8080/amadeos/services/").path("generate").path("cdm");

Response response = target.request().post(Entity.entity(multipart, multipart.getMediaType()));
if (response.getStatus() == 200) {
    InputStream is = response.readEntity(InputStream.class);
    File f = new File("path_to_target_model.uml");
    FileUtils.copyToFile(is, f);
    is.close();
}

filePart.cleanup();
multipart.close();
client.close();
response.close();
```

Conclusion and future work

- **AMADEOS - first online BPM-driven CDM generator** implemented as a web-based, platform-independent tool, is presented
- Its **usage** can be **twofold**:
 - Using the implemented client web application database designers can upload the source BPM, and get visualised editable CDM directly in the browser
 - Developers are able to invoke the exposed web service from their own applications
- The **two-phase synthesis** enables the automatic generation of the target CDM represented by UML class diagram, based on BPMs represented by two concrete notations: **BPMN and UML activity diagram**
- **In the future** we plan to:
 - **Further identify the semantic capacity of BPMs** for automated CDM design
 - **Further improve BMRL**
 - **Further improve implemented tools** (extractors, generator, layouter)
 - **Cover the whole DB design process** – forward engineering of (non)relational DBs
 - Conduct **an experiment with database professionals** using AMADEOS



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Thank You!