University of Applied Sciences and Arts Northwestern Switzerland
School of Business

Università di Camerino

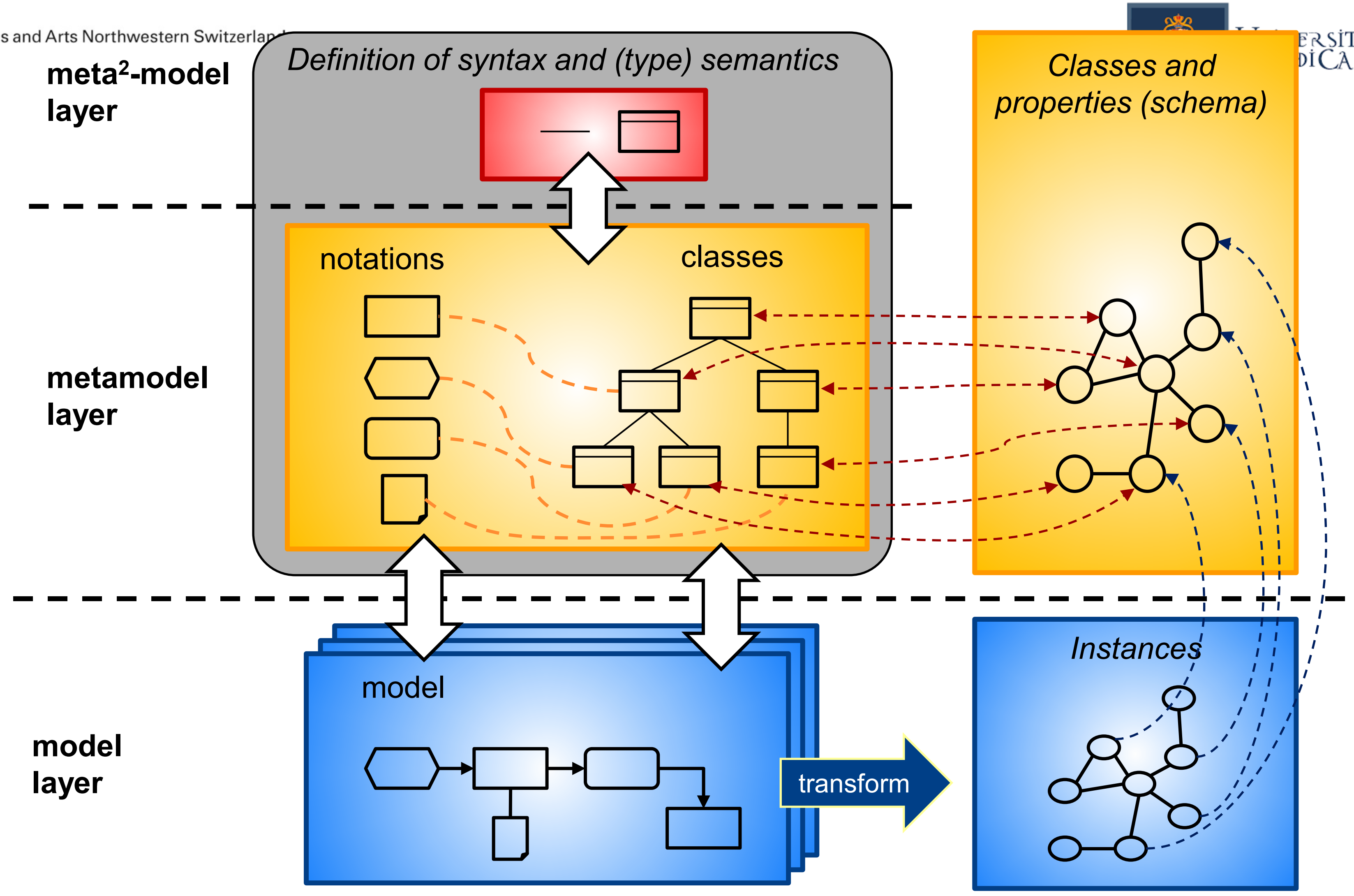
Semantic Lifting

Knowledge Engineering SS24
MSc Computer Science
Camerino, 20/05/2024
Dr. Emanuele Laurenzi

Semantic Lifting – A definition

- A knowledge engineering technique that aims to annotate model constructs with ontology concepts or instances. Semantic lifting allows the formalization of the semantics of model constructs, thus enabling reasoning on and automation of knowledge contained in conceptual models.

Semantic Lifting



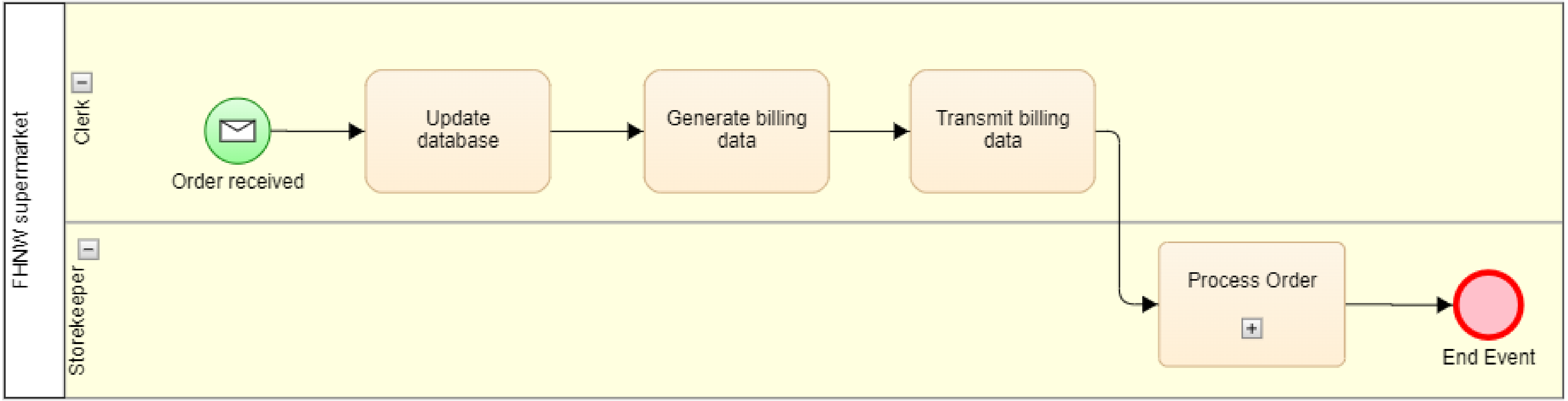
⇔ **linguistic metamodelling:** *syntax, structure, type semantics*

⇢ **ontological metamodelling (lifting):** *explication of type semantics*

⇢ **ontological instantiation:** *instance-Of relationship*

Exercise 1:

- Given the below “Order Processing” process model, create a corresponding ontology in Protégé.
  - incl. the ontology meta-model

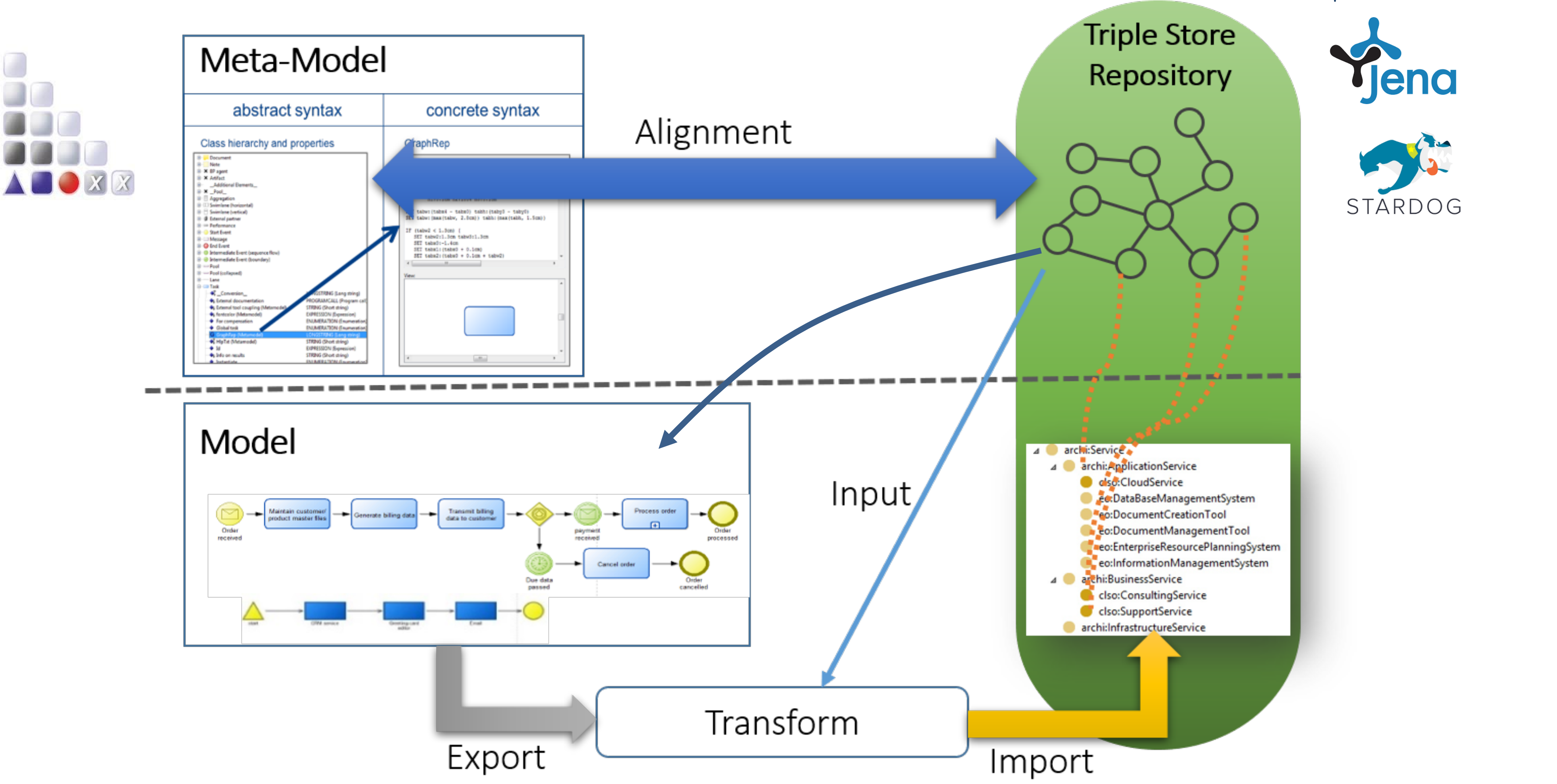


Amazon Neptune

Università di Camerino

GraphDB

Semantic Lifting: Implementation



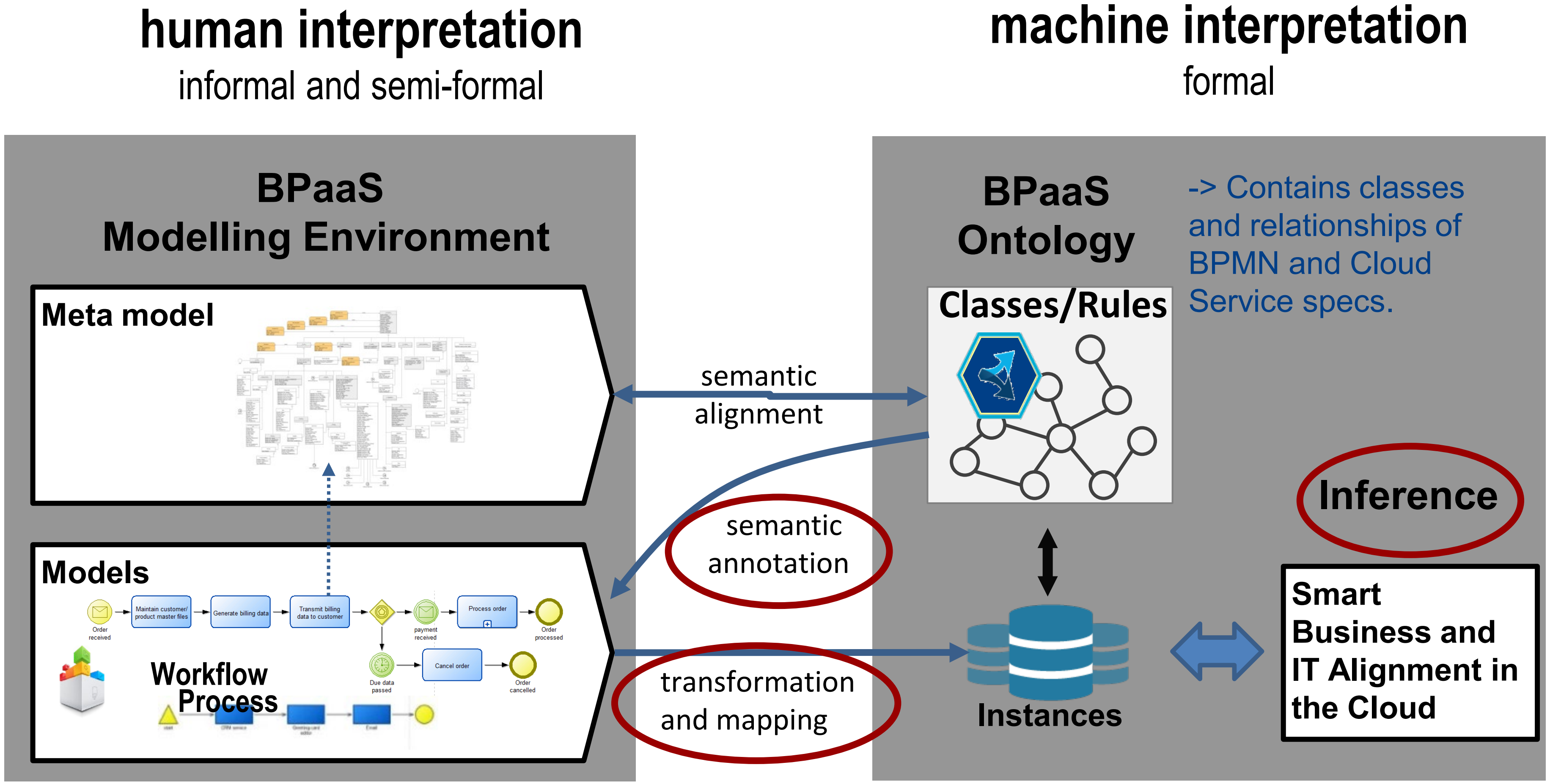
- archi:Service
  - archi:ApplicationService
    - clso:CloudService
    - eo:DataBaseManagementSystem
    - eo:DocumentCreationTool
    - eo:DocumentManagementTool
    - eo:EnterpriseResourcePlanningSystem
    - eo:InformationManagementSystem
  - archi:BusinessService
    - clso:ConsultingService
    - clso:SupportService
  - archi:InfrastructureService

XSLT transformation

Case: Business Process as a Service (BPaaS)

EU Research Project where Semantic Lifting was applied.

BPaaS environment



human interpretation

informal and semi-formal

machine interpretation

formal

BPaaS Modelling Environment

Meta model

Models

Workflow Process

semantic alignment

semantic annotation

transformation and mapping

BPaaS Ontology

-> Contains classes and relationships of BPMN and Cloud Service specs.

Classes/Rules

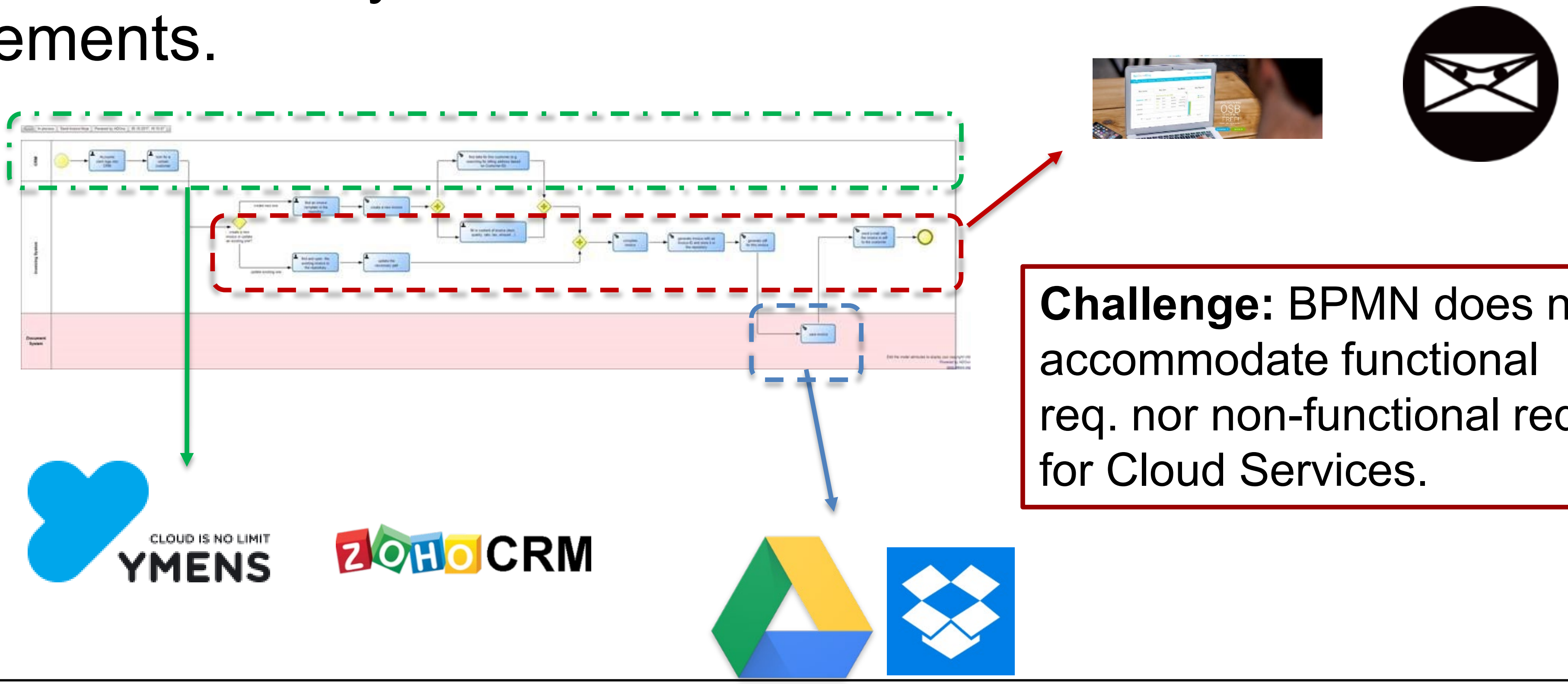
Inference

Instances

Smart Business and IT Alignment in the Cloud

Smart Business IT Alignment in the Cloud

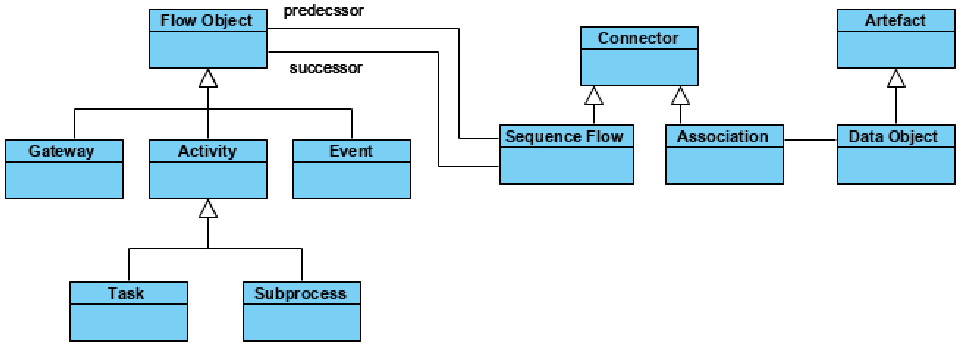
– Given a BPMN business process, retrieve all the Cloud Services that satisfy the functional and non-functional requirements.

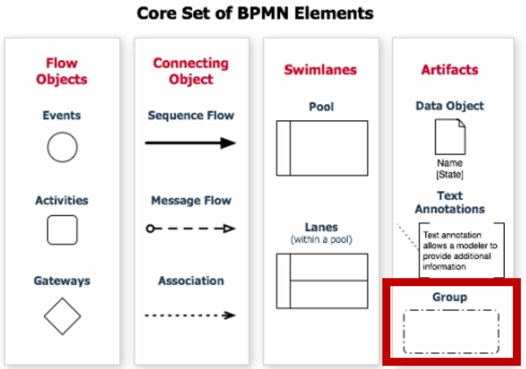


Challenge: BPMN does not accommodate functional req. nor non-functional req. for Cloud Services.

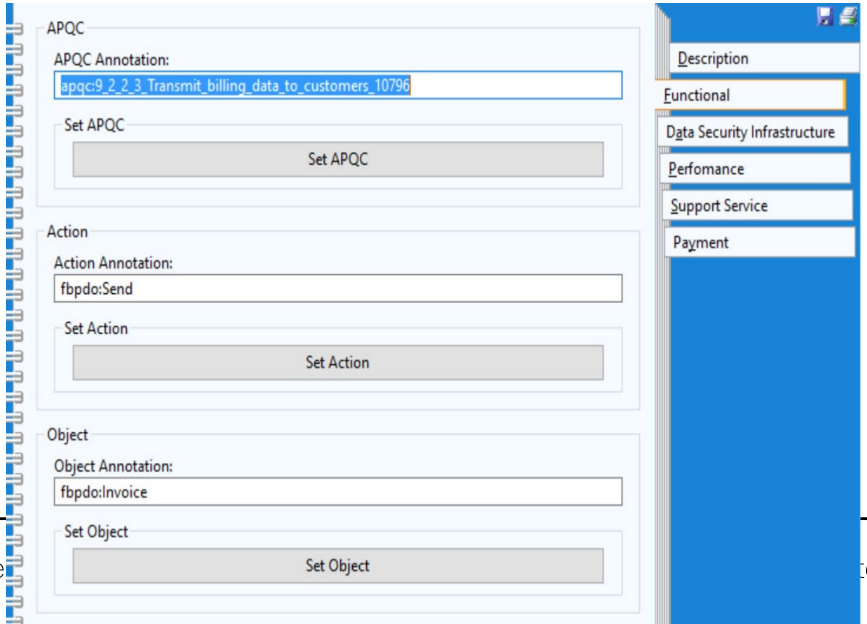
Meta-Modelling

Extend BPMN element «Group» with CS business requirements





Functional Requirements



APQC

APQC Annotation: apqc:9_2_2_3_Transmit_billing_data_to_customers_10796

Set APQC

Set APQC

Action

Action Annotation: fbpdo:Send

Set Action

Set Action

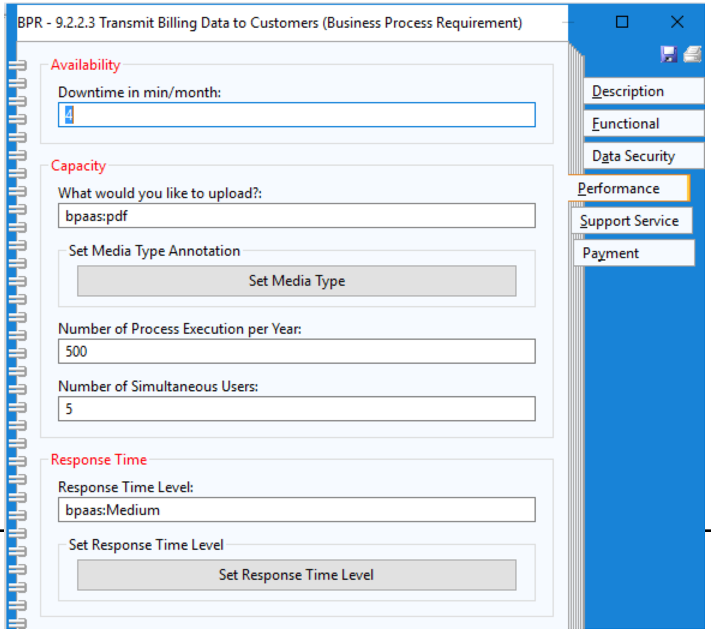
Object

Object Annotation: fbpdo:Invoice

Set Object

Set Object

Non-Functional Requirements



BPR - 9.2.2.3 Transmit Billing Data to Customers (Business Process Requirement)

Availability

Downtime in min/month: 4

Capacity

What would you like to upload?: bpaas:pdf

Set Media Type Annotation

Set Media Type

Number of Process Execution per Year: 500

Number of Simultaneous Users: 5

Response Time

Response Time Level: bpaas:Medium

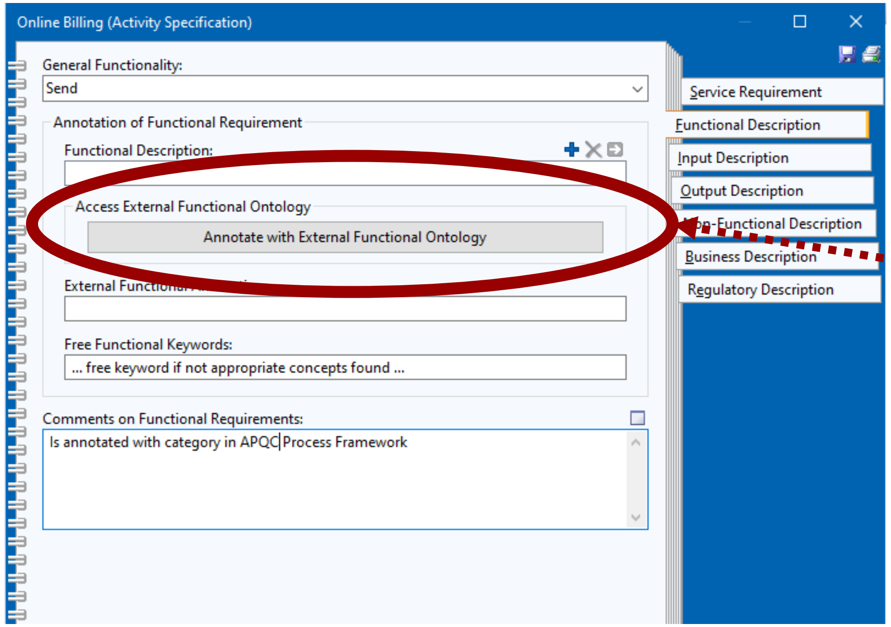
Set Response Time Level

Set Response Time Level

Semantic Annotation

Annotate modeling elements with classes or instances from the domain ontology.

Example: Functionality of a Service



Online Billing (Activity Specification)

General Functionality: Send

Annotation of Functional Requirement

Functional Description:

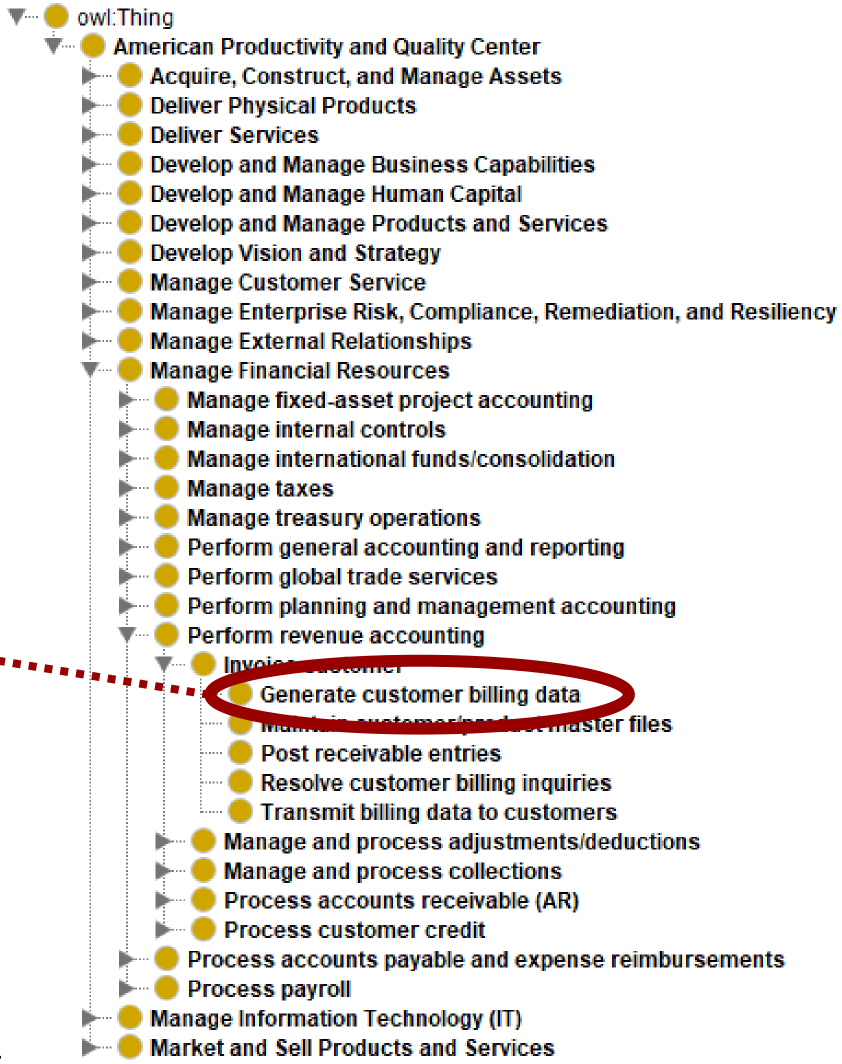
Access External Functional Ontology

External Functional

Free Functional Keywords: ... free keyword if not appropriate concepts found ...

Comments on Functional Requirements: Is annotated with category in APQC Process Framework

Domain Ontology:
APQC Process Classification Framework

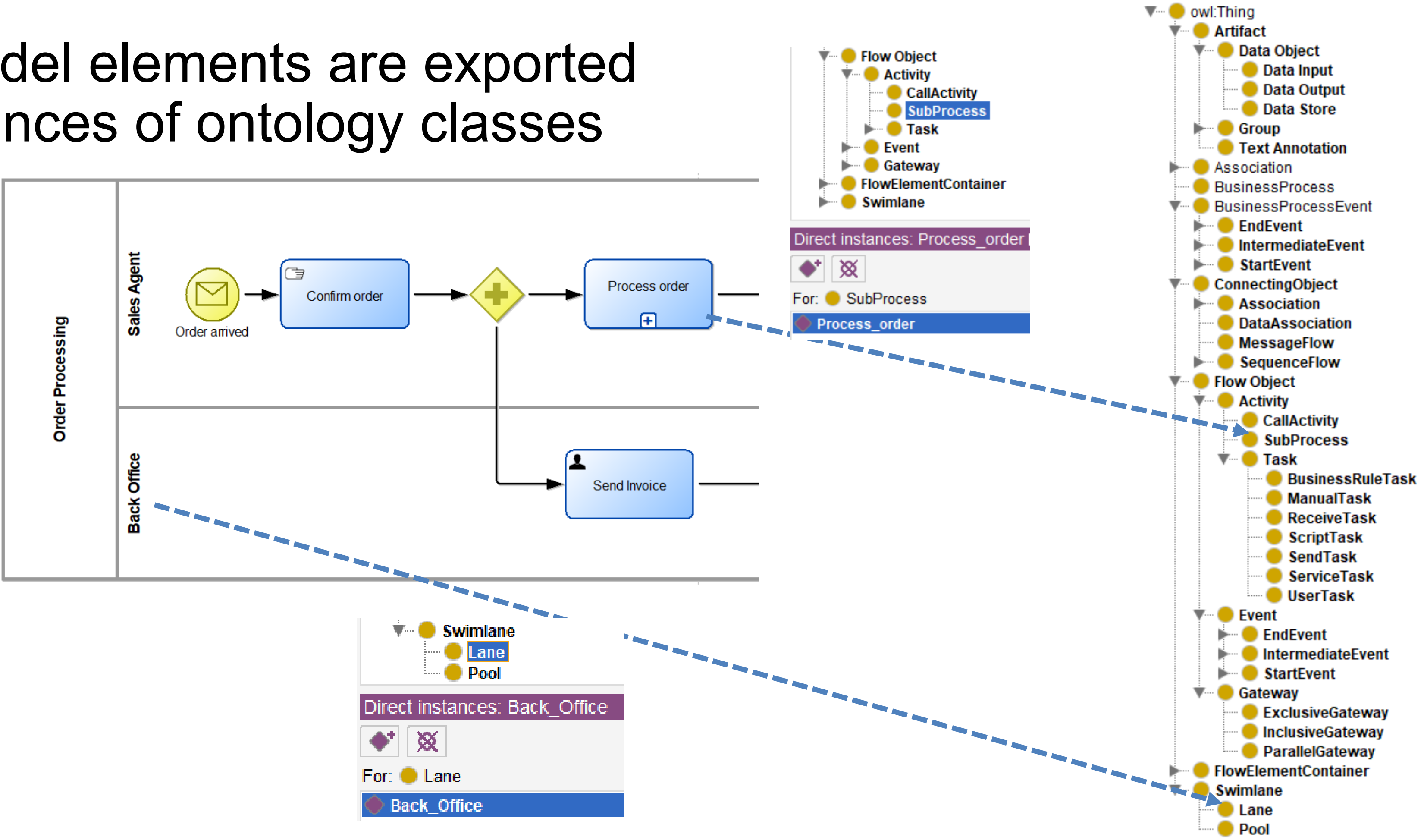


- owl:Thing
  - American Productivity and Quality Center
    - Acquire, Construct, and Manage Assets
    - Deliver Physical Products
    - Deliver Services
    - Develop and Manage Business Capabilities
    - Develop and Manage Human Capital
    - Develop and Manage Products and Services
    - Develop Vision and Strategy
    - Manage Customer Service
    - Manage Enterprise Risk, Compliance, Remediation, and Resiliency
    - Manage External Relationships
    - Manage Financial Resources
      - Manage fixed-asset project accounting
      - Manage internal controls
      - Manage international funds/consolidation
      - Manage taxes
      - Manage treasury operations
      - Perform general accounting and reporting
      - Perform global trade services
      - Perform planning and management accounting
      - Perform revenue accounting
        - Invoice customer
          - Generate customer billing data
          - Maintain customer/product master files
          - Post receivable entries
          - Resolve customer billing inquiries
          - Transmit billing data to customers
        - Manage and process adjustments/deductions
        - Manage and process collections
        - Process accounts receivable (AR)
        - Process customer credit
      - Process accounts payable and expense reimbursements
      - Process payroll
    - Manage Information Technology (IT)
    - Market and Sell Products and Services

Transformation and Mapping

– The model elements are exported as instances of ontology classes

BPMN Ontology



- Flow Object
  - Activity
    - CallActivity
    - SubProcess
    - Task
  - Event
  - Gateway
- FlowElementContainer
- Swimlane

Direct instances: Process_order

For: SubProcess

Process_order

- Swimlane
  - Lane
  - Pool

Direct instances: Back_Office

For: Lane

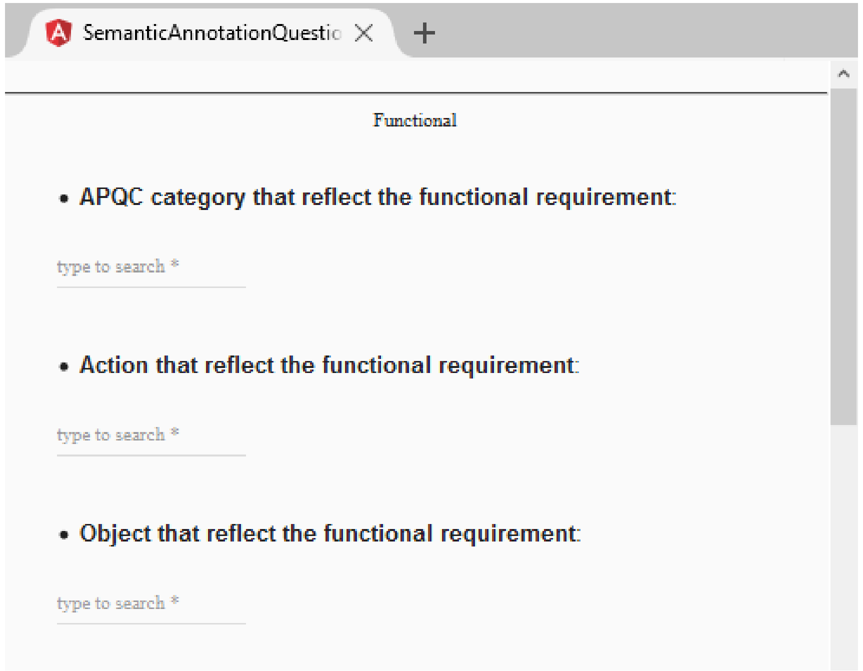
Back_Office

- owl:Thing
  - Artifact
    - Data Object
      - Data Input
      - Data Output
      - Data Store
    - Group
    - Text Annotation
  - Association
  - BusinessProcess
  - BusinessProcessEvent
    - EndEvent
    - IntermediateEvent
    - StartEvent
  - ConnectingObject
    - Association
    - DataAssociation
    - MessageFlow
    - SequenceFlow
  - Flow Object
    - Activity
      - CallActivity
      - SubProcess
      - Task
        - BusinessRuleTask
        - ManualTask
        - ReceiveTask
        - ScriptTask
        - SendTask
        - ServiceTask
        - UserTask
    - Event
      - EndEvent
      - IntermediateEvent
      - StartEvent
    - Gateway
      - ExclusiveGateway
      - InclusiveGateway
      - ParallelGateway
  - FlowElementContainer
  - Swimlane
    - Lane
    - Pool

Cloud Services Specifications

– Enter the CS specifications to the triplestore via user interface

Functionality



Functional

- **APQC category that reflect the functional requirement**:

type to search *

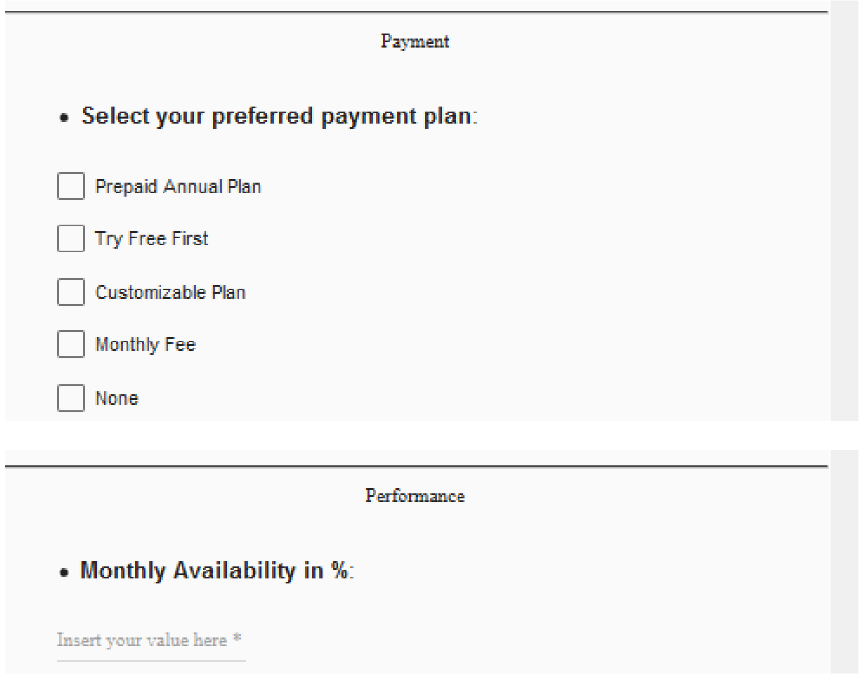
- **Action that reflect the functional requirement**:

type to search *

- **Object that reflect the functional requirement**:

type to search *

Non-functional requirements



Payment

- **Select your preferred payment plan**:

□ Prepaid Annual Plan
□ Try Free First
□ Customizable Plan
□ Monthly Fee
□ None

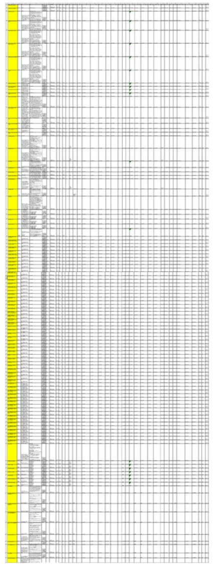
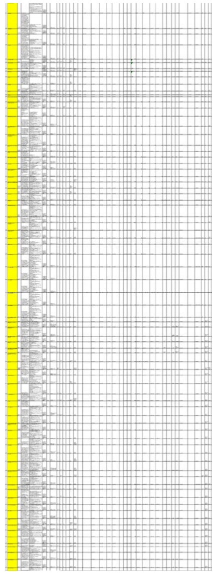
Performance

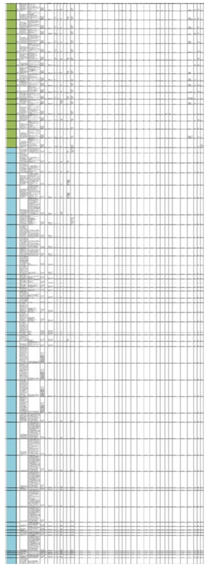
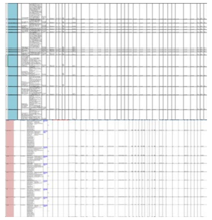
- **Monthly Availability in %**:

Insert your value here *

355 Cloud Services

- 355 CSs from 4 Marketplaces – with 13.098 specs values.
  - (yellow: UK digital marketplace; green: Also marketplace; blue: IBM marketplace; rose: Ymens Marketplace)

Machine Reasoning
to enable the retrieval of suitable Cloud Services

–Semantic rules (in SPARQL),

1. For Business-IT mapping
2. To make knowledge explicit

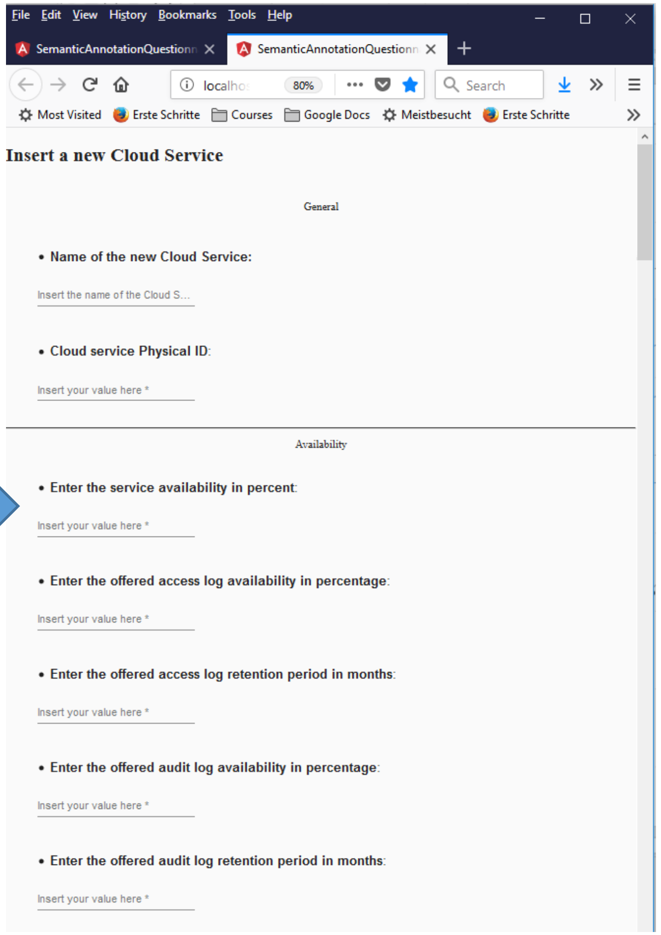
1. Semantic Rules for Business-IT Mapping

- Semantic Rule to convert CS specs in business req. e.g.
  - monthly **availability in %** to monthly downtime in minutes:

<u>SPARQL</u>

```
CONSTRUCT {
                ?cs bpaas:cloudServiceHasMonthlyDowntimeInMinute ?downtimeInMinute .
} WHERE {
                ?cs rdf:type bpaas:CloudService .
                ?cs bpaas:cloudServiceHasAvailabilityInPercent ?availability .
                BIND ((100-?availability)/100*43800 AS ?downtimeInMinute)
}
```

**43800 min is approx. equivalent to 1 month.*



Insert a new Cloud Service

General

- **Name of the new Cloud Service:**

Insert the name of the Cloud S...

- **Cloud service Physical ID:**

Insert your value here *

Availability

- **Enter the service availability in percent:**

Insert your value here *

- **Enter the offered access log availability in percentage:**

Insert your value here *

- **Enter the offered access log retention period in months:**

Insert your value here *

- **Enter the offered audit log availability in percentage:**

Insert your value here *

- **Enter the offered audit log retention period in months:**

Insert your value here *

2. Semantic Rules to make knowledge explicit

– Example: If a CS offers a backup retention time up to one year, implies also

- Up to six months
- Up to one month
- Up to one week
- Up to one day

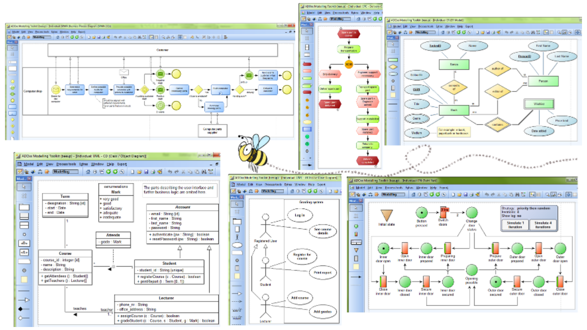
SPARQL

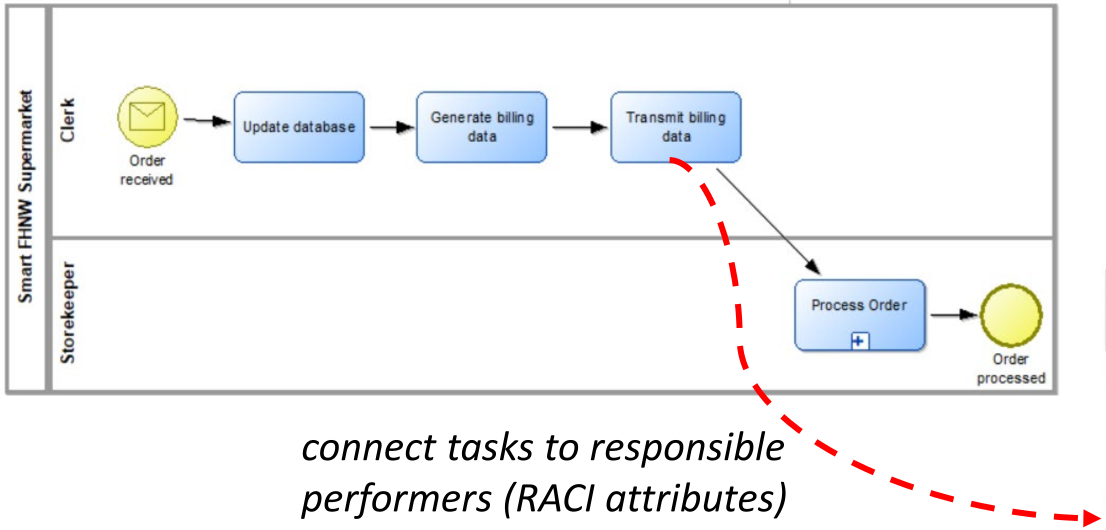
```
[CONSTRUCT {
                ?cservice bpaas:cloudServiceHasBackupRetentionTime bpaas:up_to_6_months .
                ?cservice bpaas:cloudServiceHasBackupRetentionTime bpaas:up_to_1_month .
                ?cservice bpaas:cloudServiceHasBackupRetentionTime bpaas:up_to_1_week .
                ?cservice bpaas:cloudServiceHasBackupRetentionTime bpaas:up_to_1_day .


}
WHERE{
                ?cservice rdf:type bpaas:CloudService .
                ?cservice bpaas:cloudServiceHasBackupRetentionTime bpaas:up_to_1_year .
}]
```

Exercise 2: Semantic Lifting
Modelling, Automatic Transformation and Query

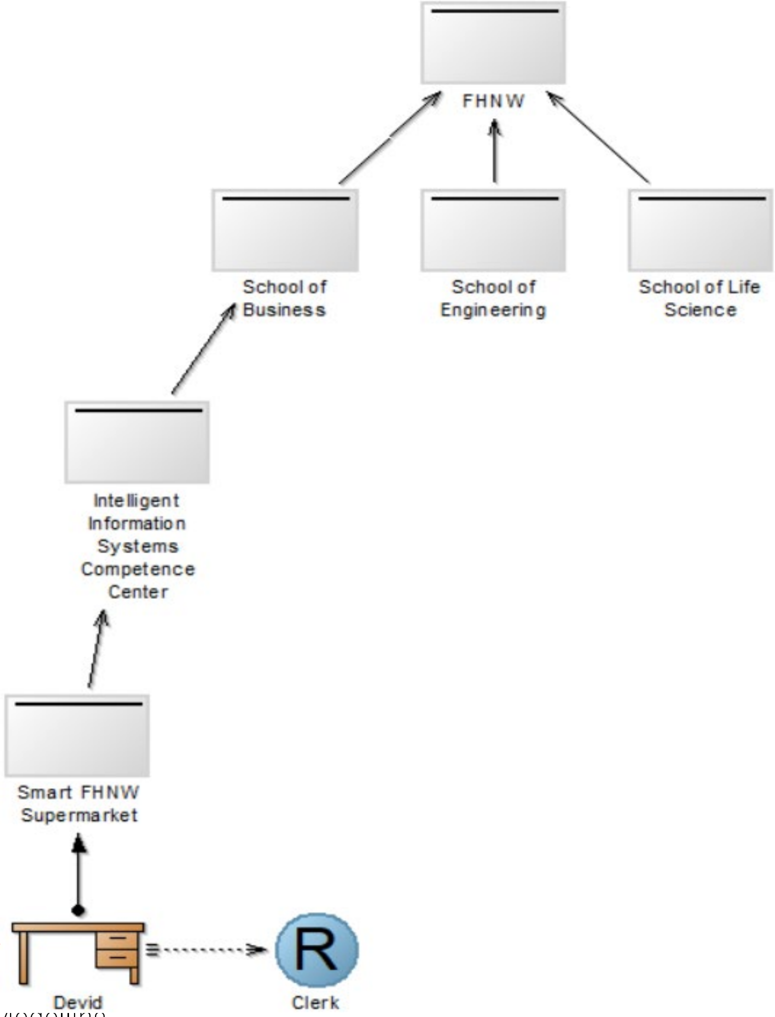
- Use the BeeUP modelling tool to model the model “Order processing” and an “Organizational Chart” for the model Order Processing.
- Add a responsible person for at least a BPMN task, through the RACI attributes.
- Export the models into an RDF(S) ontology (.ttl format)
- Create queries to retrieve the responsible persons for the BPMN tasks.
  - SELECT
    - Where { }

The BeeUP modelling tool





connect tasks to responsible performers (RACI attributes)



Discussion

What are the implications for…

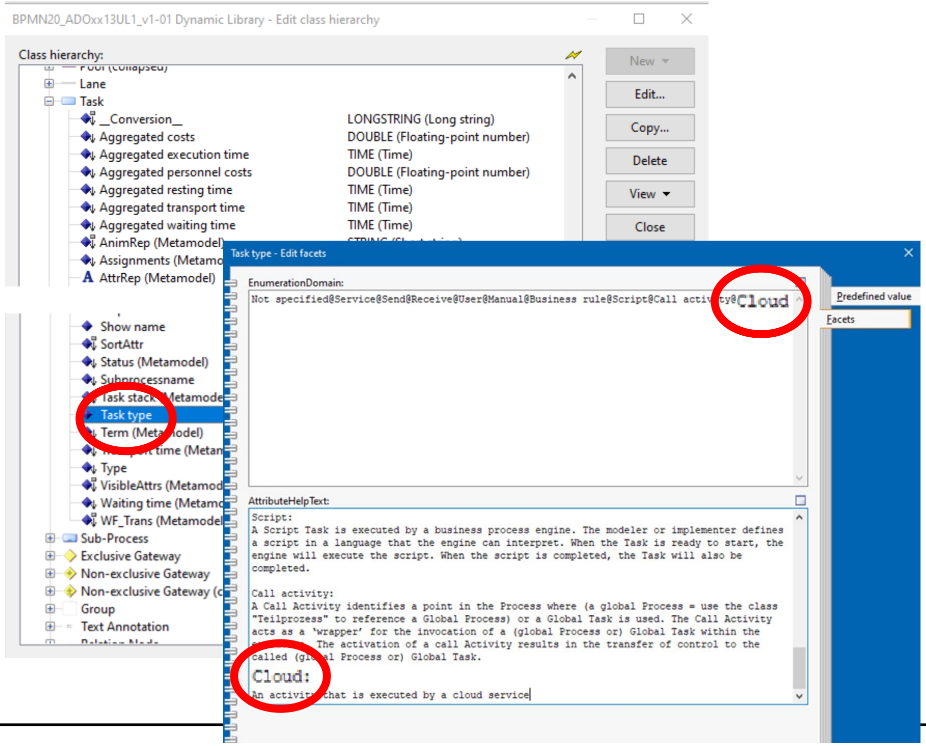
…the change of the person responsible for the BPMN tasks?

…a new modelling element is added in the language? (see next slide)

Example: New Modelling Element

– New task type: Cloud Task

Change in the meta-model:



BPMN20_ADOxx13UL1_v1-01 Dynamic Library - Edit class hierarchy

Class hierarchy:

- Pool (collapsed)
- Lane
- Task
  - _Conversion_ LONGSTRING (Long string)
  - Aggregated costs DOUBLE (Floating-point number)
  - Aggregated execution time TIME (Time)
  - Aggregated personnel costs DOUBLE (Floating-point number)
  - Aggregated resting time TIME (Time)
  - Aggregated transport time TIME (Time)
  - Aggregated waiting time TIME (Time)
  - AnimRep (Metamodel) STRING (Short string)
  - Assignments (Metamo
  - AttrRep (Metamodel)
  - Show name
  - SortAttr
  - Status (Metamodel)
  - Subprocessname
  - Task stack (Metamode
  - Task type
  - Term (Metamodel)
  - Transport time (Metan
  - Type
  - VisibleAttrs (Metamod
  - Waiting time (Metamo
  - WF_Trans (Metamodel
- Sub-Process
- Exclusive Gateway
- Non-exclusive Gateway
- Non-exclusive Gateway (c
- Group
- Text Annotation
- Relation Node

Task type - Edit facets

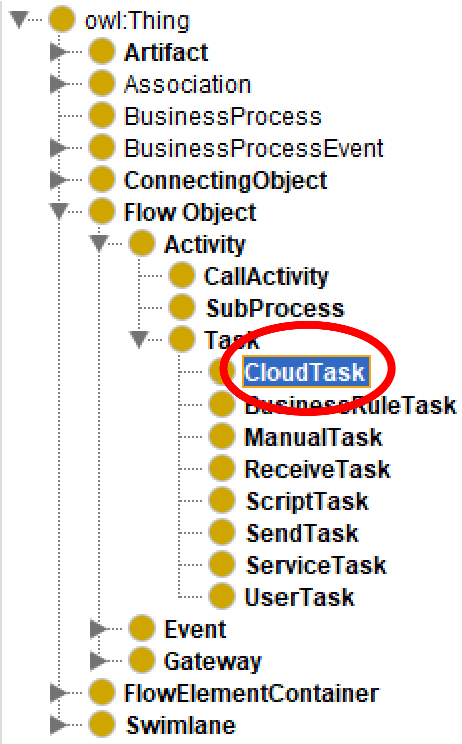
EnumerationDomain:

```
Not specified@Service@Send@Receive@User@Manual@Business rule@Script@Call activity@Cloud
```

AttributeHelpText:

```
Script:
A Script Task is executed by a business process engine. The modeler or implementer defines
a script in a language that the engine can interpret. When the Task is ready to start, the
engine will execute the script. When the script is completed, the Task will also be
completed.

Call activity:
A Call Activity identifies a point in the Process where (a global Process = use the class
"Teilprozess" to reference a Global Process) or a Global Task is used. The Call Activity
acts as a 'wrapper' for the invocation of a (global Process or) Global Task within the
execution. The activation of a call Activity results in the transfer of control to the
called (global Process or) Global Task.
Cloud:
An activity that is executed by a cloud service
```

Change in the ontology:



- owl:Thing
  - Artifact
  - Association
  - BusinessProcess
  - BusinessProcessEvent
  - ConnectingObject
  - Flow Object
    - Activity
      - CallActivity
      - SubProcess
      - Task
        - CloudTask
        - BusinessRuleTask
        - ManualTask
        - ReceiveTask
        - ScriptTask
        - SendTask
        - ServiceTask
        - UserTask
    - Event
    - Gateway
  - FlowElementContainer
  - Swimlane

Drawbacks of Semantic Lifting

- Separate Environments
  - Modelling and Metamodelling
  - Ontology
- Inconsistency
  - Metamodel and ontology must represent the same semantics but are maintained independently
  - Each change in metamodel must be reproduced in the ontology and vice versa
- Effort
  - After each change the models must be translated again into the ontology instances