1. The meta-model formalism

A meta-model is a tuple **MM**= <**MT**,≤, domain, range, card> where

i. **MT** is the set of the defined model types, i.e. for i=1,…,m we have
   MT=$\{MT_1, MT_2, \ldots, MT_m\}$.

The MT_i's (*i=1,..,m*) are itself a tuple $MT_i = \langle O_i^T, D_i^T, A_i \rangle$, where

O_i^T is the set of object types or classes, D_i^T is the set of data types, and A_i is the set of the attributes.

In CloudSocket we have additionally to the business process model types

- MT_1 Business Process Model Notation (BPMN)
  See BPMN Specification
- MT_2 Company Map
- MT_3 Document Model
- MT_4 Working Environment Model

the following 4 model types

- MT_5 Decision Model Notation (DMN)
- MT_6 Business Process Described Services (BPDS)
- Key Performance Indicators (KPIs)
  - MT_7 Key Performance Indicators (Cockpit)
  - MT_8 Business Process Indicators (BPI)

Therefore **MT**={BPMN,Company Map, Document Model, Working Environment Model, DMN, BPDS, Cockpit, BPI}.

ii. ≤ defines an ordering on O^T. I.e.,
   Let $o_1^t, o_2^t \in O^T$
   we say o_1^t is **subclass** of o_2^t, if $o_1^t \leq o_2^t$

iii. The **domain** is a function with
   $$\text{domain: } A \rightarrow P(O^T)$$

iv. The **range** is a function that maps an attribute to the power set of all pairs of classes and model types, all data types, and all model types.
   $$\text{range: } A \rightarrow P(\cup_j (O_j^T \times \{MT_j\}) \cup D^T \cup MT)$$

v. The card function
   $$\text{card}: O^T \times A \rightarrow P(\mathbb{N}_0^+ \times (\mathbb{N}_0^+ \cup \{\infty\}))$$

1.1. BPMN Metamodel

Additionally to the already defined **MM** of BPMN in [FDMM] and BPMN Specification, we have to add some extensions of some Relations to the

$$MM_{BP_{spec}} = \{MT_{BP_{spec}}, O^T_{BP_{spec}}, \leqslant, domain, card\},$$

$$O^T_{BP} := O^T_{BP\_spec}$$

$$A_{BP} := \{A_{BP_{spec}}, Referenced\ Decisions\text{-}from, Referenced\ Decisions\text{-}to,$$
$$Referenced\ Service\ Description\text{-}from, Referenced\ Service\ Description\text{-}to\}$$

Relations and InterRefs:

$domain(Referenced\ Decisions\text{-}from) = \{Referenced\ Decisions\}$

$range(Referenced\ Decisions\text{-}from) = \{Task\}$

$card(Task, Referenced\ Decisions\text{-}from) = \langle 1, n \rangle$

$domain(Referenced\ Decisions\text{-}to) = \{Referenced\ Decisions\}$

$range(Referenced\ Decisions\text{-}to) = \{Decision\ (DMN)\}$

$card(Task, Referenced\ Decisions\text{-}to) = \langle 1, n \rangle$

$domain(Referenced\ Service\ Description\text{-}from) = \{Referenced\ Service\ Description\}$

$range(Referenced\ Service\ Description\text{-}from) = \{Task\}$

$card(Task, Referenced\ Service\ Description\text{-}from) = \langle 1, n \rangle$

$domain(Referenced\ Service\ Description\text{-}to) = \{Referenced\ Service\ Description\}$

$range(Referenced\ Service\ Description\text{-}to) = \{Service\ Description\}$

$card(Task, Referenced\ Service\ Description\text{-}to) = \langle 1, n \rangle$

1.2. Company Map

See [FDMM]

1.3. Document Model

1.4. Working Environment Model

1.5. Decision Model Notation (DMN)

See DMN Specification

1.6. Business Process Described Services (BPDS)

This model type should improve the communication between the Business Process designer and a workflow engineer.

The Class 'Service Description' contains several attributes which should describe the business process services from the

- technical,
- domain, and
- business

point of view.

The formal definition of this model type is as follows:

- $O_{BPDS}^T = \{Service\ Description\}$
- $D_{BPDS}^T = \{String\}$
- Let
  $\boldsymbol{TechnicalAttrs} := \{Description, Input, Output, Functional\ Details\}$,
  $\boldsymbol{DomainAttr} :=$
  $\{Privacy, Data\ Compliance, Domain\ Country, Domain\ Description\}$,
  and
  $\boldsymbol{BusinessAttrs} := \{Vendor\ Issues, Payment, Trust, Securities\}$
  Then

  $\boldsymbol{A}_{BPDS} = \{Name, TechnicalAttrs, DomainAttrs, BusinessAttrs\}$

Attribute attachments:

$\forall\ attr\ \in \{\boldsymbol{A}_{BPDS}\}$: domain*(attr)={Service Description}*

$\forall\ attr\ \in \{\boldsymbol{A}_{BPDS}\}$: range*(attr)={String}*

card$(Service\ Description, Name) = \langle 1,1 \rangle$

1.7. Key Performance Indicators (KPIs)

1.7.1. CockPit

The formal definition of this model type is as follows:

- $O_{BPDS}^T = \{Process\ (KPI), Business\ Objective, KPI\}$
- $D_{BPDS}^T =$
  $\{String, \mathbf{Enum}_{tolerancetype}, \mathbf{Enum}_{referenceperiod}, \mathbf{Enum}_{objectivetype}, Double, Table\}$
  $\mathbf{Enum}_{tolerancetype} = \{buttom\text{-}up, top\text{-}down, both\text{-}sides\}$
  $\mathbf{Enum}_{referenceperiod} = \{Calendar\ week, Month, Quater, Half\text{-}year, Year\}$
  $\mathbf{Enum}_{objectivetype} = \{Adaptability, Asset\ orientation, Cost\ orientation,$
  $Customer\ orientation, Network\ orientation, reliability, velocity\}$

- $\boldsymbol{A}_{BPDS} = \{Name,\ Objective\ type, Tolerance\ type,\ Description,$
  $Referenced\ Period, Tolerance\ Green/Yellow, Tolerance\ Yellow/Red,$
  $Target\ values, Current\ values, Referenced\ process\ KPI\text{-}from,$
  $Referenced\ process\ KPI\text{-}to, Has\ business\ objective\text{-}from, Has\ business$
  $objective\text{-}to, Quantified\text{-}from, Quantified\text{-}to\}$

  Relations and InterRefs:
  domain$(Referenced\ process\ KPI\text{-}from)$={Referenced process KPI}
  range$(Referenced\ process\ KPI\text{-}from)$={Process (KPI)}

$$\text{card}(Task, Referenced\ process\ KPI\text{-}from) = \langle 1,1 \rangle$$

$$\text{domain}(Referenced\ process\ KPI\text{-}to) = \{Referenced\ process\ KPI\}$$

$$\text{range}(Referenced\ process\ KPI\text{-}to) = \{MT_{BP}\}$$

$$\text{card}(Task, Referenced\ process\ KPI\text{-}to) = \langle 1,1 \rangle$$

1.7.2. Business Process Indicators

- $O_{BPI}^{T} = O_{BP}^{T}$
- $D_{BPDS}^{T} =$
$$\{D_{BP}^{T}, \textbf{Enum}_{SLAtype}, \textbf{Enum}_{DataLocation}, \textbf{Enum}_{Storage}, \textbf{Enum}_{Capacity}, \textbf{Enum}_{Legacy}\}$$
$$\textbf{Enum}_{SLAtype} = \{slow, normal, fast\}$$
$$\textbf{Enum}_{DataLocation} = \{Local, Europe, USA\}$$
$$\textbf{Enum}_{Storage} = \{< 100\ Rich\ Document, \geq 100 < 1000\ Rich\ Document,$$
$$\geq 1000\ Rich\ Document\}$$
$$\textbf{Enum}_{Capacity} = \{> 10\ Parallel\ Process, > 2 \leq 10\ Parallel\ Process,$$
$$\leq 2\ Parallel\ Process\}$$
$$\textbf{Enum}_{Legacy} = \{Green, Yellow, Red\}$$

- $\boldsymbol{A}_{BPI} = \{\boldsymbol{A}_{BP}, Capacity\ KPI, Storage\ KPI, Data\ Location\ KPI,$
$$Legacy\ KPI, SLA\ type\ KPI\}$$

Attribute attachments:

$$\text{domain}(Capacity\ KPI) = \{Task\}$$
$$\text{range}(Capacity\ KPI) = \{\textbf{Enum}_{Capacity}\}$$
$$\text{card}(Capacity\ KPI) = \langle 1,1 \rangle$$

$$\text{domain}(Legacy\ KPI) = \{Task\}$$
$$\text{range}(Legacy\ KPI) = \{\textbf{Enum}_{Legacy}\}$$
$$\text{card}(Legacy\ KPI) = \langle 1,1 \rangle$$

$$\text{domain}(Storage\ KPI) = \{Task\}$$
$$\text{range}(Storage\ KPI) = \{\textbf{Enum}_{Storage}\}$$
$$\text{card}(Storage)\ KPI = \langle 1,1 \rangle$$

$$\text{domain}(Data\ Location\ KPI) = \{Task\}$$
$$\text{range}(Data\ Location\ KPI) = \{\textbf{Enum}_{Data\ Location}\}$$
$$\text{card}(Data\ Location) = \langle 1,1 \rangle$$

$$\text{domain}(SLA\ type\ KPI) = \{Task\}$$
$$\text{range}(SLA\ type\ KPI) = \{\textbf{Enum}_{SLA\ type}\}$$
$$\text{card}(SLA\ type\ KPI) = \langle 1,1 \rangle$$