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Leveraging the added value of different knowledge centric systems by aligning, interoperating and co-executing specifications

- Positional-Slotted Object-Applicative **(PSOA)** RuleML integrates table-like relationships and graph-like frames into positional-slotted object-applicative (psoa)terms.
- Three anchor languages: datalog, hornlog, (naf)folog(eq)
- The often used single-dependent-tuple independent-slot special case of psoa terms, oidless or oidful, has these forms (n≥0 and k≥0):

  Oidless:$f(t_1...t_n\ p_1->v_1...p_k->v_k)$

  Oidful:$o\#f(t_1...t_n\ p_1->_{v1}...p_k->v_k)$

- **IDP** is both the name of a Knowledge Based System and the declarative language used to create the Knowledge Base The Knowledge Based Paradigm advocates a strict separation between domain knowledge gathered in the Knowledge Base, and various possible inferences to use this knowledge to solve specific problems.
- IDP can deal both with rules and constraints.
- The IDP language adds types, aggregates and Inductive definitions to classic FO

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PSOA RuleML

```
Forall ?a ?w (
  :AircraftIcaoCategory(?a icao:Light) :-
    And(?a#:Aircraft(:mtom->?w)
        math:lessEq(?w 7000))  )

Forall ?a ?w (
  :AircraftIcaoCategory(?a icao:Medium) :-
    And(?a#:Aircraft(:mtom->?w)
        math:greaterThan(?w 7000)
        math:lessThan(?w 136000))  )

Forall ?a ?w (
  :AircraftIcaoCategory(?a icao:Heavy) :-
    And(?a#:Aircraft(:mtom->?w)
        math:greaterEq(?w 136000)
        not:Naf(:AircraftIcaoCategory
                (?a icao:Super))
    )
)
%% Sample Aircraft Facts %%

:be91#:Aircraft(:mtom->4218.41
                :mtow->9300.0
                :wingspan->45.92
                :appSpeed->100.0)

:a388#:Aircraft(:mtom->575000.0
                :mtow->1267658.0
                :wingspan->261.65
                :appSpeed->145.0)
```

IDP Aligned

```
vocabulary V {
    type Mtom isa int
    type Aircraft isa string
    MTOM(Aircraft,Mtom)
        ...  }
theory T:V{
    !a[Aircraft] w[Mtom]:
    AircraftIcaoCategory(a, Light) <=
        MTOM(a,w)
            & w =< 7000.

    !a[Aircraft] w[Mtom]:
    AircraftIcaoCategory(a, Medium) <=
        MTOM(a,w)
                & 7000 < w
                & w < 136000.

    !a[Aircraft] w[Mtom]:
    AircraftIcaoCategory(a, Heavy) <=
        MTOM(a,w)
                & 136000 =< w
                & a ~= a388
                & a ~= a38f.

structure S1 : V {
    //specific value assignments:
    Leader = {a388}
    Follower = {be91}
    ...

    //aircraft data
    MTOM = {be91, 4218; a388, 575000}
    MTOW = {be91, 9300; a388, 1267658}
    WingSpan = {be91, 45; a388, 261}
    AppSpeed = {be91, 100; a388, 145}
}
```

IDP definition

```
vocabulary V {
    type Icao constructed from {Light, Medium,
                                Heavy, Super}
    type Mtom isa int
    type AircraftID isa string
    IcaoCategory(AircraftID) : Icao
    ...}

theory T:V{
{       !id: IcaoCategory(id) = Light <-
        mtom(id) =< 7000.

        !id: IcaoCategory(id) = Medium <-
        7000 < mtom(id) =< 136000.

        !id: IcaoCategory(id) = Heavy <-
         (136000 < mtom(id)) &
        IcaoCategory(id) ~= Super.

        IcaoCategory("a380") = Super.
}
}

structure S : V {
    Mtom = {0..1300000}
    Separation = {2..8}
    AircraftID = {a388  ;       be91}
        mtom =  {a388   ,       575000  ;
    be91        ,       4218}
}
```

This paper studies Knowledge Bases (KBs) in PSOA RuleML and IDP, aligning, interoperating, and co-executing them for a use case of Air Traffic Control (ATC) regulations. We focus on the common core of facts and rules in both languages, explaining basic language features. The used knowledge sources are regulations specified in (legal) English, and an aircraft data schema. In the modeling process, inconsistencies in both sources were discovered. We present the discovery process utilizing both specification languages, and highlight their unique features. We introduce three extensions to this ATC KB core: 1) While the current PSOA RuleML does not distinguish the ontology separately from the instance level, IDP does. Hence, we specify a vocabulary-enriched version of ATC KB in IDP for knowledge validation. 2) While the current IDP uses relational modeling, PSOA additionally supports graph modeling. Hence, we specify a relationally interoperable graph version of ATC KB in PSOA. 3) The KB is extended to include optimization criteria to allow the determination of an optimal sequence of more than two aircraft.

- We discussed the alignment of both specifications and the implications for modelling choices.
- Inconsistencies in the original regulations were discovered.
- A partial interoperation brtw PSOA and IDP is possible for facts and rules.
- The advantage of each system can be exploited in a combined application