PatientSupporter

The Social Semantic Subweb of Virtual Patient Support Groups

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PatientSupporter – Idea and Implementation

The **Social Web (Web 2.0)** meets
the **Semantic Web** (ontologies and *rules*)
in a **Social Semantic Web (Web 3.0)**:

Patients advertise their **semantic** profiles
to **socialize** with others in support groups

Implemented in initial PatientSupporter prototype

Part 1: PatientSupporter Foundation in Profile Knowledge Base Interoperation

- PatientSupporter Overview
- Ontologies & Rules, Global & Local Knowledge Bases
- Local Knowledge Base (Profile) Interoperation between Prolog-extending POSL & RDF-extending N3
  - Interoperation Principles for **Relational** (POSL) and **Networked** (N3) Languages
  - POSL ⇔ N3 Transformation
- Injuries Partonomy

Later seen in Part 2:

A use case demo describes an **online-interactive Patients community** through the PatientSupporter system in Rule Responder

PatientSupporter Overview

- PatientSupporter supports a patient community that is **online-interactive** and **rule-based**
- Each patient as participant of this community has ability to:
  - **Create profiles about themselves**, containing their preferences for injuries, healing stage, treatment level, possible collaboration times, etc.
  - **Compare and collaborate with others** in the community, to track progress and schedule group discussions
- Rules for patient profiles are
  - **Authored** in rule languages such as POSL and N3
  - **Interoperated** within the community using RuleML/XML

Knowledge Bases

- Ontologies – Global
  - **Group Responsibility Matrix (see later)**
  - **Body Partonomy (see later)**
    - Structures sports injuries as commonsense ontology of affected body parts
- Rules (including Facts) – Global and Local
  - **See below**

Global Rule Base

- Contains knowledge relevant to everyone in the PatientSupporter community
- Knowledge Areas:
  - **participation**
    - Ensures that a patient's preferred group size interval is within a requested group size interval
  - **ageCheck**
    - Ensures that a patient's age is within a requested age interval
  - **goodDuration**
    - Ensures that a patient's preferred call duration is within a requested start and end time

Local Rule Bases (Profiles)

- Contain local knowledge specific to each patient in the PatientSupporter community
- Knowledge Areas:
  - **age**
    - Own age
  - **groupSize**
    - Preferred group sizes for injuries
  - **category**
    - 'In' or 'Out' patient
  - **treatment**
    - Bandage, (Major or Medium or Minor) Operation, (Major or Medium or Minor) Medication or ChangeOfLifeStyle
  - **healingStage**
    - Fresh, Medium, Convalescent or Healed
  - **duration**
    - Preferred call duration
  - **gender**
    - Male or Female
  - **communication**
    - Channel and Contact names
  - **timezone**
    - Own time zone
  - **MyDiscussion**
    - Derive patients' discussion preferences

Local MyDiscussion Sample Rule (in POSL) – Centered on Participant p0004 as First Argument


```
myDiscussion(p0004,Injury:Toe,?MinAge,?MaxAge,?MinRSVP,?MaxRSVP,?Category,?Treatment,?HealingStage,
        dateTime[?StartYear,?StartMonth,?StartDay,?StartHour,?StartMinute],
        dateTime[?EndYear,?EndMonth,?EndDay,?EndHour,?EndMinute],
        dateTime[?DurYear,?DurMonth,?DurDay,?DurHour,?DurMinute],
        MSN,?Contact,?Gender,?TimeZone)
        :-
        ageCheck(p0004,?MinAge,?MaxAge,?Age),
        participation(p0004,?Injury,?MinRSVP,?MaxRSVP),
        communication(p0004,MSN,?Contact),
        event(p0004,?Injury,Possible,
                dateTime[?StartYear,?StartMonth,?StartDay,?StartHour,?StartMinute],
                dateTime[?EndYear,?EndMonth,?EndDay,?EndHour,?EndMinute]),
        duration(p0004,?Injury,dateTime[?DurYear,?DurMonth,?DurDay,?DurHour,?DurMinute]),
        goodDuration(p0004,?Injury,
                dateTime[?DurYear,?DurMonth,?DurDay,?DurHour,?DurMinute],
                dateTime[?StartYear,?StartMonth,?StartDay,?StartHour,?StartMinute],
                dateTime[?EndYear,?EndMonth,?EndDay,?EndHour,?EndMinute]),
        category(p0004,?Category),
        treatment(p0004,?Injury,?Treatment),
        healingStage(p0004,?Injury,?HealingStage),
        gender(p0004,?Gender),
        timeZone(p0004,?TimeZone).
```

Orange designates a profile preference / fact

Local MyDiscussion Profile Facts (in POSL) – Centered on Participant p0004 as First Argument


```
age(p0004,27:integer).

groupSize(p0004,?:Toe,2:integer,10:integer).

duration(p0004,?:Toe,dateTime[0:integer,0:integer,0:integer,0:integer,30:integer]).

category(p0004,Out).

treatment(p0004,?:Toe,MinorOperation).

healingStage(p0004,?:Toe,Medium).

communication(p0004,MSN,Sam24).

gender(p0004,Male).

timeZone(p0004,-400:integer).
```

Profile Interoperation (POSL & N3)

- Support for both ***logic-relational*** (e.g., POSL) and ***graph-networked*** (e.g., N3) knowledge representations
- Users may write their profile in either language
- Support for **Prova**, **OO jDREW**, and **Euler** engines to execute queries issued to **POSL** and **N3** knowledge bases, respectively
- *Later seen in Part 2:*
  By using a RuleML subset as the exchange language and Rule Responder as the platform, queries and answers can be exchanged with all supported engines

POSL

- POSL integrates **po**sitional and **sl**otted knowledge (e.g., Prolog's positional and F-logic's slotted knowledge)
- PatientSupporter only uses ***po**sitional POSL* for ***logic-relational*** knowledge, displayed in a Prolog-like human-readable syntax

- Positional relation descriptions (**f**act and **q**uery examples):
  - **Relation names (f):**
    ```
    treatment(p0001,Toe,Bandage).
    ```
    - Each fact and rule head has a **relation name**
  - **Arguments (f):**
    ```
    treatment(p0001,Toe,Bandage).
    ```
    - Constant arguments are **strings** or **symbols**, separated by **commas** (",")
  - **Variables (q):**
    ```
    treatment(p0001,?, ?Treatment)
    ```
    - Variables can be named ("**?** **prefix**) or anonymous (**stand-alone** "**?**")

Notation 3 (N3)

- N3 is a compact, rule-extended version of **RDF**'s XML syntax. Writes triples (**subject, property, object**) as **subject** descriptions
- PatientSupporter uses ***N3*** for ***graph-networked*** knowledge
- Slotted subject descriptions (**f**act and **q**uery examples):
  - **Subject names (f):**
    - Each fact / rule head has a **subject name**

":" here denotes IRI of this local knowledge base

```
:treatment_1
    rdf:type        :Treatment;
    :profileID      :p0001;
    :injury         :Toe;
    :treatment      :Bandage.
```

  - **Variables (q):**
    - Can be anonymous (**stand-alone "?"**) or named (**"?" prefix**)

```
?treatment
    rdf:type        :Treatment;
    :profileID      :p0001;
    :injury         ?;
    :treatment      ?Treatment.
```

  - **Arguments as property→object slots (f):**
    - Each argument must have a **property** (slot **name**):

```
:treatment_1
    rdf:type        :Treatment;
    :profileID      :p0001;
    :injury         :Toe;
    :treatment      :Bandage.
```

    - Each argument must also have an **object** (slot **value**):

```
:treatment_1
    rdf:type        :Treatment;
    :profileID      :p0001;
    :injury         :Toe;
    :treatment      :Bandage.
```

POSL ⇔ N3 Transformation (Atoms)

- Transformations are bi-directional; harder left-right reading focused here
- N3 uses subjects to provide named instances/relationships.
  The **subject name** is the ":"-prefixed relation ":*name*" extended by "_*i*", where "*i*" is an instance counter. A "?"-prefixed variable can stand for a subject name
- A *POSL* **relation name** becomes defined in an N3 rule head via an **rdf:type** property using the ":"-prefixed, uppercased version of the ":*Name*"

POSL `treatment(p0001,?, ?Treatment)` ⇔

```
?treatment
   rdf:type   :Treatment;
   :profileID    :p0001;
   :injury       ?;
   :treatment    ?Treatment.
```

N3

- Starting with ***positional POSL*, slot names** (properties) can be generated and stored in signatures for reuse; **variables** and **constants** as **slot values** (objects) employ the **same names** as in POSL

POSL `treatment(p0001,?, ?Treatment)` ⇔

```
?treatment
   rdf:type       :Treatment;
   :profileID     :p0001;
   :injury        ?;
   :treatment     ?Treatment.
```

N3

POSL ⇔ N3 Transformation (Rules)

- **Rule** transformation builds on atom transformation
- OO jDREW (using POSL) typically does **top-down** (:-) reasoning; Euler (using N3) always does **bottom-up** (=>) reasoning: 'conclude ... **from** ---' becomes 'if --- **then** ...'
  :- =>

POSL

```
myDiscussion(p0004,Injury:Toe,
             ...,
             ?Treatment,?HealingStage,
             ...,
             )
             :-
             ...,
             treatment(p0004,Injury:Toe,?Treatment),
             healingStage(...),
             ....
```

⇔

N3

```
{
...
?treatment
    rdf:type          :Treatment;
    :profileID        :p0004;
    :injury           :Toe;
    :treatmentType    ?Treatment.
 ?healingStage
     rdf:type         :HealingStage;
     ... .
...
}
=>
{
_:myDiscussion
     rdf:type        :MyDiscussion;
     :profileID      :p0004;
     :injury         :Toe;
     ... ;
     :treatment      ?Treatment;
     :healingStage ?Stage;
     ... .
}.
```

Body Partonomy

- The PatientSupporter partonomy is organized as hierarchy of body parts
- Each of these corresponds to an injury (e.g., Leg, Foot, Toe, etc.)
- Mapped to a taxonomy, using **rdf:type**, **rdfs:Class**, and **rdfs:subClassOf**
- Taxonomy *classes* act as user-defined *types* to restrict rule variables

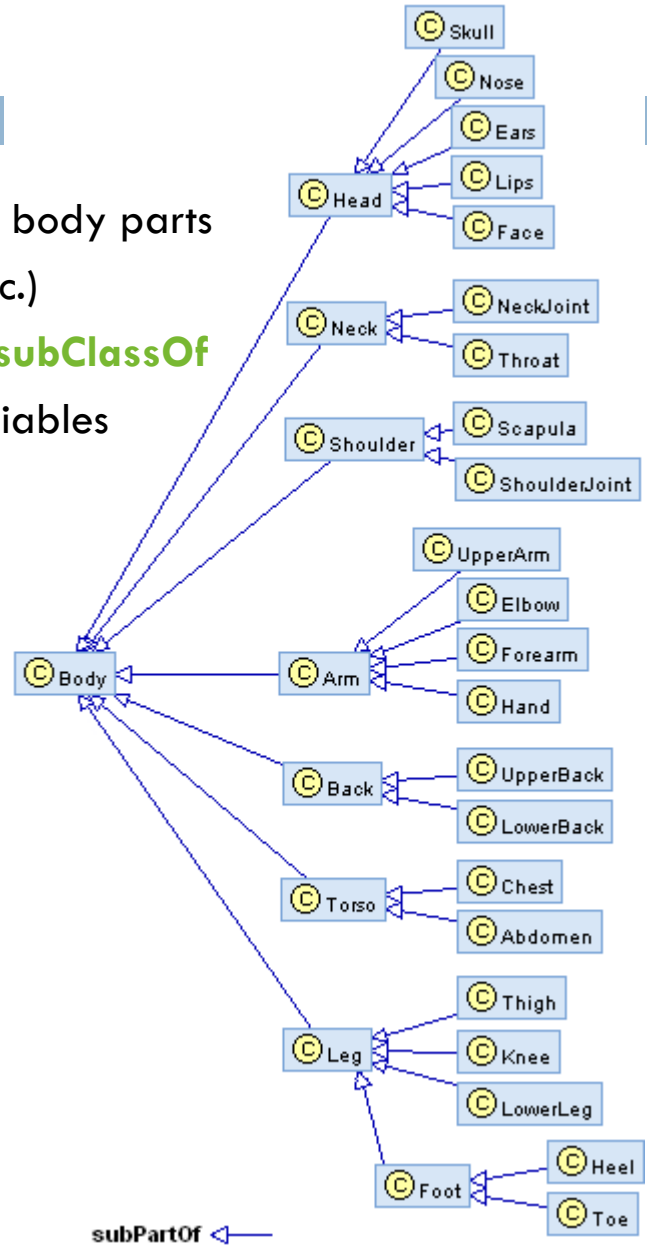
RDF (used by POSL, equivalent to a version in N3)

```
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#">

   <rdf:Description rdf:ID="Body">
    <rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
   </rdf:Description>

   <rdf:Description rdf:ID="Leg">
    <rdf:type rdf:resource="http://www.w3.org/2000/01/rdf-schema#Class"/>
    <rdfs:subClassOf rdf:resource="#Body"/>
   </rdf:Description>

...
```



Part 2: PatientSupporter for an Online-Interactive Patient Community via Rule Responder

- PatientSupporter as a Rule Responder
- PatientSupporter Conceptual View
- PatientSupporter Technical View
- PatientSupporter Agent Implementation
- Discussion Scenario: Example Queries with Live Demo

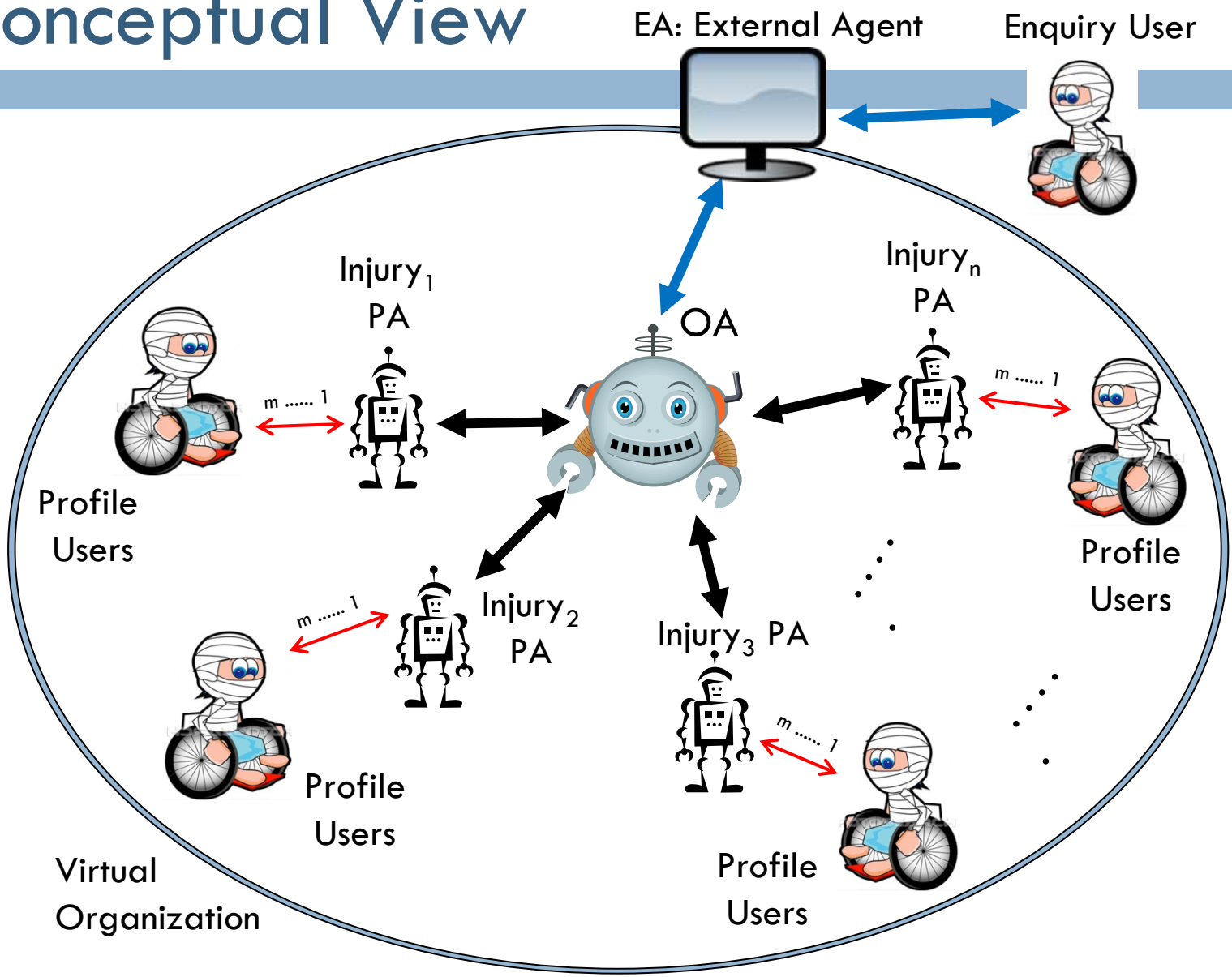
Previously seen in Part 1:

Foundation of PatientSupporter in **profile knowledge base interoperation,** which is assisted through **transformation techniques**

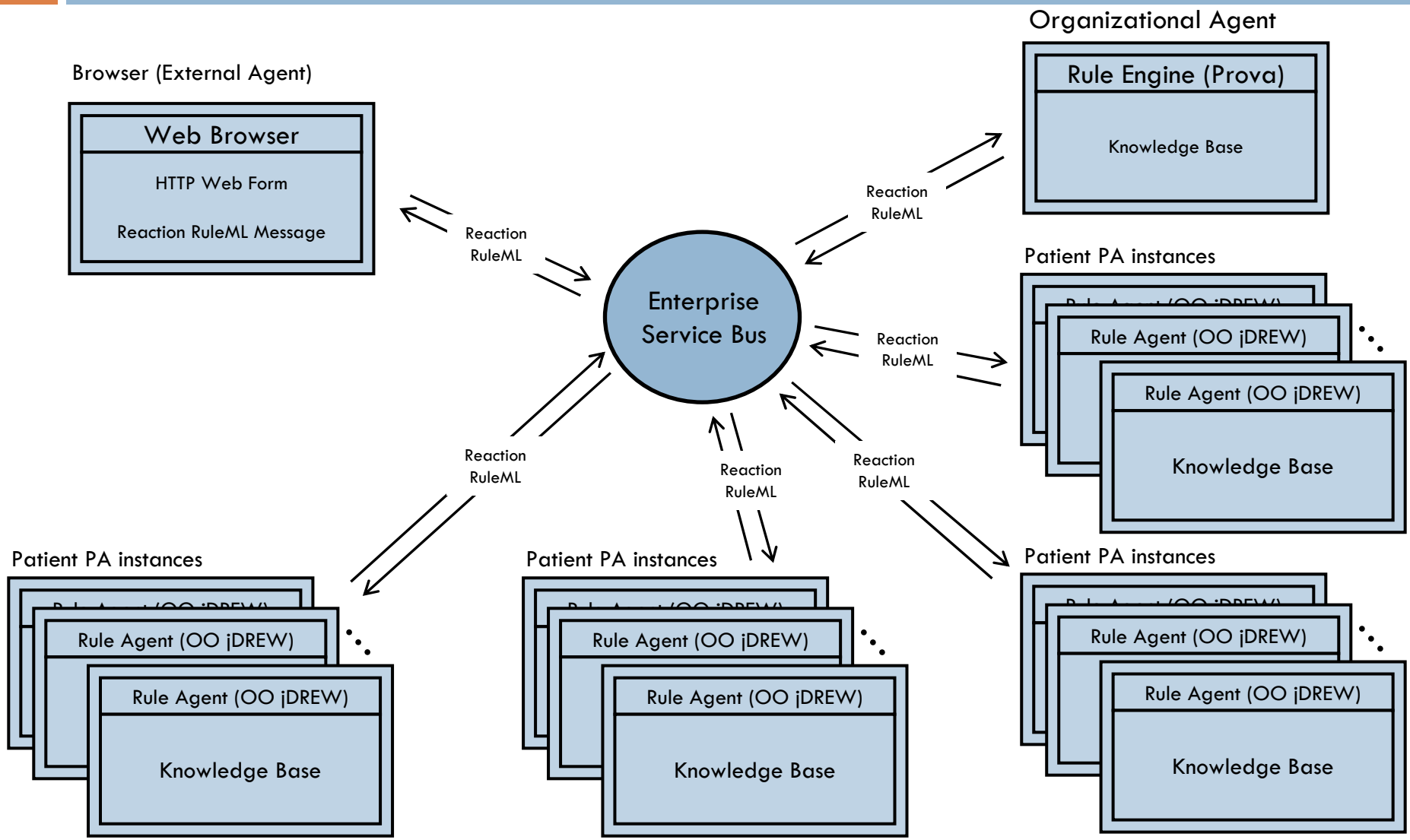
PatientSupporter as a Rule Responder

- Rule Responder is an intelligent multi-agent infrastructure for **collaborative** teams and **virtual communities**
- Rule Responder uses three kinds of agents:
  - **Organizational Agent** (**OA**)
  - **Personal Agents** (**PAs**)
    - PAs extended to select relevant profiles of patients
  - **External Agents** (**EAs**)
- The PatientSupporter instantiation of Rule Responder employs the **OA**, **PAs**, and **EAs** for **communication** and **query delegation** to support an **online-interactive community of patients**
  - Similar to WellnessRules2, WellnessRules, and SymposiumPlanner

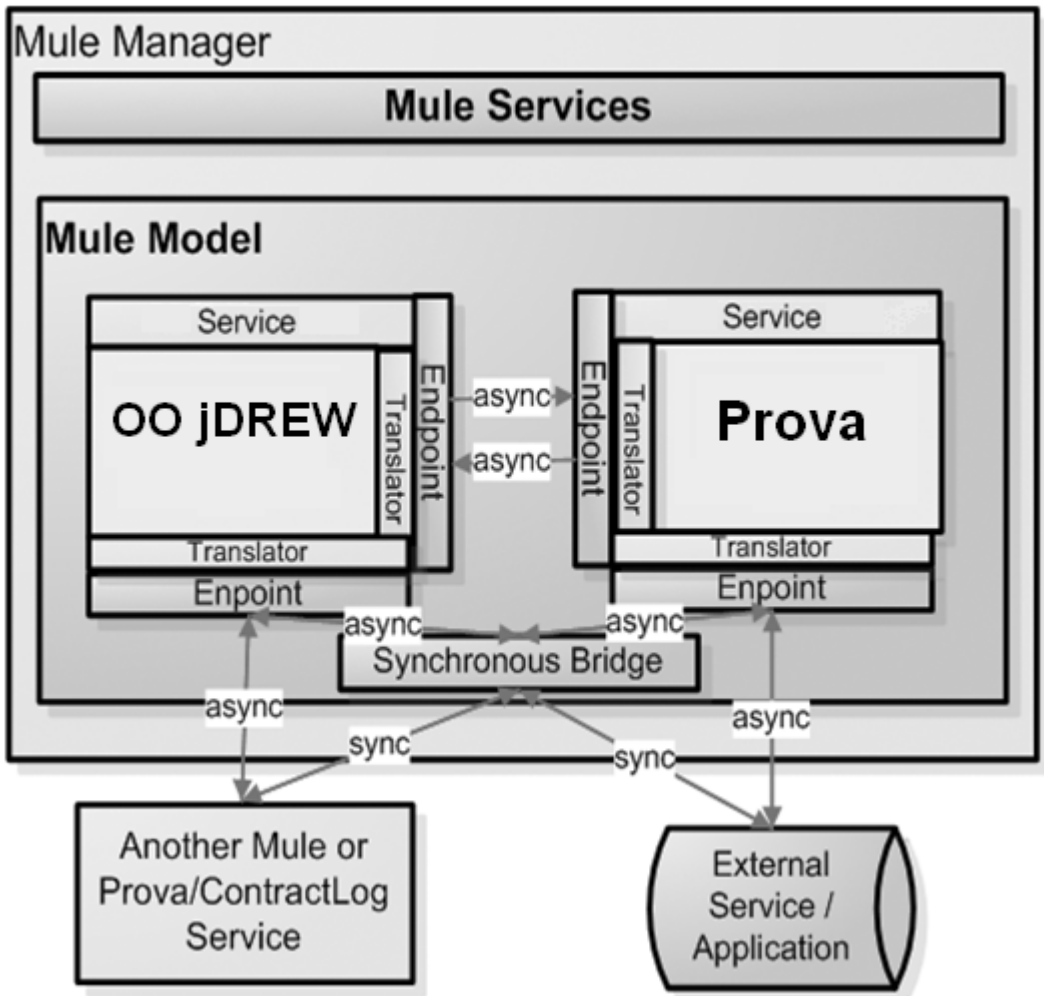
Rule Responder Conceptual View



Rule Responder Technical View

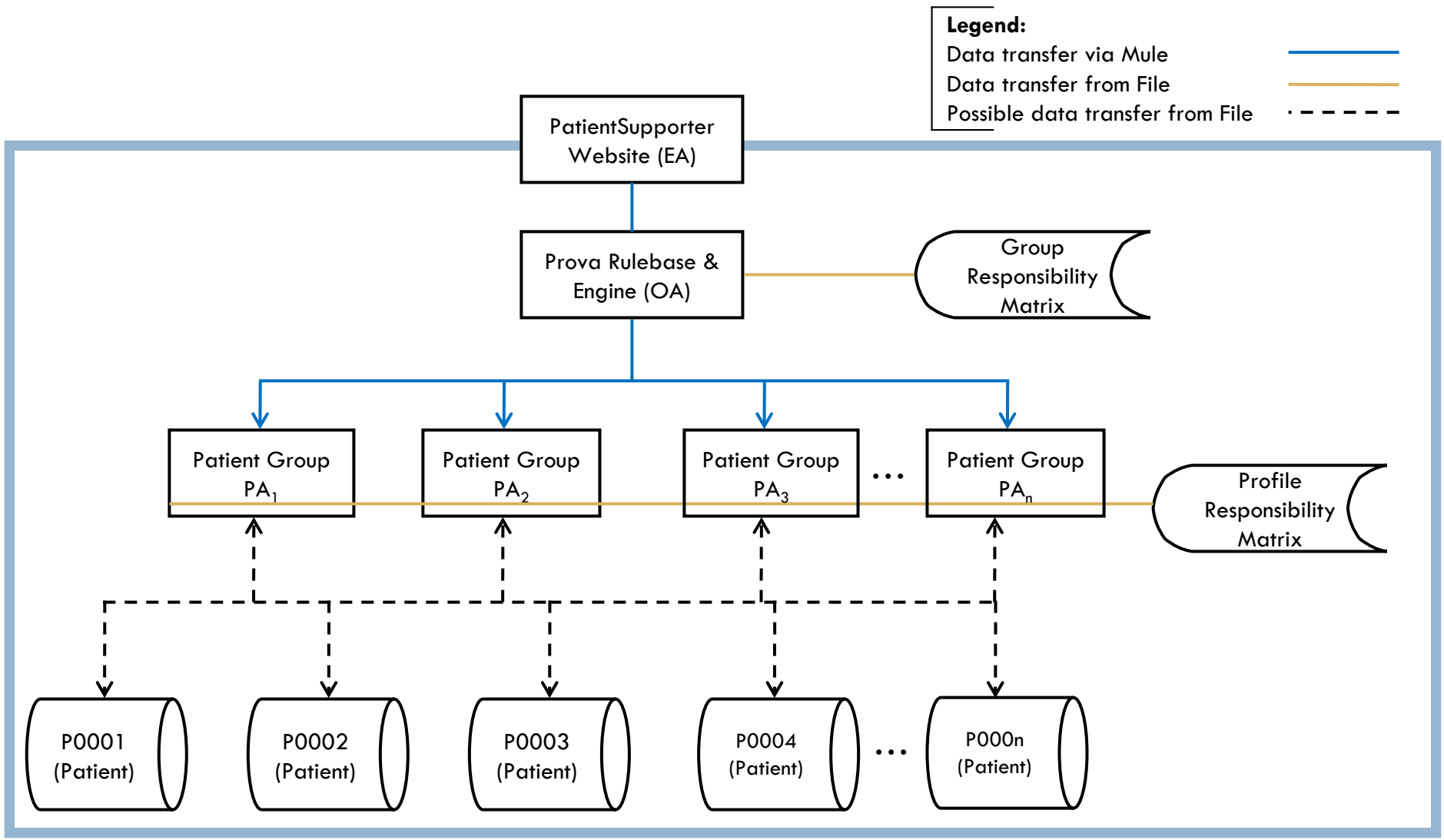


Communication using Mule Enterprise Service Bus



- Mule ESB Open Source
- Message Platform and distributed Object Broker
- Event Driven Architecture (EDA)
- Around 50 Protocols (JMS, HTTP, SOAP …)
- Synchronous and Asynchronous Communication
- Message Driven Event Processing

PatientSupporter Architecture



Rule Responder Agents (EA, OA, PAs)

- **External Agent (EA):**
  - The PatientSupporter website (shown later)
- **Organizational Agent (OA):**
  - Contains a **Prova** knowledge base which is used for incoming queries: **directs** them to **appropriate PAs** via the **Group Responsibility Matrix**
- **Personal Agent with Profiles (PA):**
  - Consists of a Java servlet and – using the two embedded engines, **OO jDREW** and **Euler** – forwards the query to **POSL** and **N3** profile knowledge bases, respectively
  - It only has **access** to **profiles** which contain **relevant information** for its responsible injury by using the **Profile Responsibility Matrix**

Group and Profile Responsibility Matrix

- Role assignment on two levels: **Group Responsibility Matrix** (GRM) and **Profile Responsibility Matrix** (PRM)
- The **GRM** contains information about PA **injury responsibility**, written as an OWL light ontology. It defines which PA is best suited for different kinds of queries
- The **PRM** contains information about PA **profile responsibility** and the **format** of each profile knowledge base:

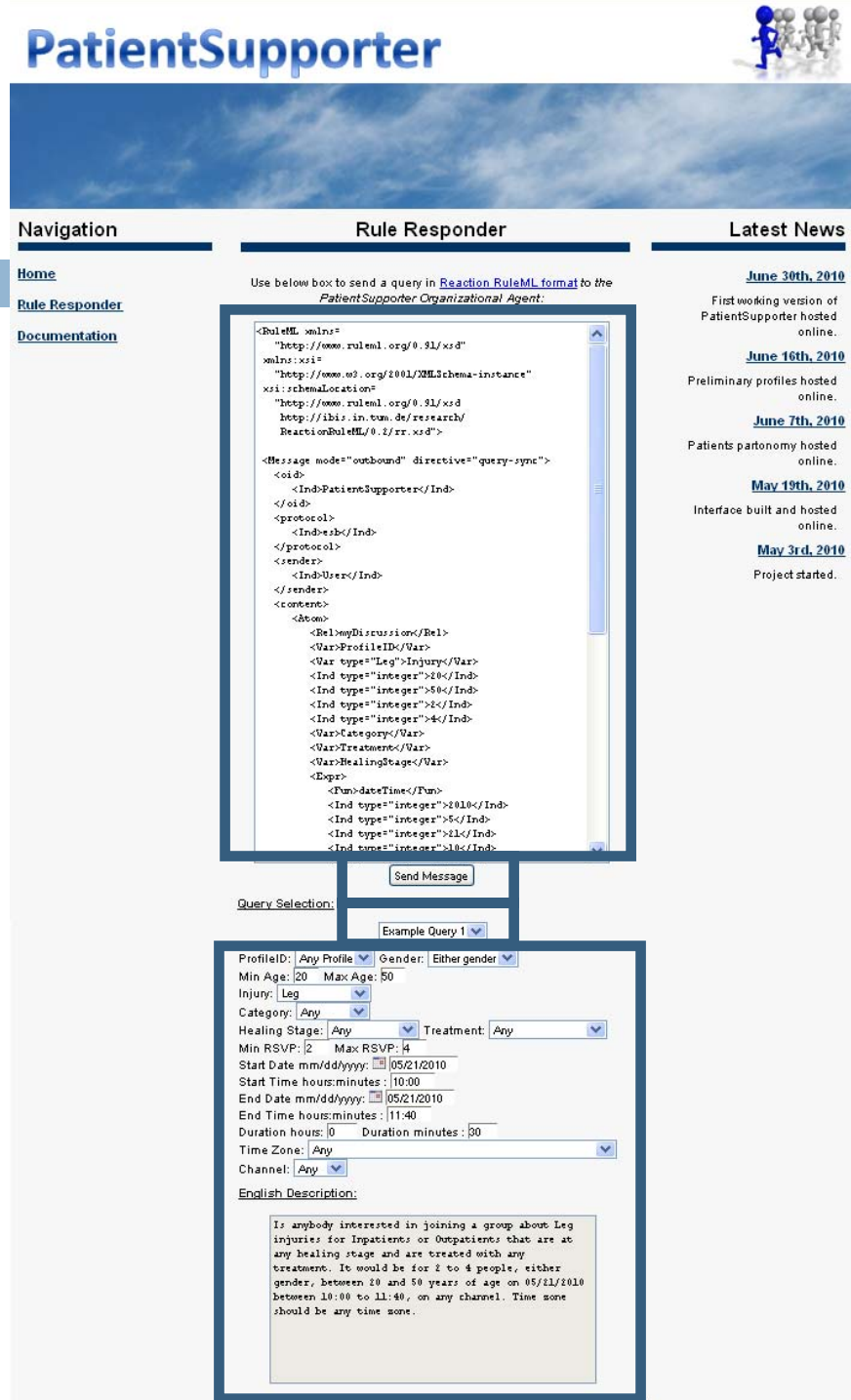
PA_{Leg} :

```
<Injury>
    <Leg>
      <ResponsibleProfile name="p0001" format="posl"/>
      <ResponsibleProfile name="p0002" format="n3"/>
      <ResponsibleProfile name="p0003" format="posl"/>
    </Leg>
    ...
</Injury>
```

Website (EA)

- EA is used to **issue queries** to the PatientSupporter **OA**
- **Query** can be written manually or constructed by using the Javascript based **GUI**
- Query is placed in the text box, in the **RuleML** format
- The **Send Message** will issue the query to the OA
- A new screen containing a list of **answers** in **RuleML** will be presented
- **Query examples** are provided with their subsequent English descriptions. Can be modified to suit your query

Online Demo:
http://ruleml.org/PatientSupporter/RuleResponder



Discussion Group Formation Scenario: Query Refinement

Introduction:

- In this scenario a participant of PatientSupporter (Paul) uses the system to find one or more partners for a Discussion on his and others' Toe injuries

Query 1:

- Paul first asks the community if some are interested in discussing Leg injuries with 2 to 10 people. Assessing the answers to this, he finds that there are too many candidates on the list, and decides to narrow down his question

Query 2:

- Paul fixes the date and limits possible times, which helps to reduce the numbers, but he still gets too many answers. While these constraints may be 'hard' for him (in this week), he should be aware that he may thereby decrease body-part *recall* (see Queries 3-4)

Query 3:

- Now he decides to further descend into the body partonomy, asking about Foot injuries (keeping the constraints of Query 2). The answer volume seems fine, but he now wants maximum body-part *precision*

Query 4:

- So, finally he focuses on Toe injuries. Paul now receives a single answer, from which he takes the contact name, Sam24, for agreeing on an MSN call

Example Query 1

Paul poses query about Leg, age, partici-pation, and call dura-tion

RuleML

```
...
   <Atom>
      <Rel>myDiscussion</Rel>
      <Var>ProfileID</Var>
      <Var type="Leg">Injury</Var>
      <Ind type="integer">20</Ind>
      <Ind type="integer">50</Ind>
      <Ind type="integer">2</Ind>
      <Ind type="integer">10</Ind>
      <Var>Category</Var>
      <Var>Treatment</Var>
      <Var>HealingStage</Var>
      <Expr><Fun>dateTime</Fun>...</Expr>
      <Expr><Fun>dateTime</Fun>...</Expr>
      <Expr>
         <Fun>dateTime</Fun>
         <Ind type="integer">0</Ind>
         <Ind type="integer">0</Ind>
         <Ind type="integer">0</Ind>
         <Ind type="integer">0</Ind>
         <Ind type="integer">30</Ind>
      </Expr>
      <Var>Channel</Var>
      <Var>Contact</Var>
      <Var>Gender</Var>
      <Var>TimeZone</Var>
   </Atom>
...
```

Green designates a relation name

- English Description:

Is anybody interested in joining a group about Leg injuries, between 20 and 50 years of age, for 2 to 10 people, for any category (In or Out) that are treated with any treatment at any healing stage? It would be on any date between any (start and end) times, for ... 0 hours and 30 minutes, on any channel, with any contact, gender, and time zone.

Blue designates a constant. More will get **blue** shortly

Yellow designates a variable

Example Query 1 – POSL & N3

RuleML

```
...
  <Atom>
    <Rel>myDiscussion</Rel>
    <Var>ProfileID</Var>
    <Var type="Leg">Injury</Var>
    <Ind type="integer">20</Ind>
    <Ind type="integer">50</Ind>
    <Ind type="integer">2</Ind>
    <Ind type="integer">10</Ind>
    <Var>Category</Var>
    <Var>Treatment</Var>
    <Var>HealingStage</Var>
    <Expr><Fun>dateTime</Fun>...</Expr>
    <Expr><Fun>dateTime</Fun>...</Expr>
    <Expr>
      <Fun>dateTime</Fun>
      <Ind type="integer">0</Ind>
      <Ind type="integer">0</Ind>
      <Ind type="integer">0</Ind>
      <Ind type="integer">0</Ind>
      <Ind type="integer">30</Ind>
    </Expr>
    <Var>Channel</Var>
    <Var>Contact</Var>
    <Var>Gender</Var>
    <Var>TimeZone</Var>
  </Atom>
...
```

N3

```
_:myDiscussion
  rdf:type          :MyDiscussion;
  :profileID        ?ProfileID;
  :injury           Injury:Leg;
  :minAge           20;
  :maxAge           50;
  :minRSVP          2;
  :maxRSVP          10;
  :category         ?Category;
  :treatment        ?Treatment;
  :healingStage     ?Healing;
  :startTime        ?StartTime;
  :endTime          ?EndTime;
  :duration         [rdf:type   :DateTime;
                     :year          0;
                     :month         0;
                     :day           0;
                     :hour          0;
                     :minute        30];
  :channel          ?Channel;
  :contact          ?Contact;
  :timezone         ?TimeZone.
```

POSL

```
myDiscussion(?ProfileID,Leg,20:integer,50:integer,2:integer,10:integer,?Category,
             ?Treatment,?HealingStage,
             dateTime[?StartYear,?StartMonth,?StartDay,?StartHour,?StartMinute],
             dateTime[?EndYear,?EndMonth,?EndDay,?EndHour,?EndMinute],
             dateTime[0:integer,0:integer,0:integer,0:integer,30:integer],
             ?Channel,?Contact,?Gender,?TimeZone) .
```

Example Query 2

Paul fixes date and limits times, giving time zone

RuleML

```
...
  <Atom>
    <Rel>myDiscussion</Rel>
    <Var>ProfileID</Var>
    <Var type="Leg">Injury</Var>
    <Ind type="integer">20</Ind>
    <Ind type="integer">50</Ind>
    <Ind type="integer">2</Ind>
    <Ind type="integer">10</Ind>
    <Var>Category</Var>
    <Var>Treatment</Var>
    <Var>HealingStage</Var>
    <Expr>
      <Fun>dateTime</Fun>
      <Ind type="integer">2010</Ind>
      <Ind type="integer">5</Ind>
      <Ind type="integer">21</Ind>
      <Ind type="integer">10</Ind>
      <Ind type="integer">0</Ind>
    </Expr>
    <Expr>
      <Fun>dateTime</Fun>
      ...
      <Ind type="integer">11</Ind>
      <Ind type="integer">40</Ind>
    </Expr>
    <Expr>
      <Fun>dateTime</Fun>
      ...
      <Ind type="integer">30</Ind>
    </Expr>
    <Var>Channel</Var>
    <Var>Contact</Var>
    <Var>Gender</Var>
    <Ind type="integer">-400</Ind>
  </Atom>
...
```

- English Description:

Is anybody interested in joining a group about Leg injuries, between 20 and 50 years of age, for 2 to 10 people, for any category (In or Out) that are treated with any treatment at any healing stage? It would be on 05/21/2010 between 10:00 and 11:40, for ... 0 hours and 30 minutes, on any channel, with any contact and gender, and on GMT -4:00.

Example Query 3

Paul focuses on Foot as part of Leg

RuleML

```
...
  <Atom>
    <Rel>myDiscussion</Rel>
    <Var>ProfileID</Var>
    <Var type="Foot">Injury</Var>
    <Ind type="integer">20</Ind>
    <Ind type="integer">50</Ind>
    <Ind type="integer">2</Ind>
    <Ind type="integer">10</Ind>
    <Var>Category</Var>
    <Var>Treatment</Var>
    <Var>HealingStage</Var>
    <Expr>
      <Fun>dateTime</Fun>
      <Ind type="integer">2010</Ind>
      <Ind type="integer">5</Ind>
      <Ind type="integer">21</Ind>
      <Ind type="integer">10</Ind>
      <Ind type="integer">0</Ind>
    </Expr>
    <Expr>
      <Fun>dateTime</Fun>
      ...
      <Ind type="integer">11</Ind>
      <Ind type="integer">40</Ind>
    </Expr>
    <Expr>
      <Fun>dateTime</Fun>
      ...
      <Ind type="integer">30</Ind>
    </Expr>
    <Var>Channel</Var>
    <Var>Contact</Var>
    <Var>Gender</Var>
    <Ind type="integer">-400</Ind>
  </Atom>
...
```

- English Description:

Is anybody interested in joining a group about Foot injuries, between 20 and 50 years of age, for 2 to 10 people, for any category (In or Out) that are treated with any treatment at any healing stage? It would be on 05/21/2010 between 10:00 and 11:40, for ... 0 hours and 30 minutes, on any channel, with any contact and gender, and on GMT -4:00.

Example Query 4

Paul focuses on Toe as part of Foot

```
...
  <Atom>
    <Rel>myDiscussion</Rel>
    <Var>ProfileID</Var>
    <Var type="Toe">Injury</Var>
    <Ind type="integer">20</Ind>
    <Ind type="integer">50</Ind>
    <Ind type="integer">2</Ind>
    <Ind type="integer">10</Ind>
    <Var>Category</Var>
    <Var>Treatment</Var>
    <Var>HealingStage</Var>
    <Expr>
      <Fun>dateTime</Fun>
      <Ind type="integer">2010</Ind>
      <Ind type="integer">5</Ind>
      <Ind type="integer">21</Ind>
      <Ind type="integer">10</Ind>
      <Ind type="integer">0</Ind>
    </Expr>
    <Expr>
      <Fun>dateTime</Fun>
      ...
      <Ind type="integer">11</Ind>
      <Ind type="integer">40</Ind>
    </Expr>
    <Expr>
      <Fun>dateTime</Fun>
      ...
      <Ind type="integer">30</Ind>
    </Expr>
    <Var>Channel</Var>
    <Var>Contact</Var>
    <Var>Gender</Var>
    <Ind type="integer">-400</Ind>
  </Atom>
...
```

RuleML

- English Description:

Is anybody interested in joining a group about Toe injuries, between 20 and 50 years of age, for 2 to 10 people, for any category (In or Out) that are treated with any treatment at any healing stage? It would be on 05/21/2010 between 10:00 and 11:40, for ... 0 hours and 30 minutes, on any channel, with any contact and gender, and on GMT -4:00.

Answer to Query 4

Paul gets precise answer

RuleML

```
...
  <Atom>
    <Rel>myDiscussion</Rel>
    <Ind>p0004</Ind>
    <Var type="Toe">Injury</Var>
    <Ind type="integer">20</Ind>
    <Ind type="integer">50</Ind>
    <Ind type="integer">2</Ind>
    <Ind type="integer">10</Ind>
    <Ind>Out</Ind>
    <Ind>MinorOperation</Ind>
    <Ind>Medium</Ind>
    ...
    <Ind>MSN</Ind>
    <Ind>Sam24</Ind>
    <Ind>Male</Ind>
    <Ind type="integer">-400</Ind>
  </Atom>
...
```

- English Description:

p0004 is interested in joining a group about Toe injuries, between 20 and 50 years of age, for 2 to 10 people, as an Out patient that was treated with a Minor Operation at Medium healing stage. It would be on ..., channel MSN, with contact name Sam24, gender Male, and on GMT -4:00.

Conclusion

- The PatientSupporter case study:
  - Uses a global as well as distributed local **knowledge bases** to support profile interoperation and querying
  - Demonstrates **profile interoperation** between ***logic-relational*** (e.g., POSL) and ***graph-networked*** (e.g., N3) knowledge representations
  - Employs an **extended** Rule Responder **architecture,** containing the **profile level** underneath the PAs
  - Supports **online-interactive communities** of patients guided by a **body partonomy mapped to a taxonomy**
  - This Rule Responder version thus **ontologizes** the architecture of earlier instantiations WellnessRules (2) and SymposiumPlanner