



# Social Semantic Rule Sharing and Querying in Wellness Communities

Harold Boley, Taylor Osmun, Derek Smith, Benjamin Craig  
Institute for Information Technology, National Research Council, Canada  
Fredericton, NB, Canada

4th Annual Asian Semantic Web Conference, Shanghai, China, Dec. 7-9, 2009

Updated: Nov. 18, 2010



# WellnessRules – Idea and Implementations

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

People advertise their **semantic** profiles  
to **socialize** with others in wellness groups

Implemented in [WellnessRules](#) & [WellnessRules2](#)

# Part 1: WellnessRules Foundation in Profile Knowledge Base Interoperation

- WellnessRules Overview
- Global and Local Knowledge Bases
- Profile Interoperation Between Prolog-extending POSL & RDF-extending N3
  - ▣ Interoperation Principles for **Relational** (POSL) and **Networked** (N3) Languages
  - ▣ POSL ↔ N3 Transformation
- Taxonomy

*Later seen in Part 2:*

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



# WellnessRules Overview

- WellnessRules supports a wellness community that is **online-interactive** and **rule-supported**. Each participant of this community has the ability to:
  - **Create profiles about themselves**, containing their preferences for activities and nutrition, their event times, and their fitness levels
  - **Compare and collaborate with others** in the community, to track progress and schedule group events
- Rules about wellness opportunities are
  - **authored** in rule languages such as POSL and N3
  - **interoperated** within the community using RuleML/XML



# Global Knowledge Base

- Contains knowledge relevant to everyone in the WellnessRules community
- Knowledge Areas:
  - **Season**
    - Defines timeframe of the seasons
  - **Forecast**
    - Describes the weather forecast within timeframes
  - **Meetup**
    - Contains activity meetup locations for maps

*Global Knowledge Base is available in [POSL](#) and [N3](#)*



# Local Knowledge Bases

- Contains local knowledge specific to each participant in the WellnessRules community
- Knowledge Areas:
  - **Calendar**
    - Used for event planning. Allows for sharing of calendars between profiles
  - **Map**
    - Links to meetup locations. Allows for sharing of maps between profiles
  - **Fitness**
    - Defines expected fitness level for a specific period of time (scale of 1-10)
  - **Event**
    - Possible/Planned/Performing/Past
  - **MyActivity**
    - Derive participants' individual activity preferences



# Local MyActivity Sample Rule (in POSL)

— Centered on Participant p0001 as First Argument

```
myActivity(p0001,Running,out,?MinRSVP,?MaxRSVP,?StartTime,?EndTime,?Place,?Duration,?Level)
:-
  calendar(p0001,?Calendar),
  event(?Calendar,?:Running,possible,?StartTime,?EndTime),
  participation(p0001,run,out,?MinRSVP,?MaxRSVP),
  season(?StartTime,summer),
  forecast(?StartTime,sky,?Weather),
  notEqual(?Weather,raining),
  map(p0001,?Map),
  meetup(?Map,run,out,?Place),
  level(p0001,run,out,?Place,?Duration,?Level),
  fitness(p0001,?StartTime,?ExpectedFitness),
  greaterThanOrEqualTo(?ExpectedFitness,?Level),
  goodDuration(?Duration,?StartTime,?EndTime).
```

Orange  
designates a  
profile  
preference

- Based on this rule the following are [p0001](#)'s preferences for Running outdoors:
  - The number of **participants** must be **within** the **minimum** and **maximum**
  - The season must be **summer**
  - It must **not** be **raining** outside
  - [p0001](#)'s **fitness level** is **greater than or equal** to the **required fitness level**



# 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 **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 **positional** and **slotted** knowledge (e.g., Prolog's positional and F-logic's slotted knowledge)
- WellnessRules only uses *positional POSL* for **logic-relational** knowledge, displayed in a Prolog-like human-readable syntax
- Positional relation descriptions (**fact** and **query** examples):
  - **Relation names (f):** `season("2009-06-15T10:15:00",summer).`
    - Each fact and rule head has a **relation name**
  - **Arguments (f):** `season("2009-06-15T10:15:00",summer).`
    - Constant arguments are **strings** or **symbols**, separated by **commas** (“,”)
  - **Variables (q):** `season(?StartTime,?)`
    - 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
- WellnessRules uses **N3** for *graph-networked* readable knowledge
- Slotted subject descriptions (fact and query examples):

- **Subject names (f):**

- Each fact / rule head has a **subject name**

```
:season_1
  rdf:type      :Season;
  :startTime   "2009-06-15T10:15:00";
  :period      :summer.
```

“:” here denotes IRI of this local knowledge base

- **Variables (q):**

- Can be named (“?” **prefix** ), or anonymous (**stand-alone** “?”)

```
?season
  rdf:type      :Season;
  :startTime   ?StartTime;
  :period      ?.
```

- **Arguments as property→object slots (f):**

- Each argument must have a **property** (slot **name**):

```
:season_1
  rdf:type      :Season;
  :startTime   "2009-06-15T10:15:00";
  :period      :summer.
```

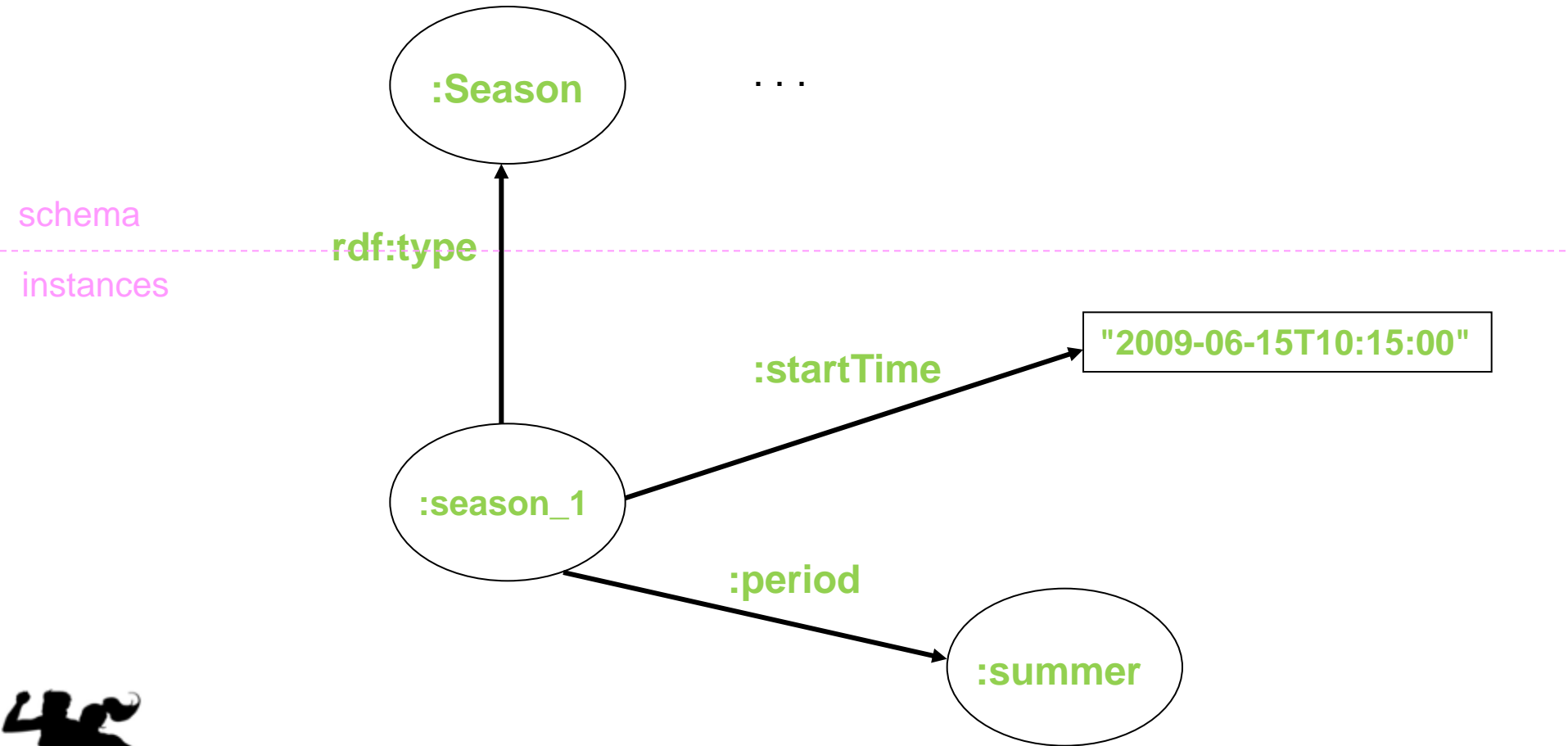
- Each argument must also have an **object** (slot **value**):

```
:season_1
  rdf:type      :Season;
  :startTime   "2009-06-15T10:15:00";
  :period      :summer.
```



# Notation 3 (N3): RDF Graph

## – Semantic Net / Light-Weight Ontology



# 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 *POSL relation name* becomes defined in an N3 rule head via an **rdf:type** property using the “:”-prefixed, uppercased version of the “:Name”

POSL

```
season(?StartTime,?Season).
```



```
:season_1  
rdf:type :Season;  
:startTime ?StartTime;  
:period ?Season.
```

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

```
season(?StartTime,?Season).
```



```
:season_1  
rdf:type :Season;  
:startTime ?StartTime;  
:period ?Season.
```

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** ...'

```
myActivity(p0001,Running,out,?MinRSVP,?MaxRSVP,  
           ?StartTime,?EndTime,?Place,?Duration,?Level)
```

:-

```
...  
forecast(?StartTime,sky,?Weather),  
notEqual(?Weather,raining),  
...
```

POSL

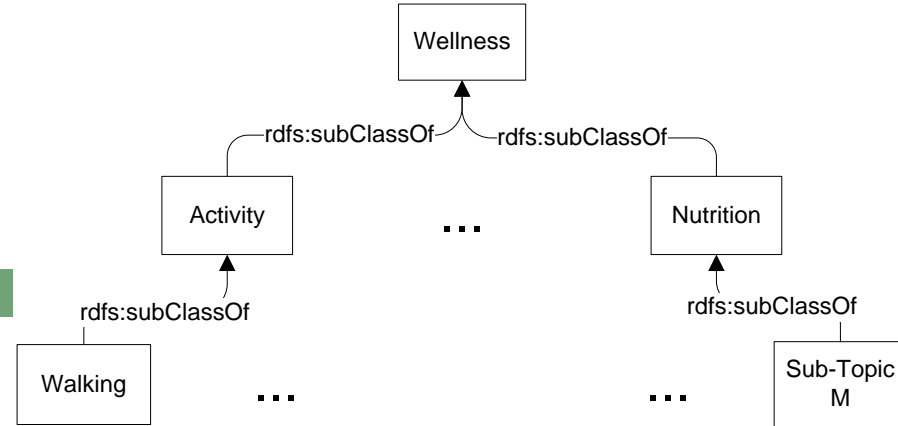


```
{  
...  
?forecast  
  rdf:type           :Forecast;  
  :startTime         ?StartTime;  
  :aspect            :sky;  
  :value             ?Weather.  
  
?Weather log:notEqualTo :raining.  
...  
}  
  
=>  
  
{  
  _:myActivity  
  rdf:type           :MyActivity;  
  :profileID        :p0001;  
  :activity          :Running;  
  :inOut            :out;  
  :minRSVP          ?MinRSVP;  
  :maxRSVP          ?MaxRSVP;  
  :startTime        ?StartTime;  
  :endTime          ?EndTime;  
  :location         ?Place;  
  :duration         ?Duration;  
  :fitnessLevel     ?FitnessLevel.  
}
```

N3



# Taxonomy



- The WellnessRules taxonomy is broken into two topics: Activity and Nutrition
- Each of these contains multiple subtopics (e.g., Walking and Running)
- Both representations use **rdf:type**, **rdfs:Class** and **rdfs:subClassOf**
- Taxonomy *classes* act as user-defined *types* to restrict rule variables

## RDF (used by POSL)

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

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

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

  ...
```



```
@prefix : <wellnessRules#>.
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>.
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>.

:Wellness      rdf:type          rdfs:Class.
:Activity      rdf:type          rdfs:Class;
               rdfs:subClassOf  :Wellness.
:Walking      rdf:type          rdfs:Class;
               rdfs:subClassOf  :Activity.
...

```

## Part 2: WellnessRules for an Online-Interactive Wellness Community via Rule Responder

- WellnessRules as a Rule Responder
- WellnessRules Architecture
- WellnessRules Agent Implementation and Role Assignment Matrix
- Activity Scenario: Example Queries with Live Demo

*Previously seen in Part 1:*

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

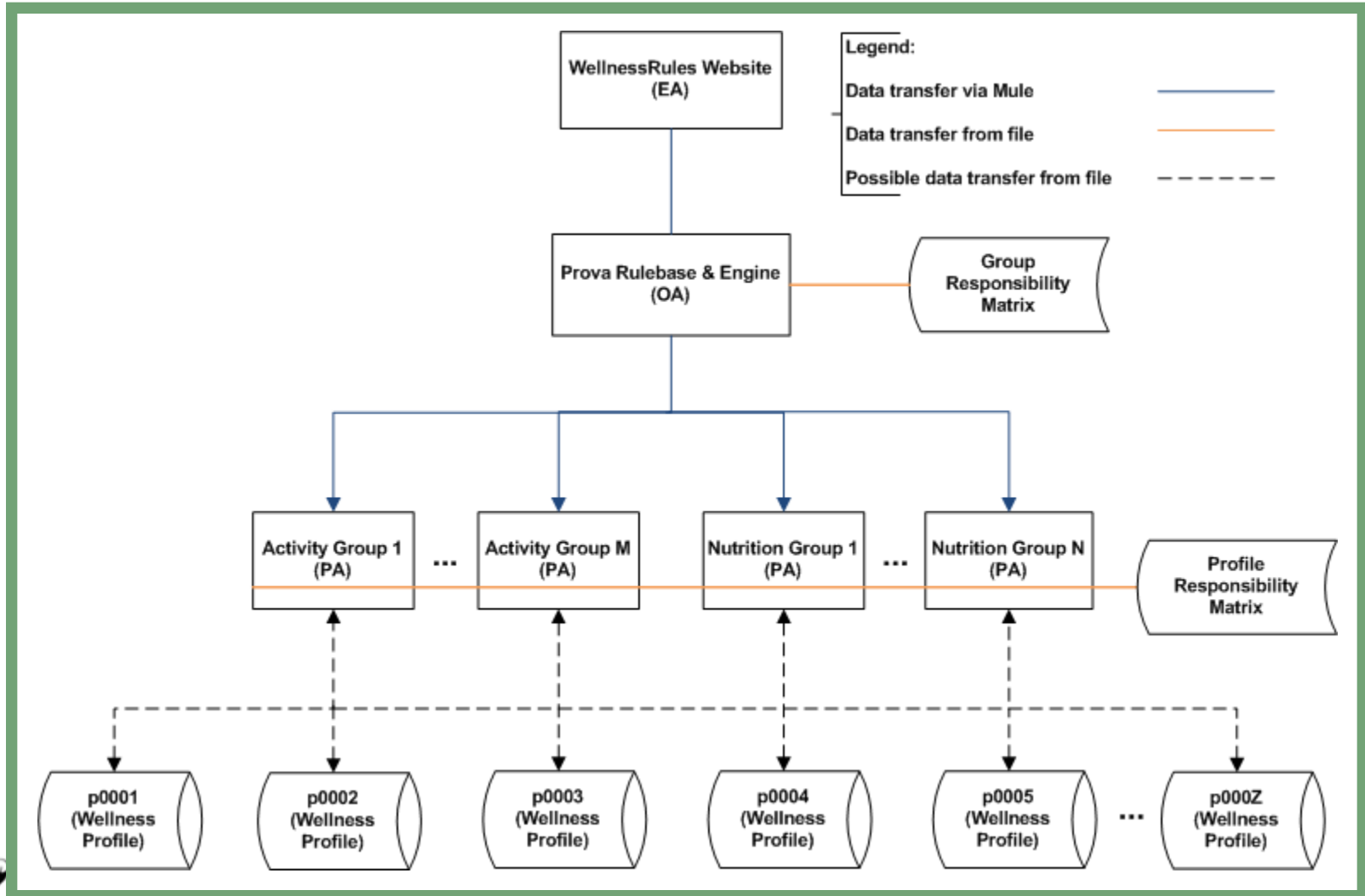


# WellnessRules as a Rule Responder

- 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 participants**
  - **External Agents (EAs)**
- The WellnessRules instantiation of Rule Responder employs the **OA, PAs, and EAs** for **communication** and **query delegation** to support an **online-interactive wellness community**
  - Similar to [SymposiumPlanner](#)



# WellnessRules Architecture



# Rule Responder Agents (OA, PAs, EAs)

- External Agent (EA):
  - ▣ The WellnessRules 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 activity 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 **wellness 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 **Walking** :

```
<Activity>
  <Walking>
    <ResponsibleProfile name="p0001" format="pos1"/>
    <ResponsibleProfile name="p0002" format="n3"/>
    <ResponsibleProfile name="p0003" format="pos1"/>
  </Walking>
  ...
</Activity>
```





# Website (EA)

- EA used to **issue queries** to the WellnessRules[1] **OA**
- Query is placed in the text box, in **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

### Navigation

[WellnessRules Home](#)

[Rule Responder](#)

### WellnessRules - The Activity Rule Responder

Use below box to send a query in [Reaction RuleML format](#) to the WellnessRules Organizational Agent:

```
<RuleML xmlns="http://www.ruleml.org/0.91/xsd"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.ruleml.org/0.91/xsd
http://ibis.in.tum.de/research/ReactionRuleML/0.2/tr.xsd"
xmlns:ruleml2007="http://ibis.in.tum.de/projects/paw#">
<Message mode="outbound"
directive="query-sync">
<oid>
<Ind>WellnessRules</Ind>
</oid>
<protocol>
<Ind>esb</Ind>
</protocol>
<sender>
<Ind>User</Ind>
</sender>
<Atom>
<Rel>myActivity</Rel>
<Var>ProfileID</Var>
<Ind>Running</Ind>
<Var>InOut</Var>
<Ind type="integer">1</Ind>
<Ind type="integer">5</Ind>
<Var>StartTime</Var>
<Var>EndTime</Var>
<Var>Location</Var>
<Var>Duration</Var>
<Var>FitnessLevel</Var>
</Atom>
</Message>
</RuleML>
```

Send Message

### Latest News

**October 15th, 2009**  
Call for profiles: If you are interested in assisting the WellnessRules initiative, please write your own profiles (in either POSL or NB) and submit to the webmaster.

**October 14th, 2009**  
WellnessRules fully implemented into Rule Responder. Support for both Euler and OOJDREW engines.

**September 14th, 2009**  
Full Rule Responder implementation of WellnessRules begins.

**August 25th, 2009**  
WellnessRules website updated to provide navigation and latest news.

**August 14th, 2009**  
WellnessRules website launched. Basic Rule Responder implementation provided.

**Query Selection:**  
The drop-down boxes show sample queries you -- as an External Agent -- can send to the WellnessRules Organizational Agent. These examples can also act as initial templates that you can edit to create your own queries.

Activity Example Query 1 ▾

**English Description:**  
Is anyone interested in general Running (indoors or outdoors), with one to five people, for any (start and end) time, location, duration, and fitness level?

Online Demo:

<http://www.ruleml.org/WellnessRules/RuleResponder>

# Activity Scenario: Structured English

## **Introduction:**

- In this scenario a participant of WellnessRules (Peter) uses the system to find one or more partners for Running some time in the near future

## **Query 1:**

- Peter first asks the community if anyone at all is interested in running with 2 to 6 people. Assessing the answer to this, he finds that there are far too many candidates on the list, and decides to narrow down his question

## **Query 2:**

- He feels that he will continue to have a fitness level of 5 for Running, and so asks a refined question wanting only Level-5 activities. In the answer list he notices p0001 (John), who is someone he has previously performed cycling with. (He finds John's fitness level of 5 for running surprising, as he did not realize he was also a good Runner)

## **Query 3:**

- Now he wishes to run with John (perhaps in a race?) and so targets p0001, and that he prefers Joe's Gym as the location. Peter now receives a single, final answer on the list, from which he takes the type of running, time, and duration, to contact John for scheduling this event



# Example Query 1

Peter would like to go for a run at some point in time.  
He poses the following question:

**Green** designates a relation name

## □ English Description:

Is **anyone** interested in general **Running** (**indoors** or **outdoors**), with **2** to **6** people, for any (**start** and **end**) time, **location**, **duration**, and **fitness level**?

**Blue** designates a constant.  
More will get **blue** as we progress

**Orange** designates a variable

```
...
<Atom>
  <Rel>myActivity</Rel>
  <Var>ProfileID</Var>
  <Ind>Running</Ind>
  <Var>InOut</Var>
  <Ind type="integer">2</Ind>
  <Ind type="integer">6</Ind>
  <Var>StartTime</Var>
  <Var>EndTime</Var>
  <Var>Location</Var>
  <Var>Duration</Var>
  <Var>FitnessLevel</Var>
</Atom>
...
```

RuleML



# Example Query 1 – POSL & N3

## RuleML

```
...  
<Atom>  
  <Rel>myActivity</Rel>  
  <Var>ProfileID</Var>  
  <Ind>Running</Ind>  
  <Var>InOut</Var>  
  <Ind type="integer">2</Ind>  
  <Ind type="integer">6</Ind>  
  <Var>StartTime</Var>  
  <Var>EndTime</Var>  
  <Var>Location</Var>  
  <Var>Duration</Var>  
  <Var>FitnessLevel</Var>  
</Atom>  
...
```

## N3

```
_:myActivity  
  rdf:type           :MyActivity;  
  :profileID        ?ProfileID;  
  :activity          :Running;  
  :inOut             ?InOut;  
  :minRSVP           2;  
  :maxRSVP           6;  
  :startTime         ?StartTime;  
  :endTime           ?EndTime;  
  :location          ?Location;  
  :duration          ?Duration;  
  :fitnessLevel      ?FitnessLevel.
```

## POSL

```
myActivity(?ProfileID,Running,?InOut,2:integer,6:integer,  
           ?StartTime,?EndTime,?Location,?Duration,?FitnessLevel).
```



# Example Query 2

Peter feels that he will continue to have a fitness level of 5 for Running. He poses the following question:

RuleML

```
...
<Atom>
  <Rel>myActivity</Rel>
  <Var>ProfileID</Var>
  <Ind>Running</Ind>
  <Var>InOut</Var>
  <Ind type="integer">2</Ind>
  <Ind type="integer">6</Ind>
  <Var>StartTime</Var>
  <Var>EndTime</Var>
  <Var>Location</Var>
  <Var>Duration</Var>
  <Ind type="integer">5</Ind>
</Atom>
...
```

## □ English Description:

Is **anyone** interested in general **Running** (**indoors** or **outdoors**), with **2** to **6** people, for any (**start** and **end**) time, **location**, and **duration**, at a fitness level of **5**?



# Example Query 3

Now he wishes to run with John, and so addresses p0001, and that he prefers Joe's Gym as the location. He poses the following question:

RuleML

```
...  
<Atom>  
  <Rel>myActivity</Rel>  
  <Ind>p0001</Ind>  
  <Ind>Running</Ind>  
  <Var>InOut</Var>  
  <Ind type="integer">2</Ind>  
  <Ind type="integer">6</Ind>  
  <Var>StartTime</Var>  
  <Var>EndTime</Var>  
  <Ind>joesGym</Var>  
  <Var>Duration</Var>  
  <Ind type="integer">5</Ind>  
</Atom>  
...
```

□ English Description:

Is p0001 interested in general Running (indoors or outdoors), with 2 to 6 people, for any (start and end) time, at Joe's Gym, for any duration, at a fitness level of 5?



# Answer to Query 3

WellnessRules will return the answer seen below. This gives Peter all of the information he needs to contact John about scheduling this event.

```
...
<Atom>
  <Rel>myActivity</Rel>
  <Ind>p0001</Ind>
  <Ind>Running</Ind>
  <Ind>in</Ind>
  <Ind type="integer">2</Ind>
  <Ind type="integer">6</Ind>
  <Ind>2009-06-15T10:15:00</Ind>
  <Ind>2009-06-15T11:15:00</Ind>
  <Ind>joesGym</Ind>
  <Ind>P60M</Ind>
  <Ind type="integer">5</Ind>
</Atom>
...
```

RuleML

## □ English Description:

p0001 is interested in Running Indoors, with 2 to 6 people, between 10:15AM and 11:15AM on June 15th, 2009, at Joe's Gym, for 60 minutes, at a fitness level of 5.

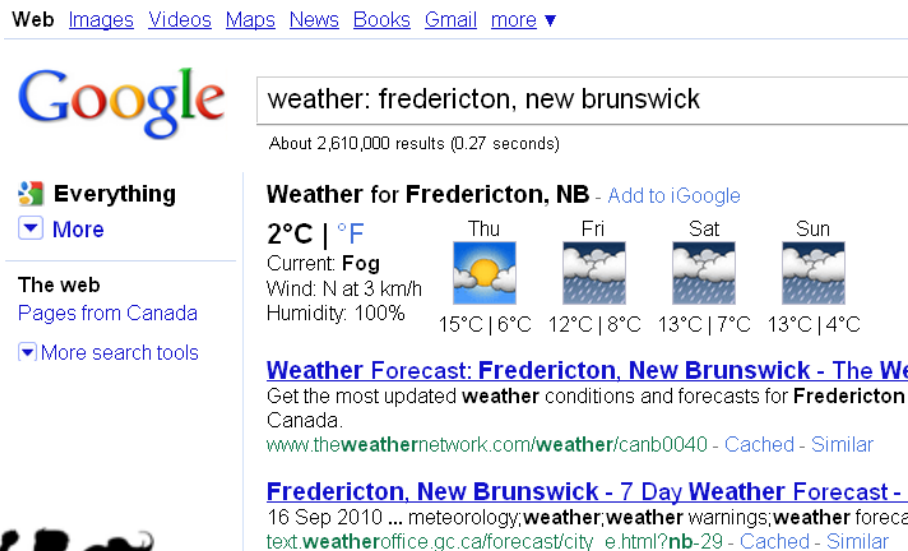


# Google Weather – GUI & XML

- Google provides a **GUI** for the weather through normal search. Google's corresponding Weather **API** is used by **WellnessRules2**
- Example: Fredericton weather, **Thursday, October 14<sup>th</sup>, 2010**

## GUI

Web [Images](#) [Videos](#) [Maps](#) [News](#) [Books](#) [Gmail](#) [more](#) ▼



Google





weather: fredericton, new brunswick

About 2,610,000 results (0.27 seconds)

**Weather for Fredericton, NB** - Add to iGoogle

2°C | °F

Current: **Fog**  
Wind: N at 3 km/h  
Humidity: 100%

|  |  |  |  |
|--|--|--|--|
| Thu  | Fri  | Sat  | Sun  |
|  |  |  |  |
| 15°C   6°C   | 12°C   8°C   | 13°C   7°C   | 13°C   4°C   |

[Weather Forecast: Fredericton, New Brunswick - The Weather Network](#)  
Get the most updated **weather** conditions and forecasts for **Fredericton** Canada.  
[www.theweathernetwork.com/weather/canb0040](#) - Cached - Similar

[Fredericton, New Brunswick - 7 Day Weather Forecast - 16 Sep 2010](#) ... meteorology; **weather**; **weather** warnings; **weather** forecast. [text.weatheroffice.gc.ca/forecast/city\\_e.html?nb-29](#) - Cached - Similar

## XML

```
...  
<forecast_conditions>  
  <day_of_week data="Thu"/>  
  <low data="42"/>  
  <high data="59"/>  
  <icon data="/ig/images/weather/  
    partly_cloudy.gif"/>  
  <condition data="Partly Cloudy"/>  
</forecast_conditions>  
...
```

Converted to Celsius during post-processing

Used in the taxonomy of weather conditions

Google Weather in XML for Fredericton, NB:

<http://www.google.com/ig/api?weather=Fredericton,NB>



# Google Weather – POSL & N3

- [WellnessRules2](#) takes this **XML** representation, converting it to **POSL** and **N3**, with similar interoperation methods as seen previously **N3**

## XML

```
...  
<forecast_conditions>  
  <day_of_week data="Thu"/>  
  <low data="42"/>  
  <high data="59"/>  
  <icon data="/ig/images/weather/  
    partly_cloudy.gif"/>  
  <condition data="Partly Cloudy"/>  
</forecast_conditions>  
...
```

```
:forecast_109  
  rdf:type      :Forecast;  
  :location     "Fredericton, NB";  
  :dateTime     [rdf:type :DateTime;  
                :year    2010;  
                :month   10;  
                :day     14;  
                :hour    ?Hour;  
                :minute  ?Minute];  
  :lowTemp     5;  
  :highTemp    15;  
  :avgTemp     10;  
  :conditions  :PartlyCloudy.
```

## POSL

```
forecast("Fredericton,NB",  
  dateTime[2010:integer,10:integer,14:integer,  
           ?Hour:integer,?Minute:integer],  
  5:integer,15:integer,10:integer,?:PartlyCloudy).
```



# Google Calendar – Current Work

- [Current Project](#) will provide an extension to WellnessRules2, which: automatically imports participants' events from their Google Calendar and synchronizes event facts with the rest of their profile

## Methodology

**Increment 1:** Servlet to **retrieve** participants' Google Calendar event information and **display** this information

**Increment 2:** Translator that **maps** event information to the N3 and POSL formats

**Increment 3:** Editor to **update** a participant's profile



# Conclusion

- The WellnessRules 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
  - Introduces an **extended** Rule Responder **architecture**, adding the **profile level** underneath the PAs
  - Supports **online-interactive wellness communities** via the online [WellnessRules/WellnessRules2](#) activity planners in Rule Responder
  - These systems, described here, were also complemented by a [NutritionPlanner](#) and by a [PatientSupporter](#)
  - More instantiations upcoming, e.g. a [Personal Learning Responder](#)