An ontology to semantically annotate the M2M data

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Motivation

- Enrich M2M data to build cross-domain M2M applications

How to get the meaning of the data?

Application 1: Smart Kitchen
- milk → 1 litter: milk
- orange → 1 kilo: orange
- 110°C

Application 2: Health
- 40°C
- 5g/L: cholesterol

Application 3: Weather Forecasting
- 22°C

- Milk contains lactose?
- Allergic to lactose?
- Orange: Color, Fruit?
- If it is a fruit it contains vitamin C
- Cholesterol-free food

Body’s temperature? External temperature? Oven’s temperature?

Suggest a recipe according to the external temperature and the health?
How to get M2M data?

- Get M2M data:
  - E.g.: temperature, food, blood glucose level
  - Sensor Web Enablement (SWE)
  - SenML protocol [draft-jennings-senml-10]
  - Semantic Sensor Networks ontology (SSN)
The M3 ontology (Machine to Machine Measurement)

- Ontology, RDF, RDFS, OWL
  - Describe concepts and their relationships in a specific domain

- Extension of the W3C Semantic Sensor Networks (SSN) ontology to explicitly describe the data
  - Observation Value concept

- Classify all the concepts in the Machine-to-Machine (M3) ontology
  - Domain (health, smart building, weather, room, city, etc.)
  - Measurement type (t = temp = temperature)
  - Sensor type (rainfall sensor = precipitation sensor)
How to deduce new knowledge?

- Rules example:
  - If Domain == Health && MeasurementType == Temperature then NewType = BodyTemperature
  - If BodyTemperature > 38°C then “Flu”
  - BodyTemperature and Flu are already described in domain ontologies or datasets!

- Reuse the domain ontologies already designed and defined by experts
  - “flu” has a meaning in health ontologies
  - “hot” has a meaning in weather ontologies
How to reuse domain ontologies and datasets?

- How to find domain ontologies or datasets?
  - Best practices
  - Semantic tools
- In a specific domain, which ontology or dataset do we choose?
- How to use the complementarity of existing ontologies and datasets?
M3: our proposed approach

How to interconnect the data provided by heterogeneous domains?

A

- M2M data (1) → Semantic M2M data (2)

data = 39°C
sensor = thermometer
domain = health

- Semantic Rule (3)
- New domain concept

If data >= 39 then flu
&& domain == health
=> New concept = flu

- Health ontology
- Flu is a disease

B

- M2M data (1) → Semantic M2M data (2)

data = 39°C
sensor = thermometer
domain = weather

- Semantic Rule (3)
- New domain concept

If data >= 39 then hot
&& domain == weather
=> New concept = hot

- Domain ontology
- Weather ontology
(hot is related to season)

Reasoning (7)

Cross domain applications (6)

Ingredients - diseases

Domain dataset 1 (5)

Domain dataset 2 (5)

Ingredients - season
M3: a hub for cross-domain ontologies and datasets

- The M3 approach
  - Enrich M2M data
  - A hub for cross-domain ontologies and datasets
  - Reason on semantic M2M data
Find the dataset corresponding to the domain ontology

- Reuse the knowledge bases already designed and defined by experts
- Link semantic M2M measurements to:
  - Linked Open data
Combine cross-domain datasets?

- **Existing domain datasets:**
  - Naturopathy (weather & ingredient & recipe & emotion & color)
  - Vacation & weather

- **We propose cross-domain datasets**
  - Naturopathy (weather & ingredient & recipe & emotion & color)
  - Vacation & weather

- **New M2M cross-domain applications**
  - Suggest you a recipe according to user’s diseases, diets, allergies, the weather, the mood!
  - Suggest activities according to the weather
  - …
Scenario 1: Body Temperature
Convert into semantic measurements (M3 ontology)

- A first prototype to validate the M3 approach
  - http://sensormeasurement.appspot.com/

- Infer a new type

Find food recommended when you are sick

1. SenML API (Simulate M2M measurements): Simulate temperature measurements
2. M2M Aggregation Gateway (Convert Health Measurements into Semantic Data):
3. We deduce that the temperature corresponds to the body temperature.
4. We deduce that the person is sick.
5. We propose all fruits/vegetables according to this disease.
6. M2M Application: Temperature => Cold => Food: (Wait 10 seconds!) Convert health measurements

Semantic M2M Measurements
Scenario 1: Body Temperature
Enrich Semantic M2M Data

- Link our semantic M2M measurements to the Linked Open Data
- Naturopathy dataset: a cross-domain dataset

Find food recommended when you are sick

1. SenML API (Simulate M2M measurements): Simulate temperature measurements
2. M2M Aggregation Gateway (Convert Health Measurements into Semantic Data):
3. We deduce that the temperature corresponds to the body temperature.
4. We deduce that the person is sick.
5. We propose all fruits/vegetables according to this disease.
6. M2M Application: Temperature => Cold => Food: (Wait 10 seconds!)

- Value = 39.0, Unit = Cel, Type = Body Temperature, Disease = Cold, Food = Kiwi
- Value = 39.0, Unit = Cel, Type = Body Temperature, Disease = Cold, Food = Lemon
- Value = 39.0, Unit = Cel, Type = Body Temperature, Disease = Cold, Food = Honey
- Value = 39.0, Unit = Cel, Type = Body Temperature, Disease = Cold, Food = Ginger

Scenario 2: Weather Temperature

Weather & Activity

1. SenML API (Simulate M2M measurements): Simulate Weather measurements
2. M2M Aggregation Gateway (Convert weather Measurements into Semantic Data):
   Convert weather measurements
3. We deduce the weather outside.
4. We propose activities according to the weather.
5. M2M Application (Temperature => weather => Activity):
   Activity & Temperature
6. M2M Application (Luminosity => weather => Activity):
   Activity & Luminosity
7. M2M Application (Precipitation => weather => Activity):
   Activity & Precipitation
8. M2M Application (Wind speed => weather => Activity):
   Activity & Wind Speed

- Value = 39.0, Type = Weather Temperature, Unit = Cel, Weather = Sunny, Activity = BeachSunbathing
- Value = 39.0, Type = Weather Temperature, Unit = Cel, Weather = Sunny, Activity = BeachVolley
Scenario 3: Luminosity & Emotion

Weather & Emotion

1. SenML API (Simulate M2M measurements): Simulate Weather measurements (5000 lux and 50 000 lux)
2. M2M Aggregation Gateway (Convert weather Measurements into Semantic Data):
   Convert weather measurements
3. We deduce the luminosity color.
4. We deduce the emotion according to the luminosity color.
5. Test 1: 5000 lux => luminosity grey since it is cloudy => sadness emotion
6. Test 2: 50 000 lux => luminosity yellow since it is sunny => happiness emotion
7. We deduce the emotion according to the luminosity color.
8. M2M Application (Luminosity => weather => Activity):

   - Value = 50000.0, Type = Weather Luminosity, Unit = lx, Emotion = Joy, Color = Yellow
   - Value = 50000.0, Type = Weather Luminosity, Unit = lx, Emotion = Happiness, Color = Yellow
   - Value = 50000.0, Type = Weather Luminosity, Unit = lx, Emotion = Fear, Color = Yellow
   - Value = 5000.0, Type = Weather Luminosity, Unit = lx, Emotion = Sadness, Color = Gray
   - Value = 5000.0, Type = Weather Luminosity, Unit = lx, Emotion = Confusion, Color = Gray
   - Value = 5000.0, Type = Weather Luminosity, Unit = lx, Emotion = Boredom, Color = Gray
   - Value = 5000.0, Type = Weather Luminosity, Unit = lx, Emotion = Depressed, Color = Gray
Conclusion & Future works

- The M3 approach
  - M3 ontology to enrich M2M data
  - Combine heterogeneous M2M data
  - Reason on semantic M2M data

- M3 enables to build cross-domain M2M applications
Thank you!