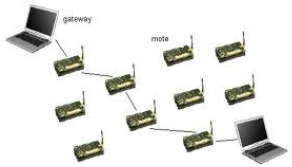
EURECOM
Sophia Antipolis



Semantic Web

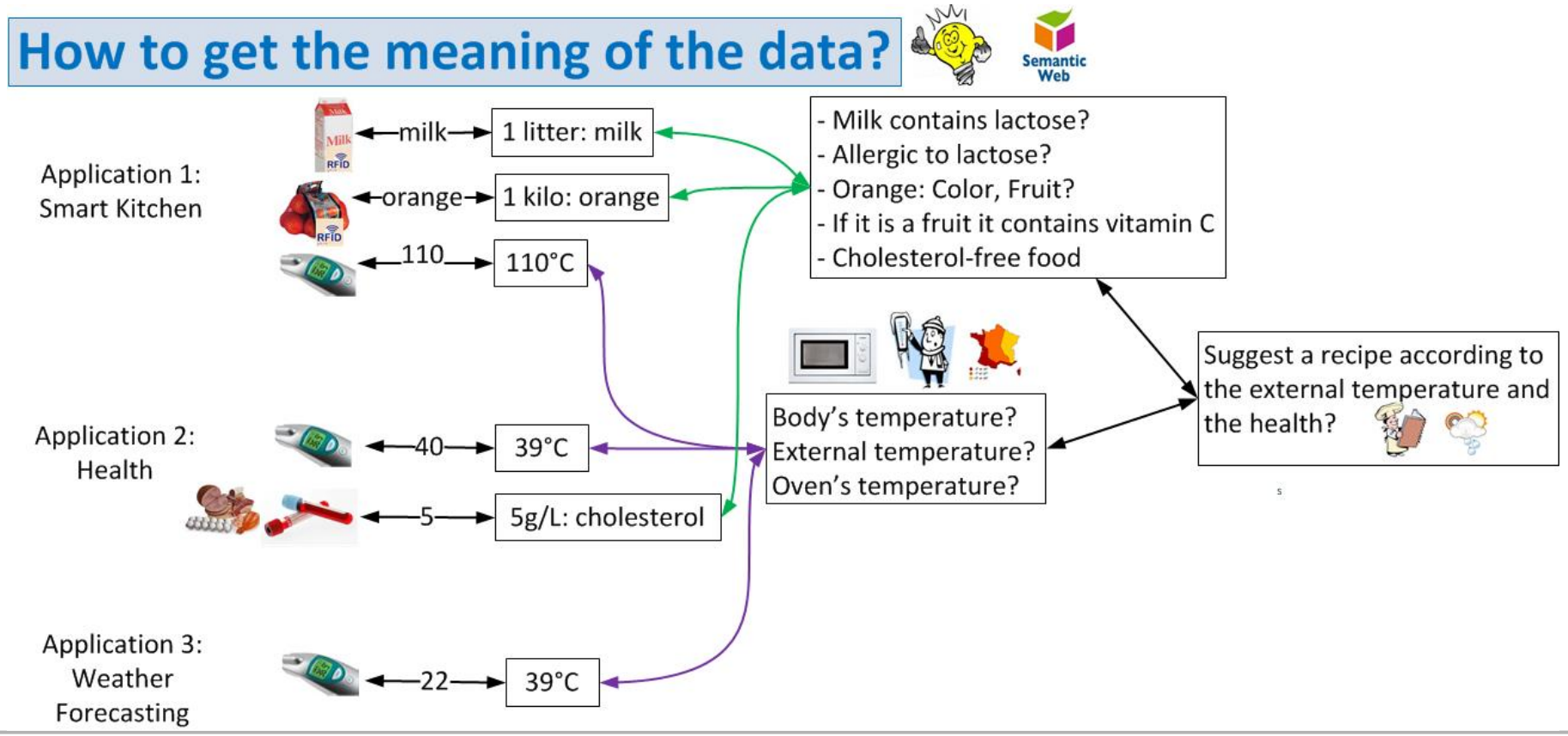
An ontology to semantically annotate the M2M data

Amelie Gyrard

- Christian Bonnet (Eurecom, Mobile Communication)
- Karima Boudaoud (I3S, Security)

Motivation

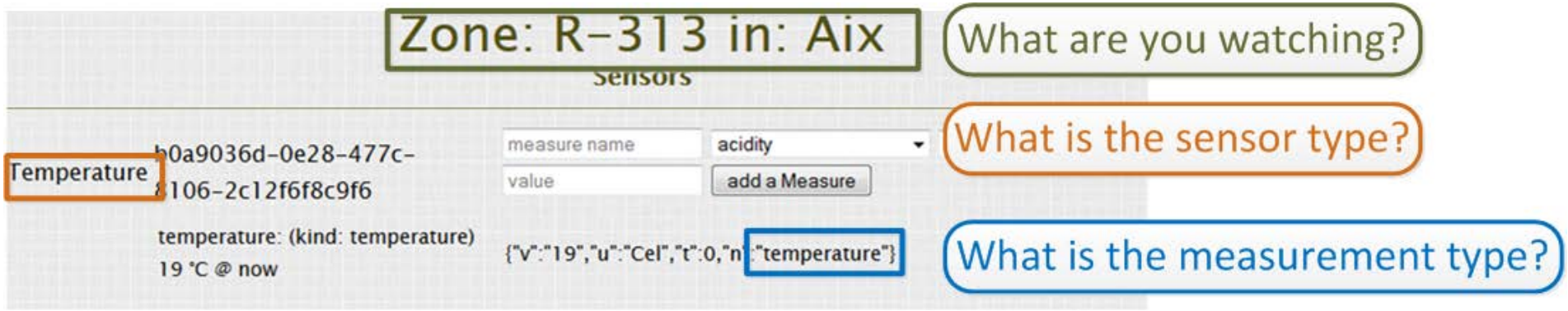
- **Enrich M2M data to build cross-domain M2M applications**



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?

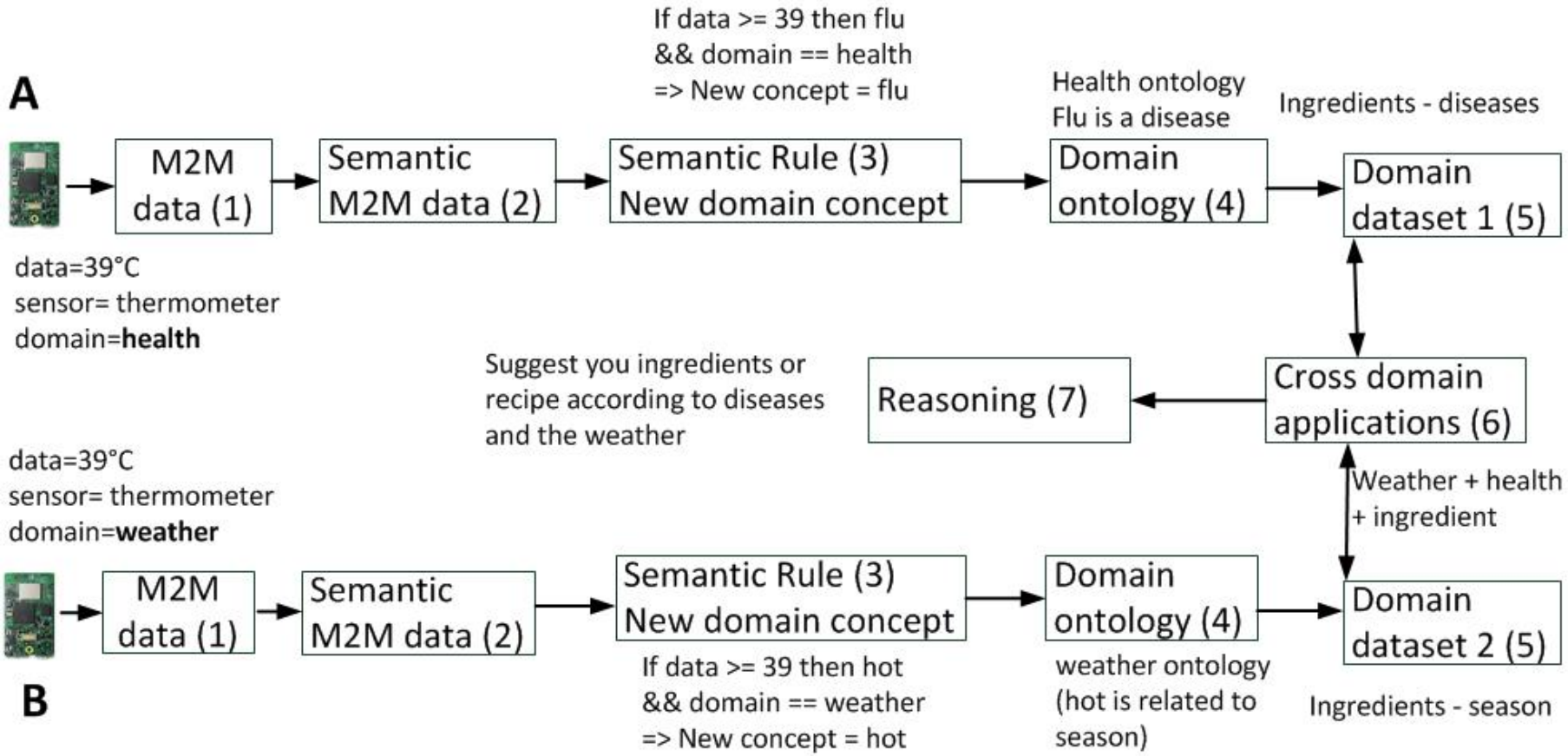
- **How to reuse domain ontologies and datasets?**
  - How to find domain ontologies or datasets?
    - Best practices
    - Semantic tools

Linked Open Vocabularies (LOV)

  - In a specific domain, which ontology or dataset do we choose?
  - How to use the complementarity of existing ontologies and datasets?

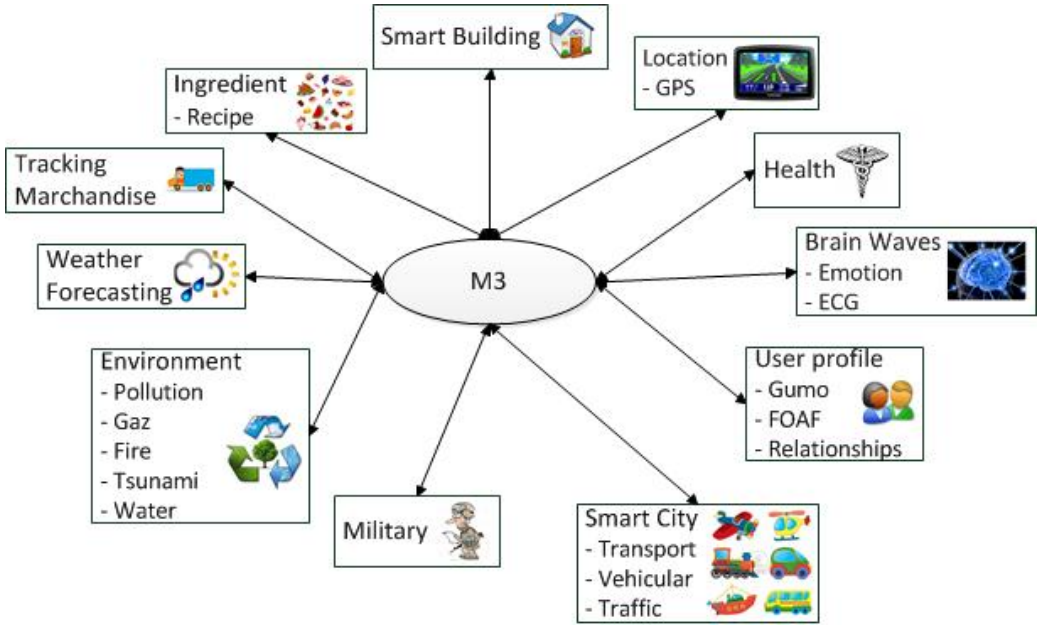
M3: our proposed approach

- **How to interconnect the data provided by heterogeneous domains?**

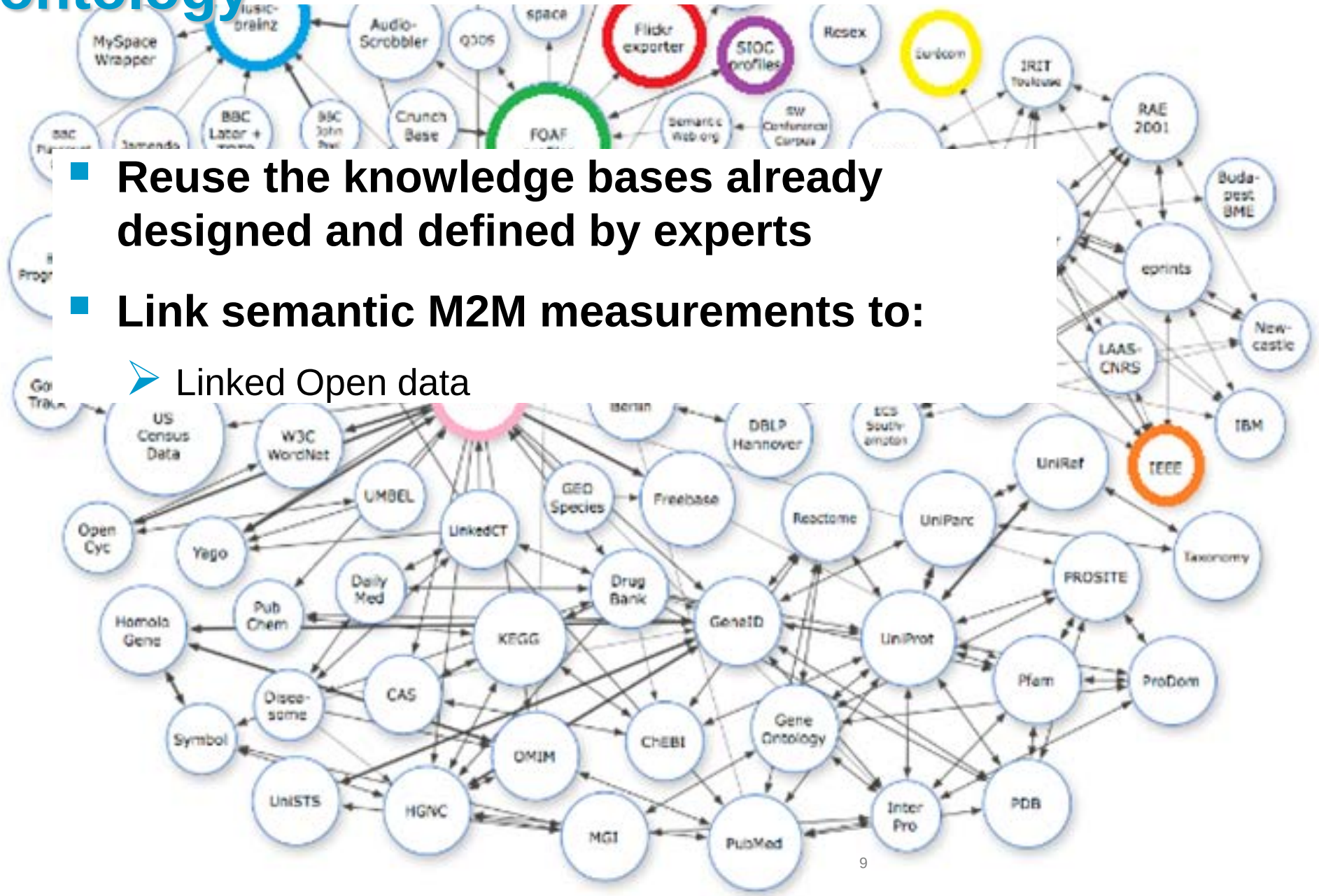


M3: a hub for cross-domain ontologies and datasets

- **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:**

- **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): Convert health measurements
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!) Food if you are sick

Semantic Web

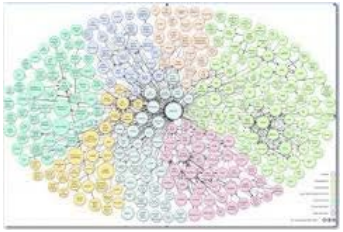
```
<rdf:Description rdf:about="http://sensormeasurement.appspot.com/m3#Measurement5">
 <m3:hasUnit rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Cel</m3:hasUnit>
 <m3:hasDateTimeValue rdf:datatype="http://www.w3.org/2001/XMLSchema#dateTime">0.0</m3:hasDateTimeValue>
 <m3:hasValue rdf:datatype="http://www.w3.org/2001/XMLSchema#decimal">39.0</m3:hasValue>
 <m3:hasName rdf:datatype="http://www.w3.org/2001/XMLSchema#string">temperature</m3:hasName>
 <rdf:type rdf:resource="http://sensormeasurement.appspot.com/m3#Measurement"/>
 <rdf:type rdf:resource="http://sensormeasurement.appspot.com/m3#BodyTemperature"/>
</rdf:Description>
```

Semantic M2M Measurements

Scenario 1: Body Temperature
Enrich Semantic M2M Data

- **Link our semantic M2M measurements to the Linked Open Data**

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): Convert health measurements
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!) Food if you are sick

- 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

- **Paper: Honey as Complementary Medicine - A Review [Singh et al. 2012]**

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

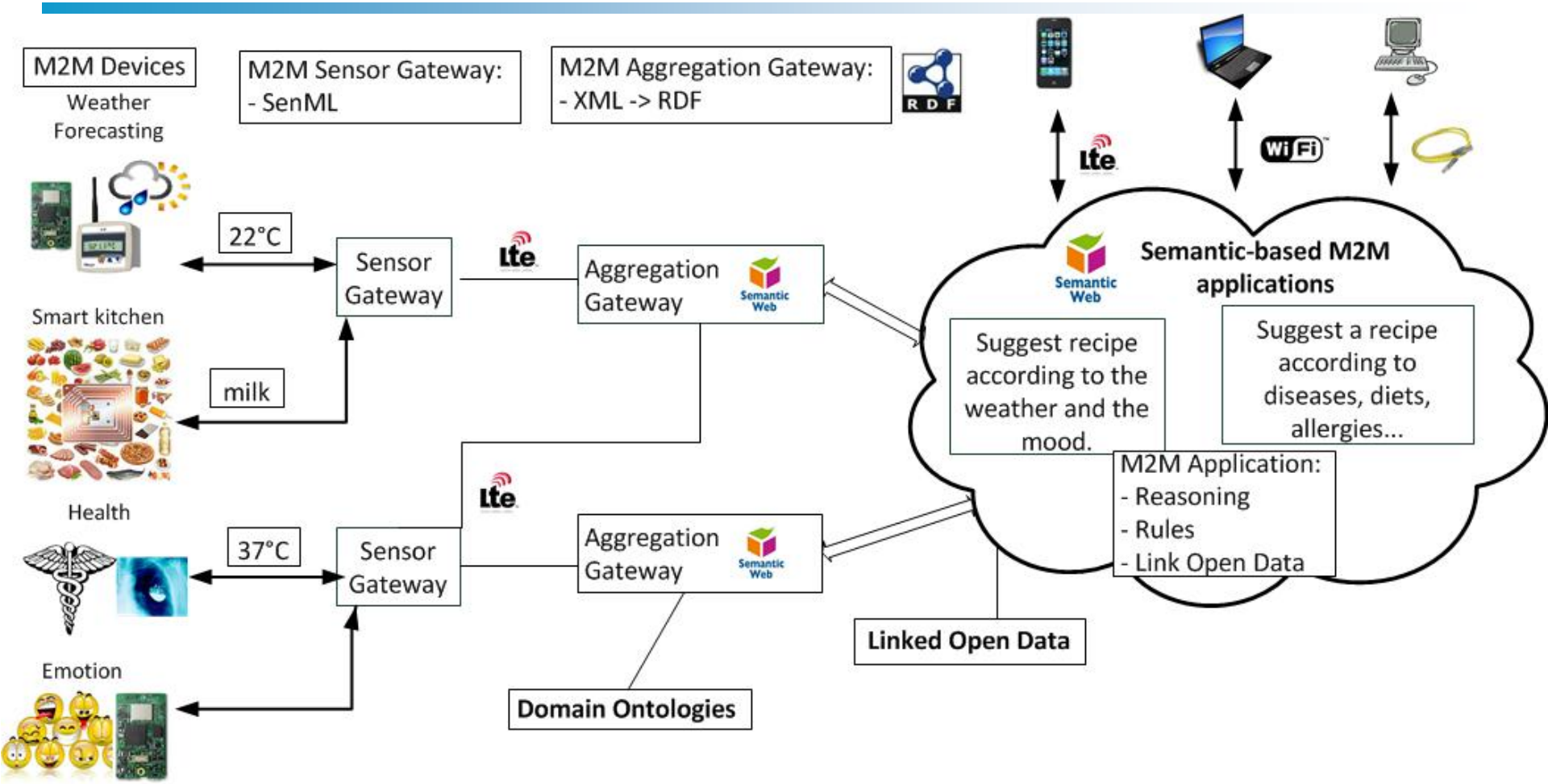
Scenario 3: Luminosity & Emotion

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): Emotion & Luminosity

- 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

Semantic-based M2M Architecture



- **Paper: A Machine-to-Machine Architecture to Merge Semantic Sensor Measurements [Gyrard et al., WWW 2013]**

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!


תודה
Dankie
Gracias
Спасибо
شكراً
Merci
Takk
Köszönjük
Terima kasih
Grazie
Dziękujemy
Děkojame
Ďakujeme
Vielen Dank
Paldies
Kiitos
Täname teid
谢谢
Thank You
Tak
感謝您
Obrigado
Teşekkür Ederiz
감사합니다
Σας ευχαριστούμε
ขอบคุณ
Bedankt
Děkujeme vám
ありがとうございます
Tack


Q&A