ISST
Information Science and Semantic Technologies

ITMO UNIVERSITY

Ontologies for Web of Things: A Pragmatic Review

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Web of Things

- ...is Internet of Things + Web.
- Number of connected devices is growing. Dozens of billions by 2020 (estimated by different sources).
- Interoperability is one of the most fundamental requirements for WoT to succeed.

Web of Things & Semantic Web

- Semantic Web is a solution for semantic interoperability.
- Semantic interoperability means that different stakeholders can access and interpret the data unambiguously.

Are existing ontologies ready to form an ontology framework for annotating real-world devices?

Our approach

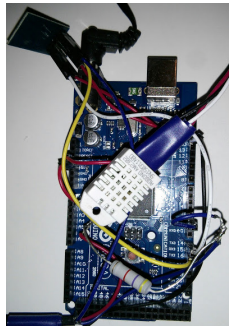
- Take three examples of real-world devices
- Define conceptual groups based on the examples
- Find suitable ontologies for each group at *Linked Open Vocabularies*[1]
- Review these ontologies with respect to *Five stars of Linked Data Vocabularies*[2]

[1] http://lov.okfn.org/

[2] Krzysztof J. et al, Five stars of Linked Data vocabulary use, Semantic Web, vol. 5, no. 3, pp. 173-176, 2014

Devices

Devices: A weather station (EnvTH-0.0.1)



Observes: temperature & humidity

Manufactured by:

ITMO University

Version: 0.0.1

Deployed at:

380 office @ Main campus

Access point: coap://example.com/env-th

Measuring property	Humidity	Temperature
Operating Range	0-100% RH	-40-80 C°
Accuracy	±2% RH	±0.5 C°
Sensitivity	0.1% RH	0.1 C°
Measurement Range	0-100% RH	-40-80 C°
Frequency	2s	
Resolution	0.1% RH	0.1 C°

Device: A wall mount exhaust bath fan

Observes: humidity

Acts: switch on/off

Manufactured by:

“Soler & Palau”

Measuring property	Humidity
Accuracy	±2.5% RH
Sensitivity	0.2% RH
Measurement Range	0-100% RH
Resolution	0.2% RH

Device: An electric meter

Observes: voltage, amperage,

active and reactive power

Manufactured by: ООО НПК “ИНКОТЕКС”

Deployed at: Kotelnikova 5/1 (60.013456,30.288267)

Deployed on: 29th April 2015

Service: ООО “WingHouse”

Conceptual groups

- CG1. Actuator, sensor, system
- CG2. Global and local coordinates
- CG3. Communication endpoint
- CG4. Observations, features of interest, units of measurement
- CG5. Vendor, version, deployment time

Ontologies

CG1. Actuator, sensor, system (1)

- Semantic Sensor Network (SSN)

```
:system-0 rdfs:subClassOf ssn:System ;
    ssn:hasSubSystem [
        a ssn:Sensor ;
    ] ;
    ssn:hasSubSystem [
        a ssn:Sensor ;
    ]
```

- SSN doesn’t have a concept of Actuator

CG1. Actuator, sensor, system (2)

- (Wang W. et al, A comprehensive ontology for knowledge representation in the Internet of Things, 2012) extends SSN among other things to provide a concept of Actuator, but the ontology is not available any more :(

- DogOnt ontology can be used instead:
  - dogont:Actuator
  - dogont:actuatorOf
  - dogont:hasActuator
  - dogont:controlledObject
  - etc.

CG2. Global and local coordinates (1)

- Basic Geo (WGS84 lat/long) ontology
- DUL ontology to link WGS84 with SSN ontology

```
:system-0 a ssn:Sensor ;
    dul:hasLocation [
        a geo:Point ;
        geo:latitude "59.956438" ;
        geo:longitude "30.3095818"
] .
```

CG2. Global and local coordinates (2)

- LIMAP, OGC GeoSPARQL, DUL and WGS84 ontologies

```
:system-0 a ssn:System ;
   limap:isOccupantOf [
      a limap:Room ;
      limap:hasLocalCoordinates [
         a limap:LocalCoordinates ;
         geosparql:hasGeometry "POLYGON((
                3.976 0, 6.765 0,
                6.765 2.273, 3.976 2.273))"^^geo:wktLiteral
             .
      ] ;
      limap:isLocated:plan-4 .
   ] .
```

CG2. Global and local coordinates (3)

```
:plan-4 a limap:EscapePlan ;
    limap:hasSourceImage <...image url...> ;
    limap:isEscapePlanOf [ a limap:Floor ;
        dul:hasLocation [ geo:floor "4"^^xsd:int ] ;
        limap:isFloorIn [ a limap:Building ;
            limap:hasGlobalCoordinates [
                a limap:GlobalCoordinates ;
                geosparql:hasGeometry "POLYGON((
                    -81.587 45.336, -81.148 39.774,
                    -69.964 39.300, -70.403 45.583,
                    -81.587 45.336 ) )"^^geo:wktLiteral
            ] .
        ] .
    ] .
```

CG2. Global and local coordinates (4)

- LIMAP ontology provides enough expressiveness, but it’s mainly focused on people
- limap:isOccupantOf has rdfs:domain referring to a person

CG3. Communication endpoint (1)

- FIPA or FIEMSER ontologies. Below is an example with FIPA:

```
:sensor-0 a ssn:Sensor, fipa:Device ;
    fipa:hasHwProperties [ a fipa:HwDescription ;
        fipa:hasConnection <coap://example.com/env-th> .
<coap://example.com/env-th> a fipa:ConnectionDescription ;
            fipa:hasConnectionInfo [
                a fipa:InfoDescription ;
                fipa:hasName "CoAP" ;
                fipa:hasVersion "1.0"
            ]
        ]
    ] .
```

CG3. Communication endpoint (2)

- Below is an example with FIEMSER ontology:

```
:sensor-0 a ssn:Sensor, fiemser:CommDevice ;
    fiemser:uses :CoAP .
    :CoAP a fiemser:NetProtocol ;
    fiemser:hasName "CoAP" ;
    fiemser:hasVersion "1.0" .
```

CG4. Observations, features of interest, units of measurement (1)

- Semantic Sensor Ontology (SSN) and Quantities, Units, Dimensions and Types (QUDT) ontologies.
- An example of observation:

```
:obs-0 a ssn:Observation ;
    ssn:observationResultTime "2015-05-18T10:00:00"^^xsd:dateTime ;
    ssn:observedBy :sensor-0 ;
    ssn:observationResult :obs-0-result .

:obs-0-result a ssn:SensorOutput ;
    ssn:isProducedBy :sensor-0 ;
    ssn:hasValue :obs-0-resultvalue .

:obs-0-resultvalue a ssn:ObservationValue, qudt:QuantityValue ;
    qudt:numbericValue "15"^^xsd:double ;
    qudt:unit qudt:DegreeCelsius .
```

CG4. Observations, features of interest, units of measurement (2)

- An example of feature of interest and its properties:

```
:Air a ssn:FeatureOfInterest ;

:AirTemperature a ssn:Property ;
    ssn:isPropertyOf :Air .

:obs-0 ssn:featureOfInterest :Air ;
    ssn:observedProperty :AirTemperature .
```

CG5. Vendor, version, deployment time

- One of the most popular is FOAF ontology
- More specialized ontologies, such as Ontology for public services and organizations (OSP), Linking-you and MMI Device ontologies.

```
:system-0 rdfs:subClassOf ssn:System, mmi:Device ;
    mmi:hasManufacturer [
        a mmi:Manufacturer ;
        rdfs:label “ITMO University”
    ] .
```

Discussion

Issues

- commonly the ontologies conform only to 2 or 3 stars
- poor documentation and lack of examples
- some ontologies are exist only in research papers
- lack of modularity, rarely does anyone use all aspects of the ontology

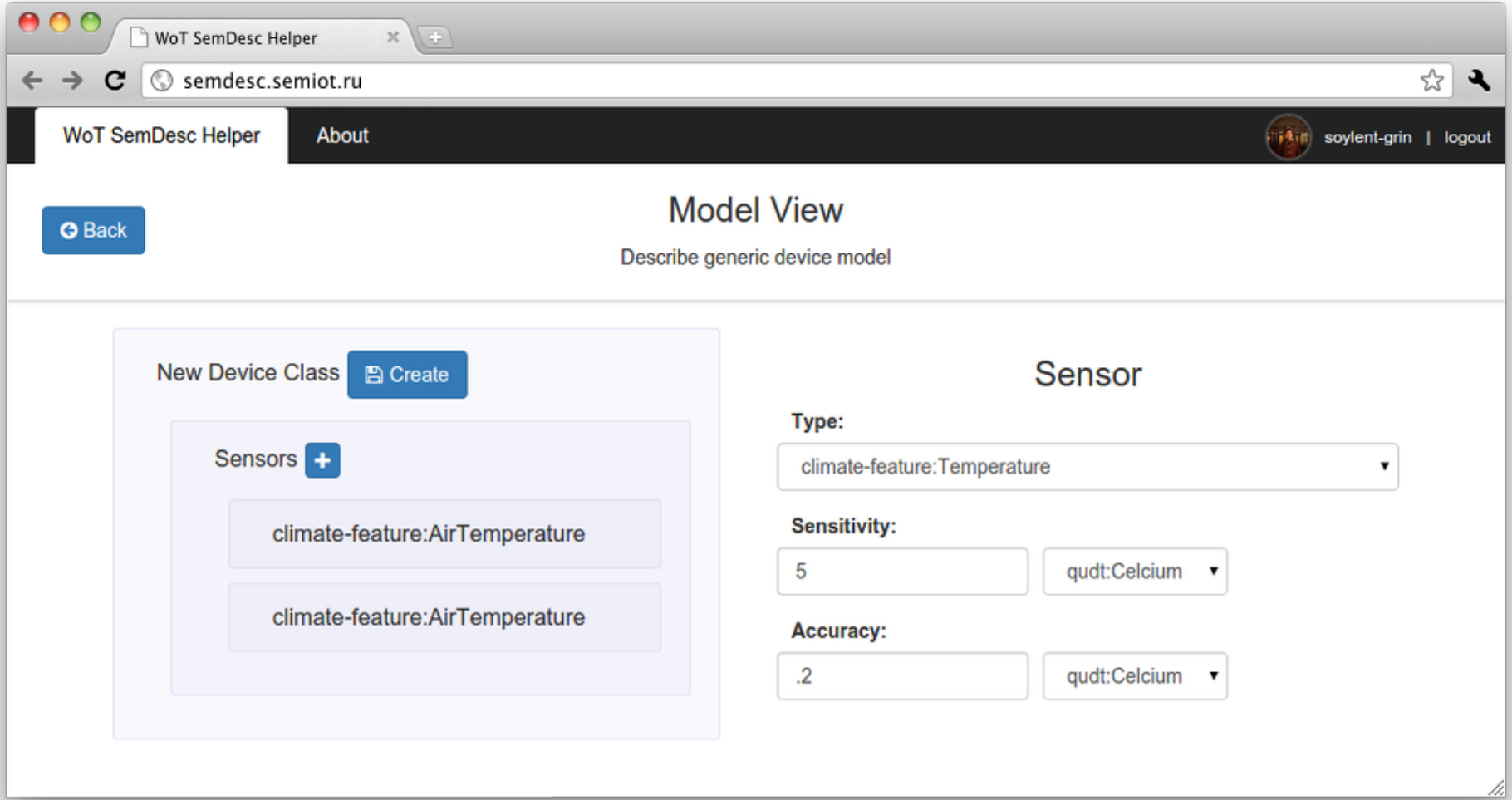
Thoughts

- Fight the *semaphobia*!
- Lower the barrier with standardisation (e.g. W3C SSN) and documentation
- Provide instruments for validation and creation of RDF-descriptions
- Make ontologies trustable via *checksums* or somehow else

WoT SemDesc Helper

Goal

- Provide an instrument for creating RDF-description of Web of Things devices based on Semantic Sensor Network (SSN) ontology and others.
- Allows to define class and instance of a devices and its observations.


WoT SemDesc Helper
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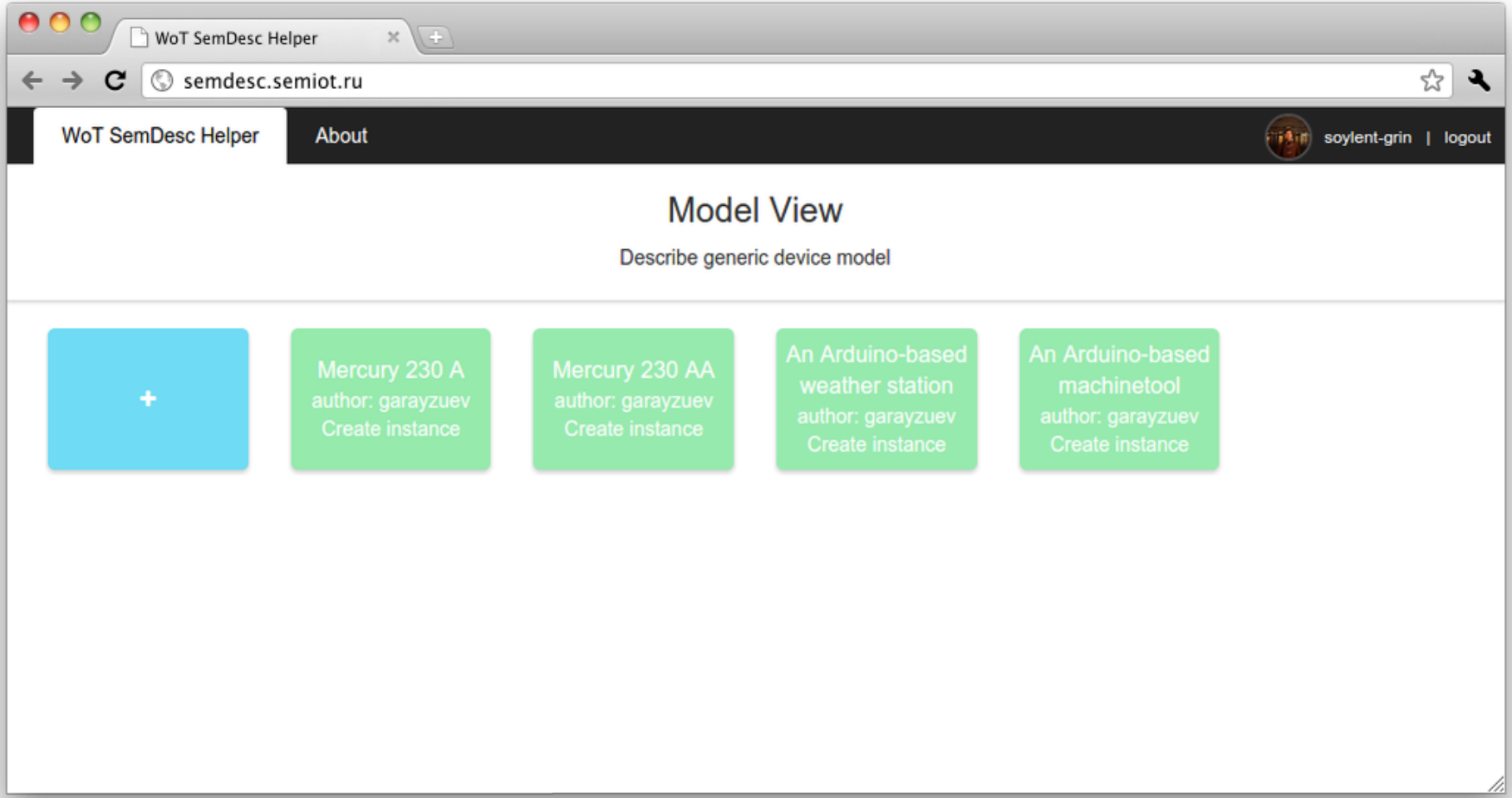
About
soylent-grin | logout
Back
Model View
Describe generic device model
New Device Class
Create
Sensors
climate-feature:AirTemperature
climate-feature:AirTemperature
Sensor
Type:
climate-feature:Temperature
Sensitivity:
5
qudt:Celcium
Accuracy:
.2
qudt:Celcium


WoT SemDesc Helper
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About
soylent-grin | logout
Model View
Describe generic device model
+
Mercury 230 A
author: garayzuev
Create instance
Mercury 230 AA
author: garayzuev
Create instance
An Arduino-based weather station
author: garayzuev
Create instance
An Arduino-based machinetool
author: garayzuev
Create instance

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Thank you! Questions?

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