

An Ontology-Driven Integration Framework for Smart Communities

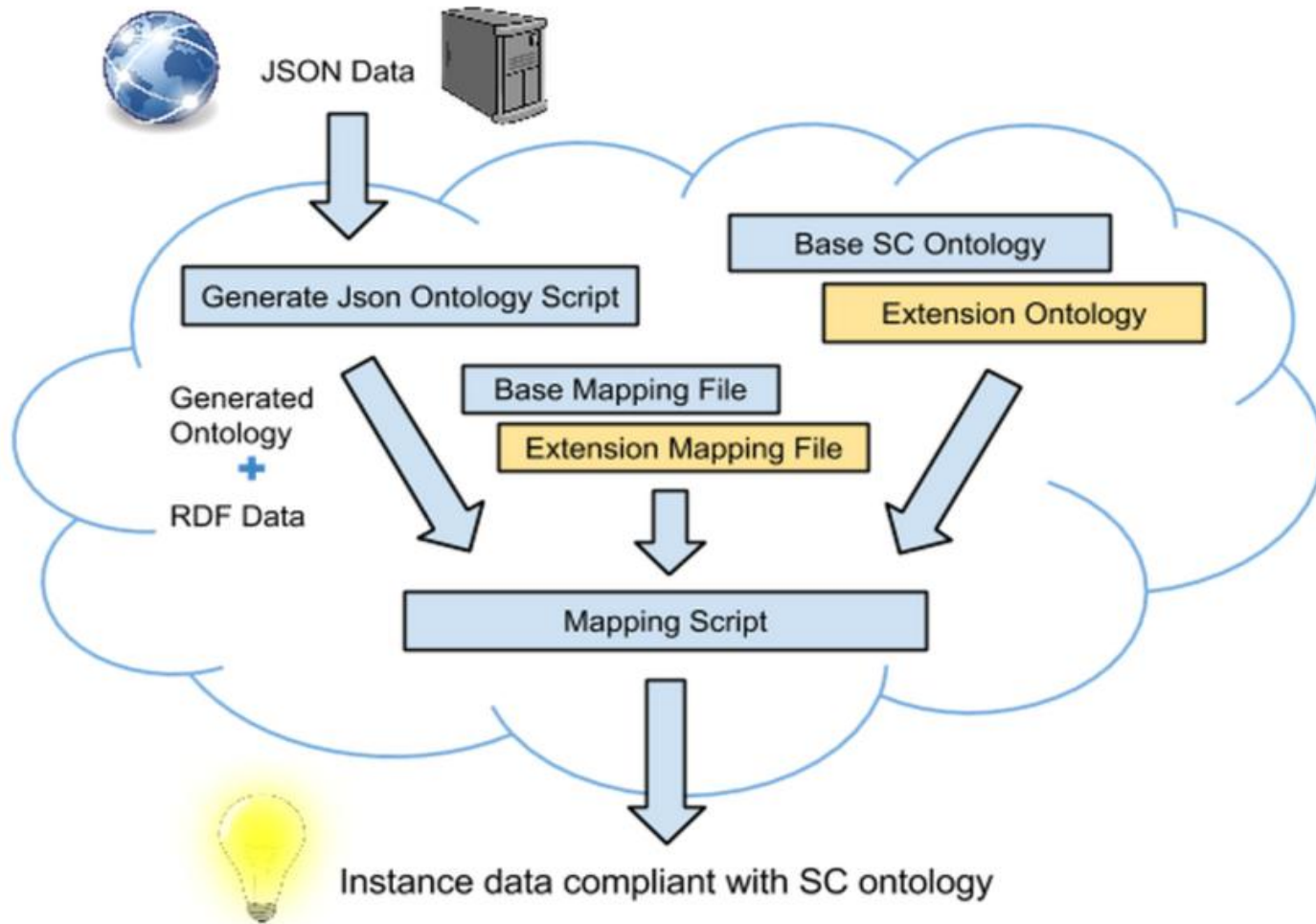
Steve Ray
Ontology Summit
February 5, 2015



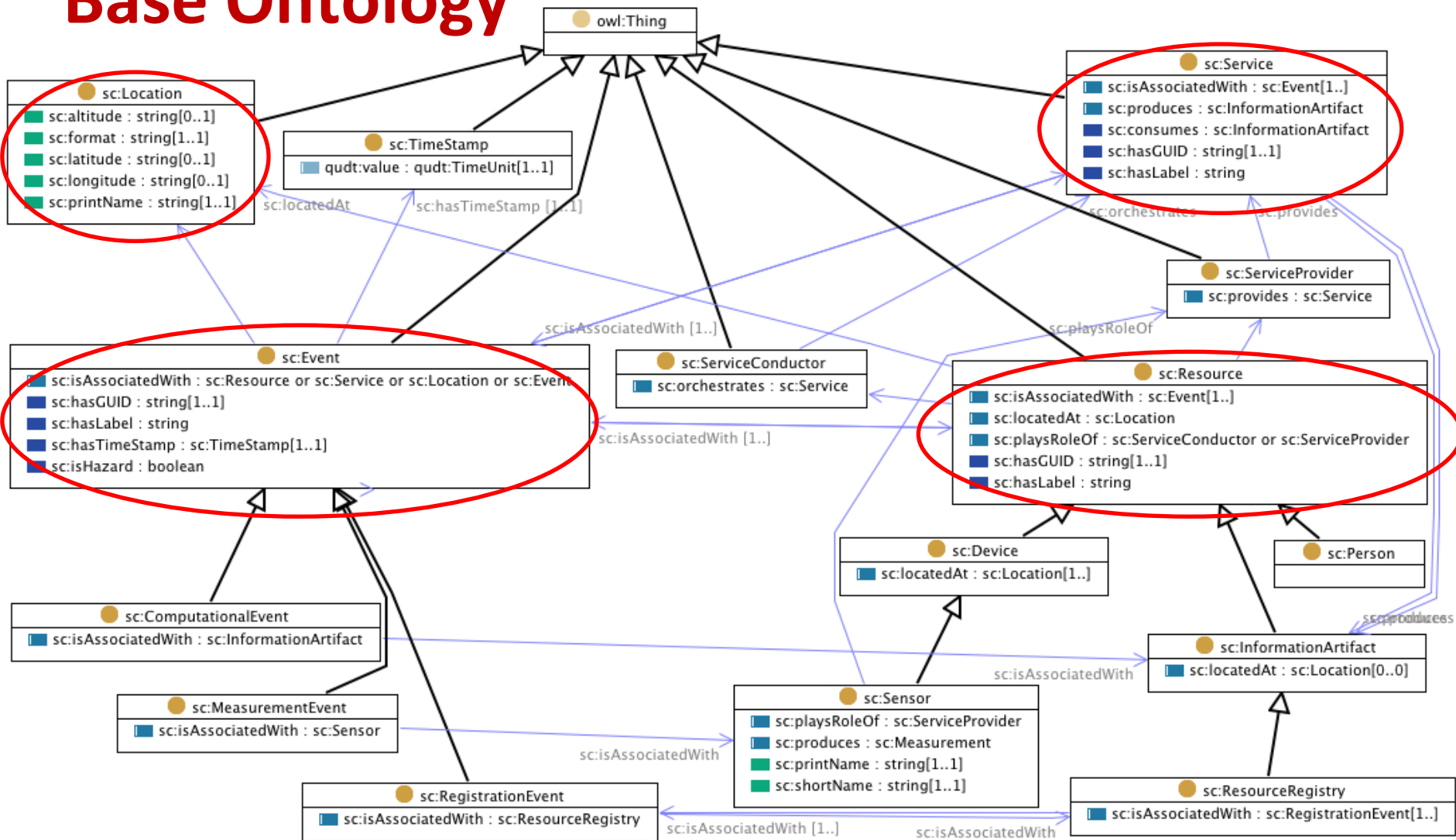
Challenge

- How to quickly and easily integrate a new data source into a generalized system?
 - Possibly without any model for the new data
 - New data may use foreign terminology
 - Any implicit model of the data may not align with the receiving system

High-Level System Design



Base Ontology



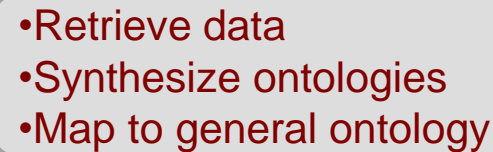
Version1 of Base Ontology available at <https://sites.google.com/a/stevearay.com/ontologies/home/repository/CoreSCModel.ttl?attredirects=0&d=1>

```
graph LR; CMUSV[CMUSV Sensor Data] --> Data((Data)); NASA[NASA Sensor Data] --> Data; OpenReferral[OpenReferral Social Services Data] --> Data;
```

CMUSV
Sensor Data

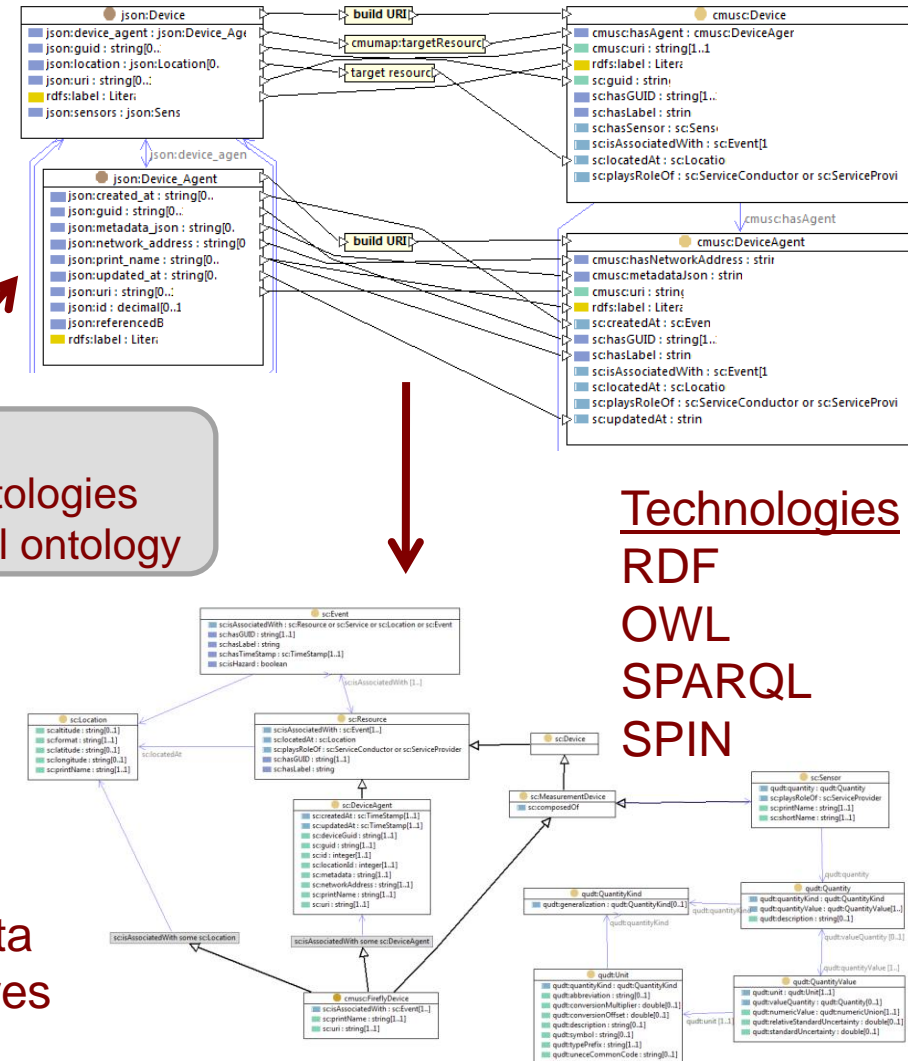
NASA
Sensor Data

OpenReferral
Social
Services Data



Also Enables

- Inferencing over data
- Federated data stores
- Distributed queries



Technologies

- RDF
- OWL
- SPARQL
- SPIN

Sample input data

- `{"uri":"23420ca4e4830bee","deviceUserDefinedFields":"For test","location":{"longitude":10.123,"latitude":10.123,"altitude":10.123,"representation":"test location description"},"sensorNames":["fireImpXAccelerometer23420ca4e4830bee","fireImpYAccelerometer23420ca4e4830bee","fireImpZAccelerometer23420ca4e4830bee","fireImpMotion23420ca4e4830bee","fireImpLight23420ca4e4830bee","fireImpPressure23420ca4e4830bee","fireImpHumidity23420ca4e4830bee","fireImpDigitalTemperature23420ca4e4830bee"],"deviceTypeName":"FireImp V1C","manufacturer":"FireImp","version":"1C","deviceTypeUserDefinedFields":"","sensorTypeNames":["fireImpXAccelerometer","fireImpYAccelerometer","fireImpZAccelerometer","fireImpMotion","fireImpDigitalTemperature","fireImpLight","fireImpPressure","fireImpHumidity"]},`

Interpreted as JSON Classes

● json:Device (10)	■ json:altitude
● json:DeviceType (10)	■ json:deviceTypeName
● json:Location (10)	■ json:deviceTypeUserDefinedFields
● json:Reading (11)	■ json:deviceUri
● json:Sensor (25)	■ json:deviceUserDefinedFields
● json:SensorType (16)	■ json:interpreter
	■ json:isIndoor
	■ json:latitude
	■ json:location
	■ json:longitude
	■ json:manufacturer
	■ json:maximumValue
	■ json:minimumValue
	■ json:purpose
	■ json:referencedBy
	■ json:representation
	■ json:sensorCategoryName
	■ json:sensorName
	■ json:sensorNames
	■ json:sensorTypeName
	■ json:sensorTypeNames
	■ json:sensorTypeUserDefinedFields
	■ json:sensorUserDefinedFields
	■ json:timeStamp
	■ json:unit
	■ json:uri
	■ json:value
	■ json:version

Class Form

Name: json:Reading

Annotations

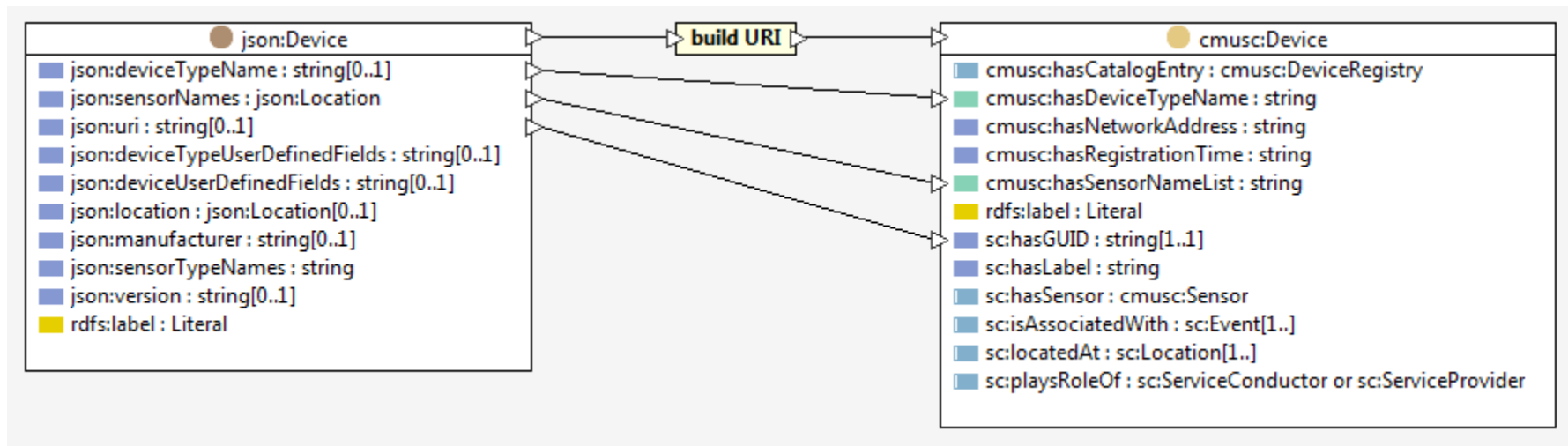
Class Axioms

rdfs:subClassOf ▼

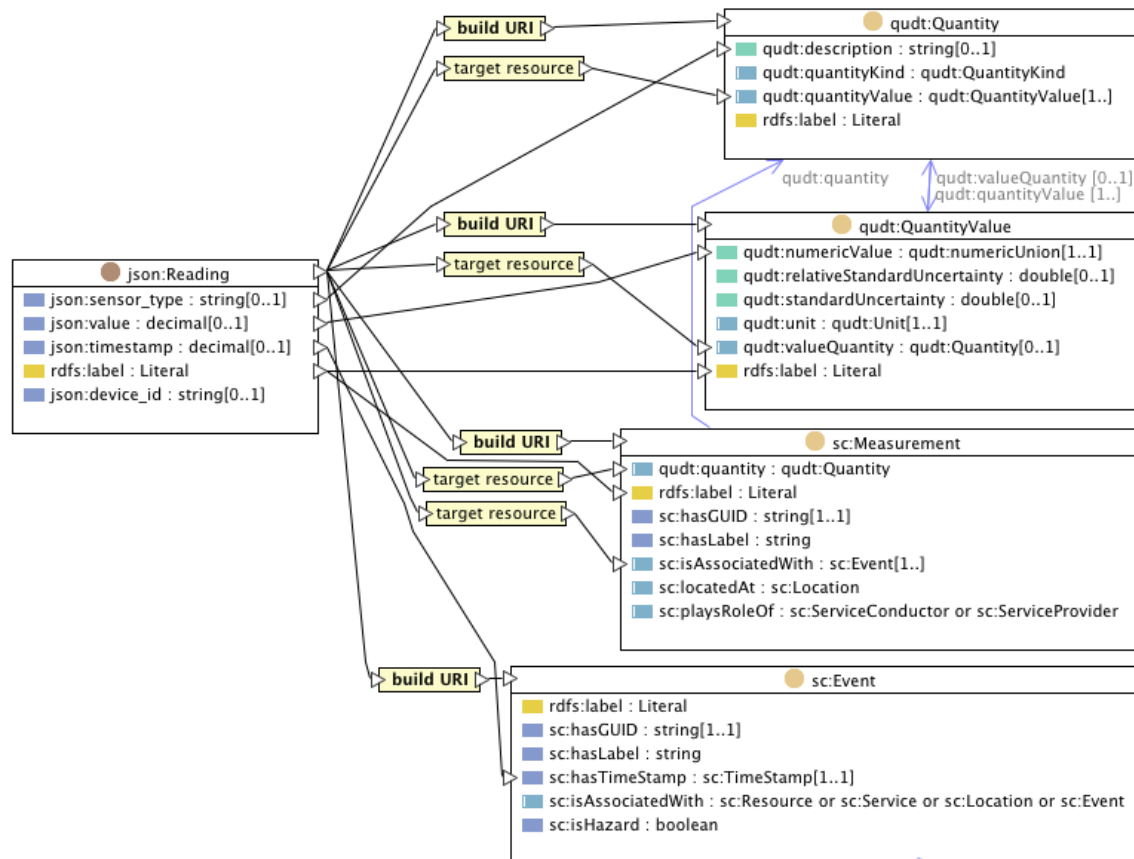
owl:Thing
json:isIndoor max 1
json:isIndoor only xsd:boolean
json:sensorName max 1
json:sensorName only xsd:string
json:timeStamp max 1
json:timeStamp only xsd:string
json:value max 1
json:value only xsd:string

Manually Map JSON Entities to Target Ontology (the one manual step)

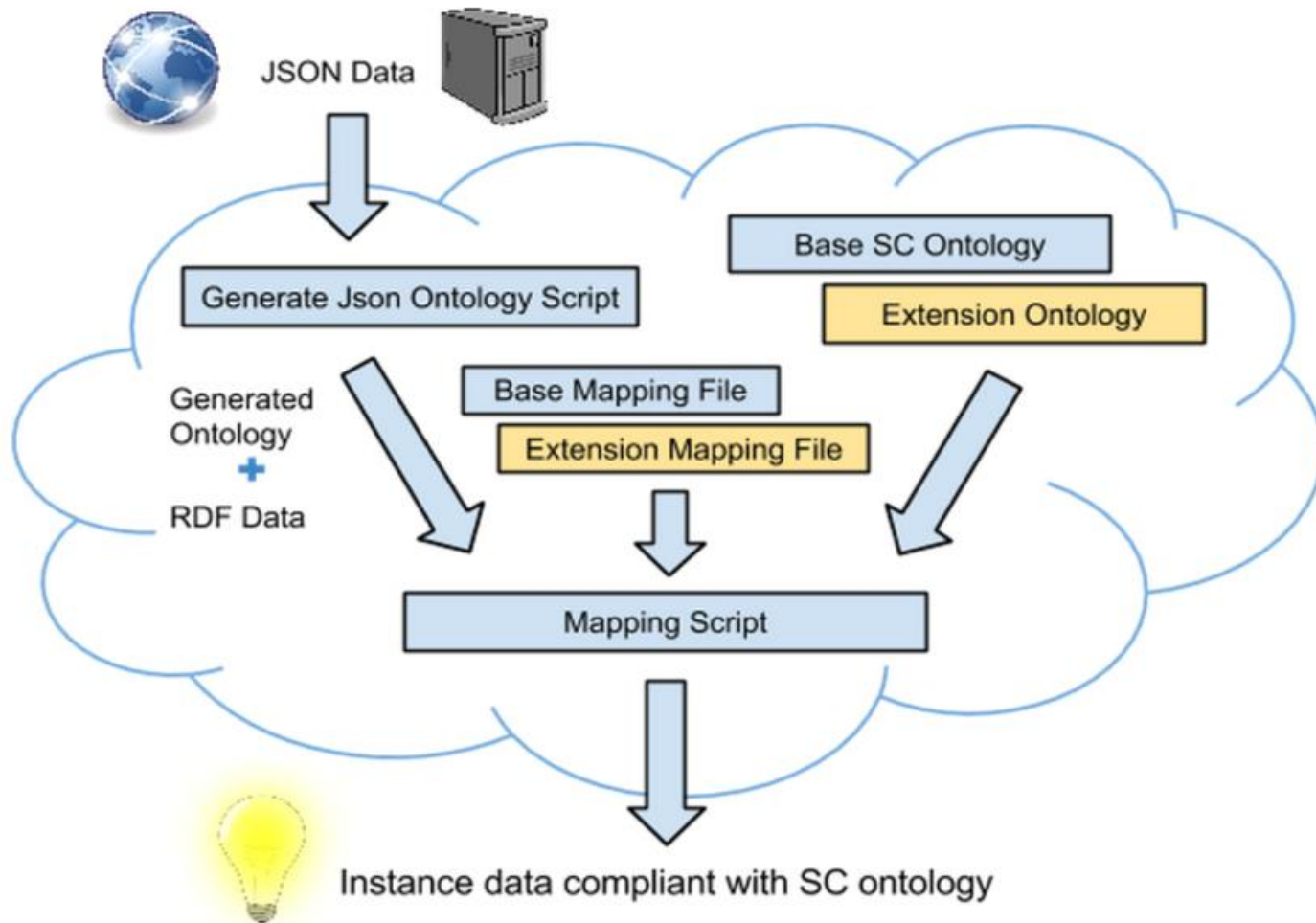
Sometimes trivial...



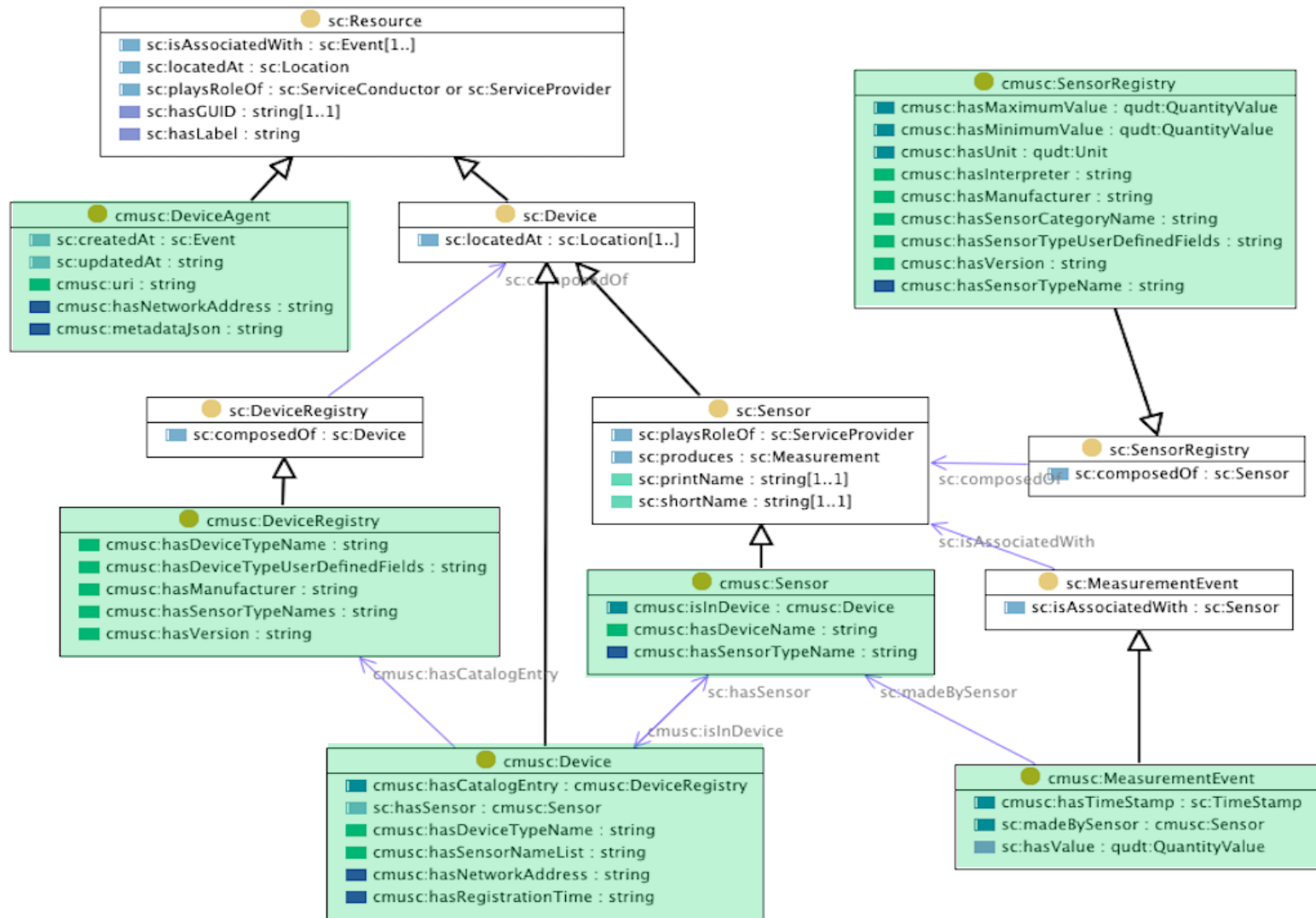
...sometimes more complex



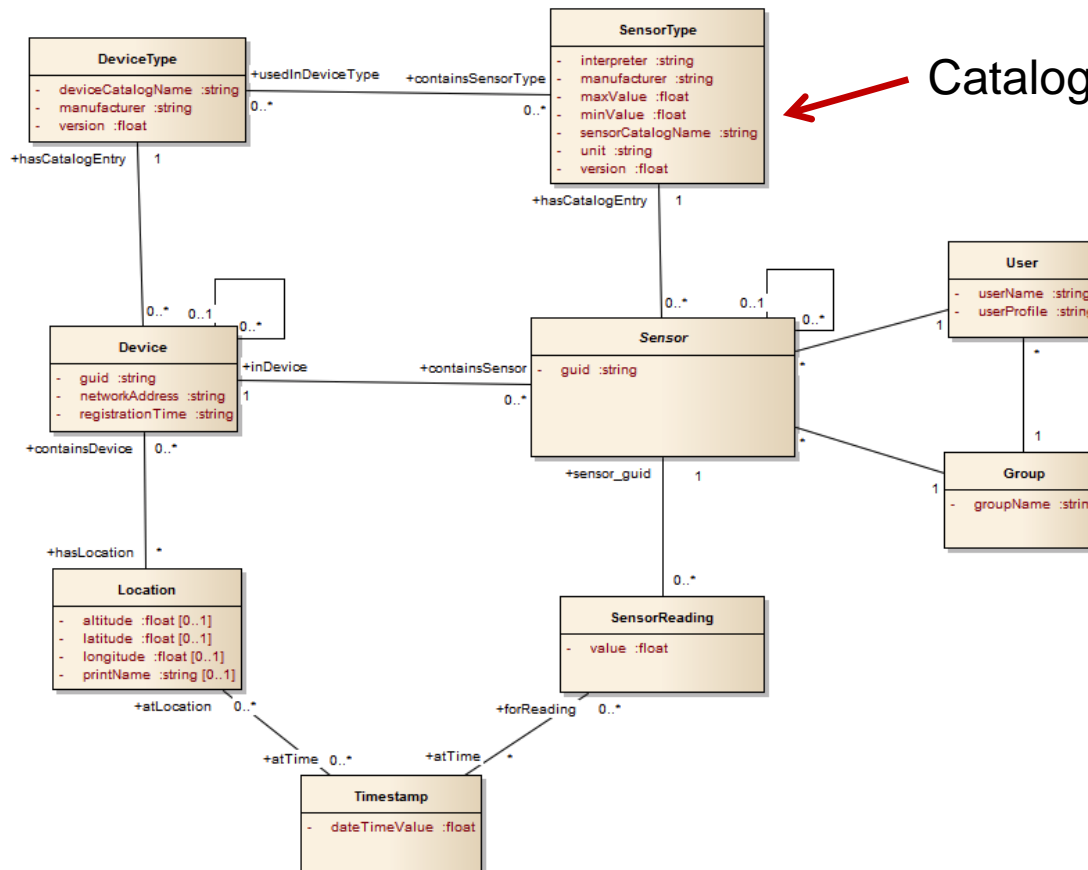
Why We Have Extensions



Some Extension Classes for a Sensor Source

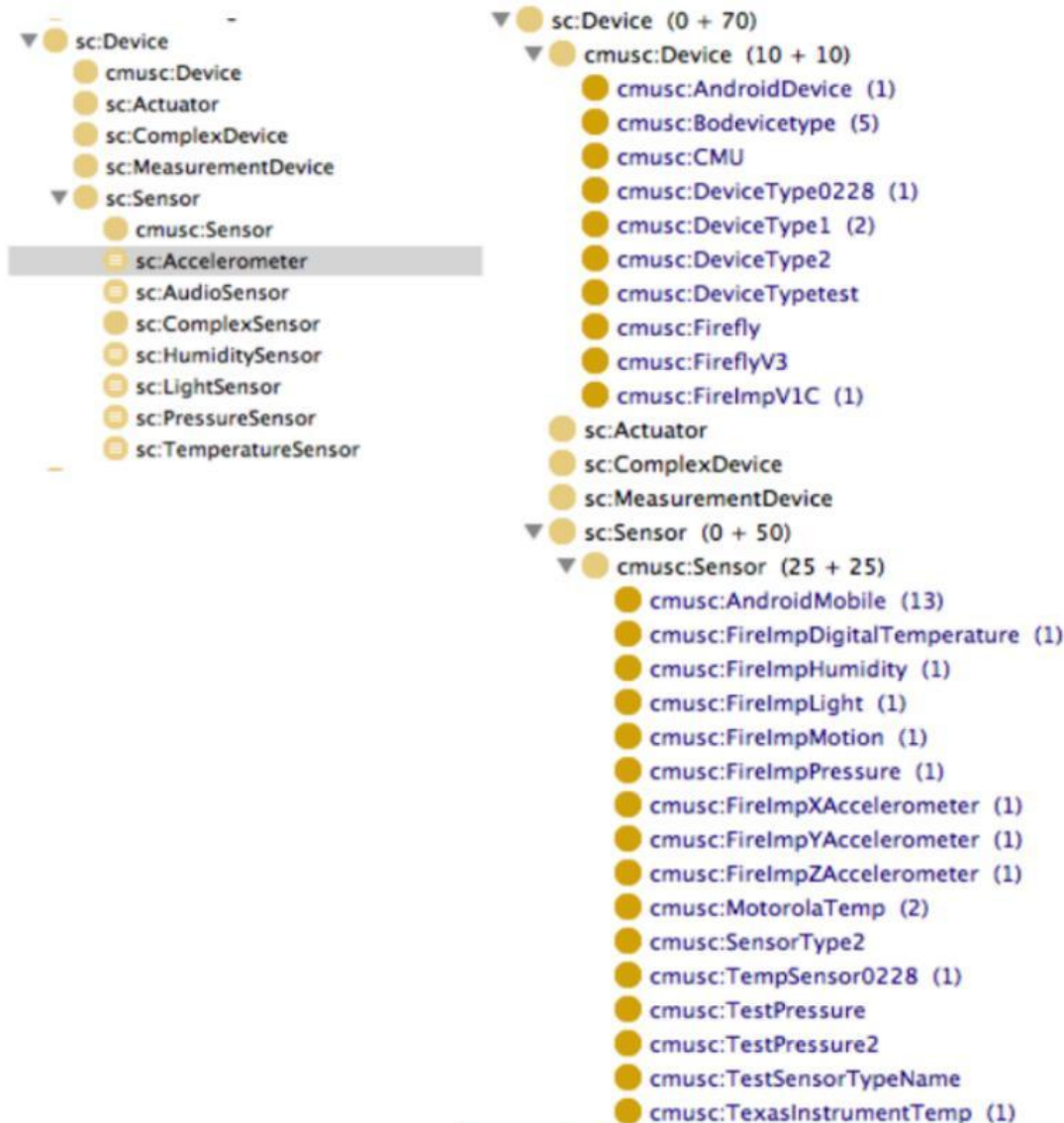


Refactoring Models



Catalog rather than subclass

Dynamic Definition of New Subclasses



Newly-defined Class and Populated Instance Data

● cmusc:FireImpV1C
■ cmusc:hasCatalogEntry : cmusc:DeviceRegistry
■ cmusc:hasDeviceTypeName : string
■ cmusc:hasNetworkAddress : string
■ cmusc:hasRegistrationTime : string
■ cmusc:hasSensorNameList : string
■ rdfs:label : Literal
■ sc:hasGUID : string[1..1]
■ sc:hasLabel : string
■ sc:hasSensor : cmusc:Sensor
■ sc:isAssociatedWith : sc:Event[1..]
■ sc:locatedAt : sc:Location[1..]
■ sc:playsRoleOf : sc:ServiceConductor or sc:ServiceProvider

Resource Form

Name: cmusc:Device-23420ca4e4830bee

▼ Annotations

▼ Other Properties

cmusc:hasDeviceTypeName ▼
S FireImp V1C

cmusc:hasSensorNameList ▼
I ["fireImpXAccelerometer23420ca4e4830bee",
"fireImpYAccelerometer23420ca4e4830bee",
"fireImpZAccelerometer23420ca4e4830bee",
"fireImpMotion23420ca4e4830bee",
"fireImpLight23420ca4e4830bee",
"fireImpPressure23420ca4e4830bee",
"fireImpHumidity23420ca4e4830bee",
"fireImpDigitalTemperature23420ca4e4830bee"]

sc:hasGUID ▼
S 23420ca4e4830bee

sc:hasSensor ▼
◆ cmusc:Sensor-fireImpDigitalTemperature23420ca4e4830bee
◆ cmusc:Sensor-fireImpHumidity23420ca4e4830bee
◆ cmusc:Sensor-fireImpLight23420ca4e4830bee
◆ cmusc:Sensor-fireImpMotion23420ca4e4830bee
◆ cmusc:Sensor-fireImpPressure23420ca4e4830bee
◆ cmusc:Sensor-fireImpXAccelerometer23420ca4e4830bee
◆ cmusc:Sensor-fireImpYAccelerometer23420ca4e4830bee
◆ cmusc:Sensor-fireImpZAccelerometer23420ca4e4830bee

rdf:type ▼
● cmusc:Device
● cmusc:FireImpV1C

Resource Form

Name: <http://www.cmusv.edu/SmartComm

▼ Annotations

▼ Other Properties

cmusc:hasTimeStampString ▼
S Mar 25, 2014 12:18:52 AM

cmusc:hasValueString ▼
S -0.75138855

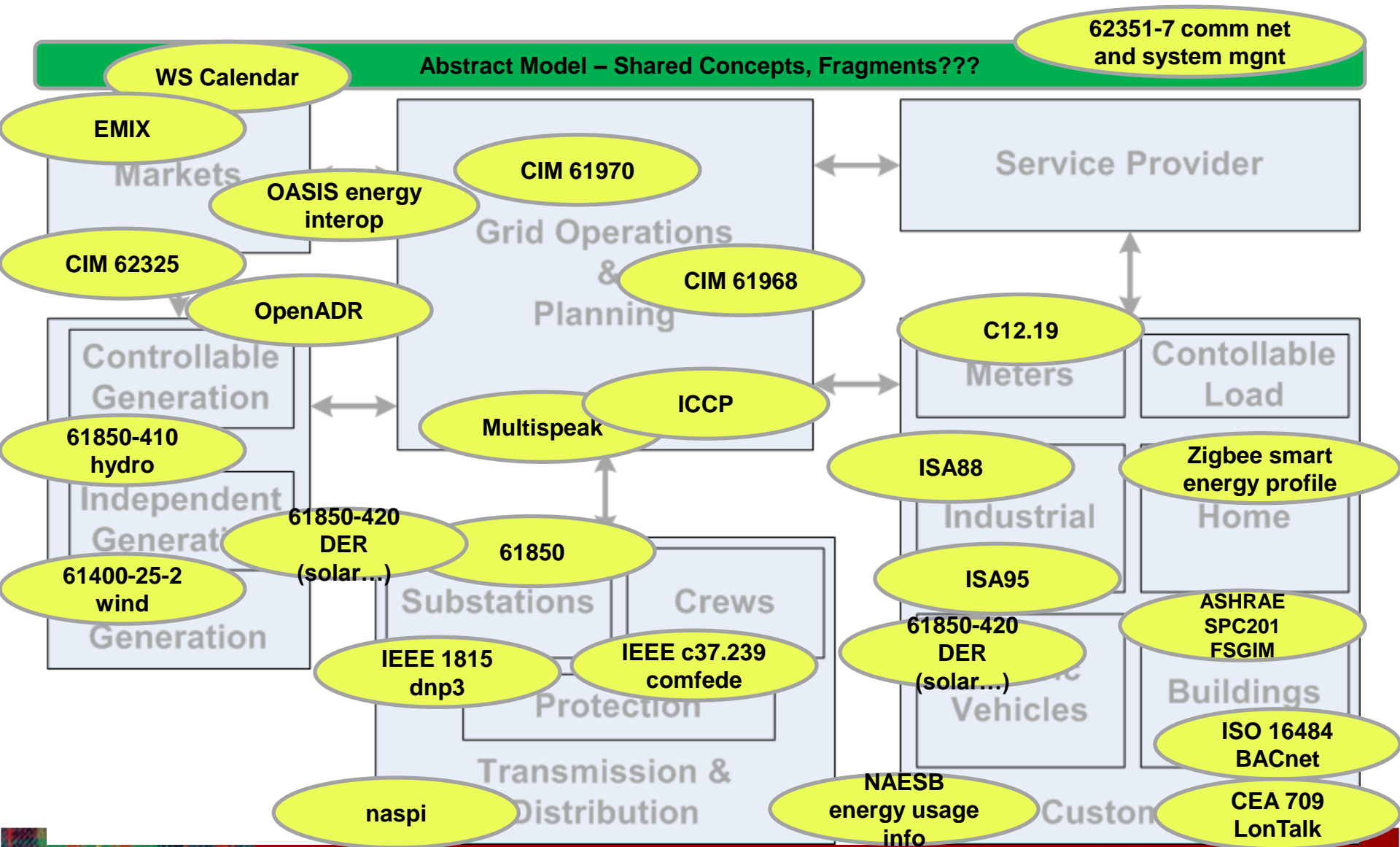
cmusc:madeBySensorWithName ▼
S androidAccelerometer

sc:isAssociatedWith ▼
◆ cmusc:Sensor-androidAccelerometer

rdf:type ▼
● cmusc:MeasurementEvent

How will this help?

One IoT Universe – The Smart Grid

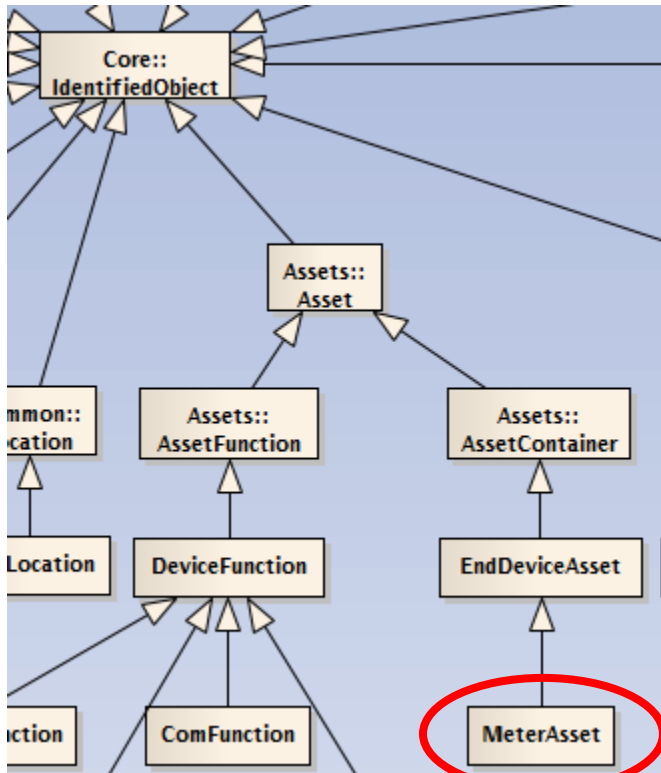


Carnegie Mellon University
Silicon Valley

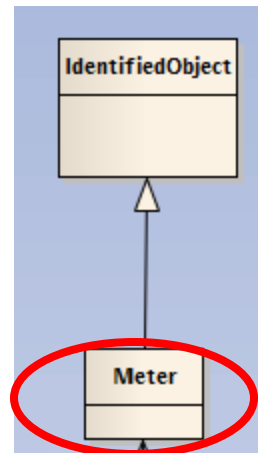
“Meter”

Do they all really mean the same thing?

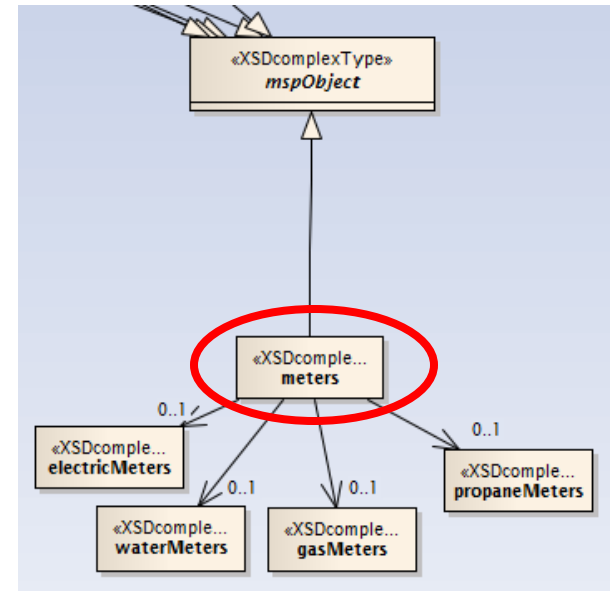
IEC 61968



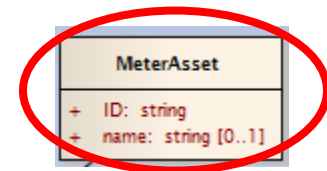
IEC 61970



Multispeak V4.1



NAESB PAP10



Interoperability Standards battles?

Industrial Internet Consortium

AT&T, Cisco, IBM, Intel...
plus ~75 others



Open Interconnect Consortium

Intel, Samsung, Dell...
plus a few others



Thread Group

Google (Nest), ARM,
Samsung appliance...
plus a few others



?

AllSeen Alliance

Microsoft, Cisco,
Qualcomm, LG...
plus ~60 others



The Open Group



Apple Homekit

