Second review, 18-01-2018, Valencia

interiot

INTEROPERABILITY
OF HETEREOGENEUS
IOT PLATFORMS.

# INTER-IoT-EWS: Interoperable Situation-Aware IoT Early Warning System

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Small Collaboration

# Agenda

1. **Introduction**
   - University of Twente (team)
   - Background: early warning system (EWS)
   - Our research: semantic interoperability of IoT EWS
2. **Collaboration**
   - Open call: detect accidents at the port of Valencia
   - Requirements, use cases, data sources (devices, IoT platforms)
   - Solution
     - Ontologies and standards, JSON-LD, semantic gateway (smartphone)
     - Health: ECG (electrocardiography) device and data, SAREF4Health
     - Logistics: transportation data and mobile app
     - Semantic translations, decision rules, output handler
3. **Project progress**
   - Plan, validation, exploitation

# Introduction: team



**The UT is a frontrunner in socially-relevant technological developments**

**Team:** one PhD student and three professors of SCS group

PhD research on semantic interoperability and model-driven engineering of early warning system (EWS) for emergency services


João

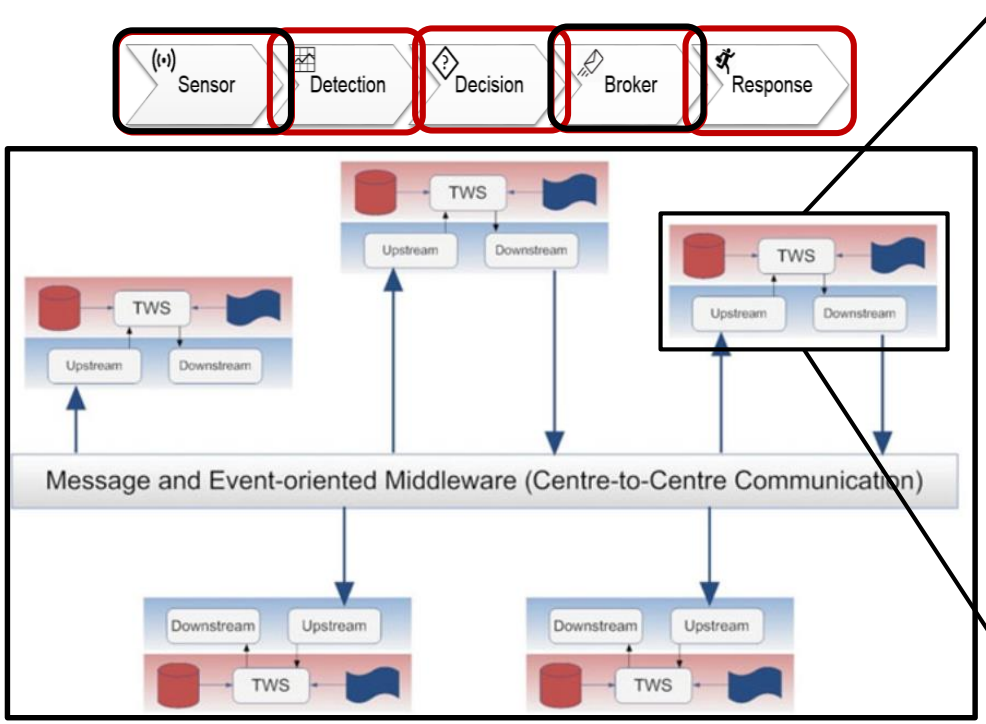

Luís

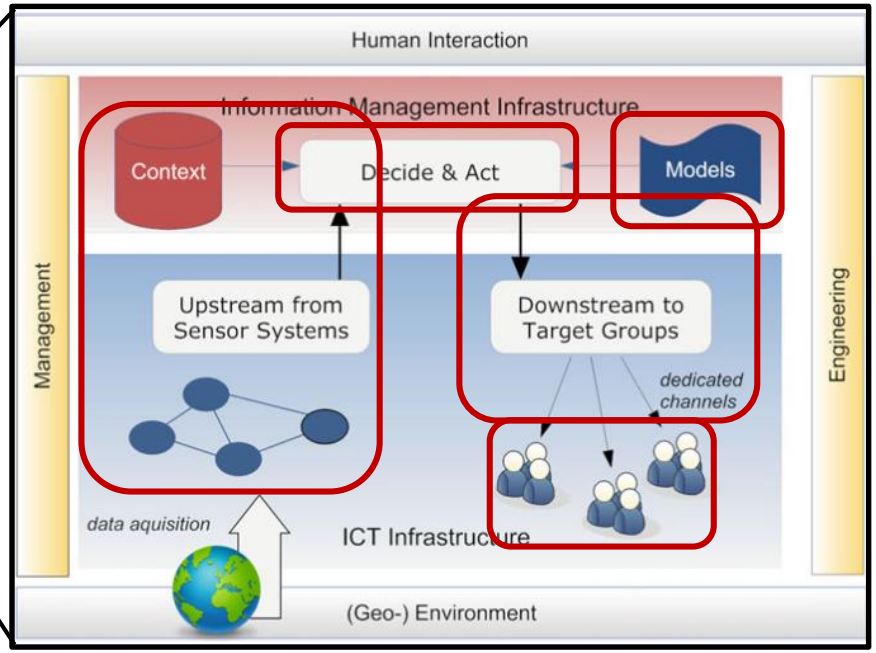

Marten


Roel

# Introduction: background

An **Early Warning System (EWS)** is an integrated emergency system to detect, monitor and alert emergency situations (Wächter and Usländer, 2014)




**Standards-Based Architecture**

**Semantic IoT EWS:** "a **core type of data driven Internet of Things (IoTs) system** used for environment disaster risk and effect management" (Poslad et al, 2015)

# Itroduction: our research

**Design problem**

How to improve the semantic interoperability of emergency services for IoT Early Warning Systems (EWSs)?

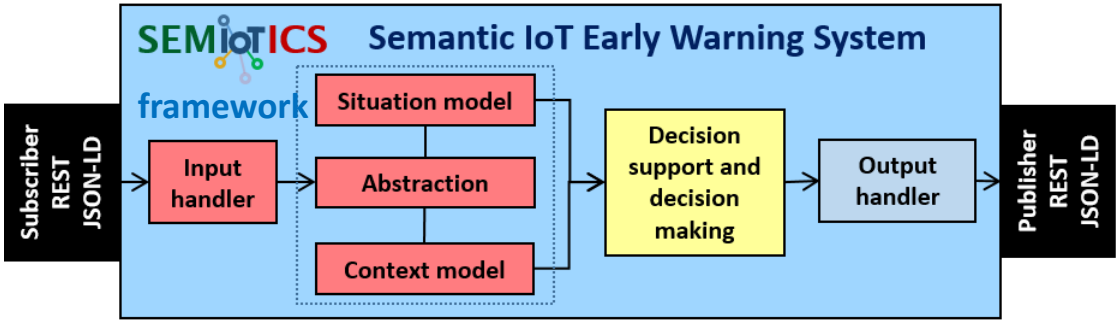
**Challenges**

(C1) **Semantic integration of a variety of data sources:** Avoid loss of semantics when multiple ontologies, standards and data models from different and overlapping domains are involved, considering their syntactic and semantic alignments

(C2) **Processing in time- and safety-critical applications:** Provide the required performance for upstream data acquisition, emergency risk detection and message brokering, in terms of scalability and total transaction time

(C3) **Data analysis for effective responses:** Enable high quality situation awareness (perception, comprehension and projection) to avoid false positives, and improve decision support based on emergency procedures

SEmantic Model-driven development for IoT Interoperability of emergenCy serviceS



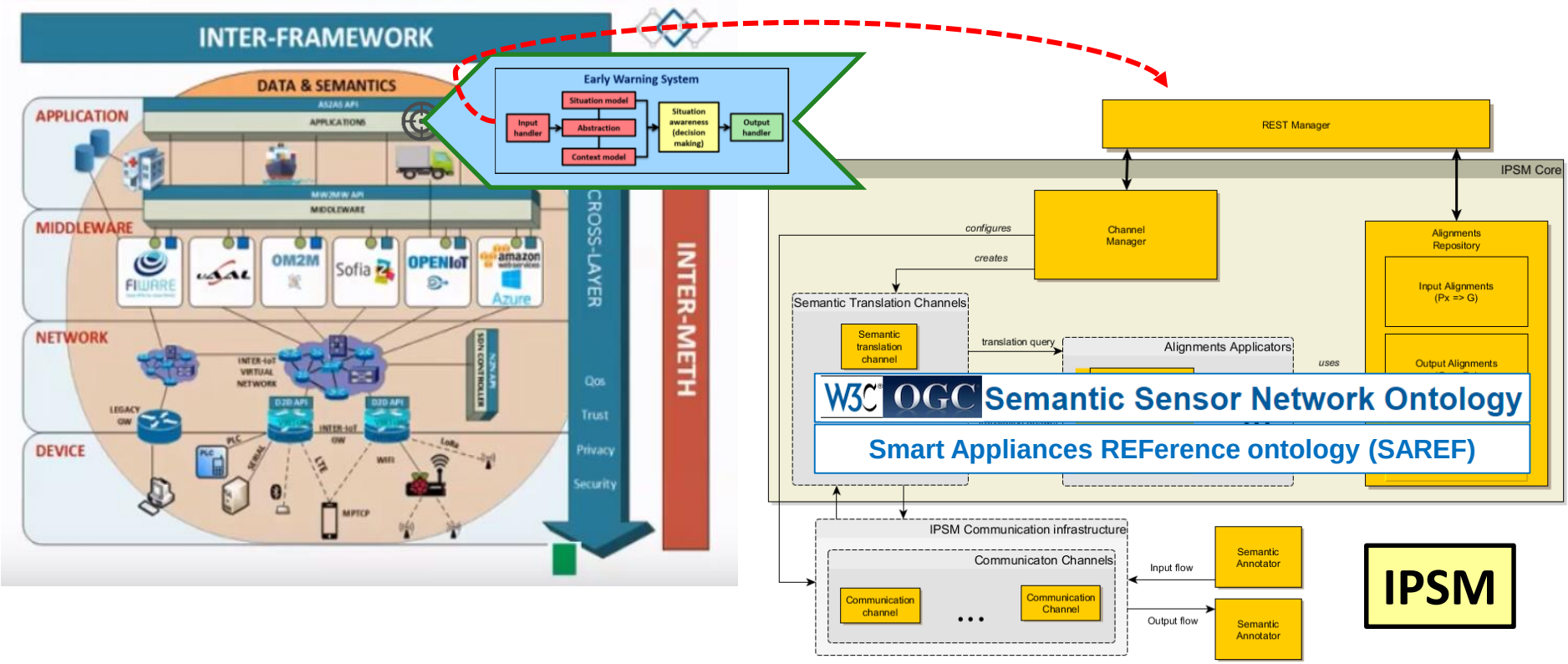

https://github.com/jonimoreira/SEMIOTICS

- **Architecture:** Endsley's situation awareness theory, standards-based (W3C SSN, OASIS EDXL)
- **Technologies:** semantic, complex-event-processing (CEP), event-driven, cloud (SOA 2.0)
- **Guidelines:** model-driven engineering (MDE)

# Collaboration: open call

## Collaboration approach with INTER-IoT:

1. **Application:** IoT EWS to detect and alert accidents with trucks at the port area [9]




2. **IPSM:** Ontology alignment (semantic translations) of SSN x SAREF

# Collaboration: requirements, use cases, data

**Functional requirements**

**(FR1)** IoT platforms should be able to coordinate with emergency systems

**(FR2)** The haulier IoT platform and the port IoT platform should be able to share health information about the driver

**Non-functional requirements**

**(NFR1)** Semantic and syntactic interoperability among IoT platforms

**(NFR2)** E-Health and logistics integration

**(NFR3)** Energy consumption (battery level) of the devices should be monitored

**Use cases**

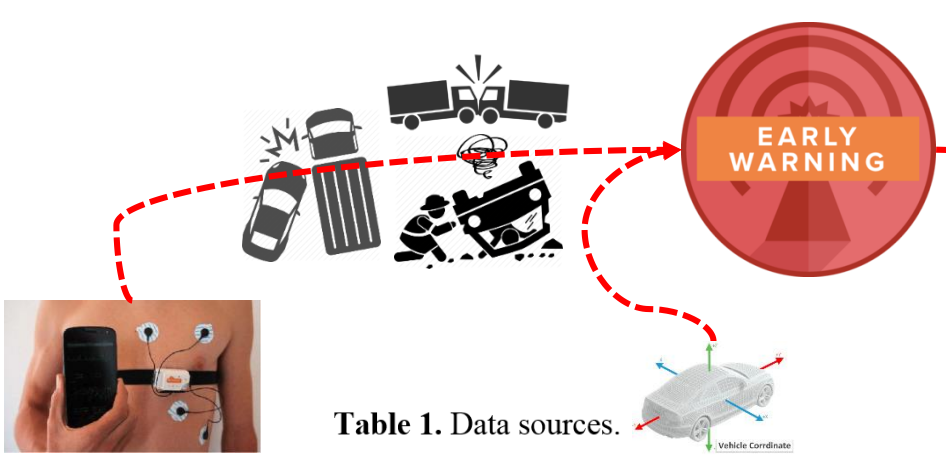
**UC01**: Vehicle collision detection

**UC02**: Hazardous health changes

**UC03**: Temporal relations (UC01 ~ UC02)

**UC04**: Wrong-way driving

**UC05**: Accidents with dangerous goods



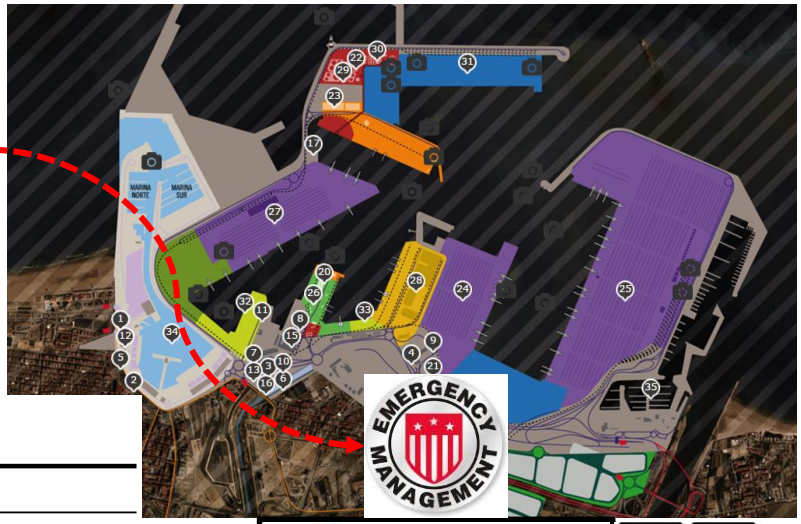



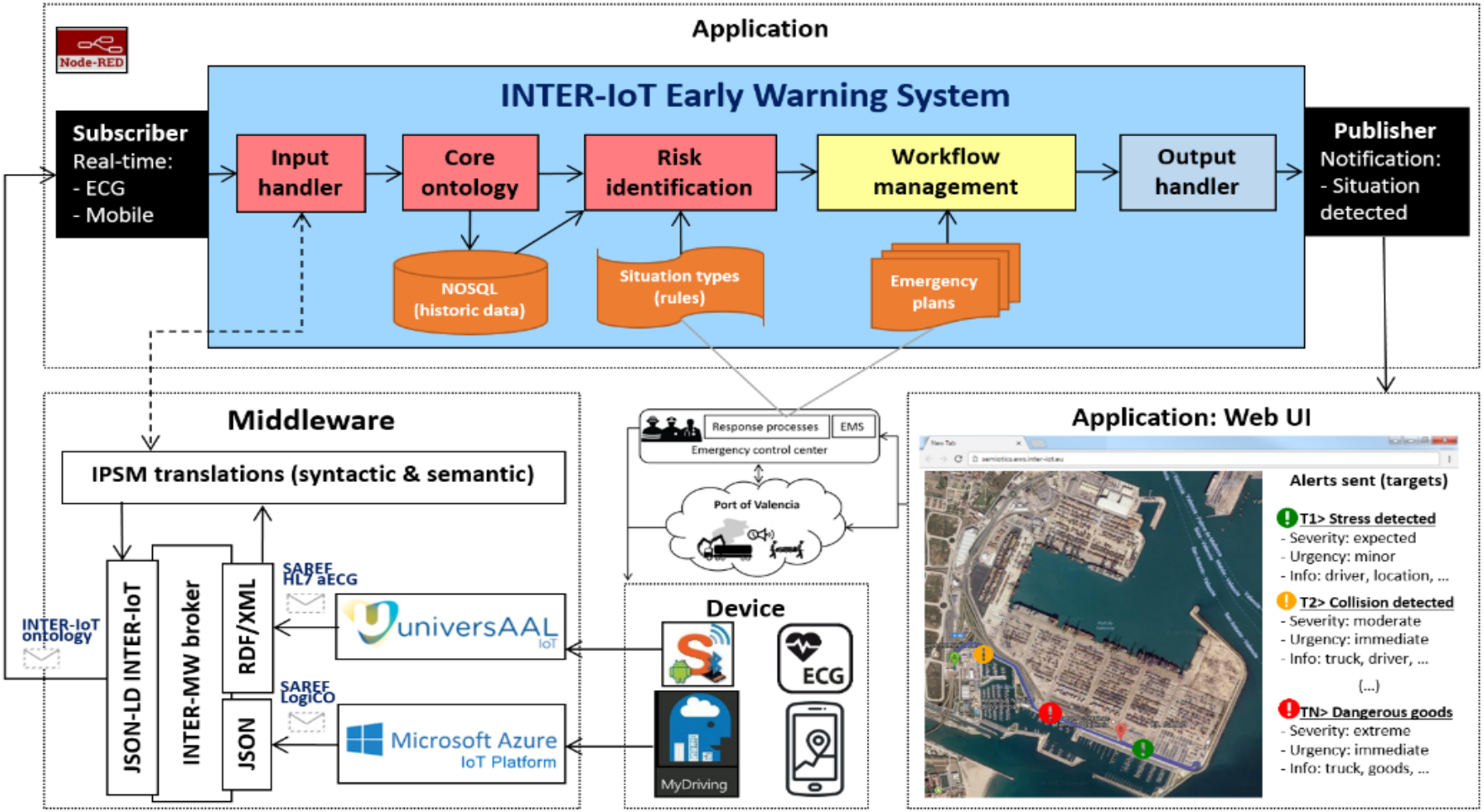

**Table 1.** Data sources.

| External | Health | Logistics |
|---|---|---|
| **Data** | Driver's ECG, HR, accelerometer | Position, speed, accelerometer, goods |
| **Device** | Shimmer ECG 3 (Capture), Mobile | Mobile (MyDriving Android or iOS) |
| **IoT platform** | UniversAAL | MS Azure IoT |
| **Ontologies** | ETSI SAREF, HL7/aECG, FHIR | ETSI SAREF, LogiCO |

Nemergent Solutions

IMS

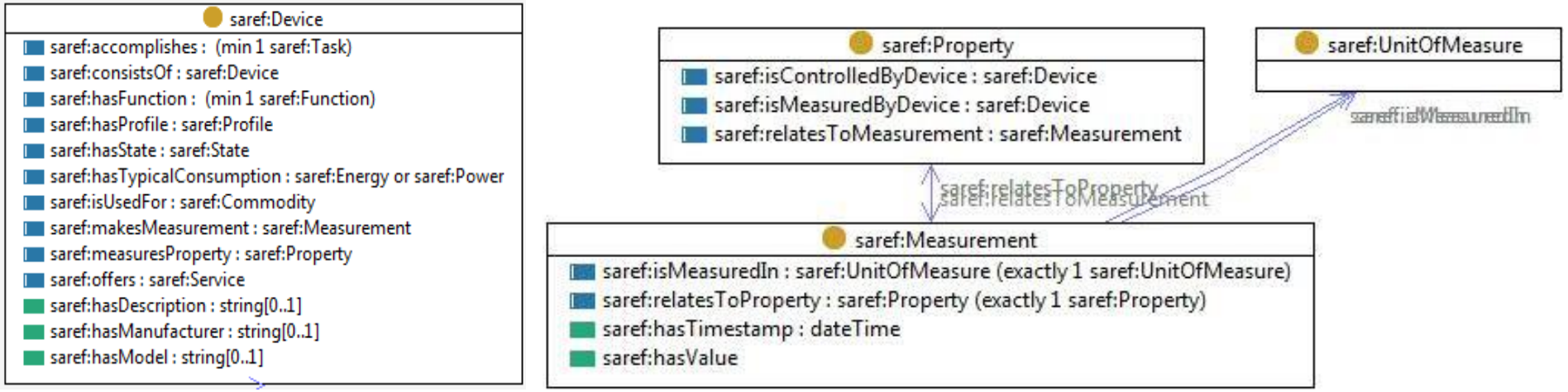
# Collaboration: solution



# Collaboration: ontologies and standards

**IoT domain**

- ETSI Smart Appliances REFerence ontology (SAREF)




- *SAREF4Health (M3-lite): Measurements Series, Health Electrical Activity*

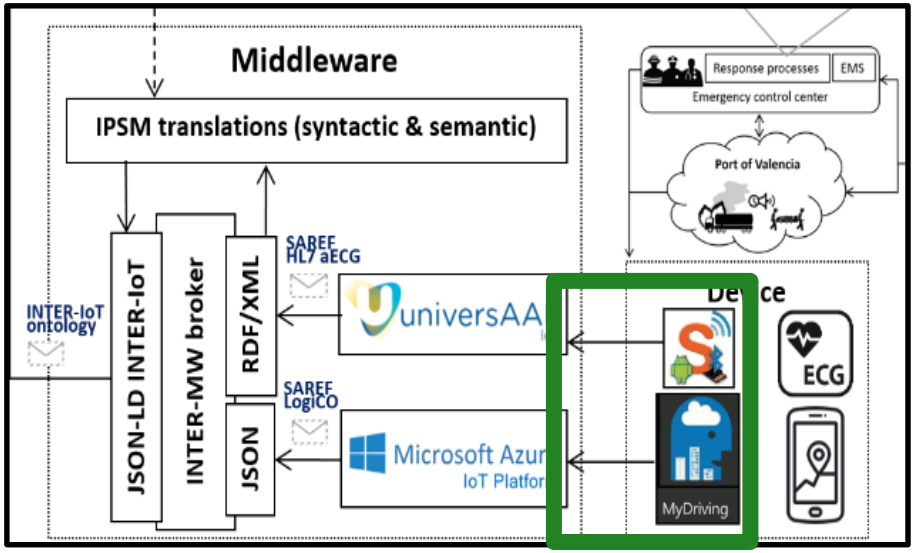
**Logistics**

- Logistics Core Ontology (LogiCO), Logistics Services Ontology (LogiServ), Transport ontology (LogiTrans): *Transport Means, Truck, Transport, Cargo*

# Collaboration: semantic gateway

## Smartphone: enrich semantics of device measurements

```
private SAREFentityMeasurement TranslateMeasurement(string signalName, SensorData sensorData, double timestamp)
{
    SAREFentityMeasurement msg = new ShimmerCaptureXamarin.SAREFentityMeasurement();
    msg.Id = GeneratePID(msg);
    msg.HasTimestamp = timestamp;
    msg.IsMeasuredIn = TranslateIsMeasuredIn(sensorData); //"saref:SpeedUnit_MeterPerSecond";
    msg.RelatesToProperty = TranslateRelatesToProperty(signalName);
    msg.Type = TranslateMeasurementType(signalName); //"saref:SpeedMeasurement";

    msg.Label = "Measurement of Shimmer 3 ECG [" + signalName + "]_" + timestamp;
    msg.HasValue = sensorData.Data;

    JObject sarefMakesMeasurementItemJSON = JObject.FromObject(new
    {
        @id = msg.Id,
        @type = msg.Type,
        @label = msg.Label,
        saref_hasTimestamp = msg.HasTimestamp,
        saref_hasValue = msg.HasValue,
        saref_isMeasuredIn = msg.IsMeasuredIn,
        saref_relatesToProperty = msg.RelatesToProperty
    });

    msg.JSONLDobject = sarefMakesMeasurementItemJSON;

    return msg;
}
```



# Collaboration: JSON-LD messages

Example: driver's smartphone (and/or truck's OBD-2)


```
{
  "@id": "sarefInst:exampleSmartPhoneSendingInfoTruck",
  "@type": "saref:Device",
  "@label": {
    "@language": "en",
    "@value": "Motorola Moto G5 Plus"
  },
  "geo:location": {
    "@id": "sarefInst:test.1.1.LocationSmartPhone_39.431478658043424_-0.35860926434736484",
    "@type": [
      "owl:NamedIndividual",
      "geo:SpatialThing"
    ],
    "@label": {
      "@language": "en",
      "@value": "Location of the smartphone, should be the same location of the truck (?)"
    },
    "geo:latitude": 39.431478658043424,
    "geo:longitude": -0.35860926434736484
  },
  "saref:makesMeasurement": [
    {
      "@id": "sarefInst:SpeedMeasurement__Test.1.1_1511466006.9682777",
      "@type": "saref:SpeedMeasurement",
      "@label": "Example of a speed measurement observed by a mobile device",
      "saref:hasTimestamp": 1511466006.9682777,
      "saref:hasValue": 14,
      "saref:isMeasuredIn": "saref:SpeedUnit_MeterPerSecond",
      "saref:relatesToProperty": "saref:VelocityOrSpeed_Vehicle"
    },
    {
      "@id": "sarefInst:AccelerationMeasurement_Test.1.1_1511466006.9682777",
      "@type": "saref:AccelarationMeasurement",
      "@label": "Example of accelaration measurement observed by a mobile device",
      "saref:hasTimestamp": 1511466006.9682777,
      "saref:hasValue": 1.4,
      "saref:isMeasuredIn": "saref:AccelerationUnit_MeterPerSecondSquared",
      "saref:relatesToProperty": "saref:Accelaration_Vehicle"
```


Location (position)

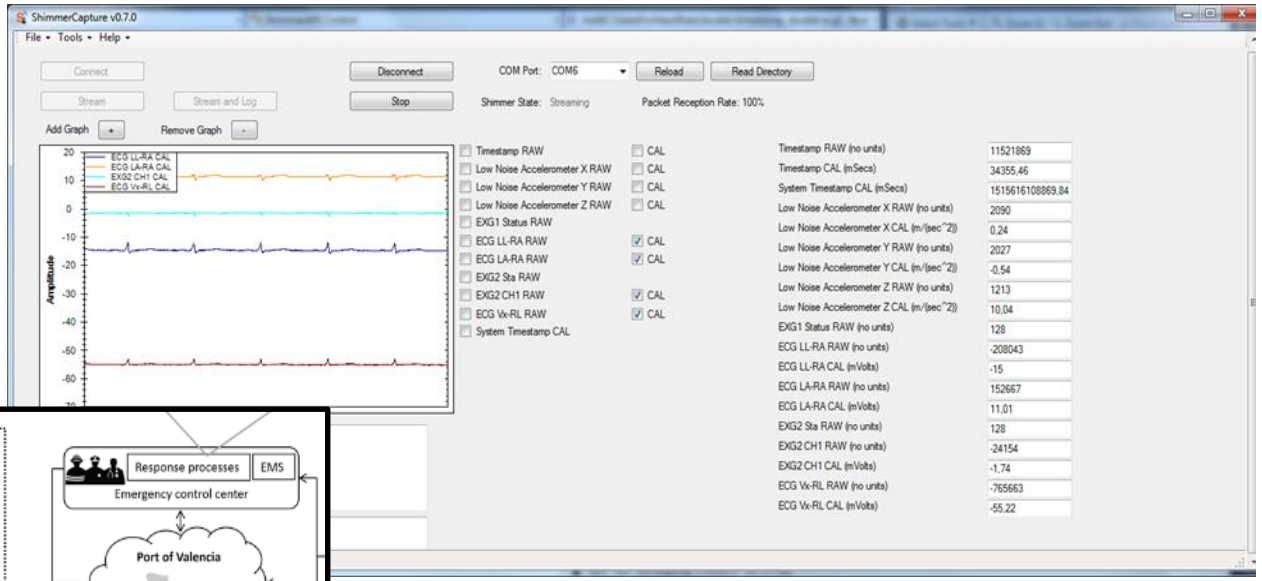
Speed

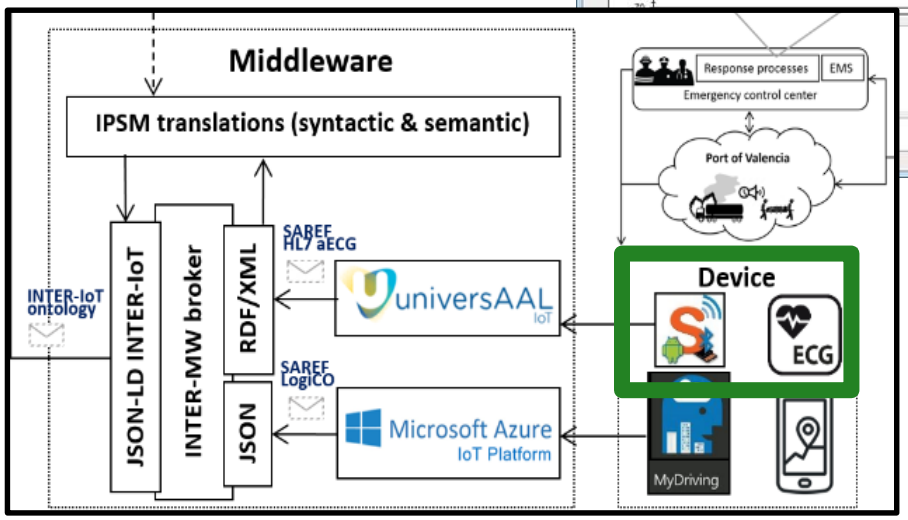
Acceleration

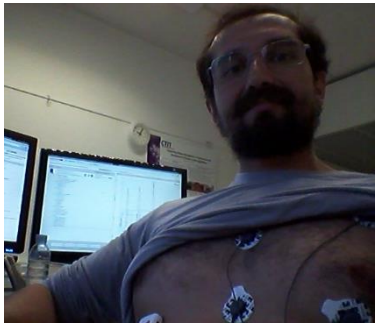
# Collaboration: ECG device

C# API (Android): https://github.com/ShimmerEngineering/Shimmer-C-API

**Shimmer3 ECG**

# Collaboration: ECG data

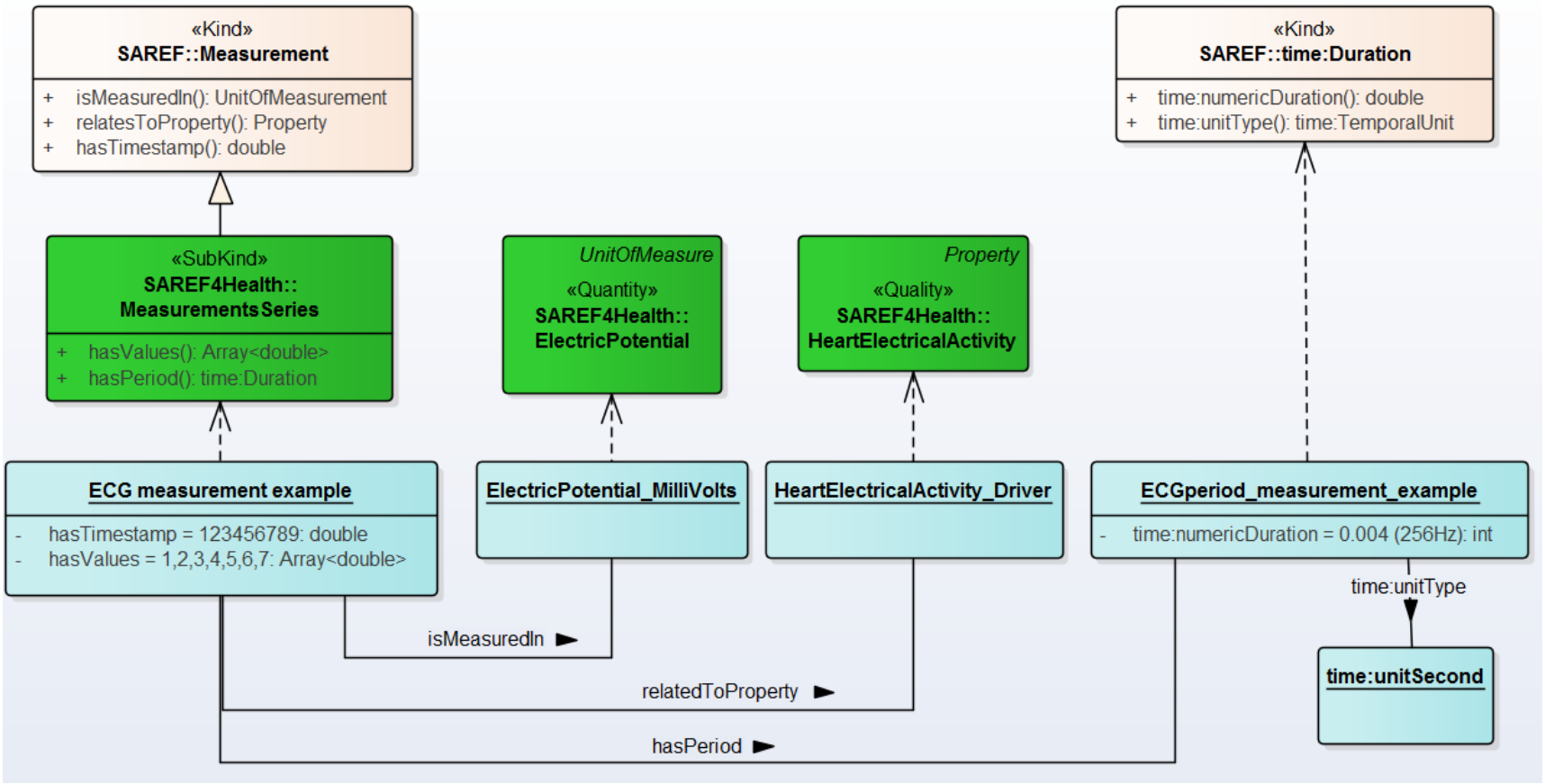
## ECG measurements (series) based on HL7/aECG and FHIR


```
"component": [
  {
    "code": {
      "coding": [
        {
          "system": "urn:oid:2.16.840.1.113883.6.24",
          "code": "131329",
          "display": "MDC_ECG_ELEC_POTL_I"
        }
      ]
    },
    "valueSampledData": {
      "origin": {
        "value": 2048
      },
      "period": 10,
      "factor": 1.612,
      "lowerLimit": -3300,
      "upperLimit": 3300,
      "dimensions": 1,
      "data": "2041 2043 2037 2047 2060 2062 2051 2023 2014 2027 2034 2033 2040 2047 2047 2053 2058 2064 2059
      2063 2061 2052 2053 2038 1966 1885 1884 2009 2129 2166 2137 2102 2086 2077 2067 2067 2060 2059 2062 2062
      2060 2057 2045 2047 2057 2054 2042 2029 2027 2018 2007 1995 2001 2012 2024 2039 2068 2092 2111 2125 2131
      2148 2137 2138 2128 2128 2115 2099 2097 2096 2101 2101 2091 2073 2076 2077 2084 2081 2088 2092 2070 2069
      2074 2077 2075 2068 2064 2060 2062 2074 2075 2074 2075 2063 2058 2058 2064 2064 2070 2074 2067 2060 2062
      2063 2061 2059 2048 2052 2049 2048 2051 2059 2059 2066 2077 2073"
    }
  },
```

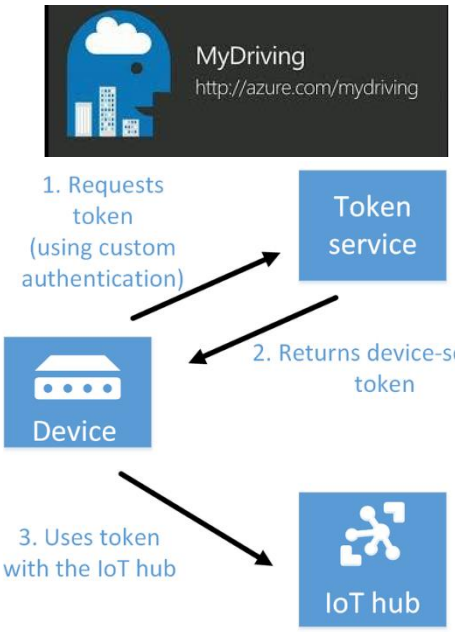

- series
- frequency = 1/period (ms)
- array of measured electrical potential (mV)

# Collaboration: SAREF4Health

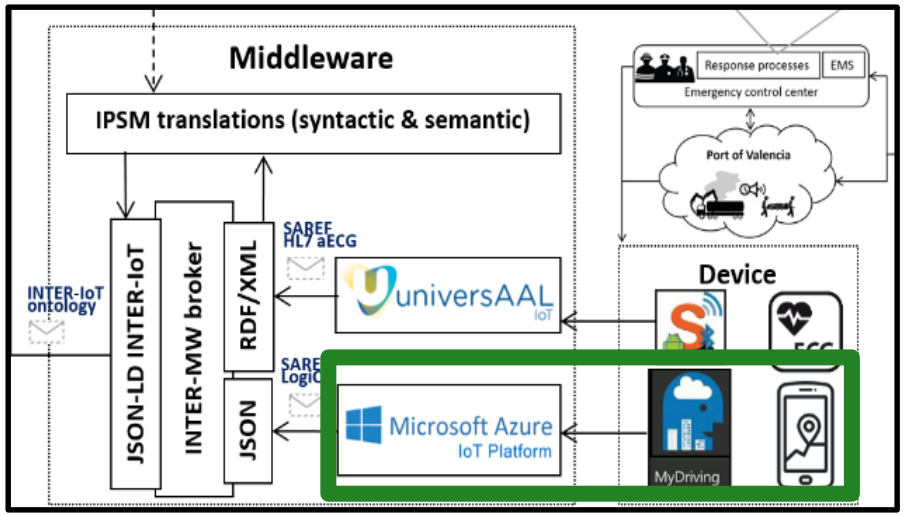
Example: ECG data object *instance of* SAREF4Health



# Collaboration: logistics




C# API (Android and iOS): [https://github.com/Azure-Samples/MyDriving](https://github.com/Azure-Samples/MyDriving)



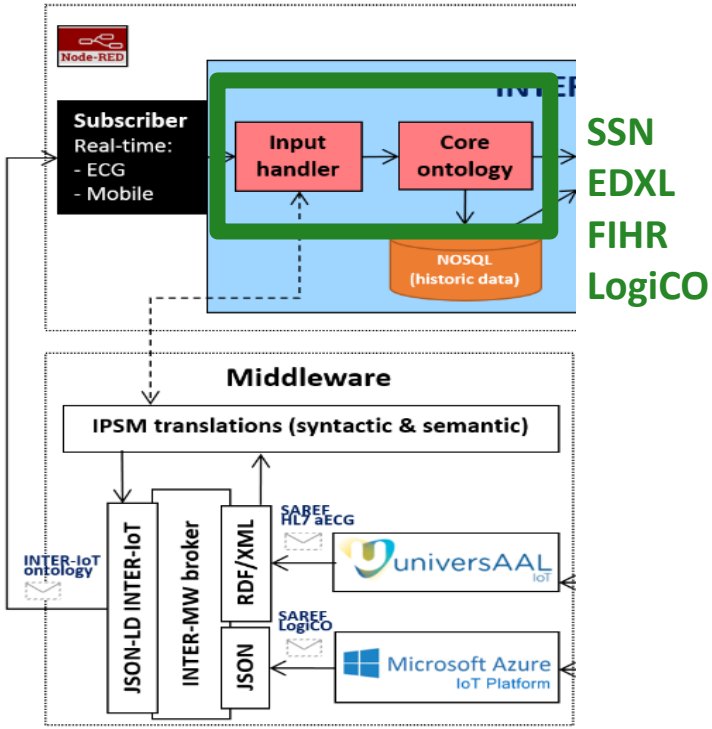

```
public class TripPoint : BaseDataObject
{
    public string TripId { get; set; }

    public double Latitude { get; set; }

    public double Longitude { get; set; }

    /// <summary> Gets or sets the speed, in km/h
    public double Speed { get; set; }

    /// <summary> Gets or sets the acceleration, in m/

    public double Acceleration { get; set; }

    public DateTime RecordedTimeStamp { get; set; }

    /// <summary> Gets or sets the sequence order numb
```

```
public async Task SendTripPointToIOTHub(string tripId, string userId, TripPoint tripDataPoint)
{
    //Note: Each individual trip point is being serialized separately so that it can be sent over as an individual message
    //This is the expected format by the IOT Hub\ML
    var settings = new JsonSerializerSettings {ContractResolver = new CustomContractResolver()};
    var tripDataPointBlob = JsonConvert.SerializeObject(tripDataPoint, settings);

    var tripBlob = JsonConvert.SerializeObject(
        new
        {
            TripId = tripId,
            UserId = userId
        });

    tripBlob = tripBlob.TrimEnd('}');
    string packagedBlob = $"{tripBlob},\"TripDataPoint\":{tripDataPointBlob}}}";
```

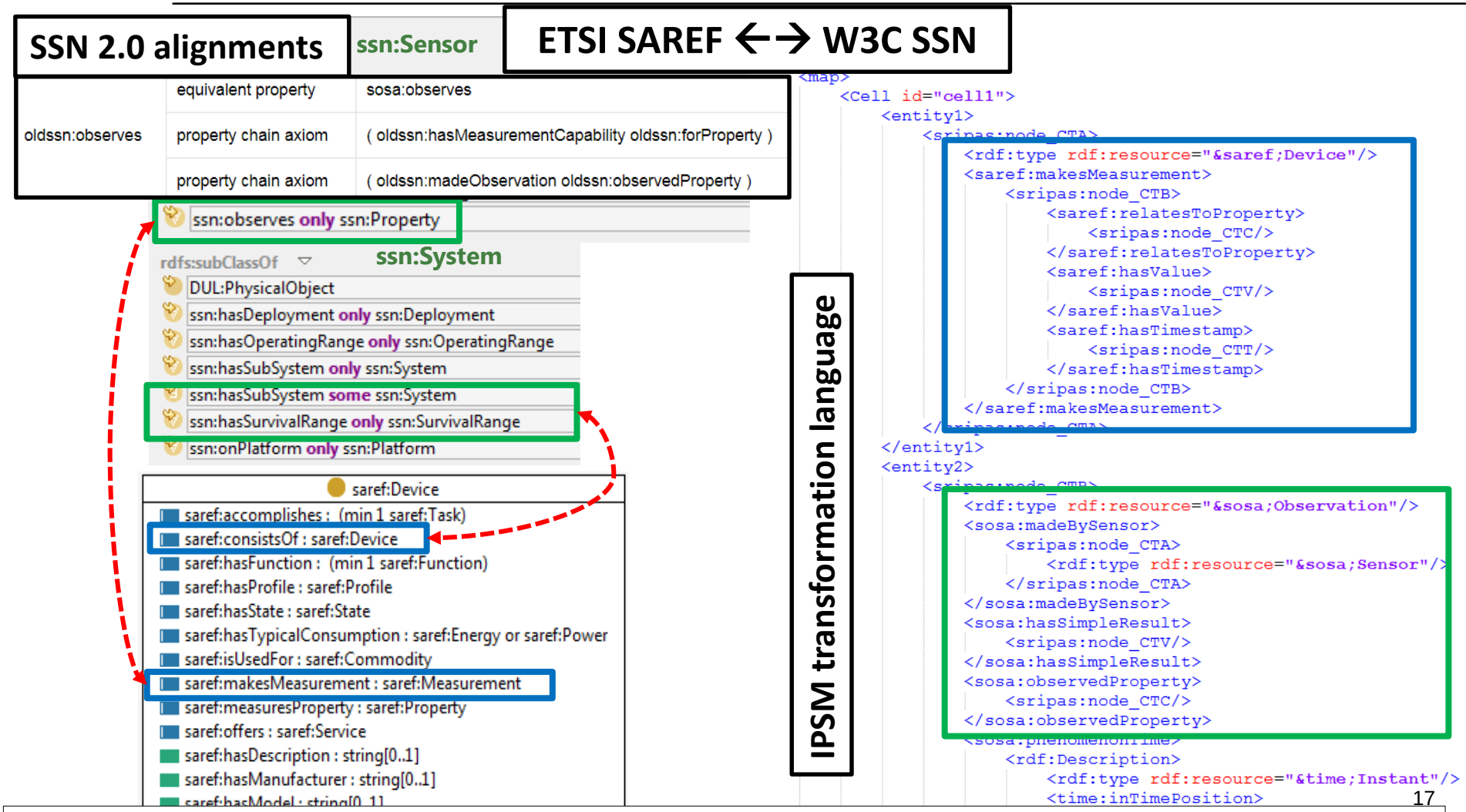
# Collaboration: semantic translations

## Required translations

- From SAREF to SSN: acceleration, speed, position
- From SAREF4Health to UniversAAL and FHIR: ECG data, HR
- SAREF to EDXL-SitRep?
- SAREF4Health to EDXL-TEP?



# Collaboration: semantic translations






[5] Moreira, J.L.R., Daniele, L.M., Ferreira Pires, L., et al. (2017) *Towards IoT platforms' integration: Semantic Translations between W3C SSN and ETSI SAREF*. SIS-IoT workshop (SEMANTICS conference).

# Collaboration: decision rules

## UC01: Vehicle collision detection

accelerometerShimmer , accelerometerMobile

Threshold_VehicleCollision = 4G

ComputeCrossAxialEnergy(accelerometer) = $x^2 + y^2 + z^2$

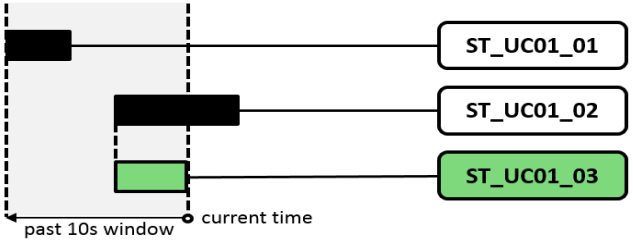
**Rule-based Complex Event Processing (CEP)**

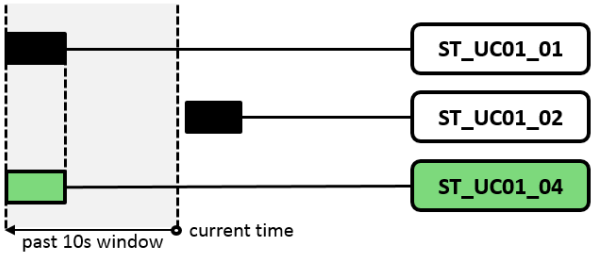
**ST_UC01_01.** IF (ComputeCrossAxialEnergy(accelerometerShimmer) > Threshold_VehicleCollision)

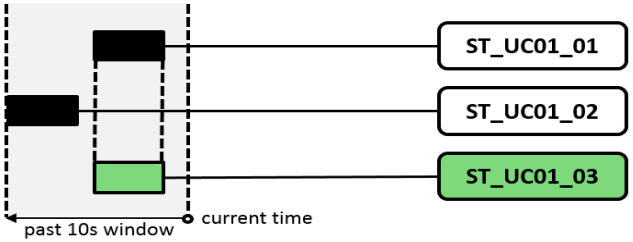
**ST_UC01_02.** IF (A=ComputeCrossAxialEnergy(accelerometerMobile) > B=Threshold_VehicleCollision)

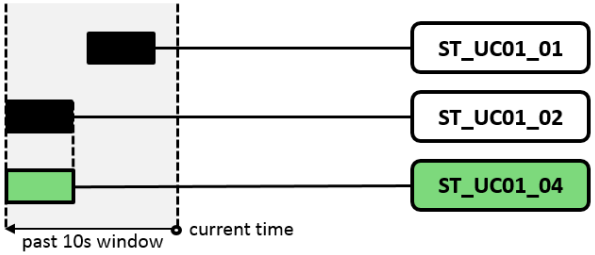
**ST_UC01_03.** IF (exists(over window:time(10s, ST_UC01_01 AND ST_UC01_02))
AND ST_UC01_01.Driver = ST_UC01_02.Driver)

**ST_UC01_04.** IF (exists(over window:time(10s, ST_UC01_01 OR ST_UC01_02))
AND ST_UC01_01.Driver = ST_UC01_02.Driver)



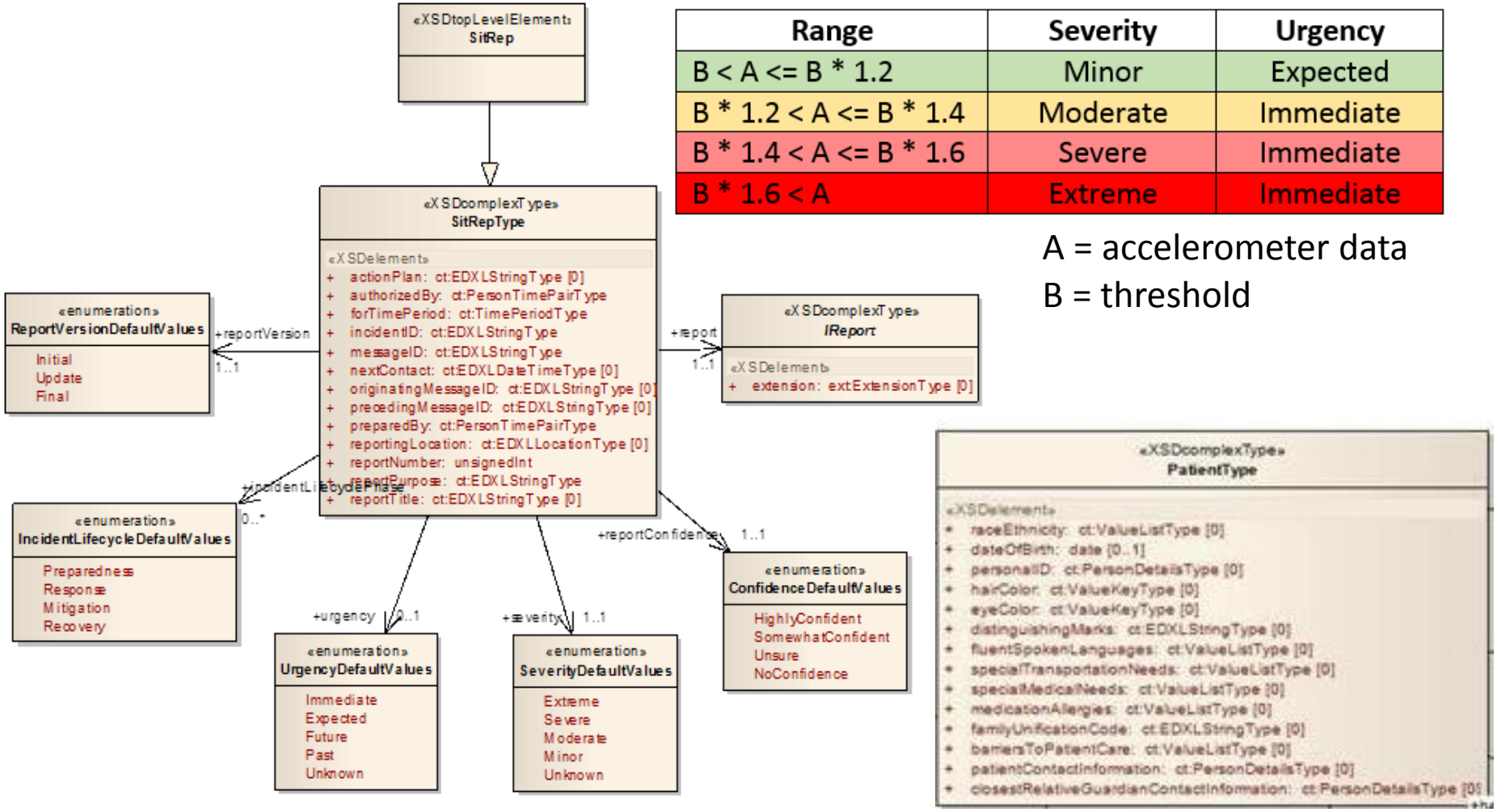



# Collaboration: output handler

## EDXL-SitRep / EDXL-TEP (JSON-LD)




| Range | Severity | Urgency |
|---|---|---|
| B < A <= B * 1.2 | Minor | Expected |
| B * 1.2 < A <= B * 1.4 | Moderate | Immediate |
| B * 1.4 < A <= B * 1.6 | Severe | Immediate |
| B * 1.6 < A | Extreme | Immediate |

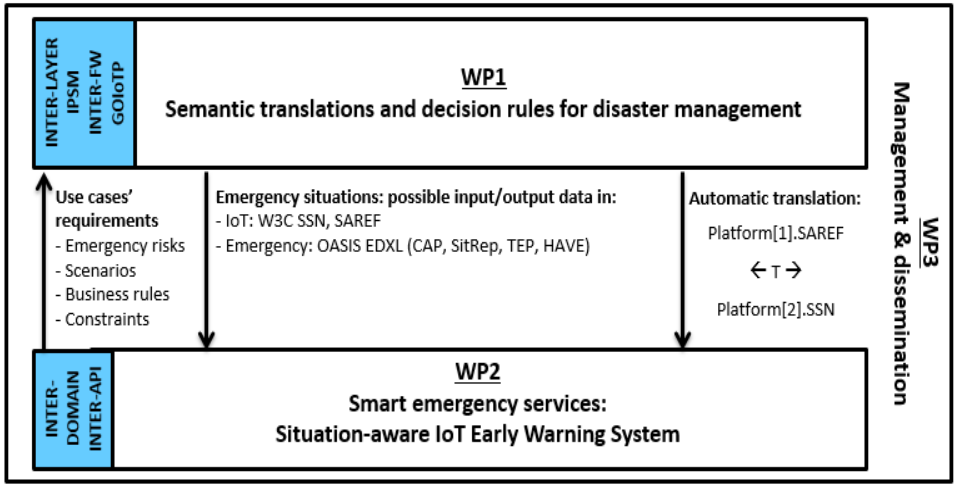
A = accelerometer data

B = threshold

# Project progress: plan

**Tasks (current status)**

T1.1. *Finished.* Outcome: ontologies
T1.2. *In progress.* Samples and tests (IPSM)
T1.3. *In progress.* Rules for each use case
T2.1. *Finished.* Outcome: use cases
T2.2. *In progress.* Solution architecture
T2.3. *In progress.* Components' integration
T3.2. *In progress.* Cost and monetization



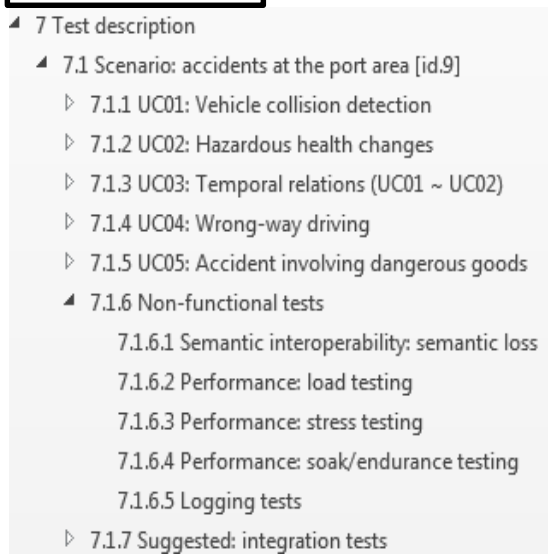

| WORKPACKAGES / TASKS | 2017 | | | | | | | | | | | | 2018 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| **WP1: Ontology translations and decision rules for disaster management** | | | | | | | | | | | | | | | | | | | | | | | | |
| T1.1 Exploit ontologies and standards that can be applied within INTER-DOMAIN use cases | | | | | | | | | | | | | | | | | | | | | | | | |
| T1.2 Configure SAREF - SSN translation and deploy in IPSM | | | | | | | | | | | | | | | D1.1 | | | | | | | | | |
| T1.3 Describe decision rules for emergency services | | | | | | | | | | | | | | | | | | | | | | | | |
| **WP2: Smart emergency services (healthcare and logistics): Situation-aware IoT Early Warning System** | | | | | | | | | | | | | | | | | | | | | | | | |
| T2.1 Detail use case scenarios | | | | | | D2.1 | | | | | | D2.1 | | | | | | | | | | | | |
| T2.2 Design EWS and integration plan | | | | | | | | | | | | | | | | | | | | | | | | |
| T2.3 Implementation and integration | | | | | | | | | | | | D2.2 | | | | | | | | | D2.2 | | | |
| T2.4 Evaluation and review | | | | | | | | | | | | | | | | | | | | | | D2.3 | | |
| **WP3: Management & dissemination** | | | | | | | | | | | | | | | | | | | | | | | | |
| T3.1 Develop and coordinate WPs | | | | | | D3.1 | | | | | | D3.1 | | | | | | | | | | D3.1 | | |
| T3.2 Develop business model, exploitation plan and economic evaluation | | | | | | D3.2 | | | | | | D3.2 | | | | | | | | | | D3.2 | | |

# Project progress: validation

**Table 2.** Validation activities.

| # | Activity | Description | Addresses |
|---|---|---|---|
| A1 | Functional evaluation | Test cases with different levels of severity and urgency, checking emergency procedures | C1, C2, C3, FR1, FR2 |
| A2 | Semantic interop.: semantic loss | Transformations: $T(T(x)_{A>B})_{B>A}$, $T(x)_{A>B}$ represents the semantic translation function from A to B | C1, NFR1, NFR2 |
| A3 | Performance eval.: data transfer | JSON x JSON-LD as payload (total transaction time), following the structure of the involved ontologies | C2, NFR3 |
| A4 | Performance eval.: data process | Total time to translate; annotate and insert into database; risk identification; and messaging (EDXL) | C2, NFR3 |
| A5 | Performance eval.: data brokering | Scalability and resilience measured for single cluster and multi-broker, throughputs of up to 700 msg/sec. | C2, C3, NFR3 |

FAT document




**(A1) Functional tests**

- **Quantitative**: comparison with expected results through unit tests (input data is framed by the decision rules and alerts sent to target groups)
  - (i) Upstream data: EWS as subscriber of INTER-MW
  - (ii) Downstream data: EWS as publisher in INTER-MW
- **Qualitative**: level of semantic interoperability achieved - user acceptance (questionnaire with INTER-IoT focus group)

# Project progress: exploitation

## Publications

1. Moreira, J.L.R., Daniele, L.M., Ferreira Pires, L., et al. (2017) *Towards IoT platforms' integration: Semantic Translations between W3C SSN and ETSI SAREF.* SIS-IoT: Semantic Interoperability and Standardization in the IoT workshop (SEMANTICS conference).
2. Moreira, J.L.R., Ferreira Pires, L., Sinderen, M. van, Wieringa, R., et al. (2018) *Improving the semantic interoperability of IoT Early Warning Systems: the Port of Valencia use case.* Interoperability for Enterprise Systems and Applications (I-ESA conference)
3. Poster CTIT 2017: Internal event of UT for PhD candidates

## Workshop organization (I-ESA 2018)

**Industrial Big Data Platforms Enabling Enterprise Interoperability for Smart Services**

- **Paper deadline: 31st January**


## Business model (monetization)


interiot

INTEROPERABILITY OF HETEREOGENEUS IOT PLATFORMS.



# INTER-IoT-EWS: Interoperable Situation-Aware IoT Early Warning System

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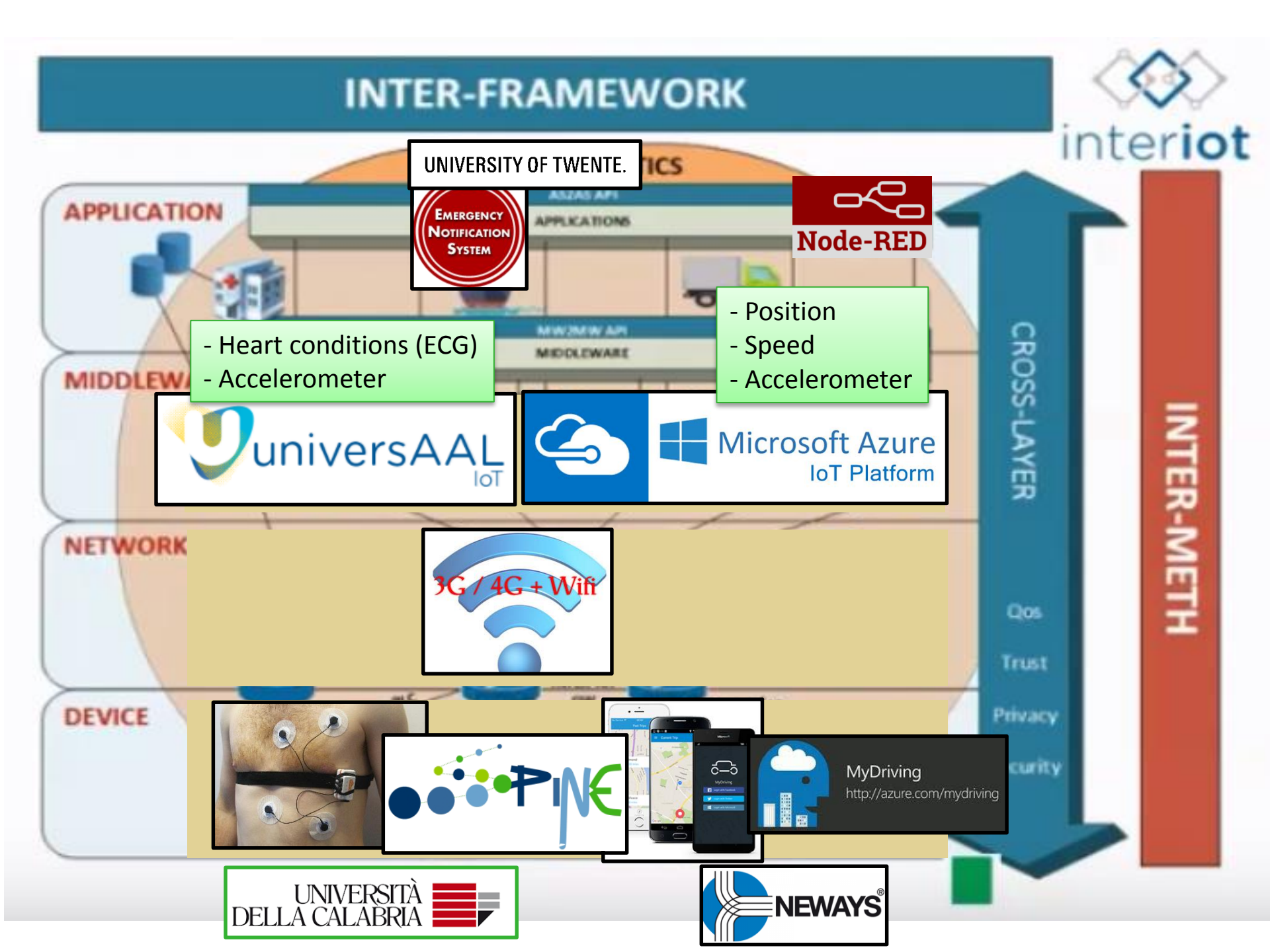
Small Collaboration


INTER-FRAMEWORK
interiot
UNIVERSITY OF TWENTE.
APPLICATION
MIDDLEWARE
NETWORK
DEVICE
EMERGENCY NOTIFICATION SYSTEM
APPLICATIONS
MIDDLEWARE
Node-RED
- Heart conditions (ECG)
- Accelerometer
- Position
- Speed
- Accelerometer
universAAL IoT
Microsoft Azure IoT Platform
3G / 4G + Wifi
CROSS-LAYER
Qos
Trust
Privacy
curity
INTER-METH
PINE
MyDriving
http://azure.com/mydriving
UNIVERSITÀ DELLA CALABRIA
NEWAYS