The M3 nomenclature to describe and interpret sensors, measurements, units and domains in an interoperable way to ease reasoning

We propose to use common terms to describe sensors, measurements, actuators and domains. Of course, we should improve it all together. This work synthetizes all concepts found in existing ontologies or projects related to Internet of Things (IoT) and are implemented in the M3 ontology to unify sensor measures/ IoT data. This step is essential to define interoperable/unified rules to interpret sensor measures. The M3 nomenclature defines a unified data model for the Internet of Things and is an extension of the W3C SSN ontology.

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Last Updated	June 4, 2015 Check actuators and RFID with M3 ontology
Status	Work in progress

Caption	• Rows in green, compliant with:
	  • M3 ontology
	  • Linked Open Rules
	  • IoT application template
	• Rows in white or red (to finish)

• Definitions	• Correctness means that are no incompatibility with other rules. • Completeness means that all sensor values are covered by an high level information.
• Links	• M3 Web site: http://www.sensormeasurement.appspot.com/ • NS_M3 = http://sensormeasurement.appspot.com/m3# • SenML language: http://www.ietf.org/archive/id/draft-jennings-senml-10.txt • LOV4IoT: • http://www.sensormeasurement.appspot.com/?p=ontologies

I. Sensor and measurement interpretation

E.g., precipitation and rainfall sensor have the same meaning and represents the same sensor, we should explicitly describe this information in machine to machine communications to ensure interoperability in each layer of the OneM2M architecture.

1. Healthcare

Table 1. Healthcare domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names (synonyms)	M3 or SenML Unit	M3 rules

Health	BodyThermometer/ BodyTemperature	Body thermometer	DegreeCelcius	Completude OK (3 rules [Obaid 2013] + 3 rules [Jara 2009]), Correctness OK
Health	HeartBeatSensor/ HeartBeat	Pulse sensor, pulse oxymeter, pulse-ox, heart beat, heart rate, pulse rate, cardiac frequency, breath rate	BeatPerMinute	Correctness ok (2 rules [5 rules Tanatong 2011] & [Hristoskova 2014]) + **Completude No (>300 nothing)**
Health	PulseOxymeter/ SPO2	Pulse oxymeter, spO2, blood oxygen saturation sensor, pulse and oxygen in blood sensor	Percent	Correctness OK (1 rule [Hristoskova 2014]) + **Completude NO**
Health	CholesterolSensor/ Cholesterol	cholesterol	MmolPerLiter	Correctness OK (1 rule [Bravo 2009-2013]) + **Completude NO**
Health	Glucometer/ BloodGlucose	Glucometer, glucose sensor, blood glucose meter, blood sugar level	GramPerLiter	Completude OK (3 rules [Guermah 2014]), Correctness OK
Health	BloodPressureSensor/ BloodPressure	blood pressure meter, sphygmomamometer, MAP (Mean arterial pressure), CVP (central venous pressure)	mmHg	0 rule
Health	SkinConductanceSensor/ SkinConductance	skin conductance, galvanic skin response sensor, GSR, sweating	?	0 rule
Health	WeightSensor/ Weight	Weight sensor, body weight, weight scale	Kilo, Pound	0 rule
Health	Pedometer/ NumberStep			

2. Weather

Table 2. Weather domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names (synonyms)	M3 or SenML Unit	M3 rules
Weather	HumiditySensor/ Humidity	Hygrometer, humidity sensor, moisture sensor, soil moisture probes	Percent	Correctness OK (Conflict resolved with [Kofler 2011] and [Rodriguez 2014]) + Completude OK (5 rules [Staroch 2013])
Weather	WindDirectionSensor/ WindDirection	Wind direction	DegreeAngle	Completude OK (5 rules [Staroch 2013]) + Correctness OK
Weather	SunPositionDirectionSensor/ SunPosition	sun position direction to detect east, west, south, north	DegreeAngle	Completude OK (5 rules [Staroch 2013]) + Correctness OK
Weather	AtmosphericPressureSensor/ AtmosphericPressure	Atmospheric pressure sensor, Barometer, barometric pressure sensor	Pascal	Completude OK (5 rules [Staroch 2013]) + Correctness OK (even with [Kofler 2011])
Weather	CloudCoverSensor/ CloudCover	Cloud cover sensor	Okta	Completude OK (5 rules [Staroch 2013]) + Correctness OK (even with [Kofler 2011])
Weather	SunPositionElevationSensor/ SunElevation	sun position elevation to detect (twilight, day, night, etc.)	DegreeAngle	8 rules [Staroch 2013] **Completude NO + Correctness NO**
Weather	SolarRadiationSensor/ SolarRadiation	Solar radiation sensor, par (photo synthetically active radiation) sensor, sun light, solar sensors, sun's radiation intensity	WattPerMeter Square	Completude OK (5 rules [Staroch 2013]) + Correctness OK (even with [Kofler 2011])
Weather	VisibilitySensor/ Visibility	Visibility sensor to detect fog	Miles, Meter	
Weather	Thermometer, AirThermometer/ Temperature	Thermometer, temperature sensor, thermistor	DegreeCelsius	Integrate [Kofler 2011] 15 rules See LOV4IoT [Staroch 2013] (6 home temperature rules)

Weather	LightSensor/ Luminosity	Light, luminosity, illuminance, lighting	Lux	
Weather	PrecipitationSensor/ Precipitation	Precipitation sensor, rainfall sensor, rain fall, pluviometer, rain, rainfall gauge	MilimeterPer Hour	
Weather	WindSpeedSensor/ WindSpeed	Wind speed sensor, wind velocity sensor, anemometer	MeterPerSeco nd	[Kofler 2011] 16 rules See LOV4IoT [Staroch 2013] 5 overlapping
Weather	WindChillSensor/ WindChill	Wind chill		

3. Smart home

Table 3. Smart home domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names (synonyms)	M3 or SenML Unit	M3 rules
BuildingAutomation	SoundSensor/ Sound	Noise, sound, microphone, audio sensor	dB	Correctness OK (3 rules [Rodriguez 2014]) + **Completude NO** (Between 30 and 110, overlapping with Vasileios]
Weather	Thermometer/ Temperature	Thermometer, temperature sensor, thermistor	DegreeCelsius	[Kofler 2011] 15 rules (only 9 implemented) See LOV4IoT [Staroch 2013] (6 home temperature rules) Rodriguez 3 rules Overlapping overlapping with Vasileios Yus
BuildingAutomation	LightSensor/ Luminosity	Light, luminosity, illuminance, lighting, illumination	lux	Pb with Vasileios
BuildingAutomation	Presence	Presence sensor, motion sensor, occupancy detector, pyroelectric IR occupancy, intrusion detector/ trespassing,	?	2 rules combined with light See LOV4IoT [Jacquet 2013]

		infrared sensor, motion sensor, motion detector, motion sensor, proximity, passive infrared (PIR)		
BuildingAutomation	PowerConsumption		Watts	
Weather	HumiditySensor/ Humidity	Hygrometer, humidity sensor, moisture sensor, soil moisture probes	Percent	5 rules See LOV4IoT [Staroch 2013] completude ok Correctness : Overlapping with kofler, Rodriguez More rules staroch
BuildingAutomation	gyroscope	Gyroscope attached to objects (e.g., mop) to detect if they are used	rad/s	No too complicated need machine learning to detect activities
BuildingAutomation	pressure	Pressure for beds, sofa, couch to detect (lying, sitting), bed occupancy		
BuildingAutomation	Accelerometer/ Motion	Accelerometer	m/s^2	
BuildingAutomation	magnetic field	Magnetometer, magnetic sensor attached to cupboards to detect if they are opened or closed		
BuildingAutomation	Camera	Video sensor		
BuildingAutomation	SmokeDetector			Percent
BuildingAutomation	GasDetector			

4. Transportation

Table 4. Transportation domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names	M3 or SenML Unit
Transportation	battery	Battery charge level	
Transportation	motorTemperature		

Transportation	RoadSurfaceThermometer/ RoadTemperature		
Transportation	SpeedSensor/ Speed	Speed sensor, speedometer, velocity sensor (car)	
Transportation	NumberVehicleSensor/ NumberVehicle		
Transportation	tire pressure		
Transportation	fuel	Fuel level	
Transportation	DistanceSensor/ Distance	Distance sensor, safety distance	
Transportation	rpm	Position and/or rotational speed	
Transportation	maf	mass air flow sensor	maf
Transportation	SoundSensor/ Sound		dB
Transportation	AlcoholLevelSensor/ AlcoholLevel		

I. Agriculture

Table 5. Agriculture domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ name	Description, other names (synonyms)	M3 or SenML Unit
Agriculture	SoilHumiditySensor/ SoilHumidity		Percent
Agriculture	LeafWetnessSensor/ LeafWetness		Percent
Agriculture	AirThermometer/ AirTemperature	Thermometer, temperature sensor, thermistor	°C, K, F
Agriculture	SoilThermometer/ SoilTemperature	Thermometer, temperature sensor, thermistor	
Agriculture	Luminosity	LightIntensity	
Agriculture	PHSensor/ PH		

5. Emotion

Table 6. Emotion domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor name	M3 or SenML measurement name	Description, other names (synonyms)	M3 or SenML Unit
Emotion	SkinConductanceSensor	SkinConductanceSensor	skin conductance, galvanic skin response sensor, GSR, sweating	

6. Energy

Table 6. Emotion domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor name	M3 or SenML measurement name	Description, other names (synonyms)	M3 or SenML Unit
Energy	EnergyMeter/ Energy	Energy	Electricity meter, electric meter, energy meter	KiloWattHour

7. Environment

Table 7. Air quality domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor/ measurement name	Description, other names (synonyms)	M3 or SenML Unit	M3 rules
Environment	AirPollutantSensor/ AirPollution	Air pollutant sensor	EAQI	5 rules Completude + Correctness Kofler + See LOV4IoT [Staroch 2013]
Environment	SaltMeter / Salinity		ppt	
Environment	oxygen	oxygen sensor		
Environment	no	Nitrogen oxide sensor		
Environment	CO	Carbon monoxide CO sensor		
Environment	SO2	Sulfure dioxide sensor		
Environment	CO2	Carbon Dioxyde Sensor	Ppm (parts per million)	
Environment	pH	pH		

8. Generic

Table 8. Generic domain: sensors, measurements and units

M3 or SenML domain	M3 or SenML sensor name	M3 or SenML measurement name	Description, other names (synonyms)	M3 or SenML Unit
Generic	HumiditySensor	Humidity	Hygrometer, humidity sensor, moisture sensor, soil moisture probes	Percent
Generic	Thermometer	Temperature	Thermometer, temperature sensor, thermistor	°C
Generic	LightSensor	Luminosity	Light, luminosity, illuminance, lighting	lux
Generic		gps	Global positioning system, gps,	lon, lat,

			location sensor	alt
Generic		frequency		Hz
Generic		shake	Shake sensor, vibration	

II. M3 Domains

E.g., Aix means Air en Provence which is a city.
E.g., you use the temperature in the health domain enable the computer to understand that the measurement corresponds to a body temperature.

For instance, Fire is a subclass of Environment.

FOI when duplication with measurement type,
FOI for feature of Interest

Table 9. Domain names

M3 or SenML Domain name	Description, other names (synonyms)
BuildingAutomation (subclass: Activity)	Smart home, building automation, or building or room (kitchen, bathroom, living room, dining room)
Health	healthcare
Weather	Weather forecasting, meteorology
Agriculture	Agriculture, smart farm, garden
Environment (subclass: Fire)	Environment (earthquake, flooding, forest fire, air pollution)
Emotion	Affective science, emotion, mood, emotional state; brain wave
Transport	Intelligent transportation systems (ITS), smart car/vehicle, transportation
EnergyFOI	Smart grid, smart energy
Tourism	Tourism
Location	Location, place, GPS coordinates
City	Smart city, city automation, public lighting
TrackingGood (subclasses: TrackingFood, TrackingCD)	Tracking RIFD goods
Generic	Others

III. Actuators

If SenML value = 0 it means the actuator is not used
If SenML value = 1 it means the actuator is used

Table 10. Actuator names

M3 or SenML domain	M3 or SenML Actuator name	Description, other names (synonyms)
Transport	FogLamp	Fog lamp
Transport	Brake	
Transport	ABS	Abs, anti-lock braking system
Transport	ESP	Electronic stability program
Transport	SeatBeltTensionSensor	Seat belt tension sensor
BuildingAutomation	WaterFlow	water flow attached to sinks, showers, flushing

BuildingAutomation, Transportation	AirConditioner	Air conditioner, ac
BuildingAutomation, Transportation	AlarmSystem	
BuildingAutomation	Heating	
BuildingAutomation	Blind	
BuildingAutomation	Ventilation	
BuildingAutomation	Curtain	
BuildingAutomation	Window	
BuildingAutomation	Cupboard	
BuildingAutomation	DishWasher	
BuildingAutomation	WashingMachine	
BuildingAutomation	Drawer	
BuildingAutomation	Door	
BuildingAutomation	Boiler	
BuildingAutomation	CoffeeMachine	Coffee machine, coffee maker
BuildingAutomation	Computer	Computer, pc
BuildingAutomation	Shower	Water actuator
BuildingAutomation	TV	tv, television
BuildingAutomation	Lavatory	
BuildingAutomation	Fridge	Refrigerator, fridge
BuildingAutomation	Freezer	Chiller
BuildingAutomation	Microwave	
BuildingAutomation	Lamp	Dimmable light, lamp

Table 11. RFID tags common terms

RFID tags name	Description, other names (synonyms)
RFID_Food	food
RFID_Book	book (isbn)
RFID_CD	cd, music
RFID_DVD	dvd, movie
RFID_Garment	clothes, garments
RFID_BrushTeeth	
RFID_Broom	
RFID_TeaBag	
RFID_Cup	
RFID_Mop	
RFID_Bed	
RFID_Sofa	
RFID_Pan	
pill box	
passport	
luggage	
parking space	
toll	
animal	
payment card	

transit pass	

IV. Others Measurement names

E.g., t temp and temperature have the same meaning and represents the temperature measurement.
The same as the one referenced for sensors

Table 12. measurement names

M3 or SenML measurement name	**Description, other names (synonyms)**
lon	longitude
lat	latitude
Others measurements are the same than those referenced for sensors	