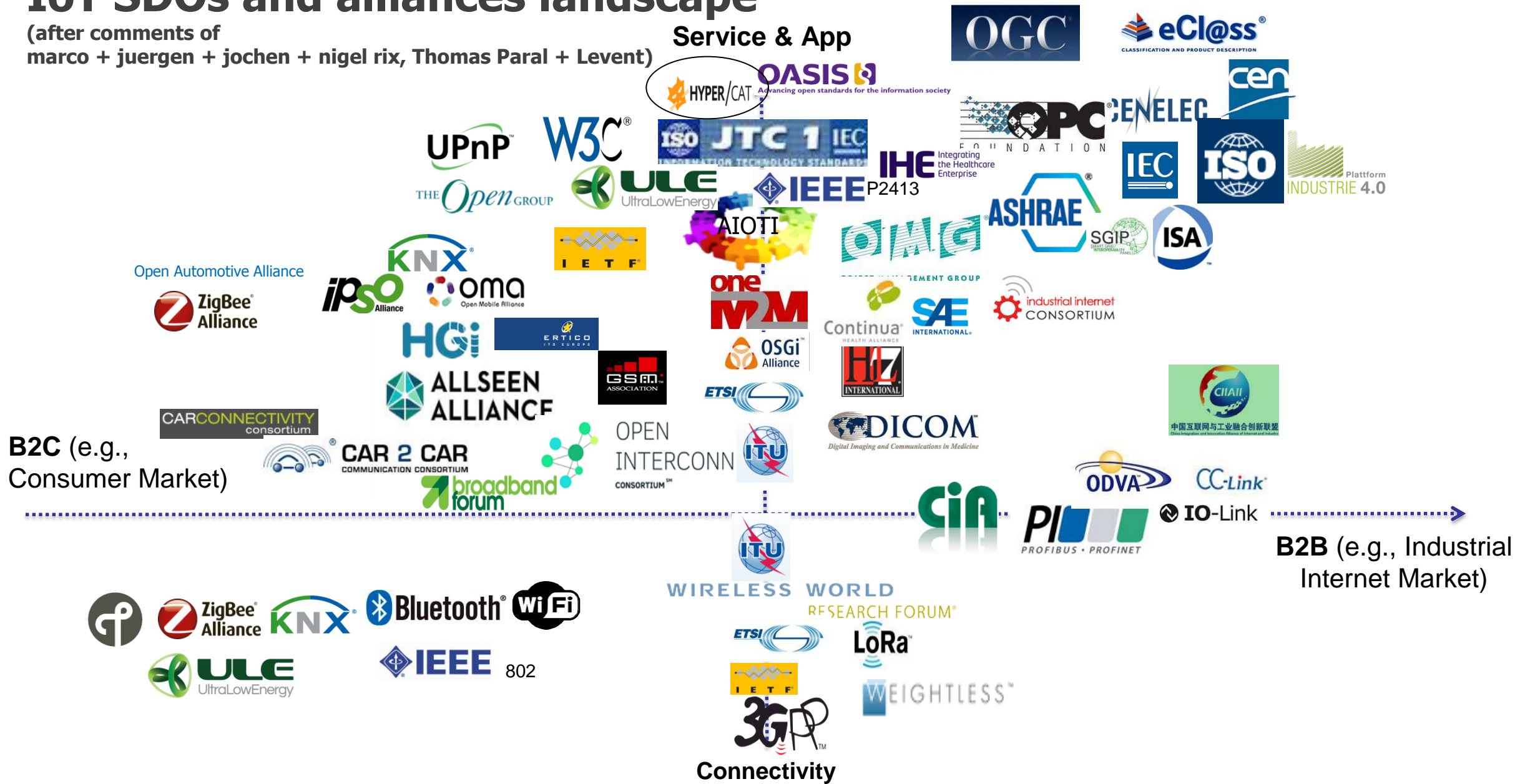


IoT SDOs and alliances landscape

(after comments of marco + juergen + jochen + nigel rix, Thomas Paral + Levent)



Source: Modified from an initial contribution from Huawei

IoT SDOs and alliances landscape

(after comments of marco + juergen + jochen + nigel rix, Thomas Paral + Levent)

Home/Building

Manufacturing/
Industry Automation

Vehicle/
Transportation

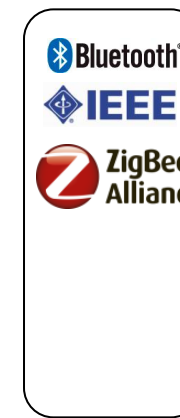
Healthcare

Energy

Cities

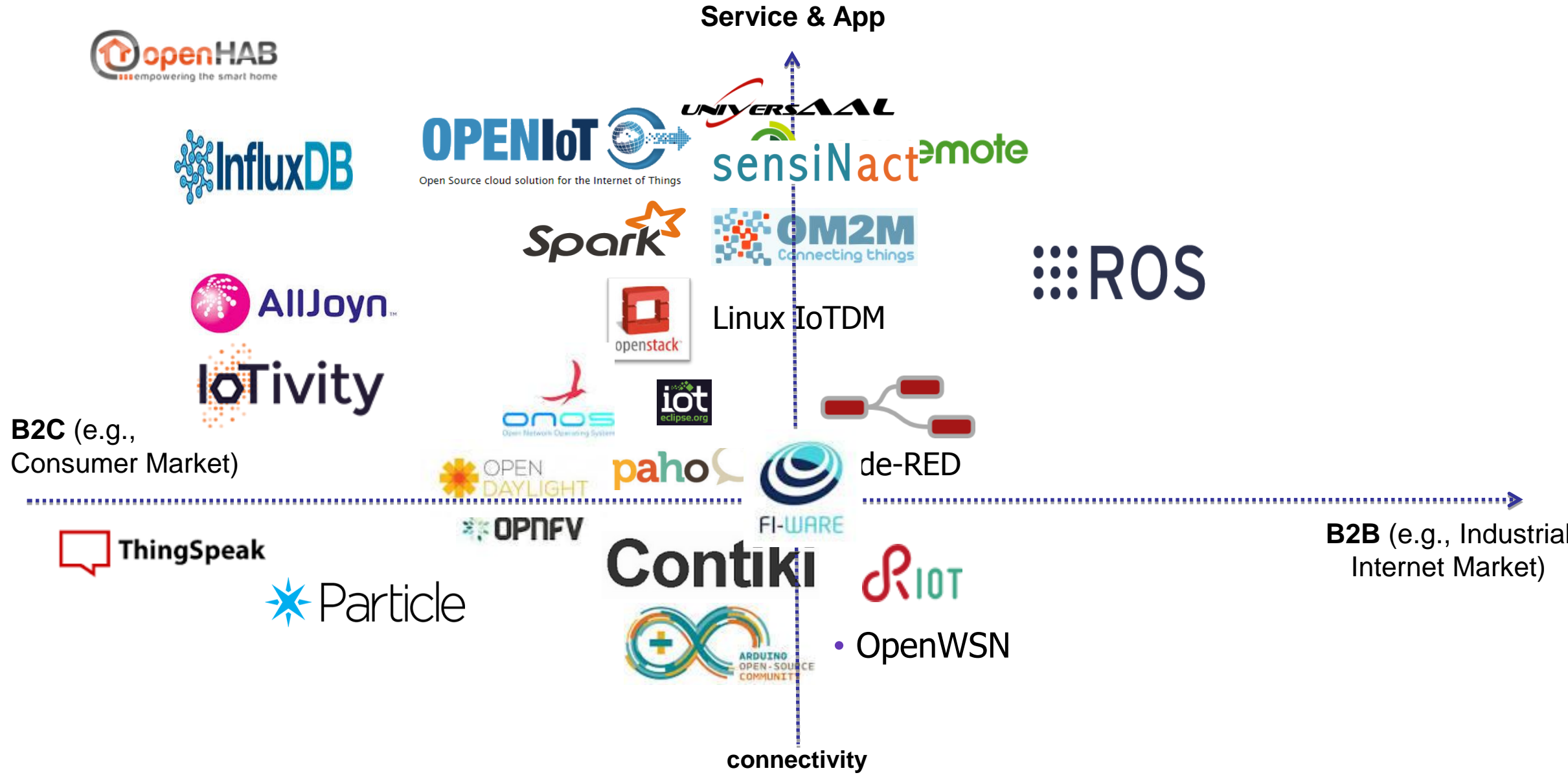
Wearables

Farming



Horizontal/Telecommunication

Open source initiatives (included input Pablo (v1) + Saied + Levent)

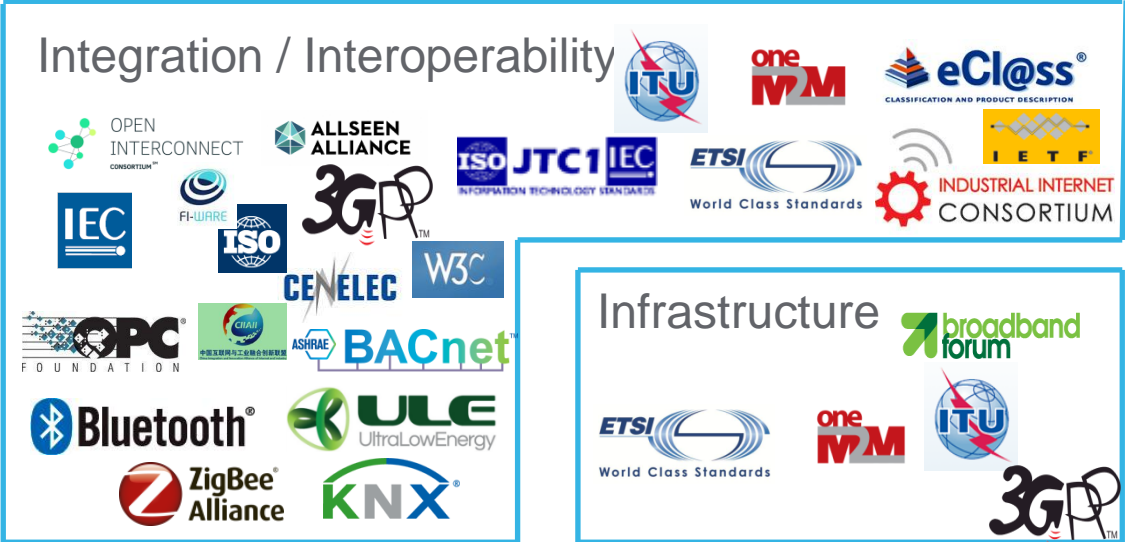


Previous slide is used and modified based on Angel's proposal

Security & Privacy

Applications

Integration / Interoperability



Infrastructure



Communication and Connectivity



Devices and Sensor Technology





IoT Architecture



Previous slide is used and modified based on Angel's proposal; comment Martin Serrano

Security & Privacy

Applications



Integration / Interoperability



Communication and Connectivity



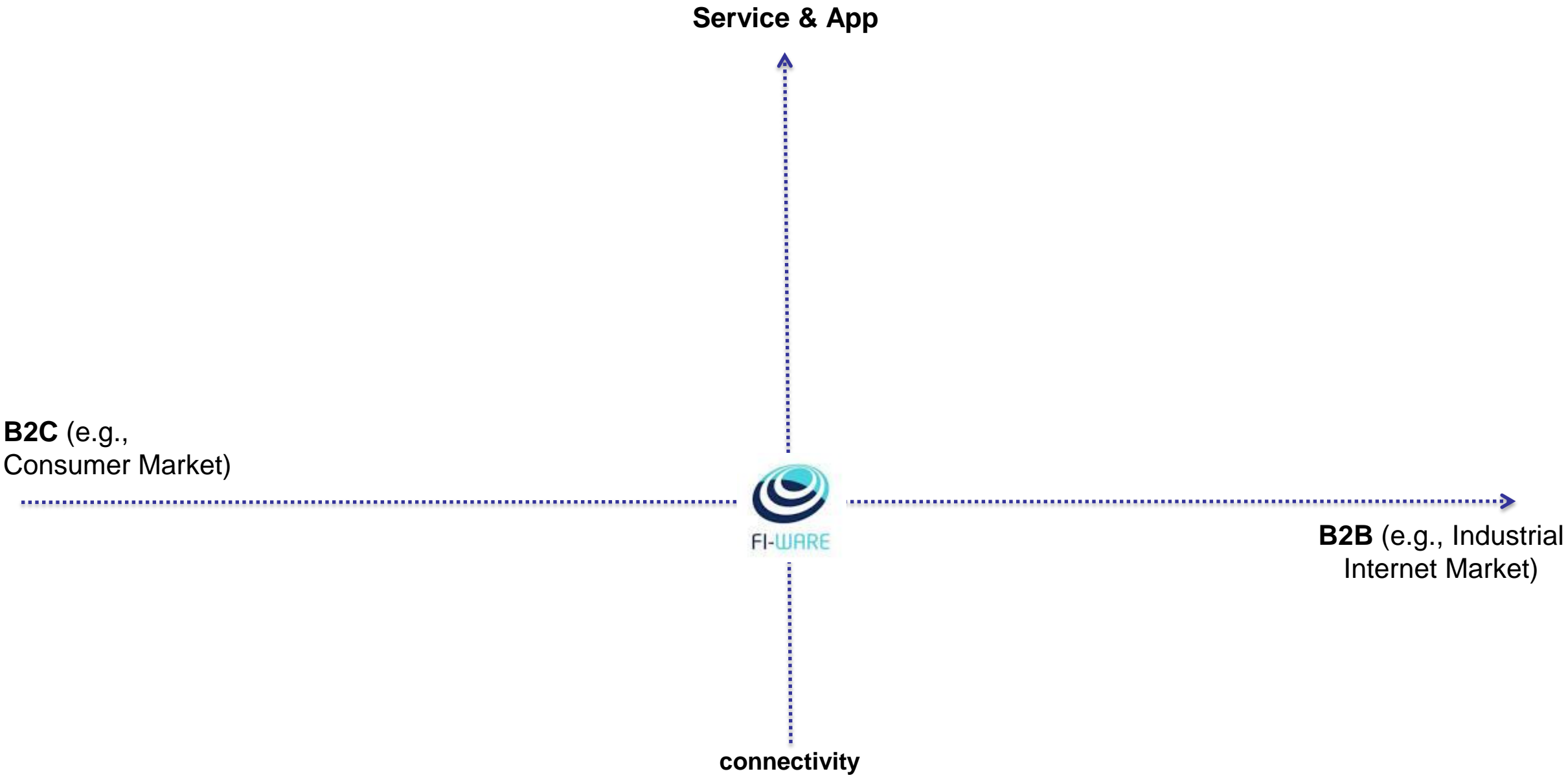
Devices and Sensor Technology



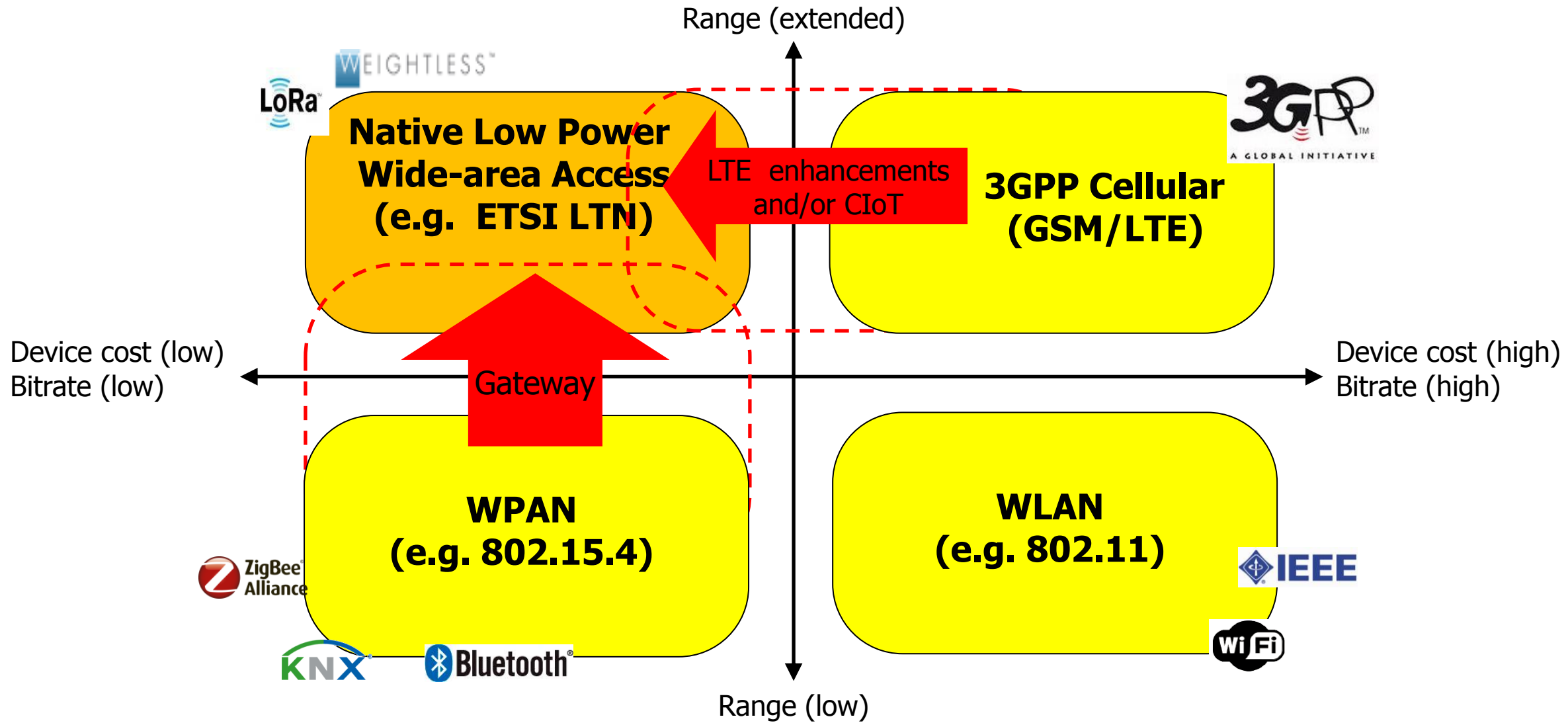
IoT Architecture



Project initiatives



Wireless connectivity trends to support IoT



Source: Alcatel-Lucent

OSS Projects (Device platforms: input Pablo)



Riot: real time OS for sensor networks (<http://www.riot-os.org/>)



Particle (formally Spark) is a complete, open source, full-stack solution for cloud-connected devices (<http://spark.github.io/>)



ROS (Robot Operating System) is a flexible framework for writing robot software (<http://www.ros.org/>)



Arduino: is an open-source electronics platform for interactive projects
<https://www.arduino.cc/>

OSS Projects (Connectivity: input Pablo)



IoTivity is an open source software framework hosted by The Linux Foundation enabling seamless device-to-device connectivity (<https://www.iotivity.org/>)



OpenWSN: open-source implementations of protocol stacks based on Internet of Things standards, using a variety of hardware and software platforms.



ThingSpeak ThingSpeak is an open source API to store and retrieve data from things using HTTP (<https://thingspeak.com/>)



Paho: client of MQTT and MQTT-SN messaging protocols (<http://www.eclipse.org/paho/>) part of eclipse Io

OSS Projects (Communications: input Pablo)



OpenDaylight: a controller infrastructure built for SDN deployments on heterogeneous multi-vendor networks (<https://www.opendaylight.org/>)



ONOS - a SDN network operating system (<http://onosproject.org/>)

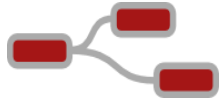


OPNFV: platform for the development of network function virtualization products and services (<https://www.opnfv.org>)

OSS Projects (Integration/Interoperability: input Pablo)



AllJoyn: framework for devices and apps to discover and communicate with each other (<https://allseenalliance.org/developers>) AllSeen Alliance



Node-
RED

Node-RED: a platform for building mashups combining, sensor, actuators and services (<http://nodered.org>) Backed by IBM.

OSS Projects (Architecture/Platform: input Pablo)



EclipseIoT: open source implementations of the standards, services and frameworks that enable an Open Internet of Things (<http://iot.eclipse.org/>)



OpenRemote: is a Open Source Middleware for the Internet of Things (<http://www.openremote.com/>)



WSO2 enterprise platform is a modular enterprise platform that provides all the capabilities needed for the server-side of an IoT architecture (<http://wso2.com/landing/internet-of-things/>)



Fi-ware: platform providing enhanced OpenStack-based cloud hosting capabilities plus a rich library of added-value functions offered "as a Service" (www.fiware.org)



OpenIoT is middleware infrastructure for collection and filtering information streams from the internet-connected objects (<https://github.com/OpenIotOrg/openiot>)

OSS Projects (Application / Services: input Pablo)



openHAB - a vendor and technology agnostic open source automation software for your home (<http://www.openhab.org/>)



Universaal: open platform that provides a standardized approach for Ambient Assisted Living Solutions (<http://www.universaal.org>)

OSS Projects (Generic, non IoT Specific: input Pablo)



Apache Spark is an engine for large-scale stream data processing (<https://spark.apache.org>)



InfluxDB is an open source distributed time series, metrics, and events database (<https://influxdb.com/>)



Open Stack: OpenStack software controls large pools of compute, storage, and networking resources throughout a datacenter (<https://www.openstack.org/>)

Segmentation of AIOTI WG3 Stakeholders

- 3GPP
- BBF
- FIWARE
- GS1
- GSMA
- Hyper/CAT
- IEC
- IETF
- IoT-A
- universAAL
- CAN in Automation (CiA)
- IRTF
- ISO/IEC JTC1 WG10
- ITU-T
- OIC
- oneM2M
- OMA
- OpenIoT
- ETSI (SmartM2M, ISG IP6)
- ULE Alliance
- W3C
- ZigBee
- OASIS (MQTT TC)

3GPP

- **Type of organization:** Partnership Program producing technical specification published by ETSI, CCSA, etc..
- **Domain:** Vertical – covering cellular communications from Phy to just below application layer (inc application layer in UICC)
- **Interoperability level:**
 - Protocols: Extremely tried and tested inter=operator/device interoperability
 - Application: Run on top of 3GPP stack, OS dependent APIs. ETSI ISG specifies pinout for modules
 - Semantic: No specified in 3GPP
- **Topology:** Global wide area cellular
- **System lifecycle:** depend on use cases both short and long lifecycles are targeted,
- **Description**
 - **Features:** Global coverage in licensed bands, very detailed specifications drive clean interoperability.
 - **Openness, maturity level, availability, adoption:** standards available for free download, global availability, open source implementations outside and independent of 3GPP. Certification programs run outside 3GPP
 - **Supported protocols:** Many
 - **IPR regime:** FRAND

BBF (BroadBand Forum)

Type of organization: SDO

Domain: horizontal and vertical

Interoperability level: connectivity, protocols, application area

Topology: all (device to device, local network, wide area)

System lifecycle : short and for some long

Description

Features: defines use cases and architectures used in the broadband wireline environment. For IoT, the most deployed BBF feature used in the IoT area is the BBF TR069 device management protocol.

Openness, maturity level, availability, adoption,

BBF specifications are freely open and available to public under IPR conditions

Security support: BBF is defining use cases and architectures that can be used for security support. The BBF TR069 device management protocol can be combined with security solutions provided by the IETF.

Privacy support: No specific activities are done in BBF regarding privacy for IoT.

Supported protocols: the device management TR069 protocol, i.e., CPE WAN Management Protocol (CWMP), which is a well deployed device management protocol

IPR regime: BBF IPR regime applies

FIWARE www.fiware.org

Type of organization: OpenSource consortium, key industrial players (including Engineering, ATOS & Telefonica) exploiting opensource components in their commercial smartcities propositions.

Domain: Horizontal, pretty successful in Smartcities domain, now introducing to other relevant domains such as SmartAgri and SmartRegions.

Interoperability Level: Capable to integrate any IoT “southbound” technology with non-IoT sources (Multimedia components, CKAn OpenData, Bigdata analytics, etc) and plug sensor data and actuation capabilities to a ContextManagement broker (based on OMA-NGSI standard), which is the unique API exposed to (web)-developer. We will be glad to consider the integration of any relevant IoT framework considered within AIOTI in the FIWARE ecosystem (e.g. OneM2M MCA)

Topology: IoTdevices/gateways <-> IDAS (FIWARE IoT-Agent) <-> Orion (FIWARE ContextBroker) <-> Developers

System Lifecycle: All lifecycle is covered, including non-IoT resources.

GS1 (<http://www.gs1.org>)

- **Type of organization:** SDO. GS1 is an international federation of not-for-profit organisations established in 112 countries. GS1 provides standards for the identification of goods, parties and items, for the automatic data capture using barcodes and RFID and for the electronic sharing of information.
- **Domain:** both horizontal and domain specific in retail & consumer goods, healthcare and transport & logistics
- **Interoperability level:** all different levels, the GS1 system of standards provides a global language of business
- **Topology:** application to application
- **System lifecycle :** both short and long lifecycles
- **Description**
 - **Features:** The GS1 system architecture describes a coherent set of standards around the Identify, Capture, Share pillars.
 - **Openness, maturity level, availability, adoption:** GS1 was founded 40+ years ago. Today's (2015) global membership is approximately 1,3 million companies. Standards are available publicly and freely.
 - **Security support:** Security addressed where relevant
 - **Privacy support:** Privacy addressed, especially for RFID, see <http://www.gs1.org/pia>
 - **Supported protocols:** Several
 - **IPR regime:** Royalty fee or RAND, see <http://www.gs1.org/ip>

GSMA – Connected Living – IDE Project

Type of organization: SDO (<http://www.gsma.com/connectedliving/>) The GSMA Connected Living programme is an initiative to help operators add value and accelerate the delivery of new connected devices and services in the Machine to Machine (M2M) market.

Domain: both Horizontal and domain specific (e.g. Smartcities, SmartAgri)

Interoperability Level: addressing IoT data interoperability for Telecom Operators. As long as there are too many IoT propositions (and more expecting to arrive) the interoperability framework is provided at an upper layer (ContextManagement) which has the benefit to smoothly integrate different IoT propositions and also non-IoT resources (which are far from IoT protocols). Developers are presented IoT and non-IoT resources in the same way and with the same API.

Topology and Description: The showcase to be presented at the next Mobile World Congress in 2016 will be based on FIWARE opensource components (**see next slides for details**).

Hyper/CAT

Type of organization: Not-for-profit Foundation, managing an Open-Source standard

Domain: completely horizontal

Interoperability level: addresses interoperability at the interface between the internet Client and the internet Server. It provides any Client with a standard API to discover IoT resources that it understands in any Server. Hyper/CAT does not have its own semantics - it points at existing ontologies using URI's.,

Topology: all (device to device, local network, wide area). Hyper/CAT is a Client-Server API which is typically used over the internet, at any scale. However its fundamental data format is transport-agnostic.

System lifecycle : short and long

Description

Hyper/CAT is a modern, RESTful Web API.

Features: Hyper/CAT provides any IoT Client with a standard API to discover resources that it can understand in any Service. It therefore enables a "many-to-many" relationship between IoT Clients and IoT Servers, helping to drive a network effect and reduce the friction to creating value webs.

Openness, maturity level, availability, adoption : Hyper/CAT is completely open - freely available with a permissive open-source license. It was originally created in 2013, and stands at version 1.1. A new Version 2.0 is now in draft form, which adds some new features in areas such as Subscription, Search, Security and Data Licenses. It has been adopted by 40+ companies and is endorsed by 400+ companies.

Security support: Hyper/CAT provides various Security features, including authentication and provenance, based on existing standards.

Privacy support : Hyper/CAT does not currently have any privacy-specific features

Supported protocols : HyperCat makes widespread use of common Web standards. The Hyper/CAT file format is JSON. An HTTP transport is defined, though any transport can be used.

IPR regime: The IPR regime is permissive open source, with the HyperCat brand being enforced by the Hyper/CAT Foundation.

• IEC (International Electrotechnical Commission)

- **Type of organization:** SDO
- **Domain:** mainly vertical (Industry Automation, Energy, Machinery, fibres/cables/wires, household appliances, healthcare, electrical road vehicles, railways, AV & multimedia, safety, dependability, security)
- **Interoperability level:** plugs & wires, equipment, connectivity, protocols, application area, data models
- **Topology:** all (device to device, local network, wide area)
- **System lifecycle :** long to short

- **Description**
 - **Covers all electrotechnical aspects from plugs, wires, voltage levels to automation, control and management.**
 - **Openness, maturity level, availability, adoption,**
 - **Participation is open via the national committees, Specifications are openly available for a fee**
 - **Various mature standards are available that are widely adopted in the industry**
 - **Security support: Has an advisory committee on security (ACSEC) and security specific working groups and specifications in some technical committees (e.g. TC57 Energy Management IEC 62351, TC65 Industry Automation IEC 62443).**
 - **Privacy support: Part of security work.**
 - **Supported protocols: various: e.g. IEC61850, IEC 61968/61970 (CIM), XMPP, DLMS/COSEM, OPC-UA, various field buses**
 - **IPR regime: ISO/IEC/ITU IPR regime applies (FRAND)**
 - **Important committees & groups: SC3D Product properties and classes and their identification, TC 8 Systems aspects for electrical energy supply, TC13 Electrical energy measurement and control, TC 57 Power systems management and associated information exchange, TC65 Industrial-process measurement, control and automation, SG8 Industry 4.0 - Smart Manufacturing, SG 9 Communication Technologies, SG10 Wearable Smart Devices, SyC Smart Energy, SyC Active Assisted Living, SEG1 Smart Cities, SEG5 Electrotechnology for mobility, SEG6 Non-traditional Distribution Networks / Microgrids**

IETF (<https://www.ietf.org/>)

Type of organization: SDO. The mission of the IETF is to make the Internet work better by producing high quality, relevant technical documents that influence the way people design, use, and manage the Internet. The IETF Mission Statement is documented in [RFC 3935](#). The IETF has an IOT directorate to deal with IOT specificities.

Domain: horizontal, covering all domains where the Internet and Internet Protocols are relevant.

Interoperability level: connectivity, transport/application protocols

Topology: device to device, local network, wide area

System lifecycle : short, long

Description

Features: Offers a complete suite of Internet Protocols. Some examples are:

application layer specification activities in the WG CORE (COAP protocol)

Network layer specification activities in the WGs 6lo, 6tisch and ROLL

Security specification activities in ACE and DICE

Openness, maturity level, availability, adoption: It is open to any interested individual.

Worldwide adoption of RFCs. Freely available to anyone. The IETF Standards Process is described in

[The IETF Standards Process](#) (see also [RFC 2026](#)).

Security support: Yes, Security considerations are part of the RFC process.

Privacy support: No specific activities are done in IETF regarding IOT privacy

Supported protocols: Defining Internet Protocols. Related to Layer 3 and 4 of the OSI model.

IPR regime: The IETF intellectual property rights rules are defined in RFC 3979 « Intellectual Property Rights in IETF technology » (updated by RFC4879).

IoT-A (Internet of Things Architecture)

- **Type of organization:** EU-funded project
- **Domain:** horizontal
- **Interoperability level:** Architectural, connectivity, protocols, semantic,
- **Topology:** all (device to device, local network, wide area)
- **System lifecycle :** long

- **Description**
 - **Features:** Architectural Reference Model, composed by a Reference Model (abstract framework for understanding significant relationships among entities), a Reference Architecture (design patterns that indicates how an abstract set of relationships realises a set of requirements) and a number of technological bricks bridging different efforts.
 - **Openness, maturity level, availability, adoption,**
 - **IoT-A is completely open. The latest version (3.0) is considered mature, and as used in industrial projects.**
 - **Security support:** IoT-A developed a security model, several security procedures at communication level, and several security algorithms at device level
 - **Privacy support As an architectural choice.**
 - **Supported protocols:** at architectural level, all. IoT-A developed also software for gateways and protocol translators (HTTP/COAP, IPv6/6LowPAN, ...)
 - **IPR regime:** n/a

IRTF (Internet Research Task Force)

- **Type of organization:** research part of IETF (pre-SDO)
- **Domain:** horizontal and vertical
- **Interoperability level:** connectivity, protocols,
- **Topology:** all (device to device, local network, wide area)
- **System lifecycle :** short and long

- **Description**
 - **Features: IoT related work on:**
 - **Thing to Thing Research Group (T2TRG), which is not yet an official IRTF defined Research Group, since it started few months ago. T2TRG focuses on issues related to IoT semantic interoperability, IOT management using restful type of protocols and security an privacy.**

 - **Openness, maturity level, availability, adoption,**
 - **IRTF is open and all its output is open.**

 - **Security support: The IRTF T2TRG is focusing among others on security and privacy related issues.**

 - **Privacy support: : The IRTF T2TRG is focusing among others on security and privacy related issues.**

 - **Supported protocols: the IRTF will investigate all IP related protocols on issues related to IoT semantic interoperability, IOT management using restful type of protocols and security an privacy.**

 - **IPR regime: based on IETF IPR regime, see RFC 3979**

ISO/IEC JTC 1/WG 10

- **Type of organization:** SDO
- **Domain:** horizontal, covering various domains like smart home, smart building, retail, smart metering, healthcare
- **Interoperability level:**
 - Connectivity between heterogeneous communication protocols (this may be changed in the future)
 - Application protocols (through own work or through referencing by liaison report to the work of other SDO's)
 - Service and applications (through own work or through referencing by liaison report to the work of other SDO's)
- **Topology:** local area, wide area
- **System lifecycle:** depend on use cases both short and long lifecycles are targeted. E.g. a smart meter will stay for many years, while the smart home equipment can have a shorter life.
- **Description**
 - **Features:**
 - providing guidance to facilitate the design and development of IoT Systems
 - promoting open and common guiding architecture leading to seamless interoperability of IoT Systems
 - making IoT Systems' components plug-and-play, so that it becomes easy to add/remove IoT Systems components to/from the IoT Systems
 - **Openness, maturity level, availability, adoption:** open to ISO NBs, 162 members (increasing), under development
 - **Supported protocols:** Not specified (this may be changed in the future)
 - **Security support:** Supported by various security mechanisms (to be performed through liaising to ISO/IEC JTC1/SC31 and especially ISO/IEC JTC1/SC27)
 - **IPR regime:** RAND

ITU-T (<http://www.itu.int/en/ITU-T/Pages/default.aspx>)

- **Type of organization:** SDO. The Study Groups of ITU-T assemble experts from around the world to develop international standards known as [ITU-T Recommendations](#) which act as defining elements in the global ICTs. Standards are critical to interoperability of ICTs and enable global communications by ensuring that countries' ICT networks and devices speak the same language. ITU-T works on consensus and has tools to ensure internal coordination as well as coordination and collaboration with external organizations such as SDOs, Alliances.
- **Domain:** both horizontal and domain specific (e.g. e-health, smart cities, others)
- **Interoperability level:** all different levels, from connectivity to transport and application protocols. Semantic level interoperability is being currently addressed in IoT activities.
- **Topology:** device to device, local network, wide area
- **System lifecycle :** both short and long lifecycles are targeted (tool flexibility to manage that)
- **Description**
 - **Features:** ITU-T addresses the different layers of ICT infrastructures for both horizontal and application domain specific perspectives, a large variety of stakeholders are involved (private sector, public institutions and administrations, universities, regulators).
 - **Openness, maturity level, availability, adoption:** Openness of standardization process and products is a basic ITU-T principle. Standards approval process declares their maturity. Standards developed for the IoT cover different topics (with different levels of depth according to members' focus and contributions). Standards produced by ITU (ITU-T Recommendations) are currently available without charge. ITU-T Recommendations are non-binding, however they are generally complied with on a worldwide scale.
 - **Security support:** Security is always addressed (mandatory in Recommendations), studied by matter-specific expert groups as well as, more generally, within the Leading Study Group on Security. This applies also to IoT.
 - **Privacy support:** Same considerations than for Security support apply.
 - **Supported protocols:** ITU-T deals with protocol support at the different layers.
 - **IPR regime:** All details can be found at <http://www.itu.int/en/ITU-T/ipr/Pages/default.aspx>

OIC

- **Type of organization:** Industry consortium producing technical specifications
- **Domain:** horizontal, covering service specific device communications between device and communication infrastructure
- **Interoperability level:**
 - Protocols: Specs to be released soon
 - Application: Specs to be released soon
 - Semantic: Specs to be released soon
- **Topology:** local
- **System lifecycle:** depend on use cases both short and long lifecycles are targeted
- **Description**
 - **Features:** Specs to be released soon.
 - **Openness, maturity level, availability, adoption:** Linked to IoTivity open source project in the LINUX forum
 - **Supported protocols:** Specs to be released soon
 - **IPR regime:** Free

oneM2M

- **Type of organization:** SDO producing technical specification published by ETSI, ATIS, etc..
- **Domain:** horizontal, covering a service layer between application and communication infrastructure (data collection, device management, semantic discovery, access control policies, etc.)
- **Interoperability level:**
 - Protocols: oneM2M does not develop application protocols, however specifies data structures to be transported by such protocols. The service layer is exposed to application by means of Restful APIs
 - Application: oneM2M defines APIs that are exposed to applications (cloud, device, gateway)
 - Semantic: allows to describe data according to ontologies, semantic discovery, etc. Domain specific ontologies are not specified in oneM2M, however one M2M defines mapping rules to oneM2M data structures.
- **Topology:** local, wide area (no support for D2D, interworking with AllSeen)
- **System lifecycle:** depend on use cases both short and long lifecycles are targeted, oneM2M is targeting multi-services
- **Description**
 - **Features:** data collection, data sharing, publish subscribe, device management, security at service level, privacy via access control policy, etc.
 - **Openness, maturity level, availability, adoption:** standards available for free download, initial commercial deployments, 3 open source implementations including from Linux and Eclipse. oneM2M is having initial interoperability events, ongoing discussions to build a certification program
 - **Supported protocols:** CoAP, HTTP, LWM2M, OMA DM (management), BBF (management)
 - **IPR regime:** FRAND

OMA (Open Mobile Alliance)

- **Type of organization:** Alliance working on Lightweight M2M, a standard for device management and service enablement
- **Domain:** horizontal,
- **Interoperability level:**
- **Topology**
- **System lifecycle:** depend on use cases both short and long lifecycles are targeted, oneM2M is targeting multi-services
- **Description**
 - OMA "Lightweight M2M" (standard for device management and service enablement) will play an important role in the Internet of Things. Furthermore, OMA has created a few more standards which are already used in M2M scenarios e.g. OMA DM (Device Management).

- **Type of organization:**
OpenSource Consortium and moving to OpenIoT Foundation.
Supporting IoT Stack Implemented Platform,
Consultancy (Industry and Academia), IoT Lecturing and
Project Support Services.
- **Domain:** horizontal, covering core domains like Smart Cities, Large Scale Deployments, Smart Agrifood, Smart Building, Manufacturing and Logistics, Assistance Living.
- **Interoperability level:**
 - Connectivity from Device Level: Device/Sensor Registry via Schema Editor
 - Application: data aggregation, exchange of information, and services discovery via linked Data using Resource Description Framework (RDF).
 - Semantic: Device/Sensor Annotation, Data Modeling
Implemented semantic interoperability between different Service/Data Silos
- **Topology:** Machine to Machine. A Gateway-like configuration using GSN, currently looking for developing toolkits to simplify topology and expand domain-specific application.

- **System lifecycle:** Full service lifecycle deployed based on IoT Stack
Annotation, Transformation, Registration, Discovery, Design, Deployment and Execution
- **Description**
 - **Features:**
 - Open Source Platform,
 - Horizontal approach focused on semantic interoperability and service deployment
 - Available on Binaries and SDK working and Toolkit for oneM2M Version In progress
 - **Openness, maturity level, availability, adoption:** Consortium with an open Source community with more than 1000 hits/downloads and industry targeted projects.
 - **Supported protocols:** Protocol agnostic but up to date tested with REST, COAP working on IPV6
 - **Security support:** Security by Design : security at all IoT Stack levels via Control Access Server
 - **IPR regime:** Open Source for Core Components and contract basis for extensions.

ETSI SMARTM2M (former M2M)

- **Type of organization:** SDO. ETSI technical committees works on a consensus basis, and allow experts from around the world to meet as to build international standards (TS + TRs) often chronologically organized in Releases insuring inter-release compatibility, in the global domain of ICT. Interoperability is key for all ETSI developments. For M2M and IOT there are two other key requirements concerning Security and Openness. ETSI_M2M has not "reinvented the wheel" and thus has used intensively standards from other bodies (ex: OMA DM, or BBF TR069). ETSI hosts 3GPP and since 2013 oneM2M_PP, which insure consolidation of work done in regional SDOs. Last but not least, ETSI, as CEN and CENELEC, is mandated by EC to write ENs (European Norms). ETSI M2M and now SmartM2M has been participating to some European mandates with CEN and CENELEC (ex M441-Smart Metering, M490-Smart Grid, M468-EV Charging,...) and EC initiatives and Workshops (ex IOT, Smart Appliances, ...)
- **Domain:** horizontal : defines services and applications interfaces through 3 domains for M2M Area : Device, Network and Applications
- **Interoperability level:** Mainly at the service level : 3 interfaces and APIs (North, South and Middleware). different levels, from connectivity to transport and application protocols. Semantic level interoperability is being currently addressed through Smart Appliances work (with EC). An Interoperability event is scheduled in September.
- **Topology:** M2M Area Networks / Networks / Applications
- **System lifecycle :** both short and long lifecycles (tools)
- **Description**
 - **Features:** The M2M standard describes Requirements and Use cases, a functional architecture and related protocols at the 3 interfaces, with related APIs
 - **Openness, maturity level, availability, adoption:** **M2M** Release 1 in 2012, M2M release 2 in 2013, Open Source code with basic functionalities available by one partner under ECLIPSE, pre tutorial work in M2M, structured tutorials in oneM2M
 - **Security support:** Security addressed
 - **Privacy support:** Privacy not specifically addressed in M2M, but considered in mandated work
 - **Supported protocols:** Several (TR069, DM, ...)
 - **IPR regime:** FRAND

ULE Alliance (<http://www.ulealliance.org/>)

- **Type of organization:** Alliance. The ULE Alliance is an international alliance with the scope to promote the worldwide allocation and market adoption of the ULE technology. The ULE Alliance is producing Application Layer specifications as well as Reference Implementations of the same. For the transport layer the ULE Alliance is working closely together with ETSI where the underlying DECT und ULE standard is defined.
- **Domain:** both horizontal and domain specific. Strong in Retail and Operators business.
- **Interoperability level:** ULE provides interoperability on Transport Layer as well as the Application Layer. A Device level certification ensure interoperability between different device vendors.
- **Topology:** Wireless Network, Simple Star Topology with repeaters where required.
- **System lifecycle :** both short and long lifecycles
- **Description**
 - **Features:** Low Power, long range (In house 50m/outdoor 500m) wireless communication system. Supporting packet mode for sensors and actors, but also voice and video (low profile) support.
 - **Openness, maturity level, availability, adoption:** Based on ETSI Standard for the transport layer (available, free to use). Application layer with profiles available for device end to end interoperability (available, free to use).
 - **Privacy support:** Privacy addressed, all communication is AES encrypted and Message Integrity ensured, encrypted broadcast channel
 - **Supported protocols:** HAN FUN as native ULE Application Layer protocol, 6LoWPAN by Q1/2016
 - **IPR regime:** Royalty fee

W3C (www.w3.org)

- **Type of organisation:** Member funded SDO.
 - W3C mission is to lead the World Wide Web to its full potential by developing protocols and guidelines that ensure the long-term growth of the Web
- **Domain:** mostly horizontal
 - We do have some vertical related groups, e.g. for payments, mobile, TV and automotive
- **Interoperability level**
 - document formats, APIs, app layer protocols, best practices
- **Topology:** device to device, local network wide area
- **System lifecycle:** ?
- **Description**
 - **Features:** broad suite of Web technology Recommendations (our term for our standards)
 - **Openness, maturity level, availability, description:** archives, drafts and standards are publicly available, globally distributed effort, internationally applicable
 - **Security support:** Yes, W3C has a strong emphasis on security considerations
 - **Privacy support:** Yes, W3C has a strong emphasis on privacy considerations
 - **Supported protocols:** Recognition that different protocols are needed in different contexts
 - **IPR regime:** Royalty Free licensing commitments for implementations of W3C Recommendations

ZigBee Alliance

- **Type of organization:** Alliance producing technical specifications, and making product certification
- **Domain:** horizontal, covering various domains like smart home, smart building, retail, smart metering, healthcare
- **Interoperability level:**
 - Connectivity up to transport layer, enabling true interoperability between different platform vendors
 - Application: layer defining protocols for interaction between products on the same network
 - Semantic: data model (ZigBee Cluster Library) for product interoperability. Interoperability is checked through certification program
- **Topology:** device to device, local area. A Gateway is needed and specified for internet/remote connection
- **System lifecycle:** depend on use cases both short and long lifecycles are targeted. E.g. a smart meter will stay for many years, while the smart home equipment can have a shorter life.
- **Description**
 - **Features:** network technology enabling to connect low power/low data rate products in a meshed network with Application layer for reporting data, sending /receiving commands in a client/server mode. Typical battery life is 5-10 years. Capability to connect ULP devices with energy harvesting for autonomous sensors
 - **Openness, maturity level, availability, adoption:** 400 members, many competing platforms, mature with 100s of Millions products deployed in Smart meters, lighting, or Smart Home in particular. Adopted by "the connected lighting Alliance". Data link layer for BACnet.
 - **Supported protocols:** ZigBee protocols based on ZigBeePRO stack (non IP). Collaboration with Thread Group for having the ZCL running over Thread stack
 - **Security support:** native from the beginning: security at all levels (link, network, application), AES 128 encryption, ECC
 - **IPR regime:** RAND

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Type of organization: OpenSource consortium led by Fraunhofer IGD, with the core team mostly from research and a growing ecosystem consisting of piloting initiatives (currently 13 in 8 countries), 20+ joined SMEs, one spin-off, few industrial players

Domain: Horizontal, with concrete success stories in smart living environments (Ambient Assisted Living) and care and health service provision.

Interoperability Level: semantic interoperability at the level of communication protocols in a service-oriented environment by avoiding domain-specific APIs and effectively reducing syntactical dependencies to one single brokerage API

Topology: arbitrary graphs of P2P networks providing for open horizontal service integration layer across all verticals (unified programming model for all levels of integration, from special-purpose devices, such as sensors and actuators, to “platform components” to applications)

System Lifecycle: covered phases: system conception (unified pattern), design and development (unified pattern and API), integration (inherent), deployment (e.g. support for configuration / customization and flexibility in the distribution of components), operation (e.g., open extensibility & adaptability), and maintenance (e.g., dynamic changes, admin facilities)

IOT Activities: (1) Semantic Interoperability (see domain + IOP-Level above, ISO layers 5/6/7), (2) High-level Architecture (see domain + IOP-Level + Topology + Lifecycle above)

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Description

Features: open service integration, common mechanisms for security / user interaction & accessibility ([IEC PAS 62883](#)) / intelligent behaviour / ..., common tools for development, deployment & maintenance

Openness, maturity level, availability, adoption: open (open API, open scope, open documentation, open source, open community), available, adopted in real life, main API existing since 2008 benefiting from related research since 1999

Security support: a few mechanisms at a few levels

Privacy support: the security mechanisms directed at trust and control; negotiations running with UMA experts (User-managed Access) on tools supporting privacy-awareness of users

Supported protocols: ZigBee, KNX, Bluetooth, PLC, EnOcean, SIP, FS20 (others in making by a “gateway-ontology-integrator” pattern ([ontology-integrator relationship 1:1](#), [gateway-ontology relationship n:m](#)) → sharing gateways across integrators as well as sharing integrators across gateways)

IPR regime: Apache Software License 2.0

CAN in Automation (CiA)

Type of organization: Not-profit users' and manufacturers' group, managing CAN-related standards such as CANopen

Domain: Access to embedded CANopen networks in various application domains such as medial-, rail vehicle-, commercial vehicle-, automotive-, building-, power generation- and further applications.

Interoperability level: addresses interoperability at the interface between the internet Client and the internet Server. Any Client with a standard API is enabled to discover IoT resources in CANopen networks. Therefore the gateway hosts the application server that maps URI-object requests to CANopen and provides a network tree in XML format.

Topology: all (device to device, local network, wide area); access from the cloud to CANopen networks

System lifecycle: long; as hardware independent

Description

Based on the existing and well-proven CANopen standard and additional CANopen application layer functions, CiA CANopen IoT activities enable access from "cloud-solutions" to CANopen networks for the purpose of diagnostics, configuration, commissioning and remote control.

Features:

- Connectivity on device level; device registry registry via XML editor
- Data aggregation, exchange of information, service discovery

Openness, maturity level, availability, adoption :

- The solution is based on existing and well-proven CANopen standards and CiA specifications. Some of them are available for free; others for RAND conditions at CiA.
- The CiA SIG CANopenIoT is working on the concept of integrating CANopen networks in the world of IoT. The work has not been finalized, yet.

Security support: Security support under development

Privacy support : Privacy support under consideration

Supported protocols : CANopenIoT makes widespread use of common Web standards. The CANopen file format is XML and XML-based Nodelist.graphML.

IPR regime: RAND

OASIS

Type of organization: nonprofit consortium that drives the development, convergence and adoption of open standards for the global information society.

Domain: OASIS promotes industry consensus and produces worldwide standards for security, Internet of Things, cloud computing, energy, content technologies, emergency management, and other areas. OASIS open standards offer the potential to lower cost, stimulate innovation, grow global markets, and protect the right of free choice of technology. One of the main TCs in the area of IoT is: **Message Queuing Telemetry Transport (MQTT)** .

Interoperability level

Topology:

System lifecycle:

Description

Based on the existing and well-proven CANopen standard and additional CANopen application layer functions, CiA CANopen IoT activities enable access from “cloud-solutions” to CANopen networks for the purpose of diagnostics, configuration, commissioning and remote control.

Features:

- Connectivity on device level; device registry registry via XML editor
- Data aggregation, exchange of information, service discovery

Openness, maturity level, availability, adoption :

Security support:

Privacy support :

Supported protocols : MQTT (Message Queuing Telemetry Transport) which is a lightweight publish/subscribe reliable messaging transport protocol suitable for communication in M2M/IoT contexts where a small code footprint is required and/or network bandwidth is at a premium

IPR regime: