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IntellioT

Deliverable D6.4
Standardization (first version)

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EXECUTIVE SUMMARY

The IntellIoT deliverable D6.4 is the preliminary deliverable reporting the Standardization activities following by IntellIoT described in Task 6.4 between M12 to M18. The objective of this document is therefore to report on suitable standards investigated during that period.

As a preliminary document (6 months since the beginning of Task 6.4), it provides a brief overview of key Standards Development Organisations (SDOs), identify a subset, which closely match IntellIoT development and finally describes standardization events to which IntellIoT contributed.

The final version of this document will include a gap analysis between existing standards and IntellIoT requirements, descriptions of specific contributions to SDOs and finally detailed reports on standardization event participations.

1 INTRODUCTION

1.1 Objectives

The 'Standardization' Task 6.4 is part of the Impact, Dissemination and Standardization WP of the IntellIoT project. Task 6.4 started on M13 and will be completed at the end of the project. The objective of T6.4 is to globally coordinate the standardization activities of the IntellIoT project. It will identify standards gaps and, when judged adequate propose contributions aimed to fill them. It will contribute to relevant Standard Development Organizations (SDO) bodies among the different IntellIoT WPs and tasks to provide a coherent impact of the IntellIoT project. Task 6.4 provides deliverables D6.4 (this document) and D6.10.

Starting T6.4 at M13 is mostly due to leave enough time for the IntellIoT WP2 activities (in particular D2.2 - Technology analysis & requirements specification) to specify the technological areas targeted by the project and the state-of-the-art contributions it will try to make. Based on this technology roadmap, T6.4 will try to identify the respective SDOs that IntellIoT needs to monitor and file proposals to advance or extend the standards they supervise.

Figure 1 provides a preliminary standardization roadmap until M18 of T6.4 for two identified key SDOs, 5G-ACIA and 5G 3GPP. Building on top of D2.2 delivered in M6, SIEMENS and EURECOM contributed to 5G ACIA activities, which SIEMENS is a member.

As founding member of the OpenAirInterface Software Alliance (OSA)[1] and related Open 5G software platform, EURECOM closely follows 3GPP activities and whenever coherent, also contributes to it. Accordingly, EURECOM provided an overview of the 5G (rel.15 and rel.16) and 5G+ (rel.17-18) standards that are related to the IntellIoT platform, in particular the interaction between the 5G components and the other components such as AI/ML, TSN, IoT or Edge management.

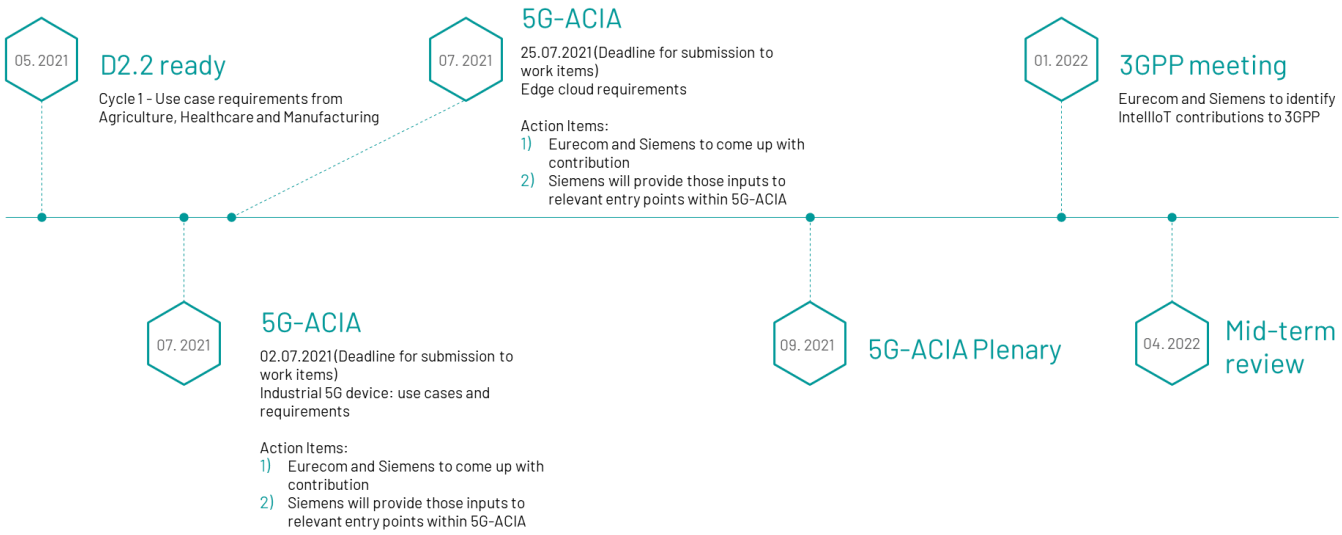

Figure 1 Standardization Roadmap for 3GPP and 5G-ACIA

[1] https://openairinterface.org/

Although it is not shown in Figure 1, EURECOM, SIEMENS and HSG followed W3C (the World Wide Web Consortium) in particular its Web-of-Things (WoT) activities, as WoT is central to the IntellIoT distributed edge orchestration and TTC followed IEEE activities related to TSN.

The rest of this document is organized as follows. Section 2 provides a rapid overview of SDOs related to IntellIoT activities. Section 4 focuses on specific SDOs identified where IntellIoT followed and plan to actively contribute. Finally, Section 5 reports on SDO events to which IntellIoT T6.4 partners participated.

2 SDO OVERVIEW RELATED TO INTELLIOT

IntellIoT is envisioned as a reference architecture for next generation IoT. To achieve its full potential in that regard and drive adoption of its proposed technologies and concepts, it needs to actively participate in standardization efforts both at the European area and globally. As such, IntellioT partners have been actively contributing the project results to SDOs and are engaged in a series of working groups realted to existing and emerging standards. The next subsection highlights those SDOs that IntellIoT is targeting.

2.1 Alliance for IoT Innovation (AIOTI)

The AIOTI was launched by the European Commission and various key IoT players, such as SIEMENS, to give EU the lead in the IoT field by creating a European IoT ecosystem. The IoT Standardisation Working Group aims to address existing IoT standards, analyse gaps, and develop strategies and use cases for consolidation of architectural frameworks and (semantic) interoperability. The IntellIoT project has aligned its activities and contributes to the IoT Standardisation WG03 and Innovation Ecosystems WG02. Specifically, our goal is to promote the HyperMAS and the associated semantic models for artefacts and things towards AIOTI.

Moreover, the three IntellIoT vertical use cases on agriculture, healthcare, and manufacturing have been aligned with "WG06 - Smart Farming and Food Security", "WG05 - Smart living for ageing well", and "WG11 – Smart Manufacturing" of AIOTI, respectively.

2.2 World Wide Web Consortium (W3C)

W3C is the international community that develops open standards to ensure the long-term growth of the Web. The W3C **Web of Things** Working Group (WoT WG) aims to accelerate the development of IoT applications by defining a description format for Things and APIs to interact with them. SIEMENS and EURECOM are founders of this group and have already exploited the current results on the Thing Description to flexibly integrate IoT devices into IoT applications defined through IntellIoT's MAS.

SIEMENS, EURECOM, and HSG will continue their contributions to the W3C WoT WG with work on the semantic models for things and artefacts and on interoperability challenges for physical, Web-connected, devices. HSG will contribute to define a charter for a future standardization group on MAS and will submit key findings of IntellIoT as a W3C Member Submission.

2.3 3rd Generation Partnership Project (3GPP)

3GPP is the international standard development organisation for cellular technology. 3GPP leads the development of 5G over releases with the aim to provide a harmonized architecture for various verticals. The IntellIoT project will closely interact with the 3GPPP by monitoring the latest Work Items (WIs) in rel. 16 and rel. 17 and integrating selected features in EURECOM's OpenAirInterface. EURECOM will contribute IntellIoT findings to the 5G smart factory, Wireless TSN V2X, Extended Relays WIs at 3GPPP. SIEMENS will contribute with extended requirements from IntellIoT.

2.4 European Telecommunications Standards Institute (ETSI)

ETSI is an independent non-profit standardization organization in the telecommunications industry in Europe. It shapes in its MEC-related standards an open environment, which allows the efficient and seamless integration of applications from different providers across multi-vendor Multi-access Edge Computing platforms. For IntellIoT, interoperability between MEC platforms and deployed IoT applications will be critical. Learning from IntellIoT's work on dynamic infrastructures for IoT environments, EURECOM will contribute here to define capabilities of MEC platforms for direct communication to provide a localized IoT context between MEC and IoT devices.

2.5 IEEE Standardization Association

This organization within IEEE develops global standards in a broad range of industries. One of the IEEE standards that will be important for IntellIoT will be the IEEE 802.1 Time-Sensitive Networking (TSN): This is the set of IEEE 802 Ethernet sub-standards defined by the IEEE TSN task group, where TTTech (parent of TTC) is a member. The standards describe mechanisms for improved or guaranteed real-time delivery of Ethernet traffic. TSN defines the first IEEE standard for time-triggered message forwarding in a switched Ethernet network, and therefore fully deterministic real-time communication. TTC/TTTech will continue to contribute here towards integrating TSN into off-highway domains, i.e., relevant for the agriculture use case. SIEMENS will provide project findings in the manufacturing use case to the TSN standardization and will observe IEEE P1918.1 (Tactile Internet).

2.6 Internet Engineering Task Force (IETF)

IETF is the organization standardizing Internet technologies. Within the IETF is the DETNET work group, which defines Layer 3 (IP) mechanisms supporting deterministic networks. DETNET currently builds from IEEE 802.1 TSN set of standards. EURECOM aims to contribute IntellIoT results to extend the IETF support for 3GPP TSN mechanisms.

2.7 OPC Foundation

OPC Foundation is an industry consortium, which creates and maintains standards for open connectivity of industrial automation devices and systems, such as industrial control systems and process control. The OPC standards specify the communication of industrial process data, alarms and events, historical data and batch process data between sensors, instruments, controllers, software systems and notification devices. TTTech (parent of TTC) and SIEMENS are members of the OPC Foundation and will look into bringing OPC to new domains, such as agriculture and contribute to the development of OPC (UA) in combination with deterministic communication (e.g., TSN) to improve reliability and timeliness of communication.

2.8 OPC Field Level Communication (FLC) Initiative

The Initiative has the goal to deliver an open, cohesive approach to implement OPC UA including TSN on field devices for all relevant industry automation use cases. The working groups in this initiative work on harmonizing and standardizing application profiles for IO, motion control, safety and system redundancy, information models for field level devices and mapping of OPC UA application profiles related to real-time operation on Ethernet networks (including TSN). SIEMENS and TTTech (parent of TTC) are partners in this initiative, and will contribute IntellIoT findings to the profiles defined by the working groups.

2.9 5G Alliance for Connected Industries and Automation (ACIA)

5G ACIA is the central global forum for shaping 5G in the industrial domain. On one platform, various industries from all over the world jointly create a new ICT and OT ecosystem and set the frameworks for a highly attractive emerging market.

3 CONTRIBUTIONS & STATUS OF SELECTED SDO

We list below the preliminary contributions or investigation of selected SDO, which either develop standards that IntellIoT needs to use, or where IntellIoT could contribute.

3.1 5G ACIA

SIEMENS and EURECOM contributed to the activities of the 5G ACIA standardization group with use cases for Edge computing in a 5G environment of a manufacturing shop floor as well as distributed AI.

3.2 W3C WoT WG

The IntellIoT use cases have been presented to the W3C WoT WG and are in the process of being included into the W3C WoT use cases and requirements document[2]. WoT extensions have been developed within IntellIoT, which will be brought to W3C. More specifically, application-oriented contributions and extensions of the W3C WoT TD Standards are planned, such as:

- Alignment of Agent-Thing interaction and storage of an interactions journal in a distributed ledger
- Re-use of TD Templates as run-time resource provisioning mechanism to separate concrete Thing API from Thing affordances
- Application of TDs in a large scenario, with development of appropriate tooling
- Extension of TD Templates to include AI-related details, such as AI metadata and AI-related capabilities.

These extensions are being integrated and evaluated, and their impact will be presented to W3C.

3.3 3GPP

3GPP recently completed its rel.16 5G NR specification and is actively working on its rel.17. In a nutshell, 3GPP rel.15 provided the specification of 5G NR, with minor support for services and functions required by IntellIoT. 3GPP rel.16 proposed extended functions of 5G NR, such a Vehicular-to-Everything (V2X) architecture, preliminary URLL mechanisms or architecture for Private 5G Networks. It will however require to wait for rel.17 and rel.18 to actually see functions that would be beneficial to IntellIoT either in its tight integration of AI, private network management or extended Device-to-Device support.

3.3.1 ULTRA-RELIABLE LOW LATENCY IN 5G RAN AND 5G CORE NETWORKS

5G system is supposed to be able to provide data transfer capability with strict performance requirements, e.g., very low latency and high reliability requirements, to fulfil the demands of vertical markets and applications.

Reaching URLL is not limited only to enhancing the 5G RAN as but also to provide management functions to maintain it during 5G communications. This also requires extensions in the 5G Core Network, to support URLLC services within 5G system, in particular

-The support of the high reliability by redundant transmission in user plane

-The support of the low latency and low jitter during handover procedure

-The enhancement of Session Continuity during UE Mobility,

[2] https://www.w3.org/TR/2021/NOTE-wot-usecases-20210518/

-The support of QoS monitoring to assist URLLC Services

Extensions are provided in 3GPP TS 23 501 TS 23 502 and TS 23 503 in rel.16 and beyond.

3.3.2 VEHICLE-TO-EVERYTHING EXTENSIONS

3GPP defined a first specification of 5G NR V2X in rel.16. Although multiple scheduling options (with or without network support) have been envisioned, 5G NR V2X rel.16 only support a basic LTB-SPS scheduler similar to LTE V2X.

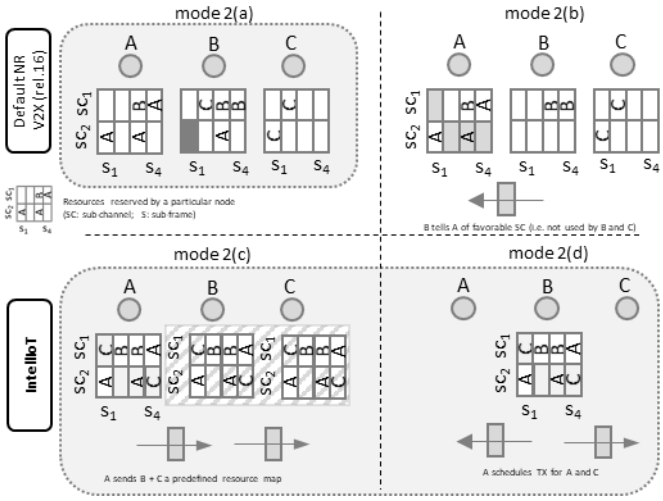

Figure 2 5G NR V2X scheduling paradigm for ad-hoc mode

Support for different scheduling paradigm (compared to the basic LBT-SPS imported from LTE V2X) is under study in rel. 17. As depicted in Figure 2, scheduling paradigms corresponding to mode 2(c) or 2(d) are promising candidates to reach URLL on the 5G NR Sidelink.

In addition, the 3GP LTE ProSe rel.12 specification has been integrated as 3PGG 5G NR Prose in Rel.17, providing a generalized description of D2D communication and services in 3GPP. This is a critical extension, as although 5G NR V2X provides significant innovations for sidelink communication, V2X remains the only supported service. 5G NR ProSe generalizes sidelink service and group management such that various robots or tractors would be able to join in non-interfering sidelink groups according to the offered Proximity Service.

Finally, 3GPP investigated functions for extended relay support in TR 22.866 rel.17 and TS 38.351 rel.18 as a way to support RAN-based relaying as well as multi-hop relaying. In particular, the Sidelink Relaying Adaptation Layer (SRAP) provides an important new feature to filter relaying packets according to radio bearers and accordingly to support QoS-based relaying or even multi-hop routing.

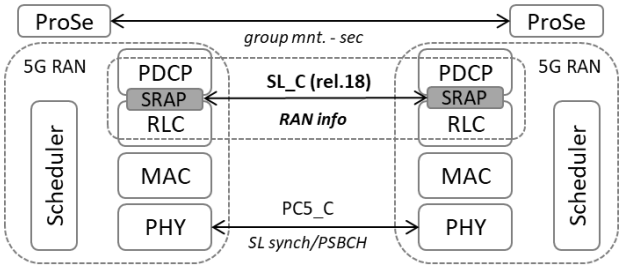

Figure 3 5G NR Sidelink Relaying Adaptation Layer (SRAP)

The 3GPP technical report related to extended relaying support for 5G NR Sidelink provides various potential use case descriptions, which could benefit from multi-hop 5G NR D2D communications. One of them is on Smart Factory. Considering potential radio obstacles and required energy saving requirements on mobile robotics or sensors, a multi-hop mesh topology is envisioned to maintain a robust connectivity between all devices and an edge gateway.

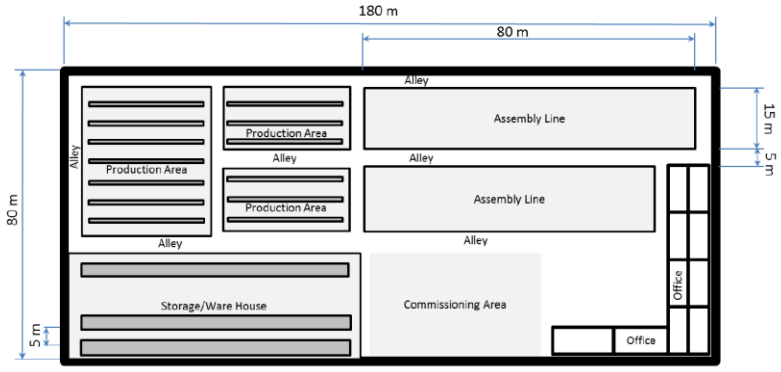

Figure 4 Smart Factory Topology and related radio obstacles

(source: 3GPP TR 22.866)

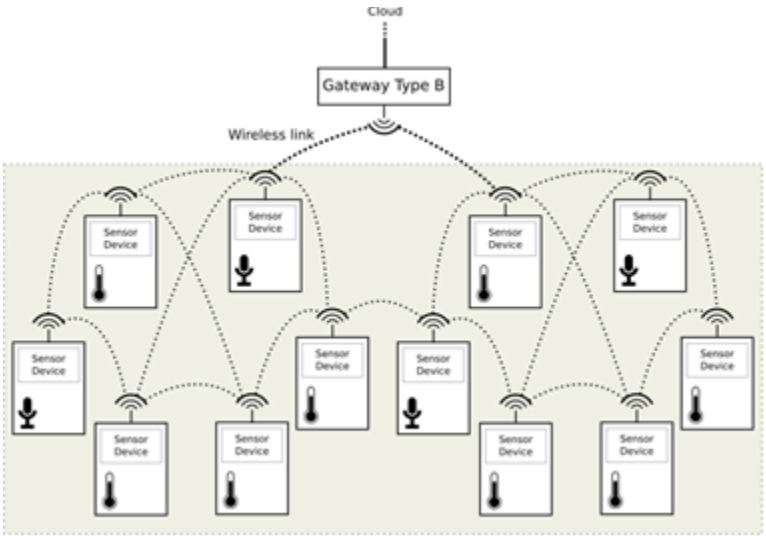

Figure 5 Smart Factory UEs forming a multi-hop mesh topology to an edge gateway

(source: 3GPP TR 22.866)

3.3.3 AI/ML INTEGRATION IN 5G SYSTEMS

3GPP rel. 18 extended the 5G Core System specification in TS 22.261 to provide requirements of the 5GC to integrate AI/ML service in future release. According to TS 22.261 rel.18, a 5G System should support the following AI/ML operations:

- AI/ML operation splitting between AI/ML endpoints - The intention is to offload the computation and energy intensive parts to network endpoints (edge devices), whereas leave the privacy and delay - sensitive parts at the end device.

- AI/ML model/data distribution and sharing over 5G system - Multi-functional mobile terminals might need to switch the AI/ML model in response to task and environment variations. The condition of adaptive model selection is that the models to be selected are available for the mobile device.

- Distributed/Federated Learning over 5G system - The cloud server trains a global model by aggregating local models partially-trained by each end device. Within each training iteration, a UE performs the training based on the model downloaded from the AI server using the local training data.

As it can be seen, these 5G extensions are perfectly in-line with what is targeted in IntellIoT, although IntellIoT will demonstrate the three AI/ML functions separately from a 5GS (yet using it). 3GPP suggests to integrate the IntellIoT AI/ML as well as IAKM components and functions in the 5G System (as described in TR 23.700-80).

In addition, 3GPP IntellIoT is in-line with this specification, as the AIKM provides the required services, which will be integrated into a 5G Core new Networked AI Function (NWAIF). Various Work Items (WI) have been initiated either on how to exchange AI/ML on a 5G RAN interface or how to manage AI models.

For example, according to TS 23.288, the NetWork Data Analytics Function (NWDAF), initially designed to gather and exchange data analytics at the 5G Core system can be extended to discover and exchange AI/ML models. For example, NWDAF may be subject to a logical decomposition into two logical functions such as Model Training logical function (MTLF) and Analytics logical function (AnLF) (see Figure 6 (ii) or trained ML model sharing between multiple NWDAF instances (i.e. 5G core networks) as shown in Figure 6 (iii). UE (edge nodes) may also instantiate a NWDAF to request a particular AI/ML function (see Figure 6 (iv). However, 3GPP also indicated that it does not intent to standardize the format or process of sharing AI/ML across vendors. IntellIoT IAKM component intend to precisely do this, although not integrated as a NWDAF.

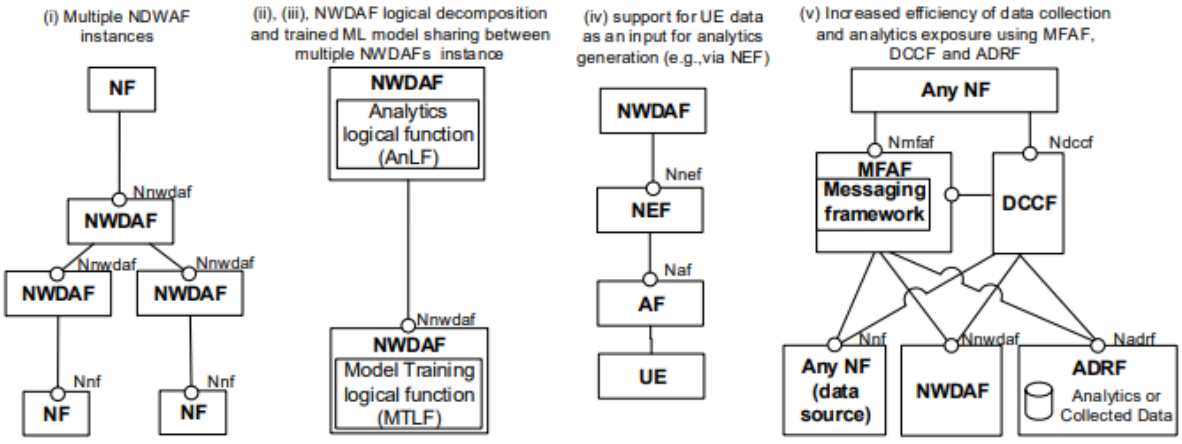

Figure 6 NWDAF extensions to support AI/ML in 5GS

(source: Hexa-X, D5.1, Fig. 4-1)

3.3.4 INDUSTRIAL INTERNET-OF-THINGS (IIOT)

3GPP since rel.16 defined industrial IoT as a major application target and has been first discussing 3GPP use case requirements and KPIs in TR 23.700-20 and second extensions of the 5G RAN to support URLL in various Application Function (TS 38.473, TS 38.423, TS 38.463, TS 38.413).

A major function required is to enable the support of Time Sensitive Network (TSN) functions in a 5G system. Various approaches are proposed, but the most probable strategy is to consider a 5G system as a TSN bridge as depicted in Fig. 8.

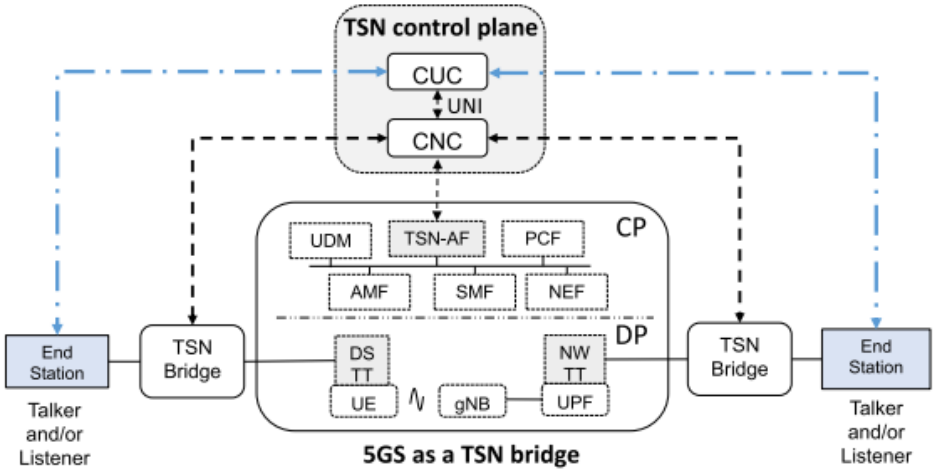

Figure 7 5G TSN architecture (5GS as a TSN bridge)

(source: S. Bhattacharjee et al, "Network Slicing for TSN-Based Transport Networks", IEEE Access)

However, challenge remains as discussed in TR 23.700-20, such as the dissemination of time synchronization between TSN devices in different TSN domains through a 5G system. Providing a transparent TSN support of a 5G system is critical to Next Generation IoT solutions.

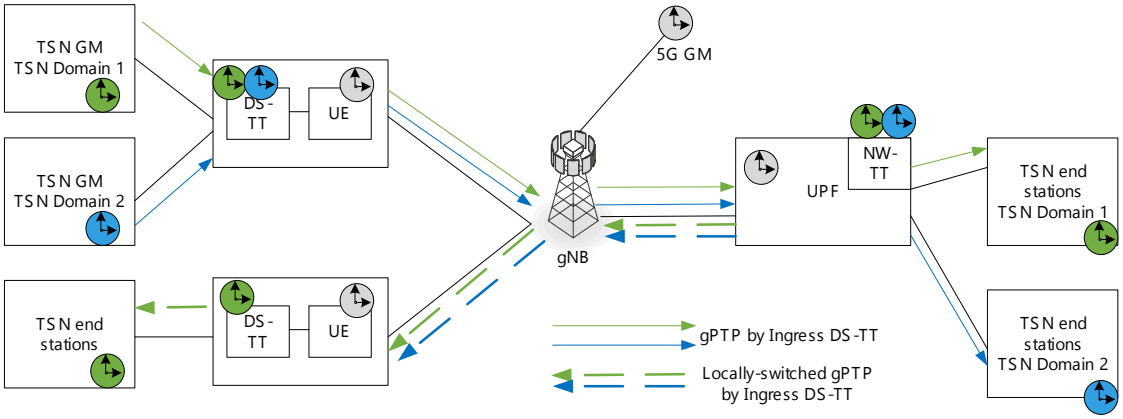

Figure 8 The distribution of UL Time Synchronization Information with the same User Plane Function (UPF)

Another 3GPP development is related to Personal (or Private) IoT Networks, whose objective is to allow the hosting of the IoT management or bypassing the IoT backend management on a 5G system. In traditional IoT systems, data and applications are hosted at the IoT system provider, which opens critical questions related to data privacy or development of personal services based on personal IoT devices. 3GPP TR 22.859 provides a description of extended functions, which will allow to consider IoT functions as well as IoT services at any other private 5G core network functions. Moreover, as described in Figure 9, 3GPP envision to enable a direct connection between a UE and a IoT PIN device (through a 5G Network) for edge provisioning and operation (case (a)). In addition, under the supervision of the private 5G Core network, a UE may directly connect to an IoT PIN device to extra data or control its actuation procedure.

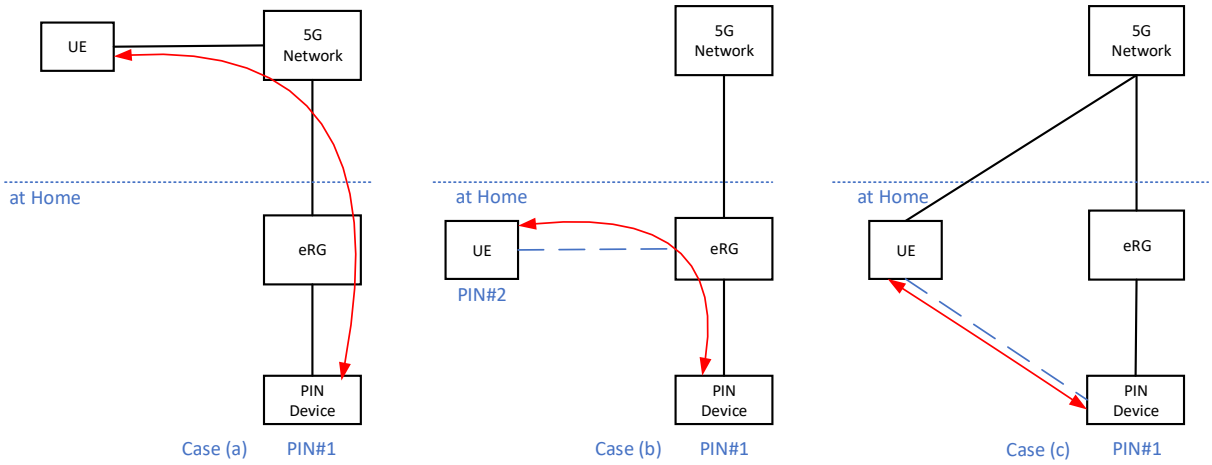

Figure 9 5G network support for a User/UE accessing services provided by in Home Devices

(source: TR 22.859 rel.18)

These new 3GPP functions are expected to be particularly important for IntellIoT Smart Health use case (UC2), where medical wearable devices would not send data to a corporate IoT server, but rather to the private 5G Core function (NWDAF or NWAIF) or directly to a connected 5G UE.

3.4 AIOTI

IntellIoT use cases have been presented by EURECOM. Currently, contributions are being prepared to the AIOTI landscape maintenance & standardisation Task Force (TF). EURECOM contributed as input to the AIOTI survey Edge Computing OSS with its OpenAirInterface platform.

4 CONTRIBUTIONS TO EVENTS

4.1 EU-IoT Webinar

IntellIoT delivered a presentation in the H2020 EU-IoT project organised online workshop on "Next Generation IoT Architectures" on November 9th , 2021. Sphynx and EURECOM jointly presented IntellIoT's architectural vision in alignment with W3C WoT. The talk covered IntellIoT's vision and Next-Gen IoT, its architecture, and alignment with WoT components.

4.2 5G ACIA event

SIEMENS joined 5G ACIA plenary meetings between 21-23 of June 2021 for providing 5G requirements about "Augmented reality for remote operation" use case being developed in IntellIoT. This was part of WI058 (5G-ACIA_Req_5G_Devices_058) activity.

5 CONCLUSION

This document reported on the first 18 months activities of the IntellIoT standardization Task 6.4. It provided an overview of SDO related to IntellIoT activities and provided status and active or planned contributions in selected SDO consisting of 5G ACIA, W3C WoT, 3GPP and AIOTI.

In the final version (D6.10), the IntellIoT consortium will include focussed standardization activities which will take place between M18 and M36. In particular, TTC will review and follow activities of the OPC foundation as well as TSN activities in IETF DETNET and IEEE.