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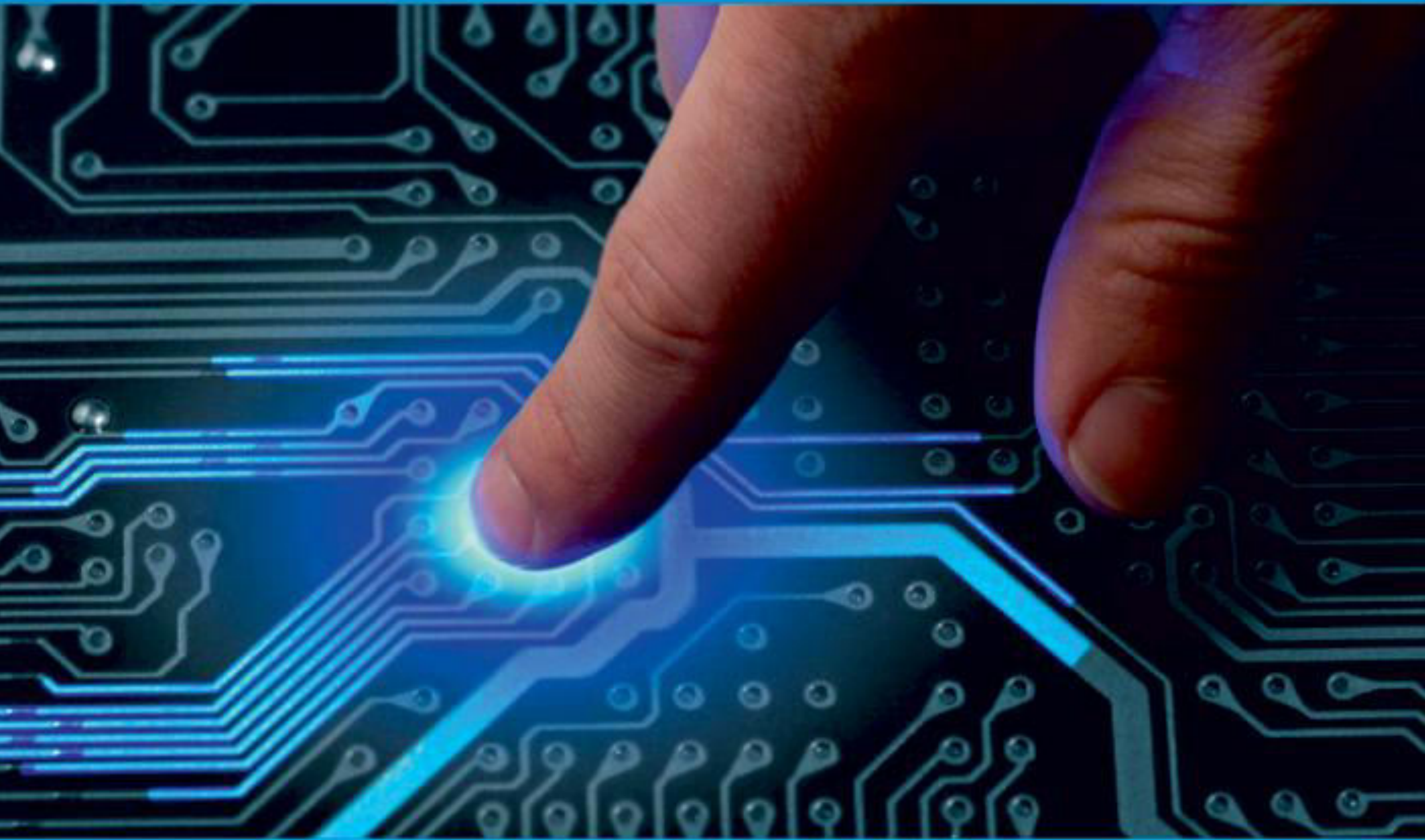

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Novel Architecture for 5G-IOT Wireless Technology

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ABSTRACT: Nowadays, the progress of advanced technology began to reach an unprecedented level in the age of the internet and its related technologies. Since the appearance of the wireless connectivity, architecture, and urban design began to take another dimension in the design process to adopt the new technology and integrated it within its envelope. At the beginning of the 21st century, new approaches began to take place in the city, such as the Internet of Things (IoT) [48] and, more recently, the 4G and 5G wireless technology. However, the effectiveness of these advanced technologies depends on both the wireless signal coverage and the deployment of their equipment. In this context, these technologies impose a new challenge for architects, urban designers, and the construction industry to embrace them within the concept of the smart city. This study focuses on the analysis of 5G technology and highlighting its advantages and disadvantages, which impact the visual appearance and aesthetics of both buildings and the city. The study also intends to explore the various possible solutions to overcome the predicament of the wireless signal coverage and the penetration of buildings. However, this research aims to define a set of recommendations for the construct

KEYWORDS: IOT, 5G technology, 3GPP, (URLLC), or massive machine type communications (MMTC).

I. INTRODUCTION

Nowadays, the so-called automation pyramid dominates the design of industrial communication networks. The automation pyramid shown in Figure 1, refers to an automation system architecture where automation functions are hierarchically built on top of each other (as reflected in the ISA 95 standard [10]) and where each layer – from enterprise resource planning to the process equipment – increases in diversity (indicated by width), visually forming a pyramid. A major challenge is the heterogeneity of industrial communication protocols and interfaces that are located in the lower layers. Especially the control devices that receive sensor values and control actuators use various communication protocols, which are not necessarily compatible with each other. These so-called field bus protocols can differ significantly depending upon use cases, applications and manufacturers. Ethernet-based field bus protocols can also be found on this level. The so-called industrial Ethernet (IE) protocols are predominantly layer 2 protocols often with modified media access control (MAC) layer [11]. This is done to meet the requirements of applications that require extremely low latency, such as motion control [12]. To address this issue, time-sensitive networking (TSN) is seen as a promising technology [13], [14]. In contrary to the field of the aforementioned operational technology (OT), the information technology (IT) area, which is found in the higher levels of the automation pyramid, uses Internet Protocol (IP)-based communication (layer 3).

II. REFERENCE ARCHITECTURAL MODEL 3GPP 5G

An Industry 4.0-related model, which is shown in Figure 3, and consists of three dimensions: hierarchy levels, life cycle & value stream, and layers. Hierarchy levels cover the required functionalities by a factory or entire plant. They are based on the IEC 62264 [21] / IEC 61512 [22] standards and extend them by elements ''product'' and ''connected world''. Life cycle & value stream is the second dimension used in the model. It considers IEC 62890 [23] and reflects the life cycle of products and machines supporting types as well as instances. The layers describe the IT-based elements of the system in a structured way. They start with a business perspective and end on asset level. RAMI 4.0 share a lot of similarities with IIRA and can be mapped to each other well [24]. Especially the basic concepts and rules given within the RAMI 4.0 reference
Each 5G system (5GS) consists of the 5G core network (5GC), the 5G new radio access network (5G NR), and one or more user equipments (UEs). These components are completed by the user, control, and management plane to enable each of the three different communication types. However, the main difference to previous mobile generations is, that the 5G architecture is service oriented. That means wherever reasonable the architecture elements are defined as

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network functions [27]. The generalized design of the 5G network functionalities also allow to operate with 3GPP and non-3GPP access technologies. The modular design of its network functions (NFs) and the configuration options to meet special communication requirements enables network slicing, where a slice can include control layer and E2E user layer functions. This allows individual customized and isolated logical networks. With the Release 16 of 5G all the requirements of the use cases selected by the TACNET 4.0 project can be met. However, new findings show that not all use cases can be assigned to the categories that were introduced with Release 15, such as enhanced mobile broadband (eMBB), ultra reliable low latency communications (URLLC), or massive machine type communications (MMTC). Therefore an additional category called ''NR-Lite'' is planned for Release 17, which will be available until the end of 2022 [28]. To address this issue, non-3GPP access technologies are also taken into account. In addition, not yet considered are the interconnection with brown field technologies such as Industrial Ethernet or the upcoming TSN which will be essential to fulfill real-time use cases. To guarantee real-time within 5G, a TSN translator was developed within the project. Since the 5G architecture serve as the main basis for the TACNET 4.0 architecture, the division into the application management and orchestration (MANO), control, and data layer can also be found in the TACNET 4.0 architecture described in the next Section. The data layer is the part of the network which is used to transfer the data traffic of the user. Packet routing is performed at this level. The control layer is responsible for establishing, monitoring, and terminating connections. The management & orchestration layer coordinates the 3GPP core network (CN), the network functions virtualizations (NFVs), and resources for the control and data layer. The service layer comprises of all communication and industrial applications as well as required services like synchronization or localization retrievable by the control and data layer. Since the focus in 3GPP 5G is on industrial applications the proposed TACNET 4.0 architecture gets extended by an application layer as well as a security layer to unify all domain specific security functions.,

III. CORE NETWORK ARCHITECTURE

The Finland testbed includes several 4G/LTE EPC and 5GC from Nokia, Aalto and Cumucore. Nokia 5GC will be running from Nokia premises in a virtualized environment connected to the testbed through dedicated fibre. The testbed will utilize these PLMNs for the testing with current eNBs and with the gNB if RAN and Transport sharing is supported. The multi PLMN test cases can be demonstrated with Aalto EPC and Cumucore 4G/5GC. Figure 69 shows the core network architecture used in FI trial site and deployed at the Aalto Data Centre located in Otaniemi campus. The Aalto Data Centre, described separately in D2.3 [2], provides a multi-server environment for deployment and co-location of virtualised network functions with sufficient capacity to host multiple PLMN instances but also meet stringent core network operational requirements outlined in previously.

UTAC/CERAM test circuit has perfect coverage of 5G networks, provided by Orange and Bouygues as illustrated by Figure 70. Nevertheless, the cells sizes can be adjusted and hence allowing particularly:

• Cross-border with overlapping 5G networks.

• Cross-border with non-overlapping 5G networks. The above mentioned terrestrial 5G radio networks will likely be supplemented by Low Earth Orbit (LEO) satellite communications. The priority of the satellite communication is to maintain the service continuity with acceptable QoS.

Particularly, we intend to test intelligent roaming/Handover supported by the satellite communication. In order to continuously benefit from the 5G technology, thanks to the satellite communication link, we ensure that the roaming/handover is made at the right timing and in a stable manner. By emulating such a situation, we intend to bridge that gap by the terrestrial and the satellite communication technology. In this case, 5G to 4G handover, and satellite communication technologies will ensure the service continuity. In doing so, the throughput degradation will happen and hence we will work on intelligent network selection and QoS control.

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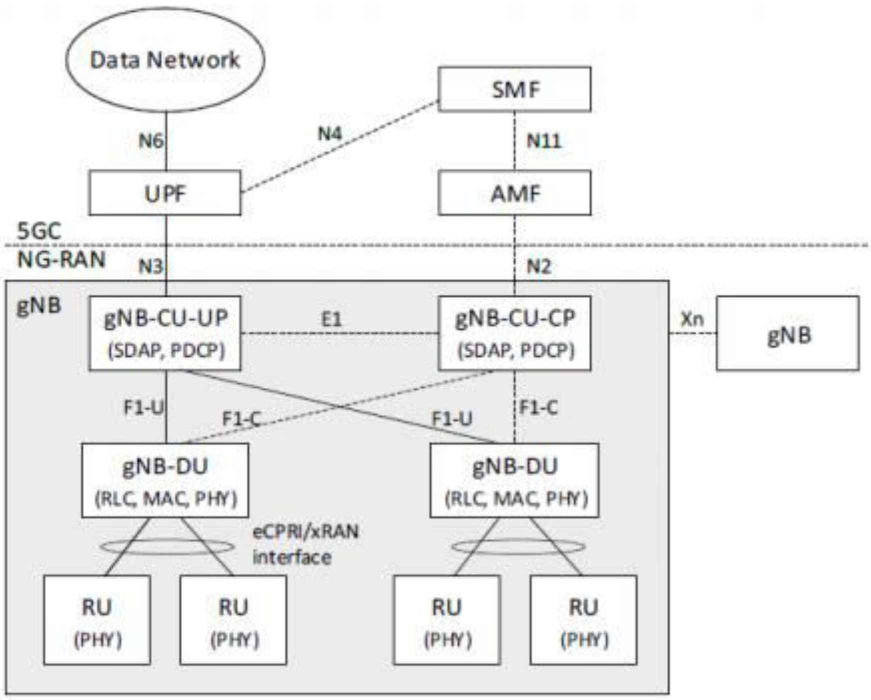

Fig: Network architecture for 5G

QoS (particularly latency) can be maintained, also under heavy traffic conditions QoS needs to be supported for time critical ITS message flows (e.g. 5QI value 84; see (3GPP TS 22.261, n.d.), either using the standardized QoS mechanisms (Rel.16), or using slicing. All partners prefer slicing, the feasibility and how to evaluate the performance of multiple slices will be investigated. Unclear yet to what extent modems will be able to support QoS (5G grade) and how end-to-end slicing could be realized (including the RAN).

IV. SERVICE CONTINUITY SHOULD BE PROVIDED AT INTER-PLMN

The handover (roaming) currently the 3GPP standards lack solutions for inter-PLMN handover in 5G networks. It will be investigated during the project how service continuity can be achieved. Table 25 provides a brief overview of attributes of projected sites of each of the individual networks (KPN, TNO and TU/e) in the area to accommodate the three use case categories. In Figure 81, a geographical layout is depicted using the KPN coverage plan as a basis and showing the intended "borders" between the three networks [49].

Fig: 5G core and NR compare

In this real-life example, applicable to both 4G and 5G deployments in a virtualized environment, a new cell site is being activated, with the radio interface unit (RIU), vDU, and vCU configured automatically. In addition to the site

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initialization, specific slice scheduling configuration needs to be managed by the RAN NSSMF in order to achieve the strict requirements of each and every slice. In order to create a new slice, NSSMF performs the following:

- Upon receiving a Network Slice Subnet Instance (NSSI) instantiation request, pre-checks are done to make sure the current NSSI will not be able to support the new request.
- The available RAN resources are checked for availability of provisioning the new scheduling rules.
- The required scheduling information is configured for each of the RAN slices from existing templates (NSMT).
- The configuration requirements are sent to RAN NFMF for configuration management and further for service assurance.

	TU/e	TNO	KPN
Mobile core	5GC	EPC and 5GC	Starting with EPC Following with 5GC
Virtualised	Yes	Yes	Yes
Virtualised infrastructure	Openstack/Opendaylight	Openstack	Openstack
Network Slicing	Yes	Yes	Yes
Orchestrator	Open Source Mano	Open Source Mano	TBD
Multiple access Edge Computing	Yes, Applications deployed using Kubernetes or Docker Swarm	Yes, applications deployed in a Kubernetes Cluster	Yes, applications deployed in a Kubernetes Cluster
Radio Access Network	mm-wave NR	LTE and NR	LTE and NR
# of sites	2-3	1 or 2	6 or 7
Vendor	Experimental/Proprietary	Ericsson	Ericsson for first stage
# of cells per site	1	2	3
# of antennas per cell	1 (multi-element)	1	2
Frequencies used	NR FR2 n258, 26.65 GHz (licensed/test-licence)	LTE B3 1800MHz, NR B43 3700 MHz	LTE 800FDD, LTE 1800FDD, 5G NR 3.5GHz (pending auctions)

Fig: 5G technologies attribute for network

Data center domain orchestration Infrastructure at various levels of DC placement (central, near-edge, far-edge, etc.) is an important aspect of 5G orchestration and automation. This includes the entire lower part of the ETSI MANO stack, taking into consideration both physical elements (compute, storage, and network) and the virtualization layer, working through a VIM or cloud orchestration [2]. One key consideration that must be taken into account is how data sources and applications are distributed. Low-latency applications will require further distribution to the edge where the end users and capabilities reside. Other applications and services may also benefit by avoiding the constant backhaul or distribution of traffic from centralized data centers. The introduction of edge computing, also known as multi-access edge computing (MEC), which is based on a distributed data center architecture, not only improves the way applications interact with end users, but also enables new applications and services that were not previously possible. The challenges of managing a centralized data center deployment can be complex in itself, but proactively managing the infrastructure, applications, data sources, and workloads distributed across many locations takes that complexity to another level. In order to tackle this new level of complexity while enabling this new era of 5G-enabled services, it is crucial to leverage an automation and orchestration solution covering the following aspects:

- Network fabric management, including service chaining functions and resource allocation per network slice.
- Network service lifecycle management, including instantiation, scaling, updating, and termination of the service .
- VNF lifecycle management, including instantiation, scaling, updating, and termination of the VNF.
- NFVI resources supporting virtualized and partially virtualized network functions through abstracted services for network, compute, and storage.

V. CONCLUSION

Automation and orchestration of a 5G network is a complex task that has to be properly planned and implemented from the very beginning of a network design. The complexity of 5G networks demands automation and orchestration to

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simplify tasks and minimize the probability of error during planning, implementation, and operation. Automation architecture, from a functional perspective, has been defined by several standard bodies. These functions should be covered and support for them provided regardless of the implementation specifics. Different vendors will have an option to combine functions within their products as they find it appropriate; however, the functions, as shown, have to be provided to ensure proper work of the automation and orchestration system. Automation and orchestration architecture is defined in two distinct layers: CFS (Customer-Facing Service) and RFS (Resource-Facing Service). Integration methods, protocols, and interfaces between these layers, and also between RFS and network domains as well as the CFS, portal, and OSS/BSS, have been defined by the standards and the overall automation architecture. Automation in 5G does not stop at the network planning level. It is an integral part of the entire network cycle, including infrastructure deployment, operations and service assurance with closed-loop remediation, and DevOps with integrated CI/CD.

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