

Hexa-X, WP6 - Deliverable 6.1

Gaps, features and enablers for B5G/6G service management and orchestration

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D6.1 Introduction & Methodology

Deliverable D6.1 contains gap analysis for Hexa-X service orchestration. The document builds on the Hexa-X foundation laid by WP 1. It is used as a basis of WP 6 work by analysing which technologies need to be developed in addition to state of the art to reach goal state for service orchestration:

$$\text{Goal State} = \text{SotA} + \text{Gap}$$

Goal State

D6.1 defines the Goal State regarding service management and orchestration for B5G/6G networks identifying the main target features.

State of the Art

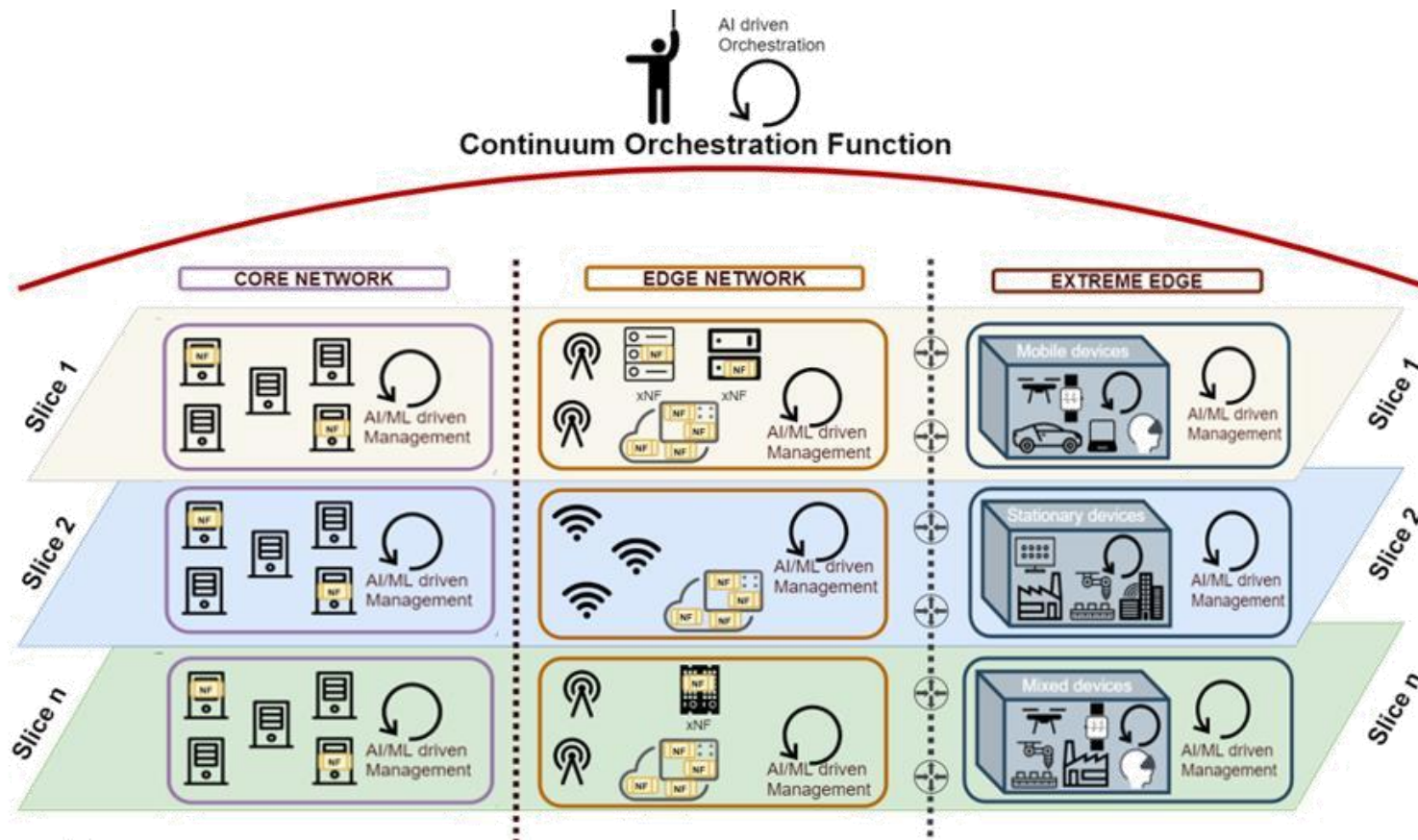
To verify how far we are from that goal state the state of the art is analysed, considering:

- SDOs and Open-Source communities
- The industry fora
- Relevant research projects
- Technological trends

Gap Analysis

Main elements of the gap are identified for each of the target features in the goal state. These elements represent the main research challenges.

Goal State - Key concept



The key concept is the “Continuous” Management and Orchestration function, including resources not only from core and edge networks, but also the extreme edge devices.

Main challenge

The number of extreme edge devices is large, and they are in an uncontrolled and asynchronous environment.

Key Enabler

AI/ML is considered a Key Enabler to support the complexity associated to the high number and heterogeneity of network functions and devices.

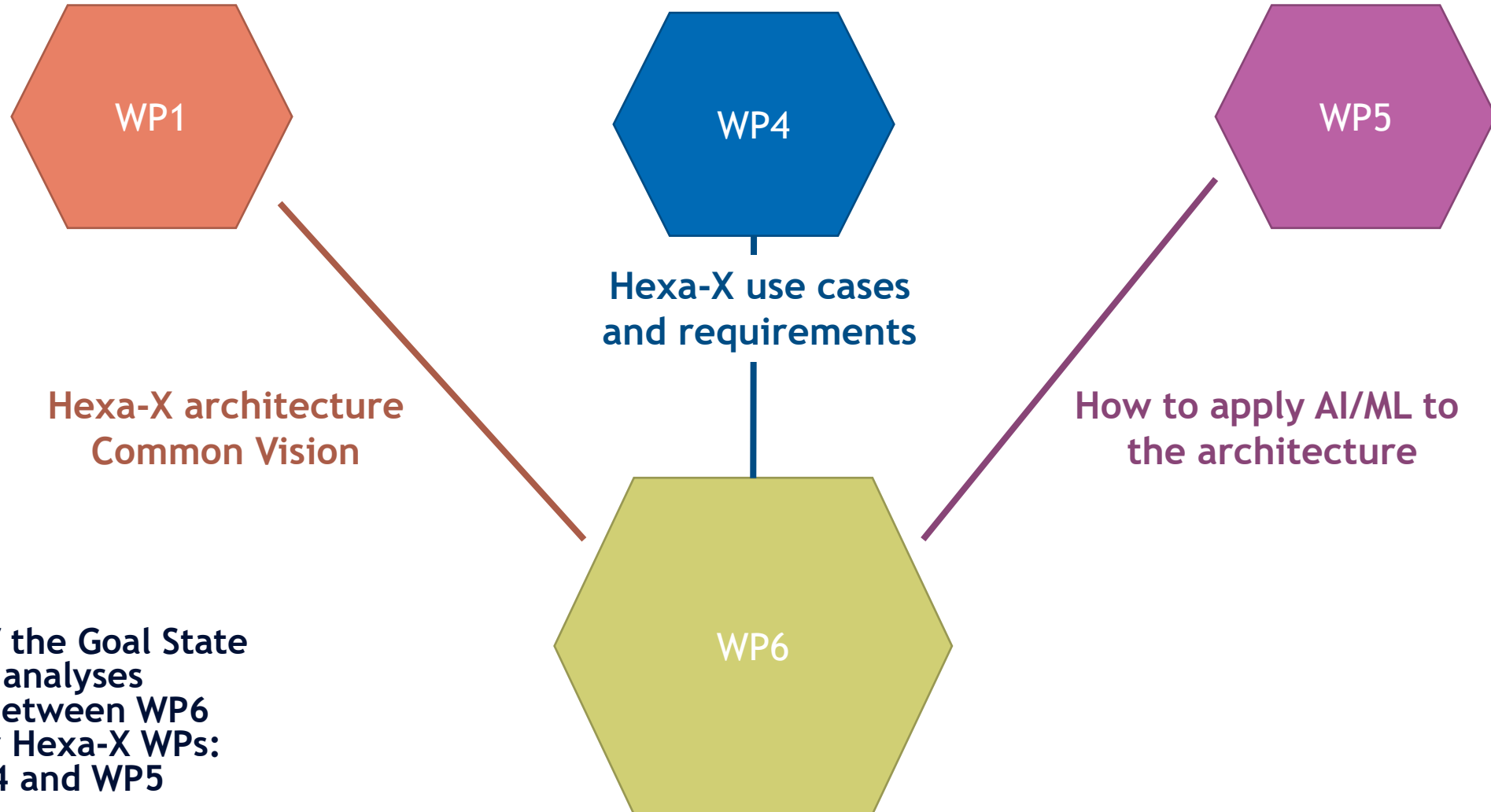
Goal State



9 main features identified:



Goal State - Link to other WPs



As part of the Goal State D6.1 also analyses relation between WP6 and other Hexa-X WPs: WP1, WP4 and WP5

Goal State - AI/ML as a Key Enabler



AI/ML Driven Orchestration (Feature #5) is considered as a Key Enabler.

It consists of 7 *sub-features*:

- ❖ Enhancement of the overall network orchestration operations.
- ❖ Support data-driven and zero touch approaches.
- ❖ Implement cross-layer predictive and intent-based orchestration mechanisms.
- ❖ Deploy collaborative AI/ML components across the network to support orchestration.
- ❖ Provide intelligence for reasoning regarding service requirements, network capabilities and external non-network factors.
- ❖ Explainable AI techniques support AI/ML actions regarding management and orchestration.
- ❖ Support sustainability actions.

State of the art (I)

In the State-of-the-Art sections D6.1 considers:

- **SDOs and open-source communities**, description of different service orchestration Standards Developing Organizations (SDOs) relevant to WP6.
 - **3GPP**: describes the relevant topics this community is carry on
 - SA2, general framework for 5G network automation
 - SA5, architecture of the management system for mobile networks including virtualized network functions
 - **ETSI**: relevant standards and frameworks as:
 - Network Functions Virtualization (NFV)
 - Open-Source Mano (OSM)
 - Zero-Touch Service Management (ZSM)
 - Experiential Networked Intelligence (ENI)
 - Multi-Access Edge Computing (MEC)
 - **IETF/IRTF and O-RAN**



State of the art (II)



- Industry fora, breadth of input relevant to evolution of service orchestration.
 - **TM Forum**: industry association.
 - **GSMA**: mobile operators' representatives.
 - Operator Platform Group (OPG) initiative.
 - **Linux Foundation**, technology consortium which standardizes Linux and promotes open-source software projects.
 - Open Network Automation Platform (ONAP).
 - **OpenConfig and NGMN**.



• Research projects:

- 5G-CLARITY
- 5G-COMPLETE
- DAEMON
- 5GROWTH
- LOCUS
- 5G-TOURS and
- 5GZORRO



D6.1 performs the Gap Analysis for each feature defined in the Goal State:

- ***Feature 1. Continuous orchestration from the end devices (extreme edge) to the core***
 - The ambition at Hexa-X is to provide device-edge-cloud continuum management with E2E seamless integration of all the network resources. The extreme edge scope has relevant features conditioning the management and orchestration processes:
 - High heterogeneity of devices
 - Diversity of devices and technologies
 - Uncontrolled/asynchronous environment
 - Large number of devices

- ***Feature 2. Orchestration for heterogeneous service definitions***

- B5G/6G management and orchestration platforms should not only facilitate the regular life-cycle management operations of regular VNFs, but it should also be able to combine third-party applications for creating new more versatile and richer set of software components.
- 6G slicing mechanisms need to support also extreme-edge components as part of the network slices, as well as predictive/proactive slicing mechanisms enabled by prediction of demand on one hand, and resource utilisation on the other hand.
- B5G/6G networks should provide an open way of mixing functions from the various sources and industries, providing the adequate level of abstraction to interconnect between the various resources and technologies.

- ***Feature 3. Multi-stakeholder orchestration***

- B5G/6G will support management and orchestration of network services different actors' resources, including CSPs, global and local cloud providers, neutral hosts or vertical industries or private networks, among others.

- ***Feature 4. Support for private networks***

- In B5G/6G, a greater degree of automation for integrating external capabilities to private networks is targeted. Management APIs are needed to open the door to independent developers to bring new solutions to the Public Network Integrated - Non-Public Network scenarios.
- A research goal for Hexa-X is looking into mechanisms supporting flexible cross-orchestration of resources between private networks, CSPs, and external IT platforms. Support for private networks in B5G/6G will build on the capabilities of Hexa-X architecture

- ***Feature 5. AI/ML Driven Orchestration***

- AI/ML techniques are considered a key enabler for continuum management and orchestration of services of B5G/6G networks. Different *sub-features* associated to this are analysed:

- ***Feature 5a - Enhancement of the network orchestration operations***

- AI/ML-based orchestration is envisioned to be applied
 - Within each domain (i.e., core, edge and extreme edge domains)
 - Globally, by means of continuum orchestration functions

- ***Feature 5b - Data-driven and zero touch approaches***
 - Mechanisms allowing for cooperative and closed loops need to be specified and developed. These mechanisms should enable horizontal and vertical interaction of two or more closed loops, including the possibility to compose (nesting) them into more complex (composite) closed loops.
- ***Feature 5c - Cross-layer predictive and Intent-based orchestration mechanisms***
 - Complete intent-based management architecture needs to facilitate the use of AI/ML/analytics in human-machine interfaces in network intelligence. Components needed include:
 - Intent interface
 - Managed automation
 - State modelling and anomaly detection
 - Self learning

- ***Feature 5d - Collaborative AI components across the network***
 - A B5G/6G service platform should provide life-cycle management functions tailored for the federated services, allowing operations for joining/leaving federated groups, or to update federation parameters.
 - Orchestration systems should provide means for coordinating multiple AI/ML agents, the system should handle the allocation of computation and communication resources for the execution of FL agents.
- ***Feature 5e - Intelligence for reasoning regarding service requirements, network capabilities and external non-network factors***
 - Mechanism relevant to the feature are:
 - Automated reasoning.
 - AI-based mechanism to adapt the use case parameters to the network conditions.
 - AI-based mechanisms to adapt the requirements of the service to the novel cloud paradigm.

- ***Feature 5f - Explainable AI for orchestration***

- For service orchestration, requirements for explainability need to be understood. For some of the service orchestration use cases, explainability is expected to be an important concept (e.g., to find the reasons behind certain fully automated actions). For each of the use cases within service orchestration, an adequate method needs to be identified.

- ***Feature 5g - AI-based sustainability applied to orchestration***

- B5G/6G network management and orchestration solutions can become a significant enabler for energy efficiency by converging various network technologies and administrative domains can enable implementing energy-savings strategies on specific use cases.
- The incorporation of AI/ML enabled analytics associated to the automatic triggering of network optimization processes in the upcoming B5G/6G networks can help to perform further progress in this direction.

- ***Feature 6. Advanced monitoring***

- For B5G/6G, enhanced real-time alerting, diagnostics, and possible maintenance are needed for supporting dependability and extreme performance in handling unexpected situations aimed at fulfilling the requirements of the 6G KVIs and KPIs. Such a required advanced monitoring system shall have the capability to integrate metrics from both:
 - Network Infrastructure, and
 - Data plane

This will make possible to implement complex management and orchestration decisions by correlating metrics from those different scopes.

- ***Feature 7. Means for automation and network programmability***

- Automation and programmability can be considered from multiple viewpoints, automation mechanism, AI/ML for service management and programmability of network infrastructures. The use of AI/ML for network management and automation needs to support distributed deployment of functionalities. Network management system (NMS) provides programmability by allowing CSPs to run their own workflows within NMS.

- ***Feature 8. Security architecture***

- Technological challenges for security management for B5G/6G must be protected against thread which are:
 - Suitable to leverage Physical Layer Security (PLS)
 - Distributed into multiple autonomous managers
 - Making use of AI techniques

- ***Feature 9. Implementation***

- This feature describes the envisioned Hexa-X distributed platform. It is also addressed as a set of relevant sub-features:

- ***Feature 9a - Joint optimization of resources***

- Technological challenges for security management for B5G/6G must be protected against thread which are:
 - Suitable to leverage Physical Layer Security (PLS)
 - Distributed into multiple autonomous managers
 - Making use of AI techniques

- ***Feature 9b - Cloud native***

- Virtualized RAN will become a key technology for the last mile of next-generation mobile networks. B5G/6G architecture will be truly cloud native, which increases complexity and poses new requirements due to higher performance requirements in service orchestration.
- B5G/6G will head towards a true end-to-end SBA that allow cloud native implementations calls for open API.

- ***Feature 9c - Interfaces***

- The support for intent-based interfaces will be enhanced to facilitate not only the provisioning, but also the runtime operation and automation of 6G services.
- The orchestration entities operating at the different layers should enable a bi-directional interaction with the AI/ML functionalities to provide the monitoring data required for training the models and taking real-time decisions.

- ***Feature 9d - Service description models***

- High-level intent-based means are envisioned to be needed for B5G/6G use cases supporting service description models, profiling, and network abstraction models.
- 6G should explore new intent-based service description models, which allow a higher level of automation and self-management for the network.

- ***Feature 9e - CI/CD techniques***

- B5G/6G needs to integrate the CI/CD as a native part of the entire network and service management processes. To achieve it, followings gaps needs to be addressed:
 - Multi-vendor related issues
 - Complete dynamic software upgrades
 - Adapt today's CI-CD approaches to the telco domain.

- ***Feature 9f - Overall KPIs***

- The KPIs identified for Hexa-X are quantitative and qualitative, they represent a leap compared to the 5G standards.
- Although Deliverable D6.1 does not go into a concrete definition of KPIs (this is done in other WP's in the project) it highlights some considerations that should be taken into account with regard to KPIs associated with service management and orchestration.
- Predictive orchestration being developed in WP6 as well as enhancements in B5G/6G system architecture is expected to contribute to reducing service instantiation time through using of AI/ML in domain orchestration.

Main Conclusions



- D6.1 identifies a set of research challenges regarding service management and orchestration in B5G/6G networks.
- D6.1 monitors developments in selected fora as well as selected research projects.
- D6.1 also monitors and update the list of technological and business trends related to service orchestration.
- Key research challenges include:
 - The functionalities participating to end-to-end orchestration in B5G/6G extend to end devices at the extreme edge domain.
 - New challenges for infrastructure management due potential high volatility and random behaviour of the devices at the extreme edge.
 - The number of the entities being orchestrated is expected to increase drastically in evolution towards 6G.
 - The use of virtualization is expected to expand from core towards RAN and involve also execution environments at the extreme edge, including end devices.
 - The availability of execution platforms on end devices may be ephemeral. Subsequently, orchestration needs to be able to cope with highly dynamic loading patterns for platforms on which functionalities are being executed.
 - The value networks participating to provision of services are expected to be more complex than in 5G. For example, a service instance may involve aggregation of resources from multiple stakeholders. Consequently, interworking mechanisms allowing flexible composition of services is expected to be important for 6G.
 - Added complexity of the resources will make the use of AI/ML a necessity.
 - The AI/ML methods being studied within WP4 will be important for service orchestration in B5G/6G. In particular, the role of AI/ML in facilitating predictive methods will be important for B5G/6G.

Thank you!

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