CampusOS Position Paper

How open and modular 5G campus networks can boost application scenarios in vertical market segments

CampusOS

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The campus network market is growing worldwide, and the share of open and modular 5G campus networks is increasing. The CampusOS[1] consortium has analyzed the key drivers of the campus network ecosystem. This position paper discusses how open and modular 5G campus networks can boost application scenarios in different market segments. It addresses suppliers (e.g., integrators, hardware (HW)/software (SW) vendors, test equipment & service providers) as well as vertical industry enterprises and operators.

The position of the CampusOS consortium can be summarized as follows:

- Open and modular 5G campus networks support specific requirements of industrial verticals.
- Open and modular 5G campus networks provide mechanisms to handle complexity over the complete lifecycle.
- Open and modular 5G campus networks address new markets and enable new business models for suppliers and verticals.
- Development and growth of the ecosystem drive further adoptions of open and modular 5G campus networks.

The reasoning behind this is explained in this position paper.

Introduction

Today's 5G campus networks[2] are implemented mostly by single-vendor solutions on an area-by-area basis. As deployment scenarios (macro and small cells, outdoor and indoor operation) and frequency bands diversify, open and disaggregated mobile networks are expected to be more advantageous. Disaggregation and openness, together with virtualization, provide flexibility, efficiency, agility, scalability, a broad ecosystem, and a variety of realization options. Open, interoperable interfaces and multi-vendor radio access networks (RAN) allow the implementation of innovative solutions from different vendors. It is expected that this will lead to more competitive vendor ecosystems and to more cost-effective network deployments. The plethora of industrial use cases is much more diversified than legacy public network use cases. Therefore, an open and disaggregated network may tackle these diverse use case requirements and ensure proper KPI fulfilment.

First multi-vendor implementations based on O-RAN Alliance[3] (Open RAN Alliance) specifications are already available and tested. These implementations show flexible arrangements of the RAN and the facilitation of features and capabilities that are beneficial for innovative services in vertical markets.

Network disaggregation occurs in different directions:

- Vertical disaggregation where network functions decouple software from hardware.
- Horizontal disaggregation, where established network functions are broken down into more granular elements, and new interfaces are designed and specified.
- Disaggregation between control and user plane.

[1] https://campus-os.io
[2] Geographically limited, local 5G private network. Sometimes also named as non-public networks.
[3] The O-RAN Alliance is a joint association of mobile network operators and suppliers promoting open, disaggregated, and virtualized radio access networks for 5G and beyond. https://www.o-ran.org/

From this approach, significant improvements are expected, which can be grouped into the following advantages:

- Higher flexibility: more degrees of freedom and solution choices, improved resilience of the supply chain.
- Faster innovation: better functionality and more features, performance improvements, faster change.
- More competition: leads to overall cost reduction – lower CAPEX, e.g., due to tailored solutions, and lower OPEX, e.g., due to higher automation and AI integration.

In order to benefit from the expected advantages, several challenges have to be managed, such as complexity, interoperability, and compatibility as well as potential associated security risks.

In this position paper, we share four findings, which are applicable when open and modular campus networks are under consideration as network choices. These findings have been confirmed during our work on the CampusOS project.

Position 1: Open and modular 5G campus networks support specific requirements of industrial verticals

Introduction

When introduced to the market, 5G promised to address diverse requirements of different industries (verticals). The faltering introduction in industry contexts, however, shows that a one-size-fits-all approach is unable to natively support these diverse requirements. Significant effort is needed by those wanting to integrate a 5G system into the existing IT and OT infrastructure to ensure that functional and non-functional requirements of the respective use cases can be met. To mitigate this situation, open and modular systems are a good basis for a more tailored and flexible realization of 5G use cases in industries. They provide relevant interfaces to those integrating the 5G system into the existing environment, and they enable more transparency compared to established monolithic integrated solutions.

Arguments

Traditionally, the availability of a standard does not ensure full interoperability, as interfaces might still be incompatible due to different interpretations or the desire to have a unique selling point. These challenges still need to be overcome by the larger 5G open modular campus network ecosystem.

For industrial verticals, 5G campus networks need to be cost-efficient, with conditions heavily depending on the use cases that are being addressed or enabled with the campus network. Opening additional relevant interfaces helps to achieve a targeted coupling with the existing IT and OT infrastructures. At the same time, the modularity of the campus network and the availability of components with different characteristics enables solution providers to omit functionalities and components that are not explicitly required. This leads to reduced complexity of the system.

A tailor-made, cost-efficient 5G campus network enables industry partners to implement (mobile) products and solutions that rely on high data volumes and time-critical behavior, for example in the field of augmented reality. Today's digitalization approaches show that market trends such as smart factories, artificial intelligence, and data mining are ready for new communication solutions. The modularity of the campus network can enable interchangeability and the addition of components that facilitate the use of future technologies (i.e., AI-based production flows, updatability or upgradability of the system) or the adaptation of the system to changes or new requirements, if needed. This contributes to the scalability of the approach. Moreover, solution blueprints provide integrators with viable designs for dedicated use cases.

Conclusion – Position 1: Open and modular 5G campus networks support specific requirements of industrial verticals

Openness and modularity allow vendors to create customized systems for specific use cases, addressing the needs and requirements of a broad range of industrial verticals. At the same time, cost efficiency and manageable complexity of the system need to be ensured through focused, tailor-made composition of functionality, the availability of relevant open interfaces to IT and OT systems, and the exchangeability and updatability/upgradability of individual components. Solution blueprints for individual industries and use cases, as well as experience from real-world deployments, showcase the compatibility of components and ensure the adoption of open and modular campus networks. Since disaggregation is not an end in itself, the focus on interfaces and features that meet the specific needs of individual industries within an overall campus network architecture is expected to be the most promising approach.

Position 2: Open and modular 5G campus networks provide mechanisms to handle complexity over the entire lifecycle

Introduction

Economic pressure in the value-creating industry requires seamless process chains. Reliable transfer of data is of high significance. Communication links are becoming increasingly more important. Modular 5G campus networks have been confirmed to be an advantageous approach for enabling private 5G communication. They support data collection as well as processing and analyzing data on-premises while delivering scalability and customized performance based on the specific use case.

At first glance, open 5G campus networks seem to be challenging: Open 5G campus network's complexity encompasses managing and maintaining several aspects and components belonging to Radio Access Network (RAN), Core Network (CN), and management of domain-specific operational devices and software. This requires different interfaces and protocols. Also, the integration of the network with the application domain/vertical is crucial, which may require more components in the overall solution. Considering all the above aspects, multi-vendor deployments and the management of the lifecycle of campus networks might become a challenging task.

Arguments

The good news is: Modern tools can effectively tackle these challenges. Network orchestration solutions, such as Open Network Automation Platform (ONAP) and Kubernetes' cloud native approach, have shown their ability to manage the lifecycle of multiple services and their dependencies. For monitoring and management, there have been proposals and implementations of standard interfaces in 5G mobile networks by O-RAN Alliance, 3GPP, and other consortia. Such standard interfaces pave the way for a more flexible and modular network architecture suitable for 5G campus networks that will positively impact vendors and users. Furthermore, known metrics and tools which are currently used for mobile network testing can still be used. This is because there is no difference between public networks and open and modular 5G campus networks in terms of radio interfaces.

Like any network solution, wireless or wireline, open and modular 5G campus networks must address the specific needs of the specific vertical use case/application. Thus, they must fit into these target environments, be managed accordingly, and interact with the OT management systems to support and adapt to changing and growing demands. The management of the complete lifecycle of the 5G campus network is coupled with the commissioning of the industrial systems, and the interaction between them through standardized monitoring and management interfaces is necessary.

Service Management and Orchestration (SMO) and RAN Intelligent Controller (RIC) are key to managing this complexity. Disaggregation is a prerequisite for innovative, flexible, multi-vendor, and high-quality network solutions. From the RAN perspective, the O-RAN operations, administration, and maintenance (OAM) specification introduces its SMO architecture for orchestrating services and applications to support radio network operations. The RIC, based on open standard interfaces, consists of two new interconnected platforms for lightweight applications to monitor and control RAN components. The first platform, widely referred to as the non-real-time RIC, can be considered part of SMO and is used for applications that execute on a time scale of seconds or even minutes. These applications are called rApps. In contrast, the second platform, called near-real-time RIC, runs so-called xApps, which can operate on a time scale of well below one second. Both RICs offer a myriad of possibilities for independent vendors to provide RAN optimization solutions for specific industries and use cases.

The interactions between the deployed 5G campus network and OT services and management systems, along with orchestration solutions, are pillars of modern 5G campus networks. It helps customers tailor the ideal solution for their use case, allowing them to deploy and manage components from different vendors to meet their needs, while avoiding vendor lock-in and improving both OPEX and CAPEX.

Conclusion – Position 2: Open and modular 5G campus networks provide mechanisms to handle complexity over the entire lifecycle

By carefully considering available and new technologies from a user and operator perspective, CampusOS demonstrates the benefits of open and modular 5G campus networks by building end-to-end testbeds in different verticals. The goal is to conduct functional and interoperability tests as well as performance evaluations of the deployed components, while highlighting the role of orchestration in lifecycle management, interoperability, and the overall network.

The benefits of open and modular 5G campus networks can be realized by effective lifecycle management of the involved components and services. Seamless interoperability between network and application domain services can be enabled through standard orchestration and management interfaces fostering innovation from the vendor's side and reducing costs for prospective operators. Most importantly, SMO is an enabler, and it is key for handling the operational complexity that disaggregated 5G campus network solutions introduce.

Position 3: Open and modular 5G campus networks address new markets and enable new business models for suppliers and verticals

Introduction

While the introduction of open and modular architectures in public networks is mainly driven by the use of specialized components and functions, the avoidance of vendor lock-ins, and an increase in cost efficiency, such architectures will also bring multifarious benefits for campus networks, in particular functions and solutions tailored to the needs of business case owners. They will gain a crucial role in tapping the full potential of 5G for verticals.

Especially the definition of open and interoperable network interface specifications can be a unique driver for innovations. They can establish Europe not only as a user market for private network solutions, but also as a supplier market. Customized functionalities can be developed and implemented by highly specialized companies that are acting beyond the scope of large end-to-end providers. This offers existing, often smaller companies, the opportunity to move up the value chain or to extend core competencies by developing and offering new SW / data driven solutions. This applies to the technological aspect, as explained in Position 1, as well as to economic implications. Private network operators can develop SW solutions on their own, based on their specific requirements. This can be the case, for example, if specific process knowledge is not to be shared externally or if an in-house development costs less or it is preferred for strategic reasons.

Arguments

There is market evidence supporting this position: As of August 2023, CampusOS has identified 50 campus networks with a known vendor in Germany by analyzing public domain information. This analysis shows that there is already a remarkable share of open and modular campus networks available today:

- Hardware-independent "software 5G cores" that can run on commercial off-the-shelf hardware or in a cloud have gained some ground: Installations with a software core already make up a share of more than 20% of the 50 isolated networks with a known vendor.
- There are 17 networks with an Open RAN installation. The RAN components of these networks are built by a single vendor. This might be an intermediary step that already shows the advantages of these architectures but avoids technical and organizational challenges that still exist today (e.g., interoperability or operational complexity). These networks are used not only by research institutes, ICT companies, and large companies, but also by SMEs.

Conclusion – Position 3: Open and modular 5G campus networks address new markets and enable new business models for suppliers and verticals

It is not just a forward-looking statement that open and modular architectures will have a strong positive impact on the development of the 5G campus network market. CampusOS' market insights prove that this is already happening today, despite the early market stage and the many operational challenges that still need to be overcome.

A greater density of potential solution providers, which can be expected through open and modular campus networks, can bring advantages in terms of the costs of 5G campus network solutions. The availability of functionalities relevant to verticals can also serve as an innovation accelerator for the market. Furthermore, they will help users to balance performance and efficiency according to individual needs. Therefore, they will have a crucial role in the development of this market.

Position 4: Development and growth of the ecosystem drive further adoptions of open and modular 5G campus networks

Introduction

The emergence of new markets and business opportunities as discussed in Position 3 leads to the development of ecosystems that address these areas. It is important to consider the relationships and interconnections as well as interdependencies of these existing ecosystems, as each typically addresses only a specific aspect of 5G campus networks, such as RAN, core, or management. The open and modular 5G campus network market paves the way for a harmonization of the ecosystems. This will establish new partnerships even beyond the network domain with different vertical domains.

Arguments

More specialized end-to-end solutions are required to meet the needs of different vertical applications. A growing and harmonized ecosystem will provide the opportunity to choose from a wider range of component suppliers and integrators to deploy a more specialized and customized end-to-end 5G campus network in a desired operating model. This also paves the way for cost reductions due to emerging competition and the resulting variety of products and their combinations. It will also make it possible for smaller companies, which have previously shied away from operating 5G campus networks due to substantial investment requirements. Furthermore, both points above mean that diversity also creates more flexibility and extensibility.

On the other hand, there are also risks associated with the multitude of possibilities. It becomes more and more difficult for interested parties to get and keep an overview of which components and combinations, depending on which functional disaggregation, are the best for the respective application. On the supplier side, there is a risk of being squeezed out of the market by the number of competitors, especially by the established larger players.

For integrators, another positive aspect is of high importance. The large number of providers and their possible combinations open up options for new partnerships and expansion of the company's own portfolio.

A major benefit of the openness of 5G campus networks is that no single company needs to provide a complete solution. Individual components and combinations can be selected from a variety of vendors. This allows smaller companies to develop products for 5G campus networks that are specialized for and focused on only one aspect of the network. It can also lead to the emergence of new companies that deal with new extensions or additions to campus networks and create new roles. As 5G campus networks might become more complex and more sophisticated, some areas of the lifecycle, such as planning, deployment, testing, operations, or optimization, can be taken over by suppliers.

Conclusion – Position 4: Development and growth of the ecosystem drive further adoptions and take-up of open and modular 5G campus networks

In summary, a harmonized ecosystem for open and modular campus networks will support faster deployment of 5G campus networks in different vertical domains. The openness of 5G campus networks inherently carries the risk of increased complexity as well as the risk of being squeezed out of the market as a small vendor. On the other hand, there are many opportunities and possibilities to enter the market on the supplier and operator side, as well as new possibilities for cheaper and more flexible solutions on the enterprise side.

As CampusOS and its six associated "satellite" projects already connect many different stakeholders, including vendors, integrators, operators, and vertical domain players, it is a good starting point for the new end-to-end ecosystem. Furthermore, the planned interactions between CampusOS and the projects of the Franco-German Program (5G-OPERA[4]) will extend this ecosystem with additional players and towards new application domains. Strong relationships and exchange with sector associations, such as 5G-ACIA and VDMA, are paving the way into relevant vertical application areas. An associated partnership model will further expand this ecosystem and these relations.

[4] https://franco-german-5g-ecosystem.eu/5g-opera/

Outlook

Four positions on open and modular 5G campus networks and the corresponding ecosystem were introduced and discussed in this paper. The positions serve as an entry point for a more in-depth discussion of open and modular 5G campus networks, their applicability to industrial verticals, their complexity, new business models for suppliers and verticals, and further ecosystem consolidation and growth. The CampusOS project will release dedicated publications on these aspects during the project lifetime.

- The first whitepaper will be available by December 2023. It will discuss vertical use cases and their requirements for open network architectures, outlining the potential benefits, drawbacks, and implications of an open and modular approach to 5G campus networks.
- An upcoming publication will consider the adaptation of the O-RAN architecture for campus networks.
- A significant contribution to the open campus network ecosystem will be a catalog of open and modular components, including solution blueprints for different use cases.
- A further whitepaper will introduce operating models from different perspectives of vertical markets.
- Finally, CampusOS will release its recommendations as a guideline ("Leitfaden"). It will summarize key project findings and will provide an orientation for the selection of suitable technical blueprints, operating models, and ecosystem considerations.

Please share your thoughts on open and modular 5G campus networks via our corresponding survey[5] or visit us at https://campus-os.io.

The research project CampusOS aims to support the setup of an ecosystem for 5G campus networks based on open and modular radio technologies and interoperable network components as defined by, e.g., 3GPP, O-RAN ALLIANCE. This enables manufacturer independence and more competition and innovation in order to strengthen the digital sovereignty of companies in Germany.

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[5] https://forms.gle/hQRtnz6iYbQaLPYJ9

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