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Research Article

5G NETWORK AND ISSUES RELATED TO NETWORK CONVERGENCE

Shaikh Abdul Azeem[1]* and Satyendra Kumar Sharma[2]

[1]Department of Computer Science, Pacific Academy of Higher Education & Research University, Udaipur, Rajasthan, India
[2]Modern Institute of Technology and Research Centre, Alwar, Rajasthan, India

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A B S T R A C T

5G services are characterized by unprecedented need for high rate, everywhere availability, ultralow latency, and high reliability. The convergence of access and metro networks, which revolves around two key trends of infrastructure integration. With the advancement in the networking technologies the next generation network (NGN) architectures must be 5G-ready & must be capable to support the next generation of applications and services. The convergence in the networking dimension, designates the integration of heterogeneous infrastructure across different network segments to allow end-to-end control of networking resources; aiming towards the integration of different types of networks, mobile, fixed and data centers, to enable end-to-end resource management. This paper provides extensive information about 5G network its features, expectation and future of Wireless network (SDN/NFV, MEC & Network Slicing) and also studied about FMC & data center consolidation.

INTRODUCTION

Scaling up network convergence to a point where the network can provide personalized connectivity to the application using it independently of the underlying technology, geographical location and infrastructure ownership provides vast benefits, greater user satisfaction & economic benefits. Number of research activities on converged network architectures aim at providing an integrated framework to bring together different 5G technologies within a unifying and coherent network ecosystem. These activities come under three distinct categories of convergence. First the convergence in the space dimension, explores the use of long-reach access technology to enable central office consolidation. Second, the convergence in the networking dimension, discusses trends and options for end-to-end integration of different network types, focusing on fixed/mobile convergence and proposing a vision where agile data centers play a pivotal role in the virtualization of network functions. Third, the convergence in the ownership domain, describes current work in multi-tenancy for access network. Whatever may be model or architecture we use or develop the end user should receive fast and correct delivery of the contents [1].

Corresponding author:* **Shaikh Abdul Azeem
Department of Computer Science, Pacific Academy of Higher Education & Research University, Udaipur, Rajasthan, India

Features of 5G Network

Future 5G services are characterized by unprecedented need for high rate, everywhere availability, ultralow latency, and high reliability. When we analyze the history of last two decades we see network convergence provides us reduction in cost of ownership by moving voice services from the synchronous TDM transmission systems to the packet switched architecture used to transport Internet data, through the adoption of Voice over IP (VoIP) technology. Technological convergence also gave the operators the opportunity to offer bundled broadband services, such as triple play (e.g., voice, Internet and TV) and quadruple play (adding mobile phone to the mix), as a means to reduce their cost and to benefit from economies of scales associated to service consolidation.

Currently major focus is on the convergence of access and metro networks, which revolves around two key trends of infrastructure integration. The first is the consolidation of the number of central offices (COs), which is typically achieved by adopting fiber access architectures with longer reach, to bypass some of the current network nodes. The second is the convergence of wireless and wireline networks, which typically focuses on the transport of data from mobile stations over shared optical access links [1].

Expectations from Future 5G Network

With the advancement in the networking technologies the next generation network (NGN) architectures must be 5G-ready &

must be capable to support the next generation of applications and services. The Next Generation Mobile Networks (NGMN) Alliance was one of the first organization which come up with a set of use cases, business models, technology and architecture proposition for 5G. The digitalization of society and economy, leading to the fourth industrial revolution, impacting multiple sectors, especially the automotive, transportation, healthcare, energy, manufacturing and media and entertainment sectors.

One of the very important expectations from 5G networks is the everywhere availability of broadband connection, as it is expected that the user experience continuity is not confined to urban districts but also extended to rural areas. The digital divide has become a major social and political issue worldwide, as fast broadband connectivity is now a necessity, and like oxygen, a fundamental right of every citizen. In this regard the European Commission has clearly stated broadband speed targets for the year 2020 of 100% population coverage with at least 30 Mbps, and 50% with at least 100 Mbps.

5G & Network Convergence

It should be stressed that the architecture must be capable of achieving advantages because it considers the network from a converged, end-to-end perspective, rather than optimizing separately access, metro and core. For example, one of the crucial parameters in long-reach access is the optimal value for the maximum optical reach, which cannot be determined if the access-metro part is considered independently from the core. The benefits of implementing node consolidation reveal that it can contribute to improving the business case for 5G, by reducing the overall network cost and energy consumption, thus providing the foundation for an architecture capable to deliver broadband fiber connection to a larger number of users, creating a ubiquitous optical access network ecosystem. The convergence in the networking dimension, designates the integration of heterogeneous infrastructure across different network segments to allow end-to-end control of networking resources; aiming towards the integration of different types of networks, mobile, fixed and data centers, to enable end-to-end resource management. Among the three convergence dimensions, this is the one that most impacts the 5G vision, as it involves integrated development with the wireless access [2].

Large-scale network convergence was the migration of voice services from circuit-switched to packet switched IP networks, generating substantial savings in cost of network ownership for operators. Extending the concept to the access network, a strong integration between mobile and fixed technologies within a everywhere fiber deployment provides the resources to serve a wide range of user and services for several years to come. As any point of access can in principle deliver several terabits per second of capacity and bring such capacity from one end of the network to the other. The idea is that to build a flexible network architecture where multiple technologies can converge and provide a pool of diverse resources that can be virtualized, sliced and managed to provide the required end-to-end connectivity to applications.

The convergence in the ownership domain, denotes the concept of multi-tenancy across network resources, allowing multiple operators to share physical network infrastructure. The proposed roadmap is through three sequential steps the first step is to reuse existing network equipment controlled by the infrastructure provider through their management system, the second step is to deploy new hardware in the access node capable of resource virtualization, so that the virtual network operators could be assigned a virtual network slice and get full control of the equipment and the third and final step is the full SDN integration, where the virtual operators access their network slice through a flexible SDN framework with standardized APIs.

Multi-tenancy enables network infrastructure sharing, reducing the cost of ownerships and opening the market to a plurality of new entities that can provide the diversity that is necessary to empower the 5G vision. While the network can benefit from all three types of convergence, some of them have contrasting requirements, for example considering the trade-off between node consolidation, requiring longer links with higher latency, and support for some of next generation mobile services, which present today very tight latency constraints.

A first set of activities, at the lower network layers, focus on the enhancement of network performance, addressing higher cell density, higher peak rate and energy efficiency, as well as scalability, latency reduction and higher reliability. This is reflected for example by the work carried out by ITU-R, ITU-T, and IEEE cited above.

A second set of activities, at the higher network layers, are targeting software-driven approaches to resource virtualization and control, through network virtualization, NFV and SDN control layers. This is believed to be a distinctive feature of 5G networks, to satisfy the ‘Polymorphic’ design principle and provide the flexibility and automation required to accommodate the envisaged diversity of requirements. Third set of activities should focus on new business and network ownership models that will have to emerge to make the integration of all the various components profitable for the market players. The convergence in the space domain signifies the consolidation of many of the current network nodes. Which is achieved by integrating the physical architecture of access and metro networks to enable node consolidation, i.e. a significant reduction in the number of central offices. The aim of this convergence is manifold, providing capital and operational cost saving through a massive reduction in the number of electronic port terminations, in addition to simplification of network architecture and management.

Different 5G use cases will have specific performance and functional requirements; hence, tailored C-plane architectures will be defined and instantiated combining subsets of the basic control functions. Functional requirements of each use case will affect the set of control functions composing the correspondent C-plane architecture. Those requirements might include the need to identify and authorize devices and subscribers over different access networks, the support of different types of mobility, the support of several QoS classes, different security levels, etc. On the other hand, performance requirements will affect the instantiation of the C-plane architecture, as functions might be implemented as virtual network functions in a network service chaining manner on general purpose hardware, high performance data center, or on cloud edge points of presence service execution close to the service consumption point.

Use case by use case, the C-plane will be composed by a set of Control functions, mutually interconnected by network function interfaces and connected to controllers via Network

Function Controller interfaces. Functions can be further distinguished between network access functions and network core functions. The same set of core functions is compatible with access functions of any access technology; this provides full FMC for device and access network. The C-plane will be paired to a clean slate D-plane. Controlled by the C-plane, the D-plane will consist of forwarding paths configured in the SDN infrastructure allowing data to be routed from source to destination. According to service requirements, an augmented D-plane may also include additional tailored network functions. Besides identifying the required set of control functions, completing the C-plane design requires to specify how to provide connectivity services, i.e. defining C-plane procedures and protocols, necessary to accomplish all associated actions. The design must fully explore the freedom offered by SDN and NFV in placing network functions anywhere in the network and as decomposed abstract service functions. As such, it will require an intelligent orchestration and control system automating and hiding details, yet executing according to operators' and customers' policies. The 5G network functions are instantiated over the 5G network infrastructure via service and infrastructure orchestration mechanisms.

While enabling convergence, the architecture must maintain the low transmission cost per bit for the devices despite of requirements heterogeneity. This should be achieved by developing Intelligent Connectivity, capable of granting access, providing addresses, establishing QoS guarantees on forwarding traffic, re-locating services, while optimizing resource usage and providing options for tailored services in the 5G system.

Management and orchestration of virtual entities, both at service and infrastructure level, will be performed according to "network-functions-to-infrastructure" decoupling principles, information elements, and interfaces specified in. The Network Functions Virtualization Management and Orchestration (NFV-MANO) architectural framework specified by ETSI has the role to manage the infrastructure and orchestrate the allocation of resources needed by the supported network services and by the virtualized network functions, including instantiation, lifecycle, fault, and performance management.

Future of Wireless network

Future of Wireless network is hidden in SDN/NFV, MEC & Network Slicing technologies. We study these technologies one by one.

SDN/NFV

SDN will play a pivotal role in the multi-dimensional convergence, both as the mechanism to orchestrate the interaction among the different network domains and technologies, and the system to integrate and automate many of the control and management operations that are today still carried out through proprietary and closed interfaces. SDN play a key role towards converged 5G networks and proposes the use of application-driven business models as a foundation of the 5G vision [1]. The development of open and programmable networks, based on the Software Defined Networking (SDN) paradigm, which will automate most of the QoS configuration hiding its complexity to network administrators. Many operators are already investigating the use of SDN in their network, with some making it their main short-term goal, and discussions have already started among industry fora for delivery of Broadband Assured Services.

Enabling end-to-end virtualization of the network, will provide the opportunity for new business models for network sharing. A pragmatic analysis reveals that SDN has so far boosted research in several areas of networking, by producing a framework where testing of new algorithms, protocols and architectures, can be quickly moved from simulation/emulation environments. One of the key messages is that an un-converged view of the network based on the piece-wise development of the individual segments is suboptimal and can lead to uneconomical decisions. A typical example is that viewing the wireless domain only as a client of the optical domain has led to issues in performance and deployment cost. Network architectures should be designed with an end-to-end vision in mind, as the real value for the end user comes only from a consistent support of the application from its source to its destination. There are many open areas of research, which we believe will become increasingly relevant in the coming years.

Next generation wireless systems are expected to embrace SDN/NFV technologies towards realizing slices of shared wireless infrastructure which are customized for specific mobile services e.g., mobile broadband, media, OTT service providers, and machine-type communications. Customization of network slices may include allocation of (virtualized) resources (communication/computation), per-slice policies, performance monitoring and management, security, accounting, etc. The challenge is thus to promote efficient *statistical multiplexing* amongst slices over pools of shared resources [4]. With NFV, each functional element is represented as a virtualized network function, allowing network operators to use generic servers and switches instead of purpose-built hardware systems. SDN, in a generic sense, plays a key role in future 5G networks by offering a much higher level of programmability to change usage of network resources, as well as functions and protocols configuration.

Mobile Edge Computing (MEC)

MEC is a network architecture concept that enables cloud computing capabilities and an IT service environment at the edge of the cellular network. MEC provides a distributed computing environment for application and service hosting. It also possesses the ability to store and process content in close proximity to cellular subscribers, for faster response time. Applications can also be exposed to real-time radio access network (RAN) information. The virtual appliance applications are delivered as packaged operating system virtual machine (VM) images. The platform also provides a set of middleware application and infrastructure services. Application software can be provided from equipment vendors, service providers and third-parties.

Network slicing

Network slicing is considered to be one of the key enablers and an architectural answer of communication system of 2020 and beyond. Deployment of network slicing enables the operation of multiple logical networks over a single physical infrastructure in order to reduce total cost, decrease energy consumption, and simplify network functions in comparison to one network for different use-cases/business scenarios. The Next Generation Mobile Networks (NGMN) introduced

Network Virtualization Substrate (NVS), which allows infrastructure provider to control resource allocation of each of the virtual instance of an enhanced Node B (eNB) before customization of scheduling of each virtual operator within allocated resource [3]. On the other hand, a heuristic-based admission control mechanism is introduced in, which dynamically allocates network resource to various slices in order to increase end user satisfaction considering specific requirements of each of the slice. One of the main objectives of network slicing is to optimize profit modeling of traditional telecommunication networks. Network slicing is still at its early stage in terms of development, therefore, further enhancement and studies are needed to become a mature technology and thus be adopted over various domains of emerging 5G system. Despite significant advantages that network slicing brings to 5G system, there are also some challenges that are arisen like Business and Profit, Security, Management, Performance, Standardization and Access Network Virtualization etc. System architecture of network slicing in 5G mobile communication provides particular focus on its business aspect and profit modeling [4][5].

Allied Technologies & Development

Fixed/Mobile Convergence

Looking at the next five years, a major goal of some of the network vendors working towards 5G is to provide a further capacity increase of up to a thousand times. Although it is still uncertain whether this is achievable, any such increase in capacity is likely to follow a similar split between improvement of transmission technology, spectrum resources and densification. Beside the challenges with delivering such a high density of capacity on the radio interface there is a comparable challenge for linking an ever-increasing number of small cells to the rest of the network in a way that is cost effective. This convergence is to run the BaseBand Processing Unit (BBU) as software on a virtual machine, in public data centers, a concept known as Could Radio Access Networks (C-RAN). This is fully in line with the 5G vision of NFV. Many research projects have worked to provide architectural solutions to the fixed-mobile convergence issue like FP7 COMBO, 5G-PPP, 5G-Xhaul. These examples show how the integration of fixed and mobile networks has become a critical factor affecting the success of next generation mobile services. In addition, as NFV is progressively moving network functions from dedicated telecommunications vendor equipment's to virtual machines, including data centers into the big picture becomes important [6].

The current implementations of Fixed-Mobile Convergence (FMC) focuses on internetworking and common interface definition data plane convergence, the 5G C-plane will also bring control plane and management plane convergence. The 5G C-plane architecture will have to overcome the limitations for scalability in today's 4G cellular networks where state is held for each active session, signaling between multiple network functions is needed for bearer setup and user services are deployed in central data center.

Data Centre Integration

The 5G framework revolves around virtualization of networks and functions, integration of access, metro and data center networks becomes essential for delivering the end-to-end vision. As NFV moves network processing towards general purpose servers, effective scale up of processing power will require a re-design of the central office architecture, which will progressively migrate towards a typical data center network. Due to the increasing role data centers are playing in the converged network vision, the optical networking community has dedicated substantial effort in exploring novel technologies and architectures for faster interconnection within the data center and among data centers. The seamless integration of wireless, optical and data center networking technologies will be instrumental to provide the necessary network agility to satisfy dynamic end-to-end allocation of connections with assured data rate and latency requirements. The increasing use of transparent optical switching in the metro architecture will increase the ability to adopt new technologies as they become available. In addition, the increasing use of virtualization to provide independency among network resource slices and end-to-end control of the leased resources will pave the way to application-oriented, and multi-tenant solutions.

Intent-based networking is the newest concept that promises to *revolutionize* the networking industry. SDN and intent-based networking share similarities, as IBN extends SDN concepts to improve network automation and abstract complexity, which includes capabilities like reducing manual network programming.

Proposed Solutions

The key concept to achieve convergence and flexibility, leveraging on the enabling technologies is depriving 5G of the single and monolithic logical architecture, which characterized mobile and fixed broadband networks until today. Rather, 5G shall define a basic set of control functions allowing dynamic definition and instantiation of C-plane architectures, fulfilling service and application requirements.

5G requirements will be achieved via the definition of an access agnostic reconfigurable control plane (C-plane), fully decoupled from a SDN driven data plane (D-plane), and instantiated on physical infrastructure according to SDN paradigm and leveraging on NFV technology. Built upon a basic set of network control functions, the C-plane will be tailored, instantiated, and operated according to device, service, and application functional requirements and performance targets. The C-plane will also have interfaces towards Network Infrastructure Controllers (allowing interaction with network physical resources) and will expose configuration APIs to third parties, service providers, and application developers, easing communication service deployment, operation, and management [6].

CONCLUSION

Next generation networks are expected to become one of the key building blocks of the forthcoming digital society, enabling a variety of different sector/vertical services, supporting new applications and connecting next generation devices. Flexibility will be the keyword for 5G network, as it will be required to integrate heterogeneous access technologies and network infrastructure, as well as to fulfil performance and functional requirements of a multitude of different services. Additionally, network operators cost reduction (both OPEX and CAPEX), ease of service deployment and support of new business models will be drivers for 5G design. With the help of number of research activities on network convergence, we conclude that it will at great extent can contribute to meet future 5G requirements. The role that SDN could play in this future convergence and the second is a vision on future end-to-end virtualization and associated business models. Converged network architecture must meet the very versatile requirements of tomorrow's applications by a cognitive 5G C-plane for everywhere every time access technologies. There are some projects funded under the 7th EU Framework Program for Research and Innovation such as METIS, COMBO, UNIFY, and other projects related to 5G or network convergence.

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