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A Step towards Software Defined Mobile Networks in 5G Scenario and Research Challenges

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Abstract – In mobile networks, nowadays, the two major constituents are virtualization and digitization in order to use basic resources and provide the means for the network as a service. Strong pairing of these two techniques determine the adaptability required to supply network resources on-requirement and to constitute and connect network assistance functions dynamically in order to fulfill needs of a vast range of users. Software Defined Mobile Network (SDMN) and Network Function Virtualization (NFV) technologies are predicted to have a crucial function in 5G scenario. These two, namely, SDMN and NFV, have been extensively used in core designing of mobile networks. In this paper, the approach of software defined Radio Access Networks (SD-RAN) is presented. It is relied that softwarization in radio access networks will be a pivotal move to help network segmentation, RAN distribution, adaptive spectrum organization and other important characteristics in 5G networks.

Index Terms – RAN, SDMN, softwarization, virtualization.

I. INTRODUCTION

Software Defined Mobile Network (SDMN) is known to be an auspicious technique to modify the outline of networks used in businesses, cyberspace, datacenters and internet etc. SDMN and Network Function Virtualization (NFV) will impart an essential part to organize mobile networks. It is essential to put SDMN in mobile core networks because the underlying functions of mobile core networks is to send network packets to another layer, data validation, confidentiality, billing, and management of mobility among devices. The common issue is the role of SDMN is in RAN. Although SDMN is designed to control the complexity in networks, similar concepts of SDMN could support to gear various types of complicatedness in upcoming generation heterogeneous networks. In this paper, requirements will be identified, business impacts will be labelled, and certain basic ideas on how to apply a software defined mobile networking technique for designing, implementing and managing the 5G networks will be proposed.

II. REQUIREMENTS FOR SOFTWARE DEFINED RADIO ACCESS NETWORKS

After a much of discussion on how 5G networks will be developed. Major techniques for 5G networks are particularized, user requirements have been sufficiently determined. Authors in [1][2] has specified a collection of 5G use cases. In Europe, the 5G PPP design financed by the Europe Commission has determined the major efficiency calculations of 5G networks [3]. The general belief is that 5G will turn into a consolidated service area to fulfill services including broadband service, large Internet of Things, and analytical machine kind of telecommunications. Certainly, recent network design and techniques are needed to serve such a huge range of services.

A. Management of Resources

From the recent network aspect, the softwarization will assist the progress of not only the management of radio resources but also the orchestration and allocation of spectrum [4]. The growing complicatedness in 5G networks demands for the enhanced network techniques. So advanced and flexible frequency approach will be required for the successful outcome of 5G. The software defined mobile networks could permit managing spectrum more precisely, using knowledge, mobility conditions and efficient usage of spectrum by allocation strategies in RANs.

B. Inter-Cell Interference [5]

However, SDMN will play a major role for managing the complicatedness in 5G mobile networks. The complexity arises in the access layer (i.e. MAC and PHY) from the major requirement to manage inter-cell radio resources. Implementation of small cells [6] in such a large volume in 5G network delivers easy approachability to the users but also give more complex conflicting scenarios. The access layer could completely believe on network level management to deliver services correctly, to give platform for coordinated multiple point transmission (CoMP) or multi-input multi-output (MIMO) networks, and highly organized signal processing.

C. Flexible Spectrum Scheduling

The more complex stage in heterogeneous mobile networks(RAN) could arise from dynamic allocation of various resources in wireless networks. As LTE networks provide the flexible spectrum scheduling, the combination of frequency and time allocation turns into a much required approach to cater radio resources and to reduce inter-cell disturbances. Moreover, present shared alternatives followed by network macro-cells in LTE are not adaptable for huge number of micro-cell positioning. An SDMN technique for RAN may give dynamic scheduling schemes, where the virtualization of network resources could advance resource management at the network layer, services at node level and flexibility among the network.

D. Network Slicing

5G RAN demands dynamic approach to make network slicing feasible and service chaining becomes possible, for different services from various vertical fields, e.g. transport, wellness, power and social security. To enhance the user observation and quality of network services, RAN could surely believe on the cloud and Edge Computing schemes for enhanced efficiency and sufficiency. Software defined mobile network type implementation of radio access network is an important way to accomplish softwarization in the radio access network layer.

III. BUSINESS IMPACTS

The advancement of SDMN will be having intense effect on the financial worth of mobile industry in future. Mobile network companies will be capable to cut down the Capital Investment (CAP-IN) and time span to set up services, as modern accessible control network elements and the software-defined control will lower time and amount to redesign and improve radio access networks, and to propose advanced network features. The software based implementation of control network architecture will permit more dynamic and adaptive usage of spectrum, available infrastructure, as well as the power resources so as to minimize the operational cost.

A. Time-to-Market(TTM)

The extended and dynamic software based network architecture will permit resilience to network resource dealers in order to install network services. It will cut down the span for initial idea to final product i.e. time-to-market(TTM), and permit novelty by embracing competition.

B. Over-The-Top(OTT) Services

Content developers will be having an exaggerated service being appropriately delivered. RANs could be adjusted for Over-The-Top services by network partitioning and resource sharing. It gives content developers and Network Operators (NO) a collaborative environment to profit their business.

C. Smoother Network Services

Mobile users will get untroubled and smoother experience of network services by the enhanced coordination between various networks. Mobile Network Operator is capable of providing customized services to please certain subscribers, and to implement enhanced services in lesser time, and also to develop other related services which add value to the network

IV. TOWARDS SOFTWARE DEFINED 5G RAN

On the basis of SDMN architecture, an example of SDMN design of RAN is described in Figure.1. With the required function advancement, the 5G mobile network [7] resource is capable to address information about cells to a newly included control layer. This newly introduced control layer can be deployed by mobile edge computing methods. This layer also has the warehouse to keep various procedures and spectrum related information. The territorial perspective of cells, in accordance with the interaction of the cells, is achieved by obtaining the information stored in the warehouse of the control layer. This perspective involves spectrum distribution, link between various network devices, and obstruction map between cells.

A. Network Function Virtualization

The territorial aspect of cells is additionally engrossed to the higher layer abstracted design, which is owned by control layer functions along with network virtualization functions(NVF) [8]. Additionally, the past experience of configurational arrangements and stats of mobile data reserved in the warehouse could be prepared or determined for the enhanced configuration of the mobile network. On the leading edge of the control layer, there are software based control functions for various control designs. New control is included with control commands at the user level from the network virtualization layer.

B. Automation at Control Layer

The time-critic configurations can be backed through bottom level control computerization or authorization to elemental radio access network segments [9]. These segments hold supervisory responsibility of organization and collaboration in between cells, describe the necessity and decide the communication direction for the coordination of nodes. It accepts control information from the upper level of the control layer and give feedback to accept control communication paths. Relying upon the preliminary requirements on postponement, signaling capacity, and control design, the direction may be from any mean of broadcast transmission or from backhauls of cells. When

the control paths are finally decided, the partitioning nodes utilize indication signals for properly systemize for the collaboration. So the main focus is to prepare an accessible stage for time-critical inter-cell automation, but not restricted to particular cooperation techniques.

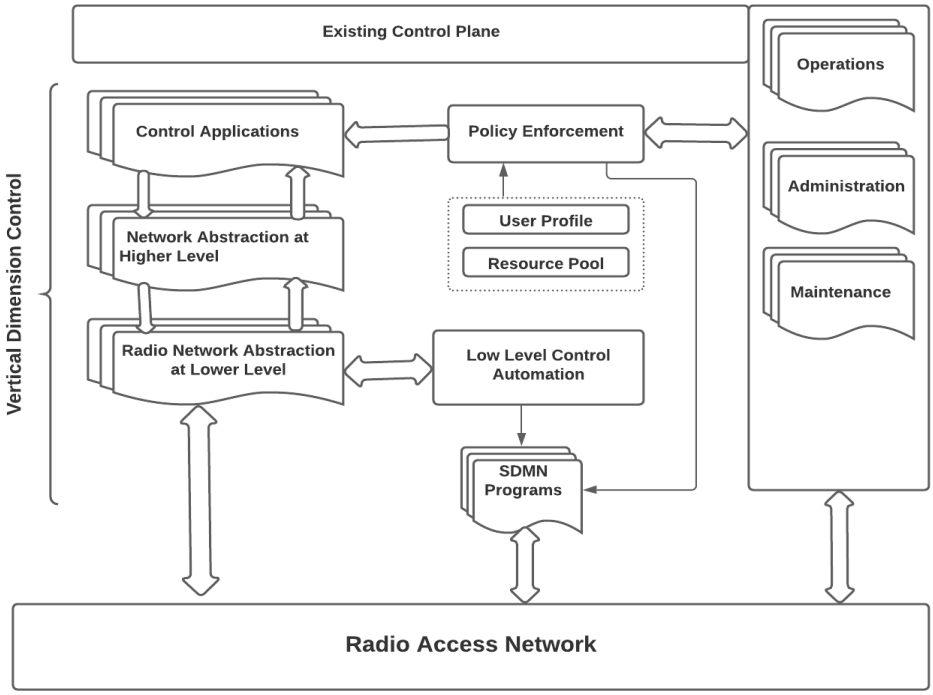


Figure.1 Software defined mobile network architecture for heterogeneous RAN

V. NETWORK SLICING IN SDMN

Figure.2 demonstrates the network slicing using the software defined mobile network designing techniques. In the figure, the bottom layer involves execution, repository, cabled/radio network view as well as Radio Frequency (RF) user-ends. The virtual elements (i.e., cloud areas) which are guarded by the framework administrator following European Telecommunication Standards Institute NFV [10] and SDMN technologies and methods lie on the upper sub-layer at the second position. The layer having NVF is a major facilitator for instant computing infrastructure i.e. infrastructure as a service (IaaS) based clouds. Virtual infrastructure of each slice should be segregated from the remaining slices to perform accurately and not disrupting the appropriate performance needs (performance segregation). Availability, flexibility and partition elasticity hypothesis concludes that it is impractical for a shared system to support flexibility, availability, and partition elasticity at one instance. Therefore, an agreement needs to be developed at the designing level for separate slices.

In order to boost the resource allocation efficiency, it is necessary to dynamically and smoothly redistribute physical resources relying on present and regional requirements, supported by various cloud controllers. Virtual assets, virtual serviceability, service cluster, and service strings, cloud, NFV and SDMN [11] methodologies should be advantaged for quick building. NFV allows for utmost adaptability when it happens to the micro-service design, chaining and administration of services, masking all the organizational intricacy of available resources i.e. physical as well as virtual. However, various network application elements have certain conditions in relation to processing time, time lag, and jitter. They need to be appropriately kept on adequate platform configurations which could fulfill the proposed application needs.

In relation to each slice of the network, the application layer of the proposed design will have to stay unaware of the actual network arrangements which is utilized by the virtual network operator, however the network slice provider should be capable of determining the accurate position of the network essentials. This needs analyzing (a)how to expose the network state and resources to facilitate network application and services, (b) how the virtual network design is accumulated and composed to design the network, and (c) how the mobile network is programmed and instantiated to support a certain application area. SDMN is developing as an obvious outcome for 5G and further generations of mobile networks, as it ensures NFV capabilities and network softwarization. We intend to switch to SDMN techniques and implement SDMN controllers along with software based data plane methods to enable enhanced programmability of the switching in mobile networks in addition to radio data-plane abstractions.

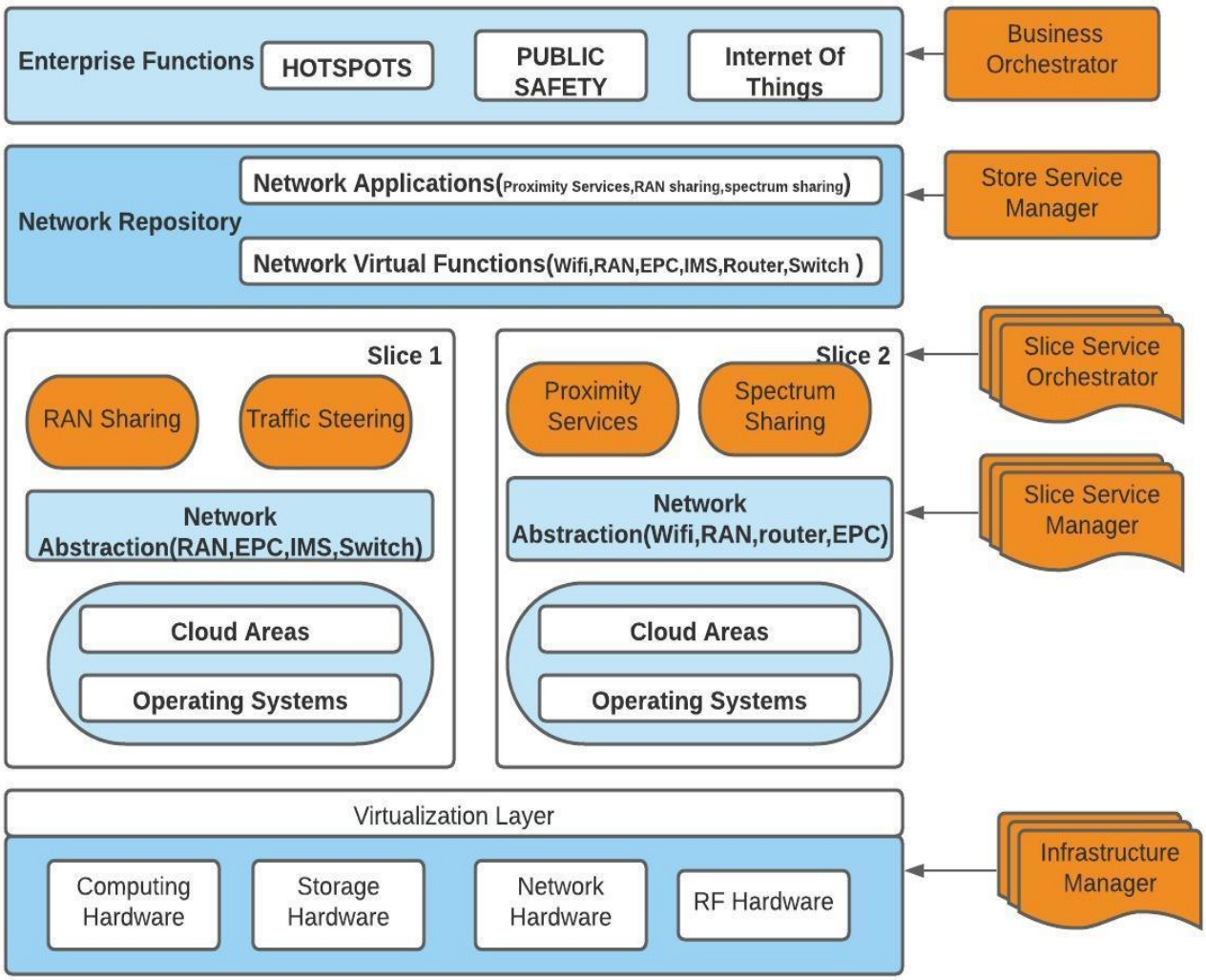


Figure.2 Network slicing in software defined mobile networks

VI. MAJOR BENEFITS OF SDMN

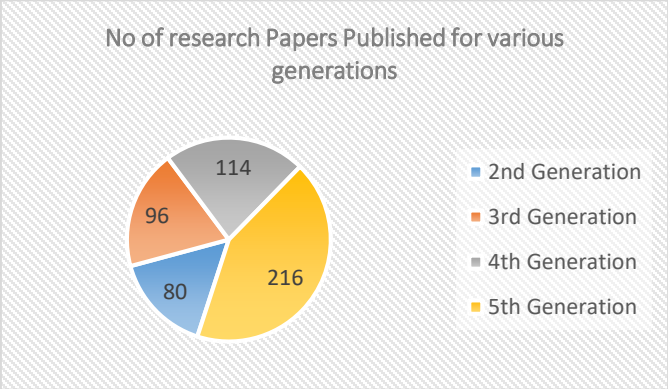
Major features of SDMN technology as given in table 1.

Table 1. Key features of SDMN

Benefit	Function
Reasonably unified controller	A centralized control is required to accomplish control decisions on the basis of worldwide aspect of the network. Control decisions become more efficient and accurate than presently available independent system based decisions.
Adaptability	SDMN mechanism considers natural guidelines amid the backhaul resources. That's why, the controller could regulate any SDN-based mobile network device from any operator because of the existence of a common platform, i.e. Openflow[12].
Intelligent network organization	Intelligent network management permit the implementation of advanced network feature in lesser time span. Additionally, it is feasible to dynamically tune the resource configurations to accomplish better utilization of resources, enhanced security and lesser call drops due to conjunction than rigid configurations. Also, corrections in network configuration is very speedily due to global view at controller.
Virtualization Concept	SDMN design conceal the complicatedness of different access methodologies and topologies. SDMN's network softwareization and designed flow model help policy control, adaptive traffic bursts and traffic partition.
More advanced innovation	The network softwareization and various application programming features expedite business modernization in mobile networks. The network provider has the option to innovate and test these proposed control designs for the network OS. Implementing these programming based applications is much quicker than implementing hardware based applications.
More course-grained control over network	The flow-based control design in SDMN model permits the implementation of granular flow control policies, i.e. session level, user level, device level, and application level. Additionally, the centralized controller can change these control policies dynamically based on network behavior.
Providing resources on-demand and online scale up of resources	SDMN concepts ensures the adaptation of virtualization in mobile networks. Virtualization of network resources enable the on-demand provisioning of network devices and scaling up of resources to fulfill demand.
Lower-cost backhaul resources	SDMN architecture separates the control plane from backhaul devices, as they are required only for very elementary functions. Therefore, SDMN switches do not need hardware having high processing power; the data plan could use very low-cost switches with lesser processing requirement.

VII. RESEARCH CHALLENGES & SCOPE IN SDMN

After a detailed literature survey on SDMN concept, conclusion drawn is shown as in pie chart below.



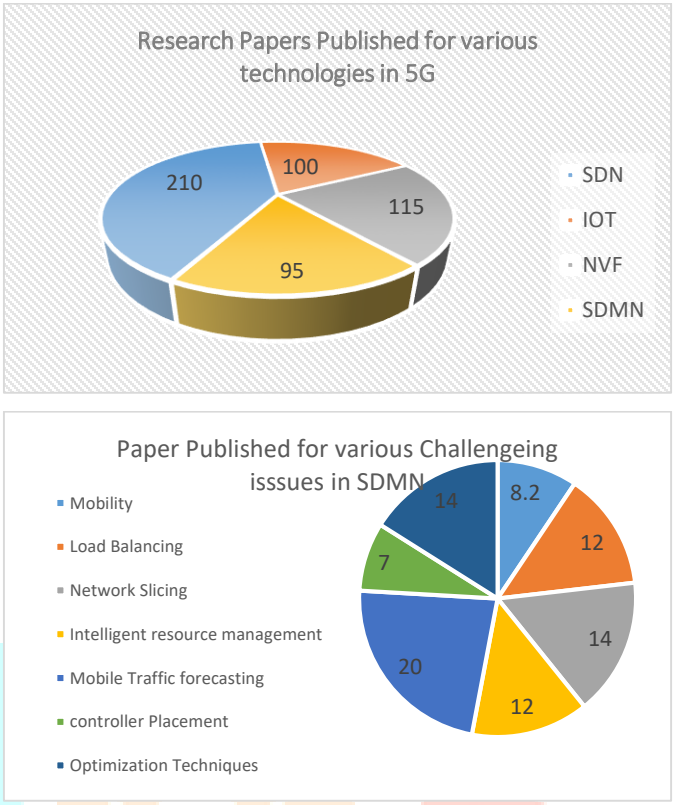


Figure 3. Pie chart showing proportionate number of papers published in each area

From the above data, it can be observed that much work is being done due to explosively growing demand for traffic. SDMN is a growing technology to fulfill the demand of more network traffic but there exist certain challenges which needs to be catered for the success of SDMN based framework. These challenges include:

7.1. SDMN aims to give centralized and programmable solutions so network abstraction is essential.

7.2. The separation of control and data planes in SDMN demands for small timeframes to be considered for effective resource management. And this can be achieved by accurate traffic prediction which is done by developing effective traffic forecasting models to implement at the SDMN centralized controller.

7.3. Network intelligence needs to be there at SDMN controller in order to support automation feature.

7.4. Due to different control requirements, integration of SDN for various networks segments is a major task to be achieved as RANs, mobile CNs, internet have different targets for control.

VIII. CONCLUSION

This paper presents a brief view of software defined mobile networks. In 5G, it considers not only enhanced spectrum distribution and advanced interface but it also provides the recent architecture designing and network methodologies. The advantages of cloud techniques, SDMN, NFV, and MEC can lead to the required tools to tear-down the existing vertical radio access network architecture into a group of horizontal micro service network functions. It has the potential to change the ecosystem of mobile networks, to enable truly mobile Internet. Advanced thinking and much more deep research are believed to consolidate SDMN implementation.

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