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International
Journal
Of Modern Engineering Research (IJMER)

SDN Communication in Radio Access Technology

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ABSTRACT:- The idea of programmable networks has recently regained considerable momentum due to the emergence of the Software-Defined Networking (SDN) paradigm. SDN, often referred to as a "radical new idea in networking", promises to dramatically simplify network management and enable innovation through network programmability. This paper surveys the state-of-the-art in programmable networks with an emphasis on SDN. We provide a historic perspective of programmable networks from early ideas to recent developments. Then we present the SDN architecture and the Open Flow standard in particular, discuss current alternatives for implementation and testing of SDN-based protocols and services, examine current and future SDN applications, and explore promising research directions based on the SDN paradigm.

Data plane: Delivery of packets depending upon status in routers and destination.
Control plane: packets are forwarding after establishing the route status.
Keywords:-*SDN, Wireless, Standardization, ONF, OpenFlow, Omni RAN, Access, Backhaul*

I. INTRODUCTION

The telecommunications sector is experiencing a major revolution that will shape the way networks and services are designed and deployed for the next decade. We are witnessing an explosion in the number of applications and services demanded by users, which are now really capable of accessing them on the move. In order to cope with such a demand, some network operators are now following a cloud computing paradigm, enabling the reduction of the overall costs by outsourcing communication services from specific hardware in the operators' core to server farms scattered in datacenters.

These services have different characteristics if compared with conventional IT services that have to be taken into account in this cloudification process [1].
In the SDN architecture, the control and data planes are decoupled, network intelligence and state are logically centralized, and the underlying network infrastructure is abstracted from the applications. As a result, enterprises and carriers gain unprecedented programmability, automation, and network control, enabling them to build highly scalable, flexible networks that readily adapt to changing business needs. SDN focuses on four key features: separation of the control plane from the data plane; a centralized controller and view of the network; open interfaces between the devices in the control plane (controllers) and those in the data plane; and programmability of the network by external applications.

Some of the mechanisms that are being considered and already adopted by operators include: sharing of network infrastructure to reduce costs, virtualization of core servers running in data centers as a way of supporting their loadaware elastic dimensioning, and dynamic energy policies to reduce the monthly electricity bill. However, this has proved to be tough to put in practice, and not enough. Indeed, it is not easy to deploy new mechanisms in a running operational network due to the high dependency on proprietary (and sometime obscure) protocols and interfaces, which are
Complex to manage and often require configuring multiple devices in a decentralized way.

Building on the revolutionary forward thinking in computer networking, software defined networking (SDN) is currently being considered as an alternative to classic distributed approaches based on highly specialized hardware executing standardized protocols. Up to now, most of the key use cases used to present the benefits of the SDN paradigm have been limited to wired environments (e.g., Google uses SDN in its datacenters [3]).

In this article we analyze the potential of applying the SDN paradigm to mobile wireless networks. First, we identify use cases where a wireless SDN approach could bring additional benefits. Then, we derive the main characteristics of a wireless SDN mobile operator`s architecture, paying special attention to the main functions and interfaces. In order to illustrate the
In traditional networks, the control and data planes are combined in a network node. The control plane is responsible for configuration of the node and programming the paths to be used for data flows. Once the paths have been determined they are pushed down to the data plane. Data forwarding at the hardware level is thus based on control information. In this traditional approach, once the forwarding policy has been defined, the only way to make an adjustment to the policy is via changes to the configuration of the devices. This is a really restrictive constraint for network operators who are keen to scale their networks in response to changing traffic demands.
In the SDN approach, control is moved out of the individual network nodes and into the separate, centralized controller. SDN switches are controlled by a network operating system (NOS) that collects information using well defined application programming interface (API) and manipulates their forwarding plane, providing an abstract model of the network topology to the SDN controller hosting the applications. Therefore, the controller can exploit the complete knowledge of the network to optimize flow management and support service-user requirements of scalability and flexibility. For example, bandwidth can be dynamically allocated into the data plane from the application.

A generic architecture for a SDN is shown in Figure 1, consisting of three layers:

T**he application layer:** applications that consume the SDN communications services,
The control layer: controllers that facilitate setting up and tearing down flows and paths;
The infrastructure layer: it involves devices that provide packet switching and forwarding.
As Figure 1 suggests, inter- and intra-layer communications occur through the following interfaces:
Southbound-API: The Southbound-API represents the interface between control- and data planes. It is the enabler for the externalization of the control plane.

Northbound-API: SDN enables the exchange of information with applications running on top of the network. This information exchange is performed via the Northbound-API between the SDN controller and an "application control plane". While the SDN controller can directly adapt the behavior of the network, the application controller adapts the behavior of the application using the network. It can be implemented as part of a single application instance to a central entity for the entire network responsible for all applications.

Westbound-API: The Westbound-API serves as an information conduit between SDN control planes of different network domains. It allows the exchange of network state information to influence routing decisions of each controller, but at the same time enables the seamless setup of network flows across multiple domains. For the information exchange, standard inter-domain routing protocols like BGP could be used.

Eastbound-API: Communication with the control planes of non-SDN domains, e.g., a Multi-ProtocolLabel Switching (MPLS) control plane, uses the Eastbound-API.

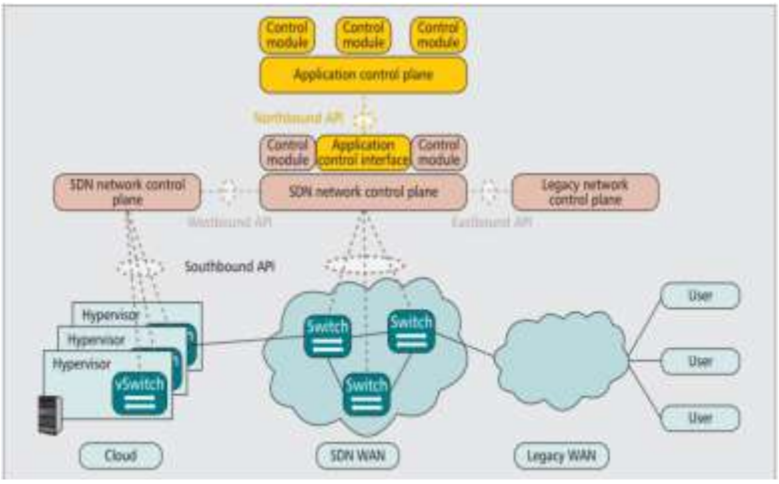


Figure 1: Generic SDN architecture

A standard communications interface defined between controls and forwarding layers of SDN architecture, called Open Flow, has been developed by ONF. Open Flow allows direct access to and manipulation of the forwarding plane of network devices, such as switches and routers. With OpenFlow, the path of network packets through the network of switches can be determined by software running on multiple routers. A number of network switch and router vendors have announced intent to support OpenFlow standard.

II. EVOLUTION

Mobile communication has become more popular in last few years due to fast revolution in mobile technology. This revolution is due to very high increase in telecoms customers. This revolution is from 1G- the first generation, 2G- the second generation, 3G- the third generation, and then the 4G- the fourth generation,5G- the fifth second generation.

A. First Generation (1G)

1G emerged in 1980s. It contains Analog System and popularly known as cell phones. It introduces mobile technologies such as Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), Improved Mobile Telephone Service (IMTS), and Push to Talk (PTT). It uses analog radio signal which have frequency 150 MHz, voice call modulation is done using a technique called Frequency-Division Multiple Access (FDMA).It has low capacity, unreliable handoff, poor voice links, and no security at all since voice calls were played back in radio towers, making these calls susceptible to unwanted eavesdropping by third parties [3].

B. Second Generation (2G)

2G emerged in late 1980s. It uses digital signals for voice transmission and has speed of 64 kbps. It provides facility of SMS (Short Message Service) and use the bandwidth of 30 to 200 KHz. Next to 2G, 2.5G system uses packet switched and circuit switched domain and provide data rate up to 144 kbps. E.g. GPRS, CDMA and EDGE [3]

C. Third Generation (3G)

It uses Wide Brand Wireless Network with which clarity is increased. The data are sent through the technology called Packet Switching. Voice calls are interpreted through Circuit Switching. Along with verbal communication it includes data services, access to television/video, new services like Global Roaming. It operates at a range of 2100MHz and has a bandwidth of 15-20MHz used for High-speed internet service, video chatting.3G uses Wide Band Voice Channel that is by this the world has been contracted to a little village because a person can contact with other person located in any part of the world and can even send messages too[3].

D. Fourth Generation (4G)

4G offers a downloading speed of 100Mbps.4G provides same feature as 3G and additional services like Multi-Media Newspapers, to watch T.V programs with more clarity and send Data much faster than previous generations [3]. LTE (Long Term Evolution) is considered as 4G technology. 4G is being developed to accommodate the QoS and rate requirements set by forthcoming applications like wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, HDTV content, Digital Video Broadcasting (DVB), minimal services like voice and data, and other services that utilize bandwidth. [2].

I. COMPARISON OF ALL GENERATIONS OF MOBILE TECHNOLOGIES [4].

Technology Features	1G	2G	3G	4G	5G
Start/ Deployment	1970 –1980	1990 - 2004	2004-2010	Now	Soon (probably 2020)
Data Bandwidth	2kbps	64kbps	2Mbps	1 Gbps	Higher than 1Gbps
Technology	Analog Cellular Technology	Digital Cellular Technology	CDMA 2000 (1xRTT, EVDO) UMTS, EDGE	WiMax LTE Wi-Fi	WWWW(coming soon)
Service	Mobile Telephony (Voice)	Digital voice, SMS, Higher capacity packetized data	Integrated high quality audio, video and data	Dynamic Information access, Wearable devices	Dynamic Information access, Wearable devices with AI Capabilities
Multiplexing	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA
Switching	Circuit	Circuit, Packet	Packet	All Packet	All Packet
Core Network	PSTN	PSTN	Packet N/W	Internet	Internet

TABLE 1

III. COMPARISON OF ALL GENERATIONS OF MOBILE TECHNOLOGIES

WHY WE NEED SDN?

1. **Virtualization:** Use network resource without worrying about where it is physically located, how much it is, how it is organized, etc.
2. **Orchestration:** Should be able to control and manage thousands of devices with one command.
3. **Programmable:** Should be able to change behavior on the fly.
4. **Dynamic Scaling:** Should be able to change size, quantity
5. **Automation:** To lower OpEx minimize manual involvement
   - Troubleshooting
   - Reduce downtime
   - Policy enforcement
   - Provisioning/Re-provisioning/Segmentation of resources
   - Add new workloads, sites, devices, and resources

6. **Visibility:** Monitor resources, connectivity
7. **Performance:** Optimize network device utilization
   - Traffic engineering/Bandwidth management
   - Capacity optimization
   - Load balancing

- ❖ High utilization
- ❖ Fast failure handling

8. **Multi-tenancy:** Tenants need complete control over their addresses, topology, and routing, security
9. **Service Integration:** Load balancers, firewalls, Intrusion Detection Systems (IDS), provisioned on demand and placed appropriately on the traffic path
10. **Openness:** Full choice of "How" mechanisms

- ❖ Modular plug-ins
- ❖ Abstraction:
- ❖ Abstract = Summary = Essence = General Idea
- ❖ Hide the details.
- ❖ Also, abstract is opposite of concrete
- ❖ Define tasks by APIs and not by howit should be done.
- ❖ E.g., send from A to B. Not OSPF.

A Software Defined Decentralized Mobile Network Architecture Toward 5G (Soft Net)

According to the analysis in the previous section of the challenges for LTE networks created by new communication paradigms, we found that some fundamental mechanisms of LTE networks become inapplicable to serve new emerged services any longer. Therefore, we propose to re-design the mobile network architecture instead of enhancing existing LTE networks to cope with those challenges. In this section, we first put forward the principles for designing an efficient and scalable mobile network, and then we propose a new network architecture called "SoftNet" that complies with the proposed design principles.

Design Principles of Soft Net

In order to design a mobile network architecture with high performance to overcome the challenges analyzed in the previoussection and satisfy new service requirements, we propose the following principles based on previous work on designing cellular mobile networks, investigation of new service requirements, and research on new network technologies.

Adaptability: There are different communication paradigms with distinct characteristics in future mobile networks, so it is impossible for the network to adopt the same approach to efficiently serve diverse types of services. Therefore, future mobile network architectures must be adaptable to cope with different communication scenarios.

Efficiency: The analysis of LTE network shows that new mobile communication paradigms may cause high signaling overhead, inefficient data forwarding, and/or long RTT latency in LTE networks, which ultimately leads to inefficient network resource utilization. Therefore, supporting new communication paradigms with efficient network resource utilization becomes a vital pursuit of re-designed mobile network.

Scalability: Scalability is important for designing futureproof network architecture, since it not only means flexibility and low cost to support unexpected services and scale up the network, but also implies that new services can be deployed quickly and new market demands can be fulfilled in time.

Simplicity: Current cellular mobile networks employ lots of protocols involving multiple network elements to perform mobility management and/or establish data forwarding tunnels, e.g. establishing a GTP tunnel involves an MME (mobility management entity), eNB (evolved NodeB), SGW, and PGW. Mobility management in current 3G and LTE networks needs to be supported by different NAS protocols. It is doubtful that so many protocols have to be implemented in future mobile networks as they incurcomplexity, inefficiency, even function redundancy of communication system [6].

Therefore, simplifying protocols should be one of objectives of designing new network architectures.

The Architecture of Soft Net

With the guidance of the design principles discussed above, SoftNet, a novel architecture for future mobile networks is proposed as shown in Fig. 2.

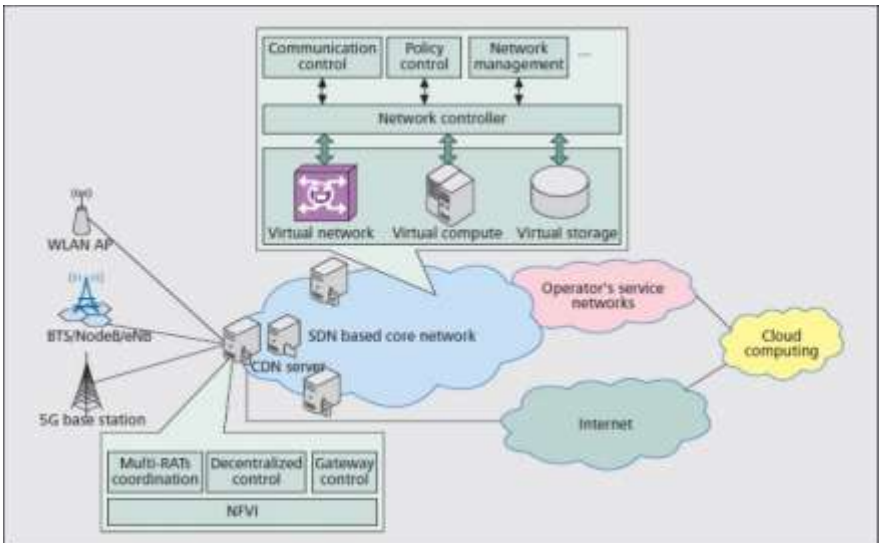


Figure 2. Architecture of Soft Net

Soft Net adopts decentralized network control on the system level to improve flexibility and scalability, but chooses centralized control on the component level to promise the efficiency of network resource utilization. Soft Net consists of a unified radio access network and an SDN based core network. In Soft Net, all radio access points in unified RAN must be connected with access servers that are at the edge of an SDN based core network, so that mobile terminals served by the radio access points can either visit the operator's service networks or third party service platforms, such as a cloud computing platform, via the core network, or access the Internet or CDN (content delivery network) server via a distributed gateway function within the access server.

The control plane network functions are supported in the SDN based core network and unified RAN separately. The network functions supported in the SDN based core network mainly include communication control functions (CCF) responsible for mobility management, policy control function supporting QoS (Quality of Service) and network policy control, and network management function (NMF) monitoring network conditions and defining network architecture.

Network functions in the unified RAN are deployed on an access server, which at least includes a multi-RATs coordination function, decentralized control function (DCF), and gateway control function. The multi-RATs coordination function can monitor wireless network conditions and steer user traffic among selected RATs. The DCF is responsible for decentralized mobility management that allows mobility events to be handled by decentralized control plane network elements. The gateway function allows mobile terminals to access the Internet or CDN without traversing the core network. The data plane network elements in SoftNet are implemented on SDN switches, including a distributed gateway in the RAN and egress gateways in the core network.

SDN Based Core Network — The core network of Soft Net is designed as an SDN flavor network consisting of network functions, network controllers, and network infrastructures.

The network functions in the SDN based core network mainly take responsibility for centralized network control such as admission control, QoS control, network management, and soon. The network controller consists of an SDN controller and virtual network function (VNF) orchestrator. The network infrastructures in the core network include NFV infrastructures (NFVI) and physical equipment. A basic network function in the core network is CCF.

The CCF can be instantiated for different usages based on the defined network architecture. If Soft Net is defined as a decentralized network by NMF, the CCF will be instantiated to manage mobility events out of the access server control.

Otherwise, the CCF will be instantiated to manage all mobility events. Another important network function is the policy control function which not only provides policies for network management, but also determines the parameters for QoS control dynamically. The policy control function may connect with cloud computing services providing big data analysis on user behaviors/habits in order to generate appropriate policy

parameters. The NMF in the core network is used to determine network architecture and manageall network functions.
Based on received instructions from NMF, the VNF orchestrator in the network controller can configure virtual machines (VMs) to corresponding VNFs, and/or calculate a VNF forwarding graph. The VNF forwarding graph has to be sent to the SDN controller to generate corresponding flow rules.

Finally, the generated rules will be installed on related virtual switches and/or physical switches.
Unified RAN — MDN [6] points out that the deployment of mobility anchors, centralized or distributed, is critical for mobility management efficiency. In Soft Net, access servers with gateway functions are deployed as distributed mobility anchors in unified RAN to support decentralized mobility management. Moreover, for a unified schedule of radio resources of different wireless networks, the multi-RATs coordination function is supported in the access server as well.

Therefore, each access server becomes a neuron of Soft Net. Radio access points, including future base stations such as 5G base stations, and existing base stations including eNB, NodeB, BTS, WLAN AP, and so on, can be served by access servers as long as the connections with the access server can be established. The access server also relies on NFV architecture to improved system scalability.

DCF is another basic component in Soft Net to support decentralized mobility management. While mobile terminals move from a radio access point to another served by the same access server, any location management or handover management signaling is handled by DCF. But if mobile terminals move between radio access points served by different access servers, DCFs in different access servers have to cooperate with CCF to perform location management and handover management. The DCF is also responsible for paging handling when it is triggered by signaling from CCF or an arriving downlink data packet.

The multi-RATs coordination function in the access server allows the network to select RATs and steer user's traffic among selected RATs. Further, by virtualizing radio resources of wireless networks, this function can even act as a controller for scheduling virtualized radio resources, as introduced in [5].

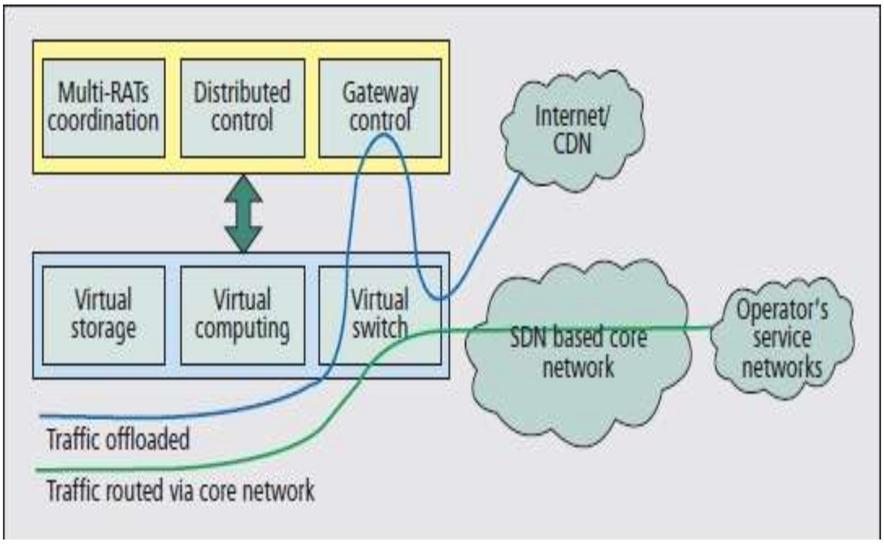
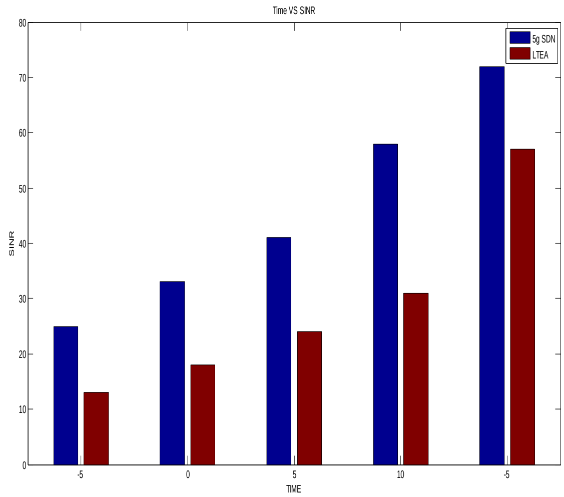


Figure 3. Traffic flows in Soft Net including traffic offload at access server and traffic routed via SDN based core network.

In order to support efficient data forwarding, the distributed gateway function is supported in the access server for traffic offloading. The control plane of the distributed gateway is implemented as a gateway control function in the access server by virtue of NFV. When mobile terminals would like to establish connections for accessing the Internet, local networks or CDN, the gateway in the access server, will act as a mobility anchor for data forwarding, and allocate an IP address for each connection. For data traffic of services for which traffic offload is not activated, such as IMS voice calls, the access server has to forward the data traffic to the core network. The traffic flows in Soft Net are shown in Fig. 3.

IV. SIGNAL NOISE INTERFERENCE

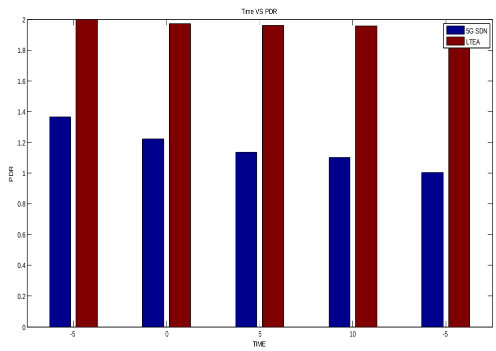
It is a quantity used to give theoretical upper bounds on channel capacity in wireless communication systems such as networks. Analogous to the SNR used often in wired communications systems, the SINR is defined as the power of a certain signal of interest divided by the sum of the interference power and the power of some background noise.



SINR(x) = P / (I+N)
P = POWER OF THE INCOMING SIGNAL OF INTEREST.
I= INTERFERENCE POWER OF THE OTHER (INTERFERING) SIGNALS IN THE NETWORK.
N = SOME NOISE TERM, WHICH MAY BE A CONSTANT OR RANDOM.
In our graph blue color indicates 5g SDN and Brown color indicates LTEA. Sothe 5g SDN is better than LTEA.

Doppler Effect

It is the change in frequency of a wave (or other periodic event) for an observer moving relative to its source.



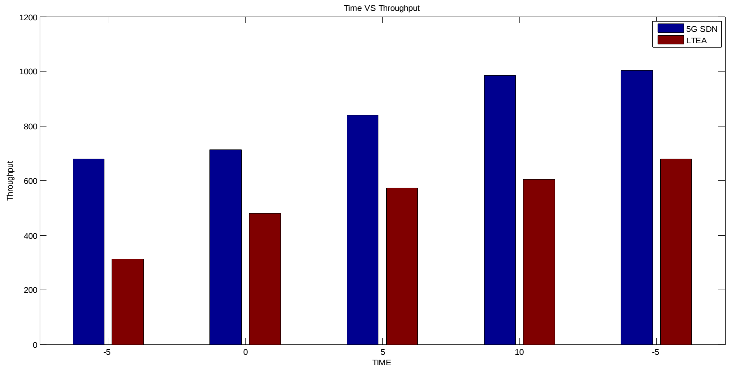
$$f = \left(\frac{c + v_r}{c + v_s}\right) f_0$$

***C*= Velocity of waves in the medium;**
v_r = Velocity of the receiver relative to the medium; positive if the receiver is moving towards the source (and negative in the other direction).
v_s = Velocity of the source relative to the medium; positive if the source is moving away from the receiver (and negative in the other direction).

In our graph blue color indicates 5g SDN and Brown color indicates LTEA. Sothe LTEA is better than 5g SDN.

Throughput:

It is the movement of inputs and outputs through a production process. Without access to and assurance of a supply of inputs, a successful business enterprise would not be possible.



$$I = R * T$$

I = number of units contained within the system, inventory.
T = Time it takes for all the inventory to go through the process, flow time.
R = Rate at which the process is delivering throughput, flow rate or throughput.

In our graph blue color indicates 5g SDN and Brown color indicates LTEA. Sothe 5g SDN is better than LTEA.

V. CONCLUSION

In this article, based on analysis on the challenges for LTE networks brought about by new communication paradigms network architecture consisting of an SDN based core network and a unified RAN, is proposed to deal with these challenges. SDN is a flexible and scalable system that can dynamically enable/disable related virtual network functions and employ new working mechanisms to improve the efficiency of network resource utilization. Thus network improves system capacity and performance. The performance evaluation is based on signaling cost, and the simulation result shows that network by employing decentralized mobility management, has decreased signaling cost compared with LTE networks.

REFERENCES

[1]. "Functional ArchitectureAleksandarfor 5G Mobile Networks" by Tudzarov and Toni Janevski published in International Journal of Advanced Science and Technology Vol. 32, July, 2011.
[2]. "5g WirelessBy VadanArchitecture"Mehta
[3]. "5GTechnology Redefiningwireless Communication in upcoming years"AkhileshbyKumar Pachauri 1 and Ompal Singh published in International Journal of Computer Science and Management Research Vol 1 Issue 1 Aug 2012 ISSN 2278 –733X.
[4]. "5G Mobile Technologies".
[5]. M. Yang et al., "OpenRAN: A Software-Defined RAN Architecture via Virtualization" Proc, ACM SIGCOMM, Aug. 2013, pp. 549–50.
[6]. S. Chen et al., "Mobility-Driven Networks (MDN): From Evolution to Visions of Mobility Management," IEEE Network, vol. 28, no. 4, July/August 2014, pp. 66–73.
[7]. https://www.sdxcentral.com
[8]. S. Sezer et al., "Are We Ready for SDN? Implementation Challenges for Software-Defined Networks," IEEE Commun. Mag., vol. 51, no. 7, Jul. 2013.

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