

Performance Evaluation of Virtualized Networks to Serve the Smart IoT Applications

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Abstract

Recently, emerging technologies such as mobile devices and applications, social networks, cloud computing, and big data have experienced explosive growth. Consequently, the end-users demand higher data rates with better quality of services (QoS). This paper proposes a Software-Defined-Network (SDN) architecture that can be used to serve multiple applications and technologies. Network simulation models are used to evaluate the performance of that architecture as well as various ones representing the traditional networking technologies for different scenarios under different conditions. The simulation results show the improvement of the SDN performance over the others. Moreover, the traditional architectures have been implemented and tested in two mobile operator's production environments and test labs. The practical measurements are compared with the simulation results for consistency. This work is considered as SDN proof-of-concept and interoperability with other technologies which is an essential aspect during the migration to SDN. So, a hybrid proposed model is simulated to gain benefits of SDN at the lowest cost keeping part of traditional network as well.

Keywords

SDN, Open Daylight, Simulated Networks, IoT applications, Performance Measurements.

1. Introduction

In the last decade, the market experienced a huge change in the number of mobile devices and smart applications requesting higher data rates with better quality of service (QoS), which is an increasing demand yearly. In this paper, a brief introduction to the software-defined network (SDN) definition was given, with its general concepts and architecture, then a deep research to show various mobile network architectures using different concepts and technologies in different durations of the mobile network evolution. Then several architectures are proposed and simulated to evaluate their performance in different scenarios including the evolutions of the traditional network passing by the virtualization ending with the software-defined network (SDN). Towards this end, modelling, and simulation of several mobile operator networks with different technologies and stages is performed. Moreover, network performance is evaluated through different measurements on the mobile operator's production/lab

environments. Both simulation results and real measurements are consistent, which validates the accuracy of the simulation results for the proposed SDN architectures for different scenarios serving the end-users.

Normally, connections between users and service providers in mobile networks must pass through a complex network core. SDN is introduced to solve the routing complexity, which enables flexible automated policy-aware routing in the next-generation mobile networks. Additionally, it enables network automation, innovated programmability, and the decrease of both capital expenses (CAPEX) and operational expenses (OPEX) by reducing costs and power consumption. The main objective is to maximize the total amount of traffic accepted over time subject to the network capacity, budget, and QoS constraints.

Long Term Evolution (LTE) is becoming the target for all network operators and providers since it supports various applications including web browsing, video streaming, Machine to Machine (M2M), Internet of things (IoT), Peer to Peer (P2P) applications, Voice over IP (VOIP) applications, video conferences, and social networking. Since the LTE provides a very high-speed radio technology, the LTE connection generates nearly ten times more traffic than a non-LTE connection.

ISP and mobile operators are facing a challenge to adopt a different set of protocols for routing, and special network elements (NE) are used for various control and data plane tasks. 4G LTE network uses IP evolved packet core (EPC) in which the data traffic of the end-users must pass by special NE starting from the e-Node B passing by Serving Gateway (SWG), Packet data network Gateway (PGW) and the traffic is routed hop by hop using load balancing or routing techniques as per 3rd Generation Partnership (3GPP) specifications, which is shown in Fig.1.

Every specific application will require different functions like detection and prevention of intrusion for enterprise customers, rate adaptation for video streaming, echo cancellation for VOIP calls, data usage measurement for billing and charging (V. Sekar et al. 2012) (L. E. Li . et al. 2012).

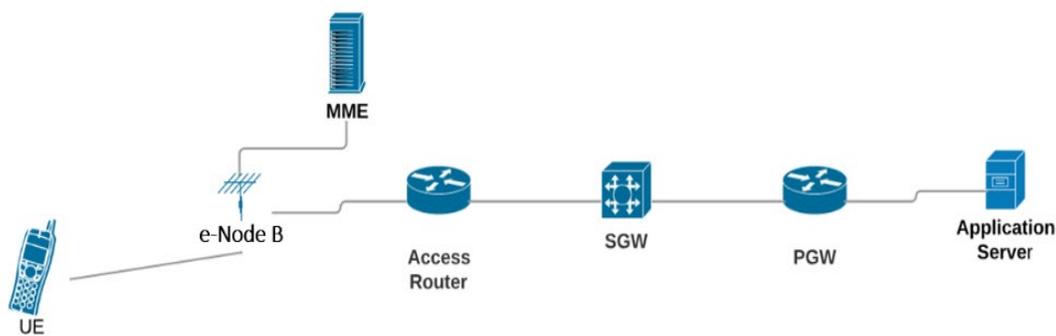


Fig.1: Routing in the LTE Mobile Network

Simply the user equipment (UE) is attached to the nearest access node called e-Node B according to the coverage strength, then this e-Node B connects to a Mobility Management Entity (MME) which checks the Access point name (APN) and tracking area identification (TAI) to send the request to SGW that connects it to the PGW that connects to the Internet or application server based on QoS which is classified and differentiated inside the PGW.

However, this structure faces multiple challenges in fully serving the customer needs due to the lack of flexibility especially in handling asymmetric traffic requests, and not getting the best of the network resources used for the end-to-end traffic steering because of the multiple nodes with different functionality, therefore the concept of SDN is introduced to face such challenges (A. Ghodsi et al. 2011) (H. Kim and N. Feamster 2013).

SDN paradigm is expected to overcome the limitations of the traditional current network infrastructure. SDN separates the network control logic representing the control plane from the underlying NE such as routers and switches (A. A. Ateya et al. 2019)-(F. Bannour et al. 2018) that forward the traffic into the data plane as shown in Fig.2. Then the NE will be just forwarding devices with low cost and they can even be virtual nodes as well. The control logic and flow

will be implemented in a centralized controller that will operate and optimize the whole network simplifying policy enforcement and network configuration and evolution (D. Sinh et al. 2017) (D. Kreutz et al. 2015).

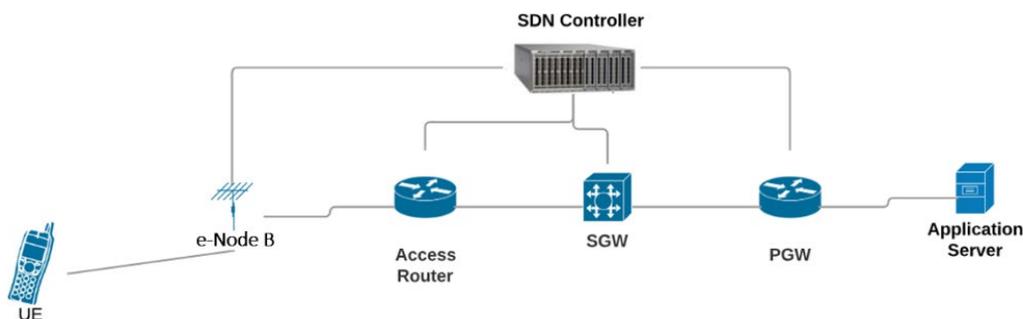


Fig.2: Routing in the SDN Mobile Network

The SDN controller has the absolute control over the physical elements through the application programming interface (API) that are well defined. The most distinguished sample of that API is the Open Flow (OF) (N. McKeown et al. 2008). The OF switch has one or more tables called the "flow table" for packet handling rules and policies. The control is applied through rules and policies that represent the traffic with different actions like forwarding, dropping, and link selection. These rules and policies are designed in the SDN controller, so the OF switches can accept them and behave like a switch, router, firewall, or even a load balancer. The separation between the control and data flow layers in the SDN is the main key to flexibility, network separation into different functions to ease the tractable items, and easier to introduce new nodes and creating or adding new rules. This flexibility and agility simplify the network management and way to more automation and innovation.

Another emerging technology to enhance the performance of mobile networks is cloud computing. Instead of the scale-up approach applied by the IT industry in building dedicated, stand-alone, high-performance software and hardware systems, the new approach is to utilize a large pool of common resources to be used or applied for a specific function to serve the network needs across various users. It can be applied to several different aspects of mobile networking, such as network function virtualization (NFV) (P. Demestichas et al. 2013), (T. Taleb 2014), which is a promising complement to SDN.

1.1 Problem statement

Unfortunately, one of the main issues in mobile operators in Egypt nowadays, is the expansion or the network improvements will cost them a lot, due to complexity of the high number of connected nodes and maintaining the same quality served for their customers, so they are not sure to expand to virtual networks with the existing physical network or to fully change to SDN. This decision is not easily taken across the market challenge and huge customer base that each operator got, and this issue will be tackled with details and a proposed solution will be introduced in this paper.

1.2 Objectives

The aim of this paper is to address the unique challenges of traffic steering and service deployment in mobile networks (Z. Cao et al. 2014) and adopt SDN as a key enabling technology to design and optimize next-generation mobile networks. Our main contributions are: SDN Utilization to enable flexible policy-aware routing and centralized network optimization and achieving higher data rates serving IoT applications in different means (Media Streaming or stable notifications). This was achieved by building the different networks simulation and doing real networks measurements on production environment in two different mobile operators in Egypt to get real measurements and compare it to the simulation done on four selected different architecture to get sure of the simulation results

consistency and so we can build on after that by proposing new models as this paper will consider with the suitable OPEX and CAPEX.

2. Literature Review

Part of this work is based on papers (Z. Cao et al. 2017)-(J. Bukhari and W. Yoon 2019) and these research efforts are classified into four directions. The first direction was trying to get a mathematical model in order to compute the latency and data rates using different algorithms for the SDN networks in general taking into consideration the core challenges (Z. Cao et al. 2017). The second direction tried to compare a different number of core nodes in SDN and traditional network running Open Shortest Path First (OSPF) comparing network performance in terms of delay, jitter, and throughput as the number of nodes changes per core (A. S. Nugroho et al. 2017). The third was simulating the M2M LTE network and evaluating its performance, especially the delay, after changing some parameters in the network, and the last research was using the software “open daylight” in order to measure an SDN Multiprotocol Label Switching (MPLS) network label switching router (LSR) initiation time, with varying in the number of LSRs (E. Husni and A. Bramantyo 2018). One of these researches, was so near in concept to apply different simulations between SDN different architectures, by changing the SDN terminals once being physical and once being logical to measure the delay and throughput but the main factor was the number of devices not the core itself as this paper will discuss later (C. N. Tadros et al. 2020). The authors of these papers are trying to enhance the mobile networks using both NFV and SDN by optimizing and measuring some different algorithms to get the best possible data rates/throughput. The authors of Comparative Analysis of UDP Traffic With and Without SDN-Based Firewall (M. F. Monir and S. Akhter 2019) were trying to apply a device to device serving network in order to test the throughput using the SDN taking into consideration the headache of the access layer using the NS3, and in Simulated view of SDN based multicasting over D2D (J. Bukhari and W. Yoon 2019), the authors were comparing different architectures with and without a firewall, which is the same idea of using different networks and measuring the delay and throughput using the SDN.

Those papers have mostly focused on the system architecture or the algorithmic aspect but have not considered comparing the measurements taken in the real or live production environment of real mobile operators and simulating a full mobile SDN architecture focusing on different types of IoT applications trying to get the best of technologies serving the new era.

This paper compares the results from the network simulation with those obtained from real network implementation with SDN and NFV to examine the reliability and applicability of the proposed architectures. It also presents several network architectures which are simulated for different IoT applications. Additionally, these results are confirmed from the implementation of a similar real network architecture in a production/lab environment in two different mobile operators in Egypt. Also, it is considered a more realistic mobile network design with real-time and non-real-time applications. As will be shown later, it shows the development of online routing flows and rules that is aware of the latency and congestion and guarantees the highest performance and throughput for a certain application.

3. Methods

In this work, several architectures have been considered in the simulation phase to have a full view of the different networks serving the smart applications. First, the physical traditional network with the Evolved Packet Core (EPC) by using the normal network components starting from the access layer passing with full physical core that got OSPF optimized using Traffic Engineering (TE). Later, NFV and cloud computing technologies are employed by converting the full physical core into a virtual function node, which is Virtual Machines (VM) performing the same function as the switching and routing physical nodes. In the end, Virtual EPC (VEPC) and the SDN are utilized by converting the core into full virtual function nodes controlled by the central programmed control node.

3.1 Design and Implementation

The Graphical Network Simulator-3 (GNS3) and the OpenDayLight (ODL) are used in this paper, as shown in Fig. 3, this is the topology used to create a virtual core to build SDN using the ODL consisting of four virtual switches which

is implemented with Ns3 to build our SDN controller in the networks used. The ODL includes the support of the OF protocol and other SDN protocols. Used with the integration of Mini-net and containerized open virtual switches (Open V-Switches) that will operate using OF protocol to sense the SDN controller.

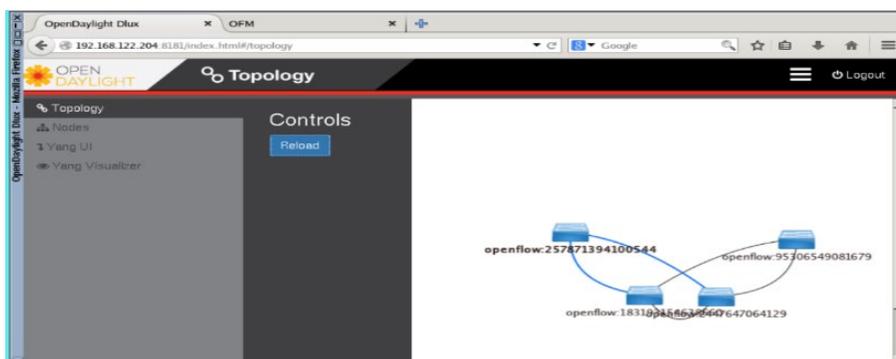


Fig.3: Open Day Light Topology

In ODL, the Open Flow Manager (OFM) is used to design the network and design all the flows that will build our logic with different priorities and conditions as a part of the flow logic and table used to in developing the QoS inside the virtual core of SDN. This will ease the design and the use of different scenarios to allow the required traffic to pass with certain QoS as required for the different architectures used. The Ostinato is a traffic generator of the GNS3 which is used to do all the test scenarios needed, that can create a physical machine on it and choose whatever type of traffic requested. In this paper, TCP and UDP protocols are used. All the traffic is generated using this component and collected by Wireshark to get the throughput of each scenario for different architecture.

3.2 Physical network

The Traditional Physical Network as shown in Fig. 4, It is the traditional normal network in most of the famous mobile telecom operators in the middle east even all over the world, that got MPLS optimized Core network connected to the SGW and PGW serving its customers for the traditional services and IoT applications, applying traffic engineering to optimize the network performance (J. Bukhari and W. Yoon 2019) (Alrawais et al. 2017). So, the traffic will be originating from the end customers handsets attached to the nearest E-Node B which serve as the access gate to the network, then to pass by the first access router to pass by the MPLS network then by S-PGW to connect it with the IoT application server, either its internal or external and hosted on the internet.

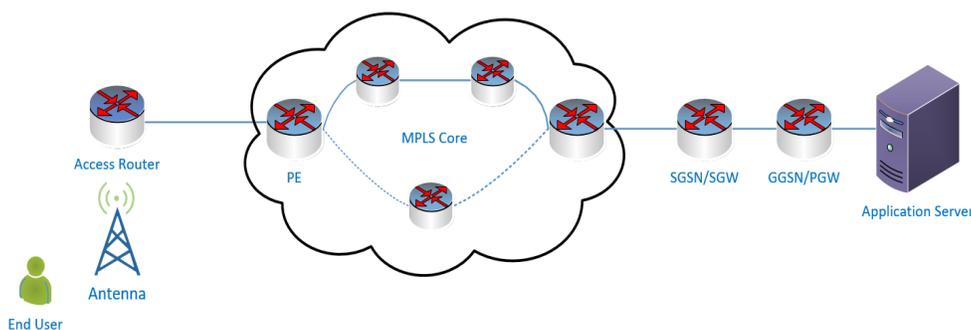


Fig.4: Traditional Physical Network

3.3 Virtual Network

The Virtual Edges Network is shown in Fig. 5. It is a mixture between the full physical network and the full transformation of the Software network by making Virtual Functions of the SGW and PGW by using VM instead of

physical routers, which is the model in most of the hybrid networks in mobile telecom operators. This approach goes half-way trying to achieve the full software or virtual network, by changing only the packet core NE to be VMs.

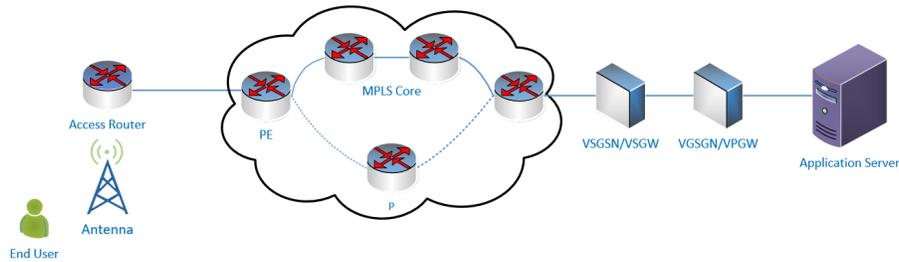


Fig.5: Virtual Network Function edge in Physical Network

3.4 Virtual core

The Virtual Core Network is shown in Fig. 6. It is a full mesh virtual switches core connected instead of the physical MPLS core network but with normal switching with no flows and not connected to the SDN controller.

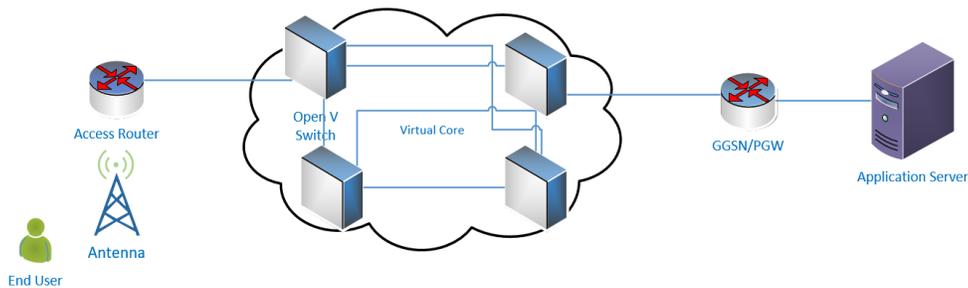


Fig.6: Virtual Core Network

3.5 SDN

The SDN is shown in Fig. 7, with full mesh virtual switches core connected instead of the physical MPLS core network with a list of flows to redirect and control the whole network giving the SDN higher priority and best routes to reach the application server.

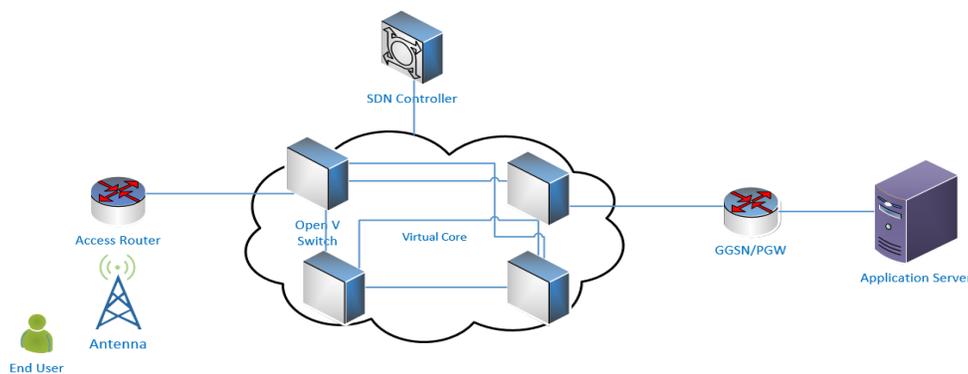


Fig.7: SDN Network

These architectures have been chosen because they provide a close resemblance to the architectures found in literature as well as in most of the mobile operators in Egypt or the Middle East. Therefore, they have been closely investigated

and simulated to tackle their problems and issues and try to predict the required network performance to serve the IoT applications.

4. Simulation Results and Discussion

Simply we got five scenarios for each type of the IoT applications to cover all the possible behaviors and different application structures. For instance, each of them is used in most of the fixed or stable notification applications, like the motion sensor, smart meter, Mobile-commerce, Mobile-healthcare etc. (Alrawais et al. 2017) and the UDP mainly for the infotainment, remote security camera, advertisements blades (which is the case for most of the multimedia applications for the IoT). The IoT TCP applications depend on a very low data rate but periodic during the day and it may be like pulses. So, it will not need high bandwidth but high availability. However, for the infotainment and any video applications need high bandwidth aside the availability so it has the highest priority. Scenarios as shown in Table 1, describing each protocol used, rate of transmission, for fixed its stable pulses like sensors, incremental got increasing rate and random for the mix between all the mentioned. Our Hypothesis here is that the virtual will be with lower throughput than full physical and SDN over higher rates will achieve higher throughput exponentially.

Table 1. Simulation Scenarios

Scenarios	Protocol	Rate of transmission	Number of Traffic Generators	Payload setup	Rate of packets
IoT notification-based application using TCP (Smart Meters, Motion Sensors, Mobile-commerce, Mobile-healthcare, etc..)					
Scenario 1	TCP	Fixed	4 Traffic Generator	500 Packets	5/sec
Scenario 2		Incremental	8 Traffic Generator	1k Packets	10/sec
Scenario 3				5k Packets	100/sec
Scenario 4		Random	16 Traffic Generator	10k Packets	200/sec
Scenario 5				10K Packets	300/sec
Multi-media application using UDP (Infotainment, Advertisements blades, etc)					
Scenario 6	UDP	Fixed	4 Traffic Generator	500 Packets	5/sec
Scenario 7		Incremental	8 Traffic Generator	1k Packets	10/sec
Scenario 8				5k Packets	100/sec
Scenario 9		Random	16 Traffic Generator	10k Packets	200/sec
Scenario 10				10K Packets	300/sec

This simulation is done on Core I7 8th Generation, 8G memory and windows 7. The simulation is done on the level of core network, ignoring all the access layer or wireless connectivity layer. The same environment is stable for testing only changing the architecture and technique of its TE. The limitation in more results with higher rates, was due to the specification and hardware resources limitation used for this paper.

4.1 Simulation Results

The results of all the different scenarios and tests with different architectures are presented showing the percentage of maximum throughput generated in each scenario with its relative architecture as shown in Table 2. After a great effort done to build the above-mentioned architectures in the simulation environment. To start testing the desired scenarios and checking its results.

From Table 2 presents the results of testing a variety of IoT applications using different protocols. It appears that the SDN performance in the case of UDP traffic is better than the case of TCP traffic. This can be attributed to the nature of the TCP protocol, for instance when the loss rate rises, TCP transmission suffers much more overhead due to the high latency and inefficient retransmission mechanisms utilized in TCP. UDP, on the other hand, is a lightweight transport protocol and is suitable for fast and efficient transmission without guarantees. Therefore, recent studies and research activities are trying to obtain a new model for data transmission over SDN, for instance, the authors of (M. H. Wang et al. 2017) propose "A Reliable UDP-Based Transmission Protocol Over SDN (SDUDP)". The main idea of this framework is to convert the TCP transmission into UDP packets to decrease the overhead during communications, such as handshaking, acknowledgment, and header overhead while using TCP. To guarantee reliability, the power of SDN is leveraged by designating the UDP packets to flow in predefined routes and monitor

them to avoid possible packet loss. When the TCP is compared to the UDP, the overhead of TCP packet headers and ACK messages is a major issue than UDP transmissions in consuming more bandwidth and time. So, the throughput of UDP is much higher than TCP (M. H. Wang et al. 2017), which proved in the simulation in Table 2.

Table 2 Simulation results

Scenarios	Physical	Virtual Edge	Virtual Core	SDN
IoT notification-based application using TCP (Smart Meters, Motion Sensors, Mobile-commerce, Mobile-healthcare, etc..)				
Scenario 1	70%	69.5%	62.5%	80%
Scenario 2	47.2%	55.6%	61.1%	80.6%
Scenario 3	66.7%	75%	80%	76.7%
Scenario 4	37.5%	34.4%	35.9%	75%
Scenario 5	29.3%	27.1%	40%	71.1%
Multi-media application using UDP (Infotainment, Advertisements blades, etc..)				
Scenario 6	37.9%	63.4%	70.3%	79.3%
Scenario 7	42.4%	47.6%	85.7%	66.7%
Scenario 8	62.5%	55%	73%	77.5%
Scenario 9	62.1%	60.5%	67.9%	69.2%
Scenario 10	43.7%	44%	56.1%	88.7%

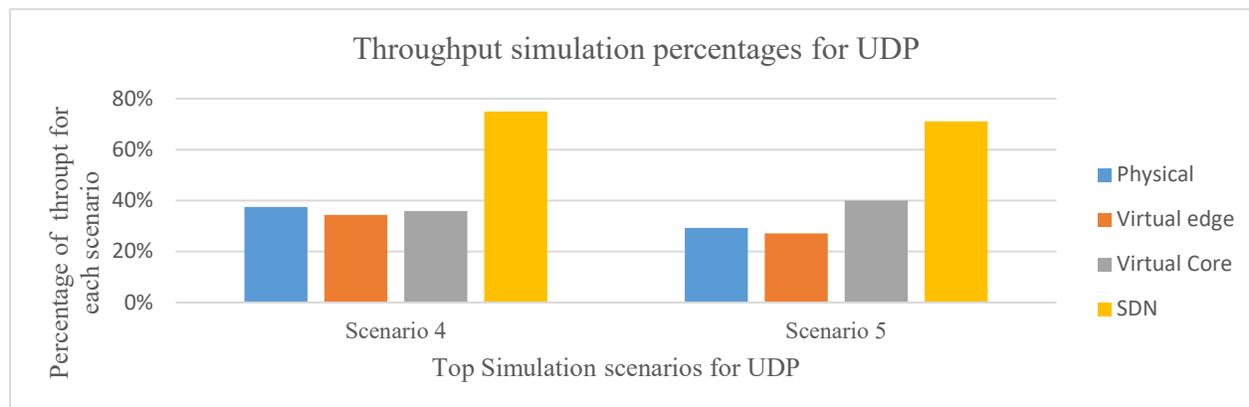


Fig. 8: Throughput Simulation Results for UDP

As could be seen in Fig.8, for the UDP traffic, the performance of the Virtual Edge network is slightly reduced compared to the full physical network specially in the TCP and slightly higher in case of UDP, which is logically correct and will be shown in the mobile operators' measurement as well as per Table 3 and Table 4. This has been already tested in Labs and production environments to validate the simulation results and prove its significance. Therefore, we can use the same simulation methodology to predict the performance of the proposed SDN architectures. As could be seen in Fig.8, the rate of increase in the throughput for UDP traffic in the SDN is higher than that of TCP traffic in the SDN, represented by app. 98% increase of SDN from Virtual core in UDP for only 32% in TCP. Also, the performance of SDN is better than all proposed structures. As will be shown all the consistency of all previous results is confirmed as it is matching the real production environment measures.

4.2 Prototype Tests and Results

The Telecom Operators are the best place to check their architectures and problems to define the new challenge searching for network upgrade. The Telecom Operators provide different types of services with different priorities and qualities, for example, Voice, SMS, Data, and IoT applications. Two mobile operators working in the Egyptian market have allowed us to perform the tests on their production networks and take snoops or traces to measure the live network performance in a live production environment in two different architectures, the first is the full traditional legacy network and with the new Virtualized network with different background traffic levels. Thanks to Etisalat-Misr

one of the two mobile operators that let us try to test on their life production network and as well the test environments to get the required results.

Some Lab measurements are done in the mobile operators to measure the throughput of the full physical networks and Virtual Edge and core networks in real life using different background traffic levels (off-peak, on-peak, and medium peak periods) where the number of customers, amount of traffic handled, and the network capacity varies in each time. The test is done once with data streaming and once with browsing to get a tabulated difference between both networks' performance in real-life labs.

The target is to see the comparison between different results and its reflection on different services provided for different background traffic levels, to be a reference for the simulation to check whether the simulated network models properly reflect real life.

4.3 Operator One

The tests conducted in the Lab in a physical traditional network under two levels of background traffic, the High peak and medium peak levels. During the High peak period, the core network or sites may contain, on average, 7.5 million customers at a time with network utilization of nearly 70%. During the medium peak period, there were nearly 3 Million customers with network utilization of 45% on average. The test results are presented in Table 3 for both video streaming and browsing.

Table 3 Physical Network prototype testing results

Condition	Video Streaming (You-tube)	Browsing internet pages
Medium Peak	44 Mbit/Sec	29 Mbit/Sec
High Peak	34 Mbit/Sec	20 Mbit/Sec

The results in Table 3 reveals the impact of the background traffic level on the throughput. The Test was done by a mobile handset to measure the throughput during data usage which will be like UDP IoT applications mentioned before that depend on streaming and browsing the internet which will represent the TCP traffic for the IoT application. Plus, another test is applied to measure the difference between the internet browsing for the physical network and virtual edge as shown in Fig. 9. The aim was to test the browsing to a list of the famous sites on the internet, simply the results are consistent with the results of the simulation done, that the virtual edge networks are slightly less performance than the physical network in case of TCP traffic. The percentage of virtual edge network compared to physical on average is 91.8% with minimum value 87% and maximum value 98.8%, however, in the simulation results done, the results of the virtual edge was 92.4% out of the physical performance which is very promising to consider that both results are consistent as well as the simulation environment to build up the other architectures. In the next section, the results of another test are presented which measure the difference between the normal traditional physical network and the virtual network during the peak hour. The virtual network is realized by adding network function instead of packet core nodes which is the NFV lab mentioned.

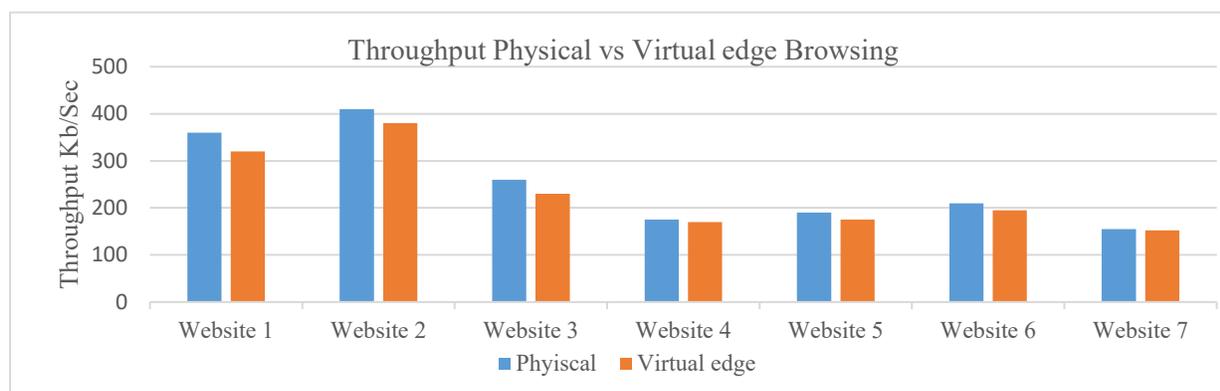


Fig. 9: Throughput measurement results for physical vs virtual edge

4.4 Operator Two

Another Test is conducted in another mobile operator in Egypt to show the difference between the different-day periods (low, medium, and high peak) comparing between the streaming and the browsing showing a complete figure using the virtual network (NFV packet core nodes) as shown in Table 4.

Table 4 NFV network prototype testing results

Peak	Streaming by Mbps	Browsing by Mbps
Low	58.9	51.4
Medium	49.63	47.3
High	36.49	40.42

As shown in the results, while comparing the measurements done, between the first operator and the second one. The comparison will be between the physical network and the virtual core, which is the only operator in Egypt operating with this technology. Comparing the traffic percentage of the physical with respect to the virtual core, in the TCP the value is 62% increase in the virtual core, which is in the similar direction as the simulation done results in 71%. However, in the UDP the percentage of the physical network is 93% out of the performance done by the virtual core, and the simulation done shows a percentage of 91% increase. Which are perfect results to confirm the system or step of the simulation is consistence with real-life measurements. This will provide the work to build on and continue to create the SDN architecture and depend on the results on the simulation of the last stage using the virtual environment building the controller. All elements in this network are native physical elements, without any virtual function.

4.5 T-Hypothesis Test

To ensure the simulations validity used across the real network measurement done on the mobile operators, the T-Test is used. Independent T-Test is used as it is comparing the same architecture of simulation and the real network nodes measuring the throughput. It is worth mentioning that the simulation model is similar to the real mobile operators' architecture but not exactly the same. Using the T-Test as shown in the Table 5, using the T-Test equation, so the null hypothesis can be accepted to refer that the simulated architecture results is similar to the real mobile operators' measurements with the nearest acceptance percentages shown in Table 5.

Table 5 Independent T-Test results with nearest percentages

Operator Vs Simulation	Final Calculated T	Accuracy percentage
TCP	2.29	5%
UCP	1.55	15%
Operator 2 Vs Simulation	Final Calculated T	Accuracy percentage
TCP	1.14	20%
UCP	2.43	4%

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

\bar{x}_1 = Mean of first sample

\bar{x}_2 = Mean of second sample

n_1 = Sample size (i.e., number of observations) of first sample

n_2 = Sample size (i.e., number of observations) of second sample

s_1^2 = Standard deviation of first sample

s_2^2 = Standard deviation of second sample

4.6 Simulation and Testing Summary

It can be concluded that the performance of the virtual core networks is slightly higher in the media/UDP on different periods across the day, however for browsing/TCP is much higher than the physical network. These results are matching what the simulation presented for both architectures. Plus, the percentage ratio between the physical and virtual core is also matching. Thus, the comparison of the first three architectures is consistent, so, it will lead the way to the fourth and final architecture which is the SDN to have trusted results. That was an important point to show how the results of the simulation can be trusted and considered enough to build on and propose a new model trying to solve

the main problem in investing a new Technology serving the IoT application with the huge increase in the data traffic, building flexible scalable network ready to use with the lowest time to market. So, it will be easy to build SDN architecture based on the results consistency and it will be reliable to do the edit/change getting new results to match the main target to solve the challenge facing the current operators to fully migrate to SDN or keep improving their network to NFV by the physical network support w.r.t its cost.

6. Conclusion

In this paper, the measurements were done by measuring different scenarios in Lab simulation and made a valuable comparison in different mobile operators' networks with the production environments getting use of real traffic with real impact of customers causing network congestion. So, all the results are significant and trusted. Performance survey is applied to measure various scenarios under different conditions serving the behavior of the IoT or new technology applications. This paper applied the same architecture built-in operators to apply new changes that will modify its performance at the lowest cost and risk. Its main target is to enhance the service delivery, maximize network utilization, and ensuring end-user max available data rate.

The rise of the 4G and its main challenges and the cellular network consists of many connected devices so a huge amount of data is generated. Therefore, to cope with this issue, the UDP performance results are better and more reliable when used with SDN and the enhancement in the TCP will not deserve that investment to migrate to fully SDN. So, if kept in the existing network will perform acceptably w.r.t cost. So, each operator or entity has to identify the need and the purpose of the investment in order to define its direction.

References

- V. Sekar, N. Egi, S. Ratnasamy, M. K.Reiter, G. Shi, "Design and implementation of a consolidated middlebox architecture," in Proc. NSDI, pp. 323–336, 2012.
- L. E. Li, Z. M. Mao and J. Rexford, "Toward Software-Defined Cellular Networks," 2012 European Workshop on Software Defined Networking, Darmstadt, pp. 7–12, Oct. 2012.
- A. Ghodsi, S. Shenker, T. Koponen, A. Singla, B. Raghavan, and J. Wilcox, "Intelligent design enables architectural evolution," In Proc. of the 10th ACM Workshop on Hot Topics in Net. Association for Computing Machinery, New York, pp. 3:1–3:6, 2011.
- H. Kim and N. Feamster, "Improving network management with software defined networking," in IEEE Communications Magazine, vol. 51, no. 2, pp. 114–119, Feb. 2013.
- A. A. Ateya, A. Muthanna, A. Vybornova, A. D. Algarni, A. Abuarqoub, Y. Koucheryavy, and A. Koucheryavy, "Chaotic salp swarm algorithm for SDN multi-controller networks," Eng. Sci. Technol., Int. J., vol. 22, no. 4, pp. 1001–1012, Aug. 2019.
- A. Shirmarz and A. Ghaffari, "Performance issues and solutions in SDN-based data center: A survey," J. Supercomput., Jan. 2020.
- F. Bannour, S. Souihi and A. Mellouk, "DistributedSDNcontrol:Survey, taxonomy, and challenges," IEEE Commun. Surveys Tutorials., vol. 20, no. 1, pp. 333–354, 1st Quart., 2018.
- D. Sinh, L. Le, L. Tung, and B. P. Lin. "The Challenges of Applying SDN/NFV for 5G & IoT ", in Proc. IEEE VTS Asia Pacific Wireless Communications Symposium (APWCS 2017), Incheon, Korea, Aug. 2017.
- D. Kreutz, F. Ramos, P. Esteves Verissimo, C. Esteve Rothenberg, S. Azodolmolky, and S. Uhlig, "Software-Defined Networking: A Comprehensive Survey," Proceeding of the IEEE, vol. 103, no. 1, pp. 14–76, Jan. 2015.
- N. McKeown, T. Anderson, H. Balakrishnan, G. Parulkar, L.Peterson, J. Rexford, S. Shenker, and J. Turner, "OpenFlow: enabling innovation in campus networks," SIGCOMM Comput. vol. 38, no. 2, pp. 69–74, Mar. 2008.
- P. Demestichas, A. Georgakopoulos, D. Karvounas, K. Tsagkaris, V. Stavroulaki, J. Lu, C. Xiong, J. Yao, Jing, "5G on the Horizon: Key Challenges for the Radio-Access Network, " Vehicular Technology Magazine, IEEE vol. 8, no. 3, pp. 47–53, Sep. 2013.
- T. Taleb, "Toward carrier cloud: Potential, challenges, and solutions," IEEE Wireless Commun., vol. 21, no. 3, pp. 80–91, Jun. 2014.

- Z. Cao, M. Kodialam, and T. V. Lakshman, "Traffic steering in software defined networks: Planning and online routing," in Proc. ACM SIGCOMM DCC, vol. 44, pp. 65–70, Aug. 2014.
- Z. Cao, S. S. Panwar, M. Kodialam, T. V. Lakshman, "Enhancing mobile networks with software defined networking and cloud computing," IEEE/ACM Transactions on Networking, vol. 25, no. 3, pp. 1431-1444, Jun. 2017.
- A. S. Nugroho, Y. Dian Safitri, and T. A. Setyawan, "Comparison Analysis of Software Defined Network and OSPF Protocol Using Virtual Media," 2017 IEEE International Conference on Communication, Networks and Satellite (Comnetsat), Semarang, pp. 106-111, 2017.
- E. Husni and A. Bramantyo, "Design and Implementation of MPLS SDN Controller Application based on OpenDaylight," 2018 International Symposium on Networks, Computers and Communications (ISNCC), Rome, pp. 1-5, 2018.
- C. N. Tadros, M. R. M. Rizk and B. M. Mokhtar, "Software Defined Network-Based Management for Enhanced 5G Network Services," in IEEE Access, vol. 8, pp. 53997-54008, 2020.
- M. F. Monir and S. Akhter, "Comparative Analysis of UDP Traffic With and Without SDN-Based Firewall" 2019 International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST), Dhaka, Bangladesh, pp. 85-90, 2019.
- J. Bukhari and W. Yoon, "Simulated view of SDN based multicasting over D2D enabled heterogeneous cellular networks," 2019 16th International Bhurban Conference on Applied Sciences and Technology (IBCAST), Islamabad, Pakistan, pp. 926-929, 2019.
- Alrawais, A. Alhothaily, C. Hu, and X. Cheng, "Fog Computing for the Internet of Things: Security and Privacy Issues," in IEEE Internet Computing, vol. 21, no. 2, pp. 34-42, March-April. 2017.
- M. H. Wang, L. W. Chen, P. W. Chi and C. L. Lei, "SDUDP: A Reliable UDP-Based Transmission Protocol Over SDN," in IEEE Access, vol. 5, pp. 5904-5916, 2017.

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