

A Survey Study on Methods of Accessibility Solutions for Resources in Software Defined Networks Environment

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Abstract—The increasing data needs to be stored in a new style of architecture which fits future network. This data is getting generated in a rapid way due to the large number of devices which are connected to the technology of Internet of Things (IoT) consisting of assorted characteristics. There are two technologies that can provide the required flexible services which can be adaptable for all kind of IoT environment namely, Network Virtualization (NV) and Software Defined Networking (SDN). This paper presents the latest updates in features of SDN application and NV with respect to IoT. Paper includes the detailed description of implementing the IoT for the above mentioned technologies. Initially the work carries for combining the NV and SDN and also presents to use this technology in cellular and mobile framework in prominence with the 5G network. The paper also gives a study on Wireless Sensor Network (WSN) which is a recent update of IoT network. At last, reviews are given for the architecture of IoT which are NV-SDN enabled along with the deployment of real time use case examples. The paper is concluded by giving some guidance for the future research on the topic.

Index Terms— Network Virtualization (NV), Software Defined Networking (SDN), Network Function Virtualization (NFV), Wireless Sensor Network (WSN), 5G, Internet of Things (IoT).

I. INTRODUCTION

By the end of 2020 era, there might be chances of 20 million to 46 million devices which gets connected with the IoT technology. The future generation will be so updated that they will have a connection from laptops, smart phones (which act as traditional tools) to their house hold appliances such as Air Conditioning, refrigerators, Home doors. It also connects the industrial systems to all the public. Many solutions were proposed and implemented to overcome the problem of sudden raise in the utilization of data but there is no solution for the data growth which are raising in billion of number where the users are the joining the network in a very less amount of time. In order to compromise with the adverse growing of data, mobile networks and wireless networks should progress in a faster to handle the data growth more efficiently by giving security which can

be adapted according to the varying data. The two technologies which can act as prominent crisis server in the future are Network Virtualization and Software Defined Network (SDN). SDN separates the control plane from the data plane. Logical procedures will be executed in the control plane which supports all the protocols of network where appropriate decisions are taken care. Packets are forwarded to the particular destination through the suitable interface in the data plane. Controller is the main unit behind the division as shown in the figure-1. Controller delivers the requirements to the correct network destinations through the interface called North Bound which helps in communication with the applications of Network. Network switches will be communicating with the controller for the guidance to move the packets by obeying the rules of controller-Installed rules.

This is how SDN manages to handle the traffic in router in all possible ways. Balancing the over load in the network and to make the most of unutilized resources in the best way by the deletion of over burden in network is one example of SDN maintaining the traffic. Network virtualization allows all the providers from multiple services which separates and isolates the virtual networks. There are many infrastructure providers which share physical resources because of the virtualization of networks. The cost of Operational expenditure and capital expenditure is reduced by virtualization of networks. It provides good market for several new applications and services. By using the concept of network slicing and subnet isolation NV provides great agility and customizations. This enables Quality of Service which can be used in many scenarios which is a vital feature of IoT that helps in rapid introduction of new applications.

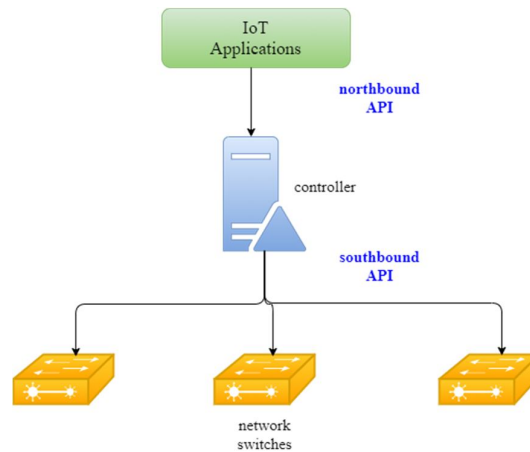


Figure 1: System view of layered SDN

Section II discusses the exceptional features of our proposal from already existing methods. The study on combination of virtualization techniques and SDN is discussed in section III. Implementing the combined technology of virtualization and SDN in mobile and wireless network is discussed in section-IV. With the help of Wireless Sensor Network, IoT scenarios are discussed in section V with respect to the application of virtualization and SDN whereas the general architecture is discussed in section VI, conclusion and future enhancement is discussed in section VII.

II RELATED SURVEY

Research community is more concentrating on the study of IoT, virtualization and SDN but till date no research have been carried out on the combination of these three areas as per our knowledge. There is a survey made on the pioneering features of SDN and its applications that can be implemented to ease the future networks [1] [2]. A survey on historical lane with respect to the programmable networks is made in [3]. Complete survey on IoT has been made by Al-Fuqaha et al [4] but information on virtualization and SDN is very little. Also no survey is made on the technologies which are used to enable SDN. One of the recent surveys which are related to our proposal is made on the WSN virtualization but even that survey has not covered any theoretical information on the architecture of IoT which can be deployed to exploit the features of SDN in complex scenarios. There is a recent related survey on mobile networks and wireless networks which covers the combination of virtualization and SDN but it does not includes the applications of IoT. The nearest survey which is related to our survey is made in [5]. This gives the information on the combination of IoT applications with SDN and virtualization part

is covered very slightly. The concept of network slicing and its combination along with the SDN which provide services for facilitating the IoT technologies are also covered in the survey.

A. Combination of SDN and Network Virtualization

The concept of Network virtualization, SDN and Network Function Virtualization shares many ideas in common but still all the technologies are different from one another. The combination of these three technologies are made to work with SDN which acts as an arranger for network slicing into virtual subnets and also for many other related functions. The combination of these technologies plays a vital role which is a key enabler for deploying the IoT applications. The combination of virtualization and SDN was first made by Sherwood et al. [6]. The work aimed to provide multi tenancy for the data centre where multiple sub networks were created by slicing the network which was inaccessible from one another. This was helpful in service optimization. Network resources which are available were allocated to different service providers that can be used by various users. Users of virtual slice believe that there is a hardware network for each of the slice they use. Therefore good performance can be promised and Service Level agreement is made. The layer of virtualization which resides in between hardware network and software controllers is called Flow Visor architecture. This architecture uses the protocol named Open Flow for the translation between network layer and control layer. For every single slice, there exists a software controller which acts as a mediator by passing all messages between the hardware network layer and controller. This technique is used to make sure that the controller passes the messages by forwarding elements which belongs to the slice of that particular software controller. When the implementation of Flow Visor is not working as expected, architecture with multiple controllers named as FlowN is deployed that provides better scalability. Every user can see virtual network that is owned only by him with the help of virtualization scheme which is defined as the containerization by making the network standalone.

The liberty to use Custom topology as per user wish is made possible by controller. Also controller provides the flexibility in address space that is mapped in between the virtual network and physical address. Mapping is done for every virtual-address space of the network where as the permission is given to controllers to access the global-physical address.

III SDN AND VIRTUALIZATION FOR MOBILE AND CELLULAR NETWORKS

A. Access Network approach

Benefits of combining virtualization and SDN were acknowledged by Granelli et al [7] which can be used in Wireless Access Network. This helps to study heterogeneity in networks when there is an interoperability problem between various wireless technologies. To overcome this problem, NFV is introduced which provides more efficiency in the network for managing the 5G in the current era. In view with the spectrum virtualization, Zaki et al [8] moved virtualization below the PHY layer. At the level of base station, a hypervisor middleware is introduced.

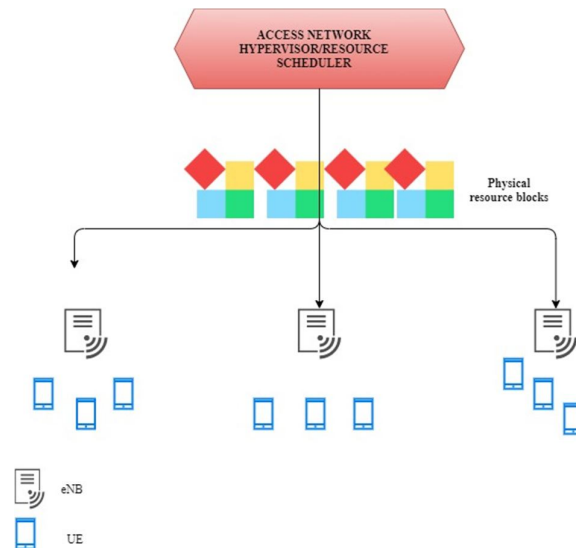


Figure 2: The Architecture as presented in Zaki et al. [8]

The concept explained in Zaki et al [8] is represented in figure 2. On the basis of Service Level Agreement, physical layer supports the creation of virtual network slices which differ from one another. One of the advantages of the mentioned concept is that it is easier to differentiate the IoT scenarios with respect to different SLA.

By the time when the paper was in processing mode, SDN concept was just in the budding state and also there was no existence of the concept Open-Flow. This is the time when hypervisor was created for controlling eNB. With the direct involvement of backhaul network, it is possible to extend this concept to the advanced layers of network stack. SDN controller can be used in co-coordinating the resources that has to be allocated.

B. Core Network Approach

Core network is benefited in a significant way by preamble of SDN and NFV. Based on the conditions of the network, extra traffic can be headed towards suitable gateways. It is possible to achieve dynamic control when there is a more traffic in the mobile network by diverting the traffic flows all the way through core of mobile packets. Provider can be benefited with reduction in cost when the decisive core elements undergo virtualization process which also provides flexibility. Example of the mentioned concept is represented in figure 3.

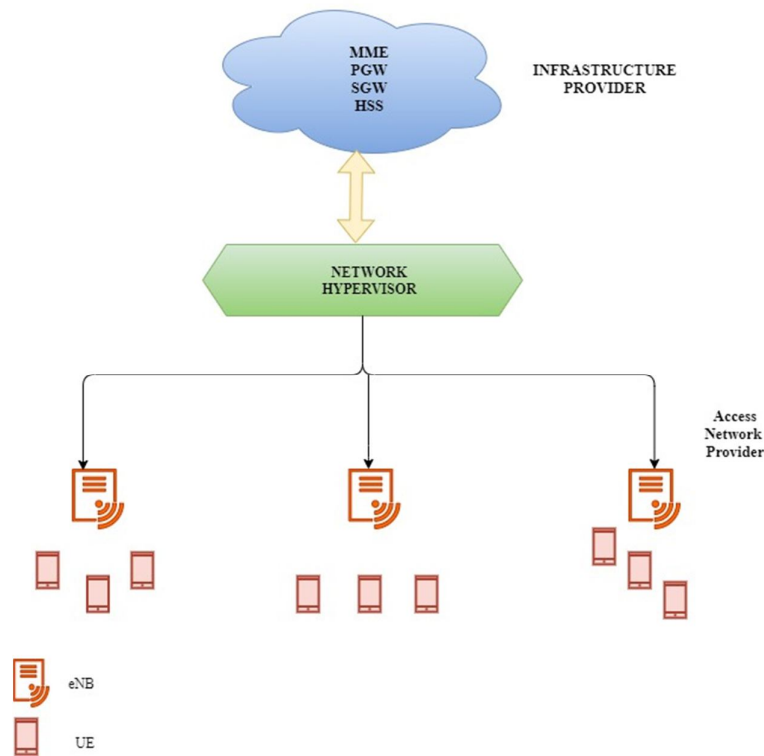


Figure 3: Virtualization of the Core Network

The infrastructure of the cloud and its premises contains the functional elements of core network. Some of the network provider which is traditional in nature controls the accessible network. For the translation of requirements from the network to the cloud to perform specific task, network hypervisor acts as a medium between the two.

IV. SYTEM LEVEL APPROACH

A cloud called telco is introduced in [9] where the author used NFV for enabling that technology. Telco is estimated to offer flexibility and adaptability in real time examples. Mobile operators can reduce the CAPEX with the help of this. This is made possible as it is easier to expand and shrink the networks by re-configuring them in the same infrastructure of physical network. But re-configuring depends on the imposed traffic load. This architecture provides end-to-end facilities which aims in optimizing the RAN and core network together. Framework of the cloud Telco is divided into 5 parts by the author. They are mentioned as below,

- **Physical Infrastructure layer:** It possesses the infrastructure of data centre which provide accommodation for the Telco cloud.
- **Virtual Infrastructure layer:** This layer serves as a hypervisor by abstracting the physical layer from application.
- **Carrier cloud service platform:** This layer is built to make sure that both virtualized core network and its respective RAN are interoperable which is facilitated by the same provider.
- **Service provider layer:** It provides the API that are necessary to end users. These high level API are evident to the end users. Examples for these type of services are the custom firewall and Content Delivery Network (CDN).
- **User layer:** This is the last layer which helps in describing various kinds of scenarios. It also helps in describing how these services can be utilized by end users.
- **Softair** is a novel proposal mentioned in [10] composed by virtualization process and SDN which is proposed for 5G networks. Architecture possess some of the key aspects,

High Network Flexibility: This network architecture is introduced with NFV. This activity takes place in core network and RAN. In core network, functions such as Quality of Service routing, management of mobility, billing are moved into cloud. In RAN, virtualization and decoupling of baseband units are processed by making the reduction in cost and this enhances the capability to co-operate between various RANs.

Network slicing: Various network entities contains several inaccessible subnetworks which are dynamically allocated to them. Each of the network entity use its own PHY layer protocols which affords personalized and modified services for the customers.

SDN enabled cloud: This includes:

- Traffic management control system, this minimizes the traffic and selects the best optimal route to travel between RAN and CN.
- Traffic classification function, which helps in identifying the application which carries the traffic and requirements of Quality of Service.
- Efficient network module, which helps in maximizing the throughput in networks.
- To understand the architecture in a better way, different traffic engineering solutions can be used. This helps to provide a better Quality of Service for various users, those solutions are mentioned as below.

Centrally co-ordinated BS clustering: Here the co-ordination takes place at the level RAN with the help of SDN.

Quality of Service resource provisioning: The aim here is to choose the most suitable and relevant transmission power combination for each of the user. This makes sure that each of the user gets configured MIMO antenna and the modulation scheme by maximizing the throughput of the system. This satisfies the data rate of the individual user and also delay requirements which can be tolerable.

Traffic classifier: This is located at the centre part of the architecture which takes statistical characteristics as its input. It also consider historical patterns for the input if it is available from the traffic flow. Later this is clustered with the help of machine learning algorithms like semi supervised learning.

Mobility management framework: To manage the handoff re-routing, location registration and location paging, a central controller is used. By the usage of SDN, signal overhead can be reduced and also location paging and registration can be simplified.

V SDN AND VIRTUALIZATION FOR WIRELESS SENSOR NETWORK

As there is a growth in IoT, there are some growth in its challenges as well. Increase in the growth of participating devices is one of the toughest challenge to overcome. Since there exist multiple devices with different configuration such as storage capacity, memory, processor speed, hardware sensors, overcoming the challenges with different configuration is not easier. Figure 4 represents the non enabled SDN and deployed multi network. In the growing era of the IoT, usage of different architecture of sensor network which is integrated with SDN and virtualization of the network will be benefited in a greater way. Some of the frameworks which are interconnected with the architecture are described below.

A. SDN for WSN

The leverage of SDN and programmable network for WSN was first found in the article [11]. SDN controller and several sensors are present within the WS which contains BS. None of the routing decisions are made by the sensors since it is dumb in nature. Based on their memory in the flowtable, sensors forward the packets by following the rules given by SDN controller. Modifying the rules of forwarding at the controller, network application can be changed. This will later convey the modified changes to the sensors. More precised framework is mentioned by an author in [12] which states that WSN that are specific in application are always rigid. Therefore it can only perform limited tasks and configure manually if they need to be deployed.

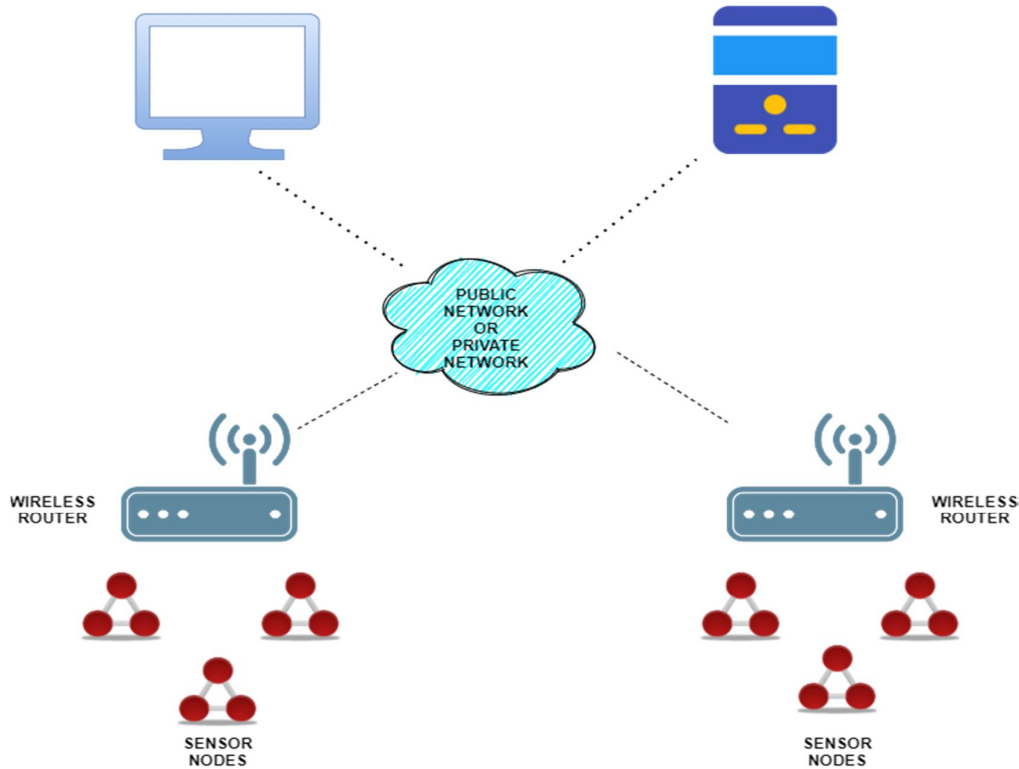


Figure 4: Architecture of Traditional WSN

Based on certain standards in hardware part, another architecture was created to reconfigure WSN in [13]. Open Flow is not used in this architecture which is more freely bonded with SDN. The decisions are not centralized in all the network nodes because only individual sensor hardware are given the authority for the decision. Controller software is deployed in each of the network node which is local and low-end technology. Virtual Machines (VM) are embedded since there are various kinds of sensor devices and this VM helps in interoperability between those devices.

B. Network Virtualization for WSN

In order to separate the physical layer and application layer, this technology was introduced in [14]. This technology will be introduced when there is a situation where sensor nodes provide multiple application services at the same time. This is how many of the virtual sensor networks are formed. Separate application is allowed to access the hardware by providing this layer in every node. Let us consider an example of accessing the component by an application that is timer of a node, runtime layer processes this request which resides between 2 layers of application and operating system which is programmed by tinyOS. It is possible to achieve virtualization in the network level only when the respective nodes receives the application code. To resolve the problem of co-ordinating sensing tasks to respective sensor nodes, a bipartite graph is modelled.

The vertices of the bipartite graph which is shown in figure-5 are two disjoint sets that is, v_1 and v_2 . There is a connection from one edge of v_1 to another edge of v_2 . Drawback of this graph is the hypothesis that only one task can be performed by one node. This eliminates the concept of virtualization.

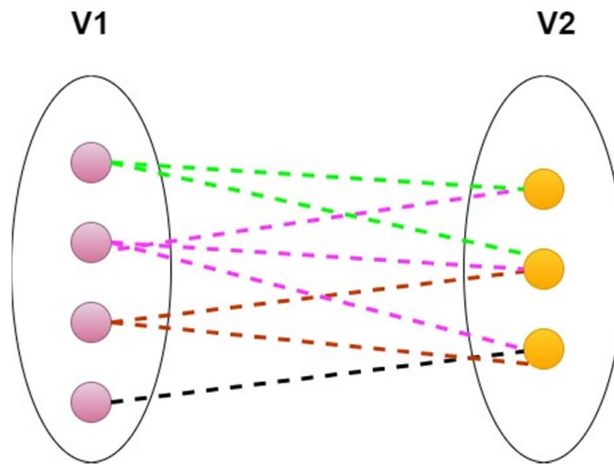


Figure 5: Bipartite Graph Model

VI: SDN Enabled IoT Architectures and Frameworks

- SDN based IoT architecture: Paper[15] consists of the description where the networks of IoT are facilitated by SDN. Central controller converts the service requirements into network requirements. Multi network environment is modelled with the help of network calculus where as schedule flows are modelled by genetic algorithm. This gives better optimization in the performance of end to end flow.
- Virtualization based IoT architectures: Telco cloud and network virtualization were used together as a combination for IoT. Access networks are virtualized to plug in the IoT devices to its core part but here, physical hardware of different kinds of sensors are virtualized which creates the infrastructure for IoT cloud. It is easy to develop the IoT applications by using the SDN controller which have a Northbound API.
- Combined architecture of SDN and IoT: Architecture has four different parts:
 - Device layer: This layer helps to perform specific tasks by collecting the data and transmitting it back to the destination.
 - Communication layer: This is the second layer of the architecture which contains gateways and switches that are enabled by SDN. SDN controller helps to transmit the data.
 - Computing layer: This layer performs the billing and accounting functions insisted by SDN controller. Other activities such as calculation of the topology and its management is also performed.
 - Service layer: This layer is used by the developers of IoT to provide high end instructions for controller which later translates them to respective commands of the network.

VII CONCLUSION AND FUTURE ENHANCEMENTS

This paper made a survey on the combination of IoT, SDN and Network Virtualization. This paper also covers the application of the combined technology of all three which is a key factor for IoT deployment. This acts as a supporting document for the researchers and also to the practitioners of industry who are interested in the field of IoT and its various applications. To preserve the space in switches, one has to perform the grouping function in all the similar devices. It is allowed to make modifications in the OpenFlow to keep some of the applications of IoT for certain amount of time with temporal behaviour which can be added to table. Applications of IoT are very heterogenous in nature which is a main consideration from the network. One of the major concern which is related with respect to the SDN application is that IoT applications are mission critical and sensitive in nature. There are certain rules to access the devices which are very complicated but SDN architecture makes it simpler for end users.

To make the network more adaptive and intellectual, machine learning techniques can be used along with the network management provided by SDN. Based on the nature of the traffic received, it is possible to make successful decisions in real time scenarios. To merge the two separate worlds of Artificial Intelligence and

Networking, customized machine learning algorithms have to be developed which can provide better performance and security.

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