

Challenges Faced By Next-Generation-Networks

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Abstract—This paper will address the challenges that Next-Generation-Networks will face and how to tackle them. As we are pumping more and more data into the current networks, there exists an inescapable need for improvement in our current telecommunication networks. This has fuelled a lot of research and surveys on the development of Next-Generation-Networks. But developing these "better networks" is not a very easy task and the process will face a lot challenges such as, (1) maintaining optimum energy efficiency, (2) keeping an eco-friendly outlook while developing new technologies, (3) dealing with security issues such as jamming and spoofing, (4) dealing with software bugs that would arise with the use of SDN (Software Defined Networking) as well as many other SDN related problems. Addressing these challenges can eventually lead to lesser costs and more efficiency.

Keywords—Next-Generation-Networks, SDN, Cognitive Radio.

I. INTRODUCTION

A. Background

Since the mid 1990's, the amount of data being sent and received over our networks has increased exponentially. To keep up with this exponential growth in exchange of data, technology has also been evolving. The demand for better networks which can handle heavier workloads at astounding speeds has driven the evolution of networks. Next-Generation-Networks are also a product of this need for better networks.

The number of people using these networks has also increased exponentially. There are a lot more people using the internet and wireless communication devices such as mobile phones, tablets etc. Looking at the table [1] will show us the number of internet users as an example for the demand on current networks.

Obviously at some point, the older networks prove to be insufficient for such enormous growth in users and hence newer networks are required. This is where Next-Generation-Networks come in. Our current network hardware and software are good enough to handle the load but not at optimum levels of satisfaction.

Table [1] World Internet Users and Population Stats

World Regions	Internet Users Dec. 31, 2000	Internet Users Latest Data
Africa	4,514,400	167,335,676
Asia	114,304,000	1,076,681,059
Europe	105,096,093	518,512,109
Middle East	3,284,800	90,000,455
North America	108,096,800	273,785,413

[Stats from internetworldstats.com]

B. Purpose of This Paper

Addressing the challenges that next-generation-networks will face can help the pioneers in the field to have a brief idea of the things to keep in mind while working on new technologies in the field. This paper is working towards a vision where difficulties in setting up and operating new networks can be overcome easily.

C. Organization of This Paper

The sections that follow will be organized as follows – Section D and E will deal with the basics of *Cognitive Radio* and *Software Defined Networking* which will be useful to understand the challenges faced by next-generation-networks.

Section II will deal with the main topic of this paper, *Challenges Faced by Next Generation Networks*. We will look at some topics briefly as it is required for understanding the challenges faced by Next generation networks.

D. Cognitive Radio Basics

A Cognitive Radio is basically an intelligent radio which has the ability to be programmed. It is a recent development, although the idea of using cognitive radio has been around for a while.

A cognitive radio has a transceiver which has the ability to analyze a frequency spectrum and look for frequency bands which are not being used and hence use those frequency bands for its operations such as transmitting etc. This feature of the cognitive radio has applications in energy efficiency and green technology, which this paper will address later.

The cognitive process works as follows –

It starts with the passive sensing of radio frequency stimuli and Radio-scene analysis which results in the estimation of spectrum holes.

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Challenges Faced By Next-Generation-Networks

Channel identification involves estimation of channel-state-information and prediction of channel capacity (*to the extent to which it can be used by the transmitter*).

The process ends with dynamic spectrum management and power control. From the above three steps, Step1) and Step2) are performed by the receiver while the Step3) is performed by the transmitter of the cognitive radio.

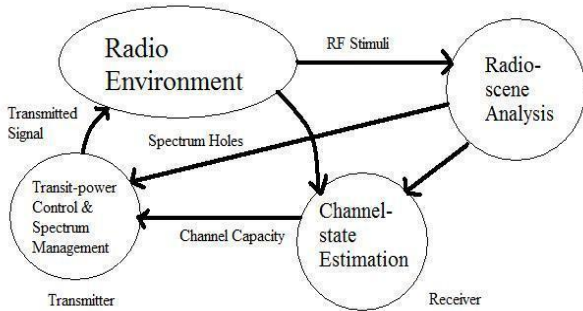


Fig. 1. The Cognitive Cycle

E. Software Defined Networking (SDN)

SDN is new approach to networking where the control part of the network or the “*Brains*” is separated from the rest of the network which allows for optimization of the control as well as the rest of the network.

The advantage of this is that the controller has a complete view of the entire network. By using this controller efficiently, a network engineer can give instructions to the rest of hardware network such as switches, routers etc. The network engineer can use the controller to tell the network about how to handle the traffic.

Currently, the protocol being used to perform the above mentioned tasks is called *Open Flow*. Open Flow allows a network engineer to easily deploy innovative routing and switching protocols in a particular network.

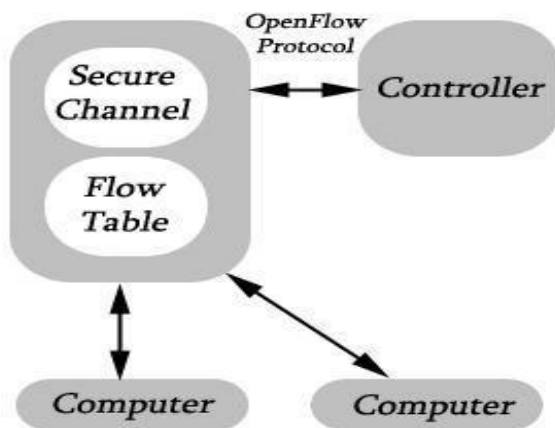


Fig.2. Open Flow Switch Communicating With Controller

The Open Flow Switch and Controller communicate using the Open Flow protocol as shown in the block diagram above. The Open Flow protocol defines messages, such as packet-received, send-packet-out, modify-forwarding-table, and get-stats.

To understand further topics in this paper, we need the knowledge of the architecture of SDN.

The architecture of SDN is as shown. The control layer is the main ‘*intelligent*’ layer which communicates with the infrastructure and application layer. The architecture is very important to understand the SDN challenges.

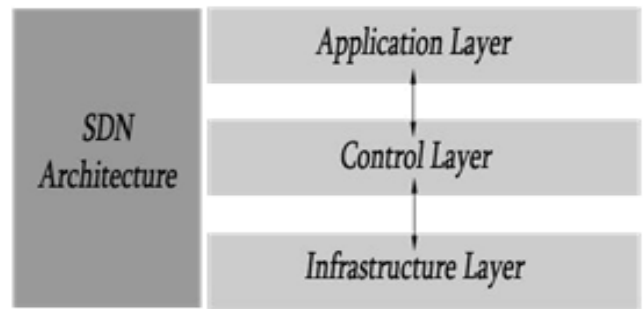


Fig.3. SDN Architecture

The benefits of SDN include but are not limited to, (1) easy control of entire network; (2) flexibility in operation as a network can be programmed to do different tasks, (3) reduction in infrastructure costs due to flexibility, (4) enables companies to create new applications that can increase revenue.

II. CHALLENGES FACED BY NEXT-GENERATION-NETWORKS

With the basic understanding of the concepts mentioned above, the challenges faced by next-generation-networks can be investigated.

A. Energy Efficiency, Maintaining an Eco-Friendly Outlook.

Due to the rapid increase of number of people using our networks, a lot of the spectrum is being consumed. But the amount of spectrum being used is nowhere near the total available bandwidth. Even so, we are facing shortage of bandwidth due to wastages and inefficient usage of the spectrum. This has happened due to overcrowding of the spectrum by various wireless systems and services.

The greater the spectrum being used, the more expensive it gets to keep the services running. Thus next-generation-networks will face a challenge in keeping the services running at an economical rate. Thus utilizing the spectrum properly will lead to lesser energy being spent and hence more money being saved. Because of this financial aspect, many organizations are running independent research in order find methods of utilizing the spectrum in a much better way. One such method to utilize the complete spectrum efficiently is cognitive radio. The cognitive radio as described looks for spectrum holes which are not being used. Once it finds such spectrum holes, it checks for its capacity to carry the load and then uses that spectrum band to run services.

The world’s mobile communication network has a huge carbon footprint which is set to triple by 2020. We know the drastic effects of higher carbon in the atmosphere and our current networks are contributing a lot to this. Therefore there is an undeniable need for next-generation-networks to be green and eco-friendly.

Lesser the energy usage, lesser is the carbon output. Therefore cognitive radio can have applications in environmentally stable networks. Dynamic Power Scaling is another way to ensure that only the required amount of energy is used. In Dynamic Power Scaling, the amount of energy spent is based on the network requirements. For example, if a network is running at full capacity, then maximum energy is used. On the other hand, if the load on the network is very less, then only certain parts of the network are active and the others are in stand-by mode, which saves energy.

B. Security Issues

The next-generation-networks will be using a lot more software (like SDN) than previous generations. This opens it up to a lot of security concerns. Whenever there is software involved, there are also security concerns. Security risks may arise as a result of a voluntary attack or software bug that occurs naturally. Jamming and spoofing are examples of voluntary attack on software and hardware. Jamming is the process of blocking a signal with the help of another signal. Spoofing involves fooling a GPS to think that a signal is arriving from a satellite and hence make it report wrong coordinates.

The most vulnerable are new software applications like SDN as our security experts do not really know about the vulnerability and weak points of these new software.

C. Quality of Service (QoS) Challenge

QoS is extremely important for the next-generation of Internet applications such as VoIP, video-on-demand and several other consumer services. Some older networking technologies such as Ethernet were not designed or meant to support prioritized traffic which offer guaranteed performance levels. This makes it extremely difficult to implement QoS across the current infrastructure of the internet.

Data networks were not designed to carry voice, but the next-generation-networks will need to carry data and voice simultaneously. To make this possible, the network must be able to carry voice as a series of data packets. The internet routers try to send the data packets across as fast as possible. This is the main priority of a router, but this does not result in very good quality of service. The individual data packets experience different transmission delays and hence there might be overlapping of voice or cracking of voice at the receiver end. This is one of the main challenges faced by next-generation-networks. The solution to this would be to use RTP (Real-time Transport Protocol). RTP gives a way in which the timestamps and the sequence numbers of data packets can be used to reconstitute a message signal even if individual data packets have different transition delays.

A basic block diagram of an OSI model is given below. We can understand how RTP works by learning the place of RTP in the OSI model. Usually, the RTP is in the transport layer, but can also be situated in the application layer.

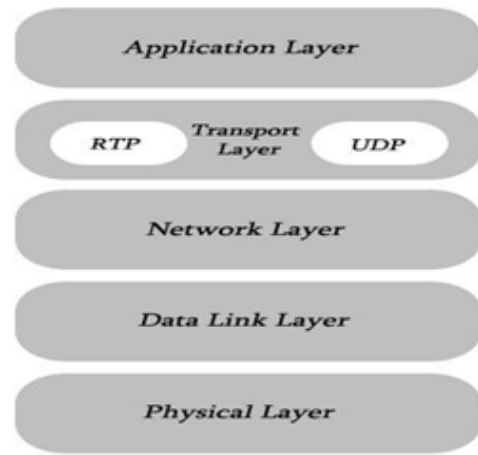


Fig.4. RTP in the OSI Model

There is no clear rule as to whether RTP should be placed in the transport layer or the application layer. Nowadays, RTP is commonly implemented as an application library too. RTP does not exactly assure real-time delivery, but it gives us the following advantages –

- Jitter elimination/reduction

- Synchronization of several audio and/or video streams that is present in the same multimedia session.

- Multiplexing of audio/video streams that belong to different sessions. Translation of video a/v streams from one encoding type to another

D. Reliability

As a network grows, there are more and more aspects that come into the picture. A large network will have thousands of software/hardware components, even if one of these components fail, there may be a drop in quality of service or a total disruption in service. This is obviously unacceptable. For example, a small network, say, servicing about a 100 people can be regularly checked and maintained to ensure 100% uptime. Now, imagine a network that serves 100 million people, there is no way that all of it can be under constant surveillance. When a problem occurs, it often takes a lot of time just to find the fault in such a large network, let alone fix it. Therefore, with growing networks, reliability is going to be a big issue. But this can be addressed with the use of SDN as mentioned before. In the SDN, a controller has the overview of the entire network and hence can find and correct faults in a short period of time.

E. SDN Related Challenges

There is general trend that organizations are using SDN to develop new network and network applications due to its many advantages. But SDN itself has problems that put up challenges to the next-generation-networks.

(1) Defining the problem

It was mentioned earlier that use of SDN could locate and help solve a problem or fault in the network. While this is true, the process of solving the problem has another step. The problem needs to be defined.



Challenges Faced By Next-Generation-Networks

The controller can find that there is a fault and even give a list of general fixes, but it cannot pinpoint as to the exact cause of the problem. For this reason, an operator must define the problem for the controller.

(2) Performance, Security

Performance is the main issue for any network. If every packet of data has to be moved from the main data plane up to a different level (*control plane*) and then back to the data plane, it will create a huge latency in the network which the users as well as service providers will have to bear.

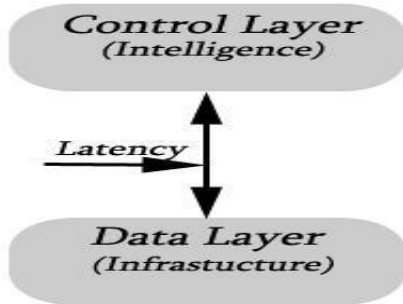


Fig.5. Latency due to movement of data

There seems to be a need for more intelligence in the way SDN handles these data packets. When a packet of data has been identified, the data plane should be able to deal with it easily without having to bring the packet to the control plane. This seems simple, but there are things to consider here too. As discussed before, if a packet is spoofed (*a harmful data packet disguised as a safe data packet*) and designated as 'safe', there is no intelligence in the switches to decide that it is a bad data packet. Now this data packet is allowed to go about the entire network without any resistance. This bad data packet could potentially harm the entire network.

The solution to this would be to build intelligence into the switch so that the packets can be inspected and ensured to be safe at the data plane itself.

(3) Speed of Operation

The control layer in SDN has many tasks to perform. These tasks include – interact dynamically with the other layers and make logical decisions based on *policy, flow & application awareness, time & external changes*. Completing these tasks, the control layer can give commands to the application as well as the data layers to perform their duties.

Here is the anatomy of the control layer, showing the tasks that the control layer must perform quickly –

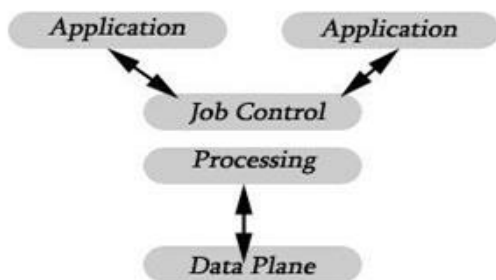


Fig.6. Application, Control and Data plane.

The *job control* and *processing* are part of the control layer and executing these stages will take some time as they are not instantaneous processes. This can delay the whole operation. So speed of operation will need to be worked on.

(4) Disruption Tolerance

The whole intelligence of next-generation-networks revolves around the SDN controller. All the functions of the network are controlled by this main unit, so any disruptions to the controller can have drastic effects on the entire network. It is essential that the controller has self-repairing mechanisms or protocols that will help rebuild the controller if any damage occurs. This damage is usually software oriented; this can be repaired by having protocols for different types of software crashes. But hardware issues are another aspect altogether. We cannot have protocols for repairing hardware damages to a controller.

It is essential that these protocols help the SDN controller to stay in a working condition all the time and repair itself as soon as possible when some damage occurs.

(5) Compatibility

A typical heterogeneous network may involve a variety of devices and networks. But all of these devices and networks may not be compatible with the SDN controller due to many reasons such as different protocols and infrastructure type. An SDN controller will not be able to work with non-compatible devices directly, but it can do so by using other control mechanisms, such as standard routing or configuration protocols.

It is important that some changes to the current policies are made so that we can have a unilateral protocol for all networks being set up in the future. We must also define protocols to make the new networks become more compatible with the older existing networks.

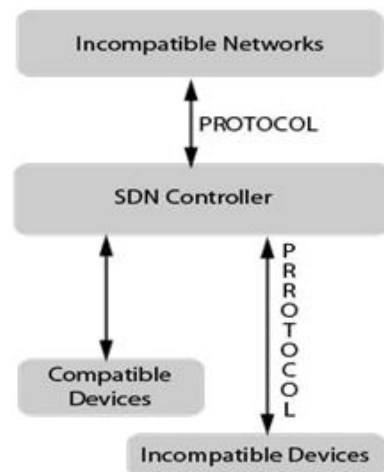


Fig.7. Compatible and Incompatible devices with SDN

F. Always On, Anywhere

What people come to expect from newer technologies is better services. The quality of service is not the only factor that decides whether a new technology is more useful or not, there are other factors as-well. These factors include – *coverage* and *uptime*.

Coverage is basically the area over which the network can offer its services. The coverage can be small for local networks whereas it can span thousands of square kilometers for large networks. In cellular networks, the coverage area is divided into smaller “cells” which have their own control mechanisms. When a subscriber moves out of a “cell”, that particular subscription is said to be on roaming mode. Uptime is basically the amount of time that the network is available for the subscribers to use. Emergency networks need to be up 100% of the time whereas other forms of networks tend to have some downtime. Service providers try to provide 100% uptime to subscribers but unexpected downtime can occur.

The importance of these factors is underlined by the fact that most telecom operators look to emphasize on these aspects in their advertisements. The newer networks must be able to serve more number of people over a wider geographical area, all the time. This requires extensive infrastructure developments and this infrastructure needs to be economical.

III. CONCLUSION

In this paper, we have covered the various aspects that can potentially be barriers to the development of next-generation-networks. The challenges included energy efficiency, environmental acceptableness, security issues, quality of service (QoS) issues etc. Challenges to the *Software Defined Networking* were also discussed. These included performance, compatibility, speed of operation and tolerance to disruption. To understand the SDN related challenges, we also saw a brief description of what SDN and Cognitive Radio are and how they work.

The issues stated are done so with the hope that they can help the network engineers in building bigger and better networks that are close to “*Perfect Networks*”, although no such thing exists due to the fact that needs keep changing and hence the definition of “*Perfect Networks*” too keeps evolving.

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