

5G HetNet: SDN model, Issues, Security and Services

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Abstract—5G Heterogeneous Network is the next generation network with lower latency and jitter problem. It is focused to be more secure for the software defined network and Radio access network. Discrete algorithm is used to prevent the network system from the attack. The paper introduces the network model for designing the 5G Heterogeneous Network and its System Model. There are different security issues on different layers in the network as well as with the Heterogeneous Network System when dealing with tight centralized coordinate system and power control and scheduling algorithm. Migration as well as mobility and coverage should be easier when the user moves from one cell to another cell in different kinds of Network.

Keywords—5G Network, Heterogeneous Network, SDN (Software Defined Network), Network Function Virtualization (NFV), Services, System Model, proposed Model, Cellular Network, Security, Attacks

I. INTRODUCTION

From first generation to currently accepted fourth generation, there has been an evolution of wireless network, now resulting in upcoming fifth generation analogy. With the increase in the population, there has been increment in number of mobile users as well as data due to which there is more demand of quality service and data services[1][2][4][6][15]. Numerous mobiles are connected to the network at the same time[2]. A lot of data services is exploded along with the grown demand of wireless broadband resulting in data traffic[1][2][3][16]. And the demand of this quality assurance can be achieved by 5th generation(5G) wireless network system[14][15]. With 5G the latency and energy consumption will lower down, also there will be no packet loss and jitter[14][15]. The Quality is then assured by SDN Network(Software Defined Network)[11]. 5G Network system and its architecture is a kind of Heterogeneous Network. It ensures the integrity and reliability as well as energy and cost-efficient network system[2][11][12][15]. There are two different technologies SDN and NFV

[2].

II. HETEROGENEOUS NETWORK

Heterogeneous Network completely focuses on cost efficient network. It is based on one cellular standard. Heterogeneous network consists of various types of infrastructure elements like macro-, pico-, micro- and femto- Base stations. The usage of all three elements in a network is necessary. Heterogeneous network currently focuses on traffic demand for which cell of various sizes are deployed (mostly small) instead of using macro-Base stations [2]. It helps us to improve the capacity and the resources as well as the cost of the resources [2].

Intelligence related to Heterogeneous Network can facilitate the following infrastructures:

1. Transceivers: They are involved in handling the situations.
2. Spectrum(bandwidth)
3. Transmission Power
4. Traffic Distribution

A. Software Defined Network(SDN)

It is the network architecture which has central network controller which allocates traffic to network elements which are already located in separate data plane(Fig 1). The network controller here maintains the intelligence and state.

The network controller provides the global view and resources of the network to upper layer application. These network layer application can easily deployed[2][7][10][13].

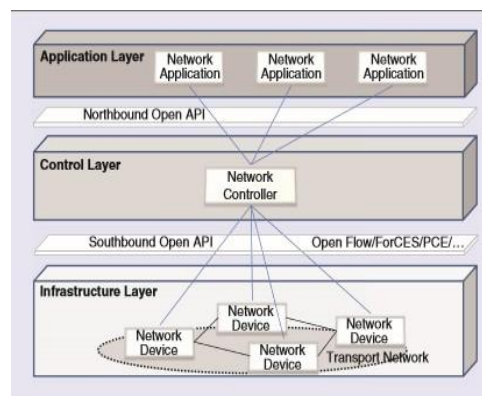


Fig 1: SDN layering Concept Overview

Open Networking Foundation defines Open Flow as the interface between network devices and controller. It supports various service providers, operators and manufacturers. North-bound interface of SDN protocol is currently under development[2]. Also, [7] has proposed two SDN Designs based on Radio access Network(RAN) in order to maximize the sum-rate for latency(delay in packet transfer): Pure SDN and Hybrid SDN.

1. Pure SDN
2. Controllers has been used to construct the SDN Design.[7]
3. Hybrid SDN

Controllers has been used for some task only in Hybrid SDN.

B. Network Function Virtualization(NFV)

NFV is said to be complementary of SDN. It provides infrastructure to SDN due to which SDN will be able to run. It builds end to end network [as in Fig 2]. Its virtualization

technology enables the support for another heterogeneous network [2][13].

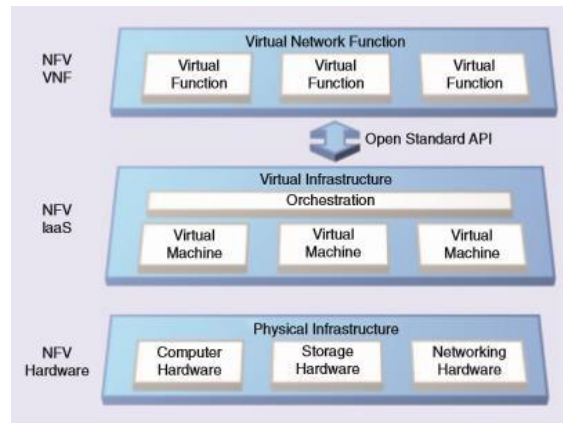


Fig 2: NFV Concept Over View

1. Virtual machines are installed on hardware servers with large storage devices.
2. These servers are then connected through network switches.
3. Software are separated in order to define the network function of different network devices.
4. Automate installation of virtualized network
5. Management of generic hardware and network functions.

C. Extreme Densification

It helps us to increase the capacity while deploying the heterogeneous Network.

D. Different ways to increase the throughput of cellular network

We can increase the throughput of the Heterogeneous network using following ways [4].

1. Coupling the low complexity base stations with conventional macro base stations.
2. Incorporate SCs (those SCs that operate on unlicensed and licensed mmWave band).
3. Switching and aggregations can be performed between the base stations.

III. 5G NETWORK SLICING USING SIGN CRYPTION SCHEME

There are three layers which correlate each other as follows and while network slicing these layers are taken into consideration.[9]

1. Infrastructure resource layer
This layer contains cloud nodes, network nodes 5G devices, access nodes and related links.
2. Business enablement layer
Configuration parameter and the software module can be downloaded from the resource database system
3. Business application layer
At this layer, application and services are deployed on 5G network.

In 2018, Liu, Zhang and sun has used two sign crypton scheme in which there was no bilinear pairing Between CLC (certificateless Cryptography) and PKI (public key infrastructure) cryptosystem[9].

IV.PROPOSED MODEL FOR HETEROGENEOUS NETWORK

A new mmWave Heterogeneous Network model has been proposed in [4] which states that throughput and QoS for the user can be maximized with the use of LTE and mmWave along with. This Proposed model has following advantages listed [3].

- a. Users can switch between different frequency bands because of the combination of the dual air interface which leads to increased throughput.
- b. 5G wireless networks use relays to support dense networks. Relay is added into the model taking consideration of two hops(nodes) transmission scheme. These two hops are considered from base station to relay and then relay to users.
- c. The subcarriers applied can differ from one hop to another hop. This process is known as sub carrier pairing. It helps us to improve the sum-rate of the system [4]. sub carrier can also be combined with frequency band selection. This will help us to enhance coverage (at mmWave frequencies).

This scheme will help for utilizing frequency bands and mmWave with different characteristics of (1) Heterogeneous Network. With this proposed scheme we can couple macro base stations with small mmWave base stations which will help us to maximize the requirement for each user [4].

V. ISSUES IN HETEROGENEOUS NETWORK

There have been two forms of development in wireless network. One is cellular System and the other is WLAN(Wireless Local Area Network)[16]. The problem comes with the designing of the Heterogeneous network and optimizing it.

A. Cellular Network

It operates in licenced frequency bands. They are designed using some protocol and are highly regulated. IEEE, ITU, 3GPP are some bodies who standardize the protocol. For example: fourth generation is based on 3GPP- LTE and IEEE 802.16m standards. The deployment of cellular architecture is pre-planned and requires the large nodes that are mounted on roofs (towers, antennas).

B. WLANS(Wireless Local Area Network System)

Wireless network is the reason behind the demand of multimedia devices like smartphones and tablets. A new model is being accepted to meet the needs. The factor that will help us to achieve high end system with spectral efficiency is spatial reuse. In spatial reuse we scale down the size of cells and use the same spectrum on dense spatial scale. Then comes Heterogeneous Network. Systems that need to be carefully planned are as follows:[16]

1. Cooperative control: User deployed infrastructure should be provided.
2. Beamforming Optimization: Interference should be addressed.
3. A tight centralized coordinate system to be maintained.
4. Scheduling and power control: allocation algorithm, power control system should be devised.
5. Heterogeneous Network Management: Migration from one cell to any other macro cell should be easier for the user terminal. Ensure coverage and mobility between different hierarchical cells.

Many of the research to modify and enhance the system are focusing on the above points.

C. Content Delivery Issue

As there is congestion in the cellular network due to the growing demand of data services and QoS by the mobile users. We know that there are many user's requests at the same time and the same content, but the base station responds to the requests one by one which results in the service delay and degrades the Quality of Service. When the user sends request to the

server for the content, then instead of searching it on the server, the network can extract it from its own cache. Network can also request for the content from the adjacent user with the help of D2D connection link [5].

Due to this there is more demand of caching services as they directly establish D2D(device to device) connection links to transmit the content. There are two types of caching: D2D caching and SC caching than can result in throughput improvement and spectral efficiency [5].

VI.SYSTEM MODEL FOR HETEROGENEOUS NETWORK

A. Network Model

Suppose a wireless cellular network consist of Macro Base Station then [6],

λ_M : intensity of Euclidean plane

Θ_M : a stationary process for the distribution (distributed at different stationary points)

RM: distribution of distance

Probability density function (pdf) is given by:

$$f_{RM}(r) = 2\pi\lambda_M \exp(-\lambda_M \pi r^2) \quad (1)$$

B. Signal-to-interference Model

Let the base station be at any location. While the user is

$$\text{SINR}_M(x \rightarrow u) = \frac{P_{t,i} h_x g(x)}{\sum_{y \in \Theta(x)} P_{t,y} h_y g(y) + \sigma^2}$$

located at Origin. The formula mentioned below is Fig 2: Formula for SINR [6]

considered when the user 0 is to be transmitted x. Then the formula for SINR (Signal-to-interference-plus-noise ratio) is given by

$\Theta(x)$: set of nodes

$P_{t,i}$: transmission power at tier

h_x, h_y : channel power because of small scale fading [6].

C. Base station sleep mode strategies

In this, [6] has focused on two policies which can help to analyze and optimize the consumption of power at each Macro Base stations. The equation for the power consumption to be maintained at the sleep mode with the same network coverage is by selecting and employing the control power.

$$P_{t,M} = \beta P_{to,M} \quad (2)$$

B = increseing amount of transmission power in Macro Base station

1. Random sleeping

This model uses Bernoulli trial as a sleeping strategy at each station to operate with probability P and sleep with probability P-1, not considering other independent base stations [6].

2. Strategic sleeping

In this case Macro Base stations are switched off when their activity is low which means when there is low traffic and load. We do not randomly switch off the Macro Base stations. It helps to optimize the traffic and load based problem [6].

VII. SECURITY REQUIREMENTS FOR 5G WIRELESS MOBILE NET WORKS BASED ON HELNET

While providing high speed data and latency, the network system faces some security and privacy issues like Jamming Attack, Eves Dropping, Man-in-middle attack, Spoofing, Eves Dropping, Dos(Denial of Service) attack and many more[14]. It is difficult to provide Confidentiality, Integrity and Authenticity at the same time due to limited bandwidth[15]. Security issues and vulnerabilities are faced at different OSI Layer like Physical Layer and MAC(Media Access Control) layer. There are some steps or countermeasures that are most to be taken to ensure the 5G network protection[14][15].

A. Different types of possible attacks

As mentioned above there are different types of possible attacks that makes the system insecure. But there is basically two types of attack on Wireless Network System: Active Attack (easy to identify that the attack has happened) and Passive Attack(not known about the attack).

TABLE I. TYPES OF ATTACK

Active Attack	Passive Attack
Attackers modify the data	No intension of Harming the system, only makes use of information
Integrity of the data does not remain.	Violates confidentiality and privacy of users
MT(Man-in-the- Middle)attack, Denial of Service attack, replay attack	Examples: Eves Dropping, traffic Analysis

Types of Attack

1. Eaves Dropping Attack: It is a type of Passive attack where the attacker intercepts the communication by capturing the message. It cannot be detected easily. To prevent the network from this attack, encryption is done over the radio link [14][15].
2. MIMT: Man-in-the-middle attack happens when the attacker controls the system secretly. Attacker can modify the message. It is an active attack. The users then compromise the CIA services[14][15]. The attacker can also trace the location of the mobile user.
3. Jamming: The attacker completely disrupts the communication between the users by injecting the malicious node [14][15]. Authorized users are then prevented from accessing the radio resources [14]. Direct Sequence Spread Spectrum (DSSS) Technique and frequency hopping spread spectrum (FHSS) are the anti-jamming scheme that are used to secure the communication from jamming at physical layer [14][15].

4. DoS and DDoS: The attacker send the multiple requests to the system and exhausts it. This attack violates the availability of services. Jamming is used for Dos Attack. This is an active attack. High penetration massive devices are used to detect Dos attack [14].
Topology Poisoning Attack: The attacker can control the packets in open flow architecture and can poison that global information which has been collected by control plane. Attacker monitors LLDP, records its syntax and then modifies it. LLDP packets can be in the form of port number. [15]
 5. Side Channel Attack: In OpenFlow Network, the attacker learns the network configuration by comparing the time of test stream and base line packets. The network configuration studied can be in the form of switches flow table, aggregate flow in links, records of host communication, configuration of network access control, and network monitoring policies. [15]
- B. Security Services in 5G Wireless Network
1. Confidentiality: It is of two types: data confidentiality and privacy. It prevents the access and disclosure of the message from an unauthorized user
 2. Integrity: The unauthorized should not be able to change or modify. Integrity takes care that the attacker should not be able to modify the information. Hashing method is used to provide integrity services to the users.
 3. Availability: The services should be accessible by the legitimate user anytime from anywhere. Various attacks are possible against the availability. Dos and jamming attack are the example that interrupt the communication and accessing of resources. DSSS and FHSS are the two PLS solution to prevent the system from availability attack.
 4. Authenticity: There are two types of authentication: message authentication and entity authentication. Entity authentication is done to verify the person who claims to be the legitimate user whereas message authentication refers to the correct message being delivered to those users without any packet/ data loss [14]

CONCLUSION

Heterogeneous network will play a vital role for upcoming 5G Wireless Network. The vital role will be played by relays and co-operative protocol to make the network system more significant than the conventional network. Its because of the strong interference arising due to user deployed infrastructure. On the other hand, security will be the main concern, preventing the user's data. Different services like authenticity and integrity is to be provided in terms of security and services.

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