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An Automated Handover in Software Defined Networks (SDNs) Based on QoS Metrics

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***Abstract*: With the advent of ubiquitous networks like the Internet of Things and fog networks, among others, modern wireless networks are seeing a paradigm shift in terms of management and optimisation. Future wireless networks will have to contend with issues including scarce bandwidth, growing user populations, and abundant data creation. As a result, software defined networks (SDNs) have become widely developed. The goal of software-defined networking technology is to enhance network performance and monitoring by providing dynamic, programmatically efficient network design. The problems with Quality of Service (QoS) caused by real-time fading effects are one of the main difficulties SDNs encounter. As a result, there will inevitably be a trade-off between the utility of network capacity and QoS measurements like error rate and throughput. Switching or handover methods are therefore required for SDNs in order to maximise available bandwidth and preserve a high level of network quality of service. In this study, a QoS-based handover mechanism based on QoS metrics is proposed for Software Defined Networks (SDNs) to enable the transition from traditional cellular networks to device-to-device (D2D) networks. The outage and error rates have been chosen as performance metrics of the system..**

Keywords: Software Defined Network (SDN), handover, outage, throughput, bit error rate, QoS.

I.INTRODUCTION

With Software-Defined Networking (SDN) is an approach to networking that uses software-based controllers or application programming interfaces (APIs) to direct traffic on the network and communicate with the underlying hardware infrastructure. The goal of SDN is to make networks more flexible, scalable, and programmable. In traditional network architectures, the control plane, which determines how data should be forwarded, and the data plane, which actually forwards the data, are tightly integrated into the networking devices (such as switches and routers). SDN separates these two planes and centralizes the control plane, allowing administrators to dynamically adjust network behavior via software without having to alter the physical hardware. Key components of SDN include:

SDN Controller: The central component of an SDN architecture, the controller acts as the "brains" of the network. It communicates with the switches and routers in the network, providing a centralized view of the entire network and making decisions about where to send data.

Southbound APIs: These interfaces allow the SDN controller to communicate with the networking devices in the data plane. Common southbound APIs include OpenFlow, which is a widely used protocol in SDN environments.

Northbound APIs: These interfaces allow the SDN controller to communicate with the applications and business logic in the control plane. Northbound APIs enable the programmability of the network and facilitate communication between the SDN controller and higher-level network applications.

Benefits of SDN include:

1. Flexibility and Programmability: SDN allows for easier management and configuration of network resources, enabling automation and programmability.
2. Scalability: Centralized control simplifies network management and makes it easier to scale the network to accommodate growing demands.
3. Cost Efficiency: SDN can lead to cost savings by optimizing resource utilization and reducing the need for expensive, specialized hardware.
4. Improved Network Management: Centralized control provides a comprehensive view of the network, making it easier to monitor and manage.
5. SDN is commonly employed in data centers, enterprise networks, and telecommunications infrastructure to enhance network performance and agility

II.HANDOVER IN SDNS

In the context of Software-Defined Networking (SDN), "handover" typically refers to the process of transferring the control of a network flow or connection from one network device to another. Handovers are crucial in scenarios where devices move or change their network attachment points, such as in mobility scenarios or when dealing with virtualized network functions. Handover mechanism include:

Centralized Control: In an SDN architecture, the control plane is centralized in an SDN controller. The controller has a global view of the network and can make decisions about how to manage handovers. When a device, like a mobile user or a virtual machine, moves from one part of the network to another, the SDN controller can dynamically update forwarding rules to ensure that the flow or connection is seamlessly handed over to the appropriate devices.

Dynamic Flow Management: SDN enables dynamic flow management, allowing the controller to modify flow entries in the switches or routers to redirect traffic as needed. This is particularly useful in scenarios where a device transitions between different access points or network segments.

Programmability through Northbound APIs: SDN controllers expose northbound APIs that allow higher-level applications to communicate with the controller. Applications responsible for mobility management or handover decision-making can use these APIs to instruct the controller on how to handle handovers.

Flow Prioritization: SDN allows for the prioritization of network flows. When a handover occurs, the controller can ensure that critical or real-time traffic is given priority during the transition to maintain quality of service.

Integration with Network Function Virtualization (NFV): In virtualized environments, SDN often works in conjunction with NFV. Virtualized network functions (VNFs) can be dynamically instantiated or migrated to different locations in response to changes in network conditions, and the SDN controller plays a role in managing this dynamic instantiation or migration.

By centralizing control and providing a programmable interface, SDN simplifies the management of handovers in networks, making them more efficient and adaptable to changing conditions. This is particularly valuable in scenarios where seamless connectivity and mobility are critical, such as in mobile networks, IoT environments, or data center networks with virtualized workloads.

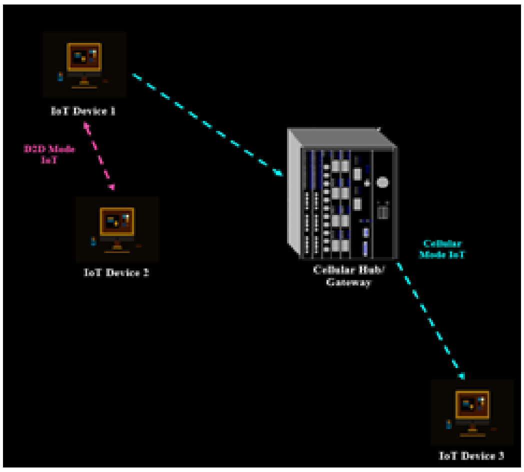

Fig.1 Cellular vs D2D Based SDN Architecture

Typically, the SDNs can be classified as:

1) Cellular enabled SDNs.

2) D2D enabled SDNs.

To ensure satisfactory quality of service, a handover mechanism, is required. The handover needs to include the Quality of Service (QoS) as a governing metric.

III.METHODOLOGY

The methodology for the proposed approach for automated handover is presented as:

```
Algorithm:
Start
{
Step.1: Generate random data x(n) to emulate the real life SDN data transfer mode.
Step.2: Divide data into packets based on packed size 'L'.
Step.3: Generate complex value data stream as:
    $x(t) = K_1 sin(\omega t) + jK_2 sin\,(\omega t)$

The signal can also be expressed as a complex exponential,
$x(t) = K_1 s e^{j(\omega t-\varphi)} + K_2 s e^{j(\omega t-\varphi)}$

Step.4: Design random channel characteristics for SDN as:
$H(f) = \int_{-\infty}^{+\infty} h(t) e^{-j2\pi f t} dt$

Step.5: Add random noise to emulate a practical wireless media as:
$n(t) = 10^{\left[\frac{SNR\ in\ dB}{10}\right]}$

Step.6: Implement data reception as:
    $S_i = sign\{real[S_{composite}(t)]\}$
    $S_q = sign\{real[S_{composite}(t)]\}$

Step.7 Implement handover based on the following condition:
        Simultaneously estimate $BER_C$ & $BER_{D2D}$
        Find $\{Min(BER_C, BER_{D2D})\}$
        Choose multiple access technique based on result of step above
        }
        Stop
```

The QoS based performance metrics to be computed as:

1) **Optimum Distance:** The distance at which we can switch from cellular mode to D2D mode maintaining satisfactory (QoS).

The minimum distance at which such a switching can take place termed as r_d can be expressed as:

$$r_d = d_0 . 10^{\left[\frac{P_{td} - P_{rmin} + 20\log_{10}\left(\frac{\lambda}{4\pi d_0}\right)}{10\eta}\right]} \times \exp(k) \quad (1)$$

where

$$\exp(k) = exp\left[\frac{\xi erf^{-1}(1-2P_d)}{\alpha}\right]$$

here P_d stands for power received at a distance 'd' and d_0 stands for a constant reference distance.

Outage Probability: It's an indication of the Quality of Service (QoS) and helps in deciding the mode of operation. The outage probability of the system can analyzed with respect to UE density, distance and SINR
The Outage probability as a function of the above parameters can be given by:

$$q(\lambda) = \exp\left\{-\frac{2\pi^2}{\eta \sin\left(\frac{2\pi}{\eta}\right)} R_k^2 V_k^{2/\eta} \lambda\right\} \quad (2)$$

where the successful transmission probability can be given by:

$$P(SIR_k \geq V_k) = \exp\left\{-K_k \sum_{j\epsilon\phi} \gamma_{kj}\lambda_j\right\} \qquad (3)$$

where, $K_k = C_k R_k^2 V_k^{2/\eta}$
here R_k stands for distance
V_k stands for SINR and
λ stands for UE density
Thus the analysis of optimum distance and outage probability helps in deciding the optimum mode of operation.

Channel State Information: The medium between the transmitting and receiving device is called the channel. The Channel State Information (CSI) is the information about the nature about the state or condition of the channel. Different devices are allocated different frequencies for data transmission. The channel generally behaves differently for different frequencies. Some frequencies face heavy or severe fading (decrease in strength). This causes low signal strength which causes high bit error rate (BER) and poor quality of service. Hence it is necessary to use the channel state information (CSI) to select frequencies with good response and reject the frequencies with poor response. This can reduce the errors and hence improve the quality of service.

IV.EXPERIMENTAL RESULTS

The results obtained using the proposed techniques are given below. The effect of shadowing has been clearly cited using the parameter σ.

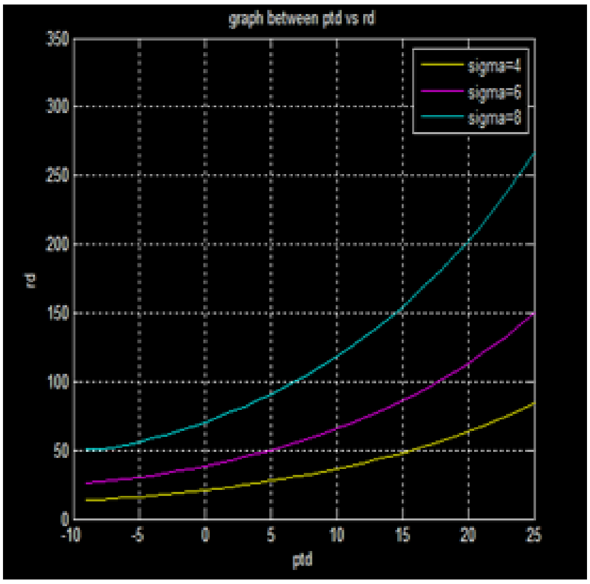

Fig. 2 Graph for optimum distance

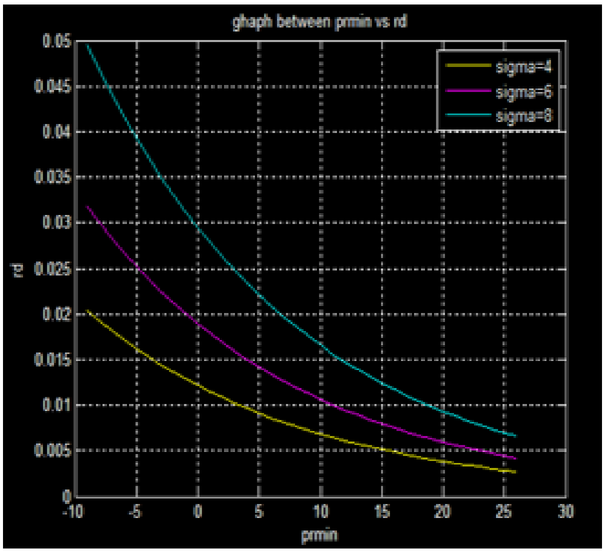

Fig.3 Graph between prmin and rd under varying shadowing effects

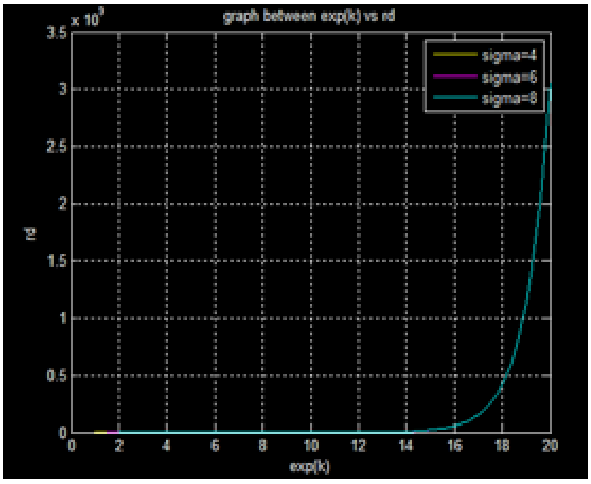

Fig.4 Graph between exponential constant and optimum distance under varying shadowing effects

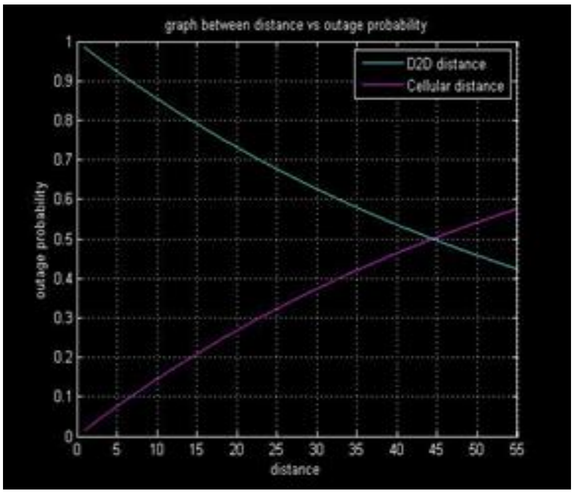

Fig.5 Graph between outage probability and distance

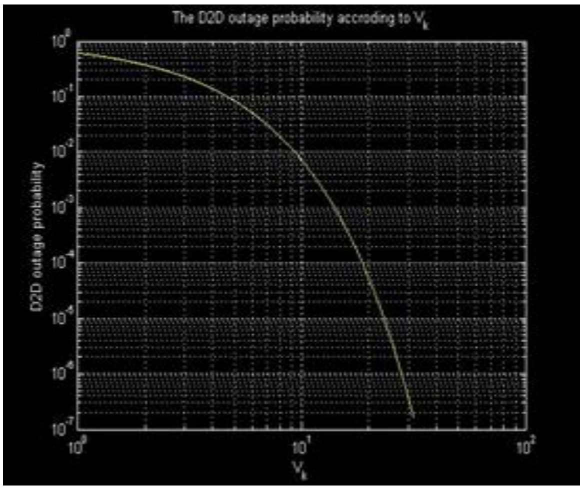

Fig.6 Graph between outage probability and SINR

The results clearly indicate the Cellular mode works better for larger distances while the D2D mode performs better for lesser distances. The handover, can be implanted based on the optimum distance ‘d’ under simultaneous outage conditions. Moreover, the path loss co-efficient σ has been considered to emulate the shadowing conditions.

V.CONCLUSION

In this study, we examined the ideal distance for direct-to-consumer (D2D) communication in terms of the exponential constant k, the minimum received power, and the sent power. In the case of transmitted power, the optimal distance rises with transmitted power. The ideal distance in the minimal received power situation gets smaller as the minimum received power rises. As is well known, a signal outage results in signal fading. In order to solve this issue, we examined outage likelihood in relation to SNR. We found that the likelihood of an outage decreases as signal strength rises. As a result, there would be fewer opportunities for signal deterioration at the receiving end, improving communication reliability. A clear condition of transitioning from cellular to D2D mode and vice versa can be obtained by analysing the outage likelihood with respect to device density in the network, distance between devices, and Signal to Noise and Interference Ratio (SINR). The shadowing conditions and noise addition to the channel have been considered for the proposed work as well to mimic a real life SDN environment.

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