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HST Communication Network by Integration of Software-Defined Networking and Network Function Virtualization

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***Abstract:** The new challenges introduced in the wireless communication systems by the rapid developments of high-speed trains (HSTs) and more usage of the smartphones. The smart transportation involves the large crowd with smart phones, that requires a more efficient network for communication without disconnection. To achieve that, the handover process, need to be done quickly with respect to the speed of the train. To sustain its session connectivity to the internet, it requires the disconnection from the current access point (APc) to the next access point (APn). IN this project, we use the open flow and open stack protocols for integrating the interface between the infrastructure and the controller. Along with this, the integration of software-defined networking and network function virtualization is also done. The project majorly concentrated on the modification of the routes of the packet flow from one access point to the next required access point with the use of the triggering signal from the train which gives the location of the train. The suggested method works by the transmitting the signal from train to the next access point in advance so that the SDN controller changes the path of the packets to the next access point. The parameters like Signal strength, packet loss, average delay, path delay is evaluated. Along with these parameters the energy dissipation near the network also evaluated. The experimental results are evaluated using MATLAB tool.*
***Keywords:** Network Function Virtualization, OpenFlow in SDN, OpenStack, Software Defined Network.*

I. INTRODUCTION

The smartphone generates more traffic than the conventional phones. Smartphones already become a regular resource for everyone, and the statistics also prove that about 41% passengers travelling on public transportation use smart phones while travelling [2]. Hence, at high mobility, the mobile date rate traffic is generated heavily. To keep track with the huge mobile traffic and the large number of users accessing the internet at high speed, the new technology mobile networks, i.e., the fifth generation (5G) must replace the fourth generation’s (4G) long-term evolution-advanced (LTE/LTE-A) with respect to the data rate and capacity [3]. Over-taking the 4G implies that 5G should be highly flexible and configurable to address specific use cases [4] "broadband access in public transport" [5] is one of the requirements under consideration. Since 3G and 4G frequency band are not sufficient to the increasing quality of service for the present and future cellular networks, so, the 5G mobile systems as to broaden the spectrum to high frequency (i.e., 6-300 GHz). Additional challenges arise for broadband communication at high mobile user speed. With the limitation in the coverage area and transmission rate its difficult to accurately estimate the rapid varying channels.

A handover is the process by which an MT maintains an active connection while moving from one cell to another cell without losing the connection. When the MT is at the cell-edge, the source BS selects the best neighboring BS using a set of criteria and hands over the MT to the best neighboring BS [16, 17]. The "handover hysteresis" and "time to trigger" (TTT) are the two settings that usually triggers the MT. The MT speed, radio network deployment, propagation conditions, and system load [18, 19] are the factors that affect the optimal values of the settings. At high speed over an extended period of time, the handover occurs very frequently. For example, an MT moving at 200 km/h, will initiate handovers every 15-25s for a cell size of 1.5-2 km. Hence, the handover procedure is much more challenging at high mobility because there might not be sufficient time.

Furthermore, at high-speed large number of MT move at the same time, in public transport vehicles, large number of users travel thus large number of handover process initiations require and large amount of network resources also should avail. The large number of handover processes initiated simultaneously will lead to excessive handover failure if conventional handover schemes are directly implemented in high mobility scenarios.

II. NETWORK ARCHITECTURE

In HST network the mainly applied link is, the communication link between the BS and the onboard users in train. The frequent handovers along the rail track, can be mitigated by the use of remote antenna units (RAUs) with the same frequency and parameter settings are used to enlarge the cell [23, 24]. However, significantly low power signals are received due to the high VPL caused by the metalized windows and carriages of the train. Hence, for the improved quality of service (QoS), we use a promising two-hop network architecture. For broadband wireless access on HSTs several two-hop network architectural schemes have been proposed [24–26], where the communication link is divided into BS-to-HST link (the backhaul link) and HST-to-onboard link (the access link).

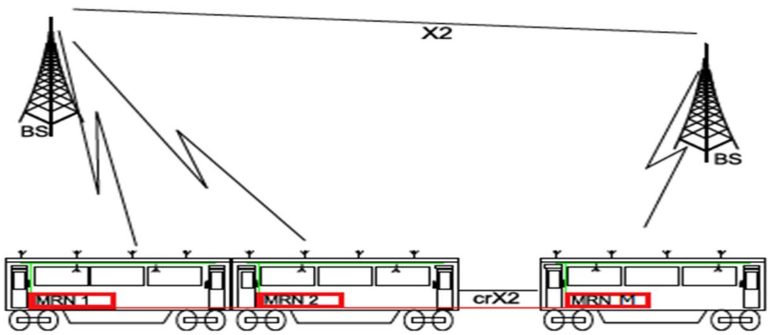

Fig. 1.1. Cooperative MRN system model

The Wi-Fi is employed on the access link inside the vehicle in most of the proposed networks. However, the mobile operators use moving relay nodes (MRNs) on the access link for the full control and management of the core network. The use of relay systems for HST as shown in Fig. 1.1. The use of MRN gives three advantages

1) It ensures generally good channel conditions for high-rate communication by providing the relative positions of onboard MTs in respect to the MRN.
2) By congregating the handover processes of the onboard MTs to an individual process of a single MRN will reduces the signaling overhead.
3) The transmit power of onboard MTs cab be reduced by the relatively close placement with MRN.

Furthermore, for the MRN backhaul link, the use of mm wave for 5G networks gives high directionality with electronic steering capabilities. In band relaying, the backhaul links and access link are operated on different frequencies to avoid the interference, but these comes at an additional cost to the mobile operator. In the in-band relaying, the high VPL of an HST can potentially eliminate the interference at high operating frequencies. The notion of the using relay systems for HSTs was first presented in [27].
In this concept, the high data rate is achieved due to the establishment of the multiple backhaul links and integrated extension of the cellular network. The MRNs has multiple antennas and are realized using optical fiber which provides zero latency.

III. SYSTEM MODEL

In mass transportation all over the world, high speed railway is playing an important role. The people's lives become more convenient with the development of high-speed railways. The numerous communication data need to be transmitted to train passengers through wireless channels as the number of HST users increasing. The HST wireless communication network provides fast and seamless wireless service for users on the HST, where the last one-kilometer communication between the HST and the wayside base station (BS) which act as access points plays a key role to guarantee the quality of service (QoS) for users onboard. The design of accessing the access points when the train entering the path is taken as a challenge in this project. To manage and monitor the communication network globally, Software defined network (SDN) has been proposed. SDN helps the network operators to manage the network flexibly by separating the control plan and data plane.

IV. TECHNOLOGIES USED

To facilitate the understanding, some technologies are proposed that including object speed calculations, millimeter-wave (mmW) AP, massive multiple-input multiple output (MIMO) antennas, wireless gigabit (WiGig) AP, identifiers of network and host, IP address and mobility.

A. Target Speed and Wireless Registration

High-speed moving targets (trains or cars) suffer from interrupted wireless services when they cross from the attached AP to a new one. That is, the wireless registration process which includes disconnecting from current AP and connecting to the new AP. Suppose that the speed of a moving target is 350 km/h, the delay time of the layer 2 wireless registration CP is
50–250 ms [15], and the distance between any two adjacent APs is 200–1000 m. With a simple calculation via (1), we can estimate the delay time that is required by a moving target to move from one AP to another as flows, such that $t = d/v$ where t is the time required to cross the distance d with target speed v.

1) Separation distance between APs is 200 m:
350 km/h = 97.222 m/s
so 200 m/97.222 m/s = 2.057 s.

2) Separation distance between APs is 1000 m:
350 km/h = 97.222 m/s
so 1000 m/97.222 m/s = 10.286 s.

It is evident that we have enough time to handle the data packets between the separation of the APc and APn.

B. Millimeter Wave AP

The most important feature of an mm wave is its frequency band ability to carry multigigabit throughput data rates at a range from 1 m to a few thousand meters [16], [17]. The frequency band (30–300 GHz) of the mmW can give 200 folds more than the usage of current wireless bandwidth. For use in outdoor and indoor small cells ranging from a few meters to a few kilometers the mmW Aps are used due to the wide bandwidth [18], [19]. The multi-Gb/s rate can be delivered to the users by the beamforming technique, that helps in overcoming short and loss of channel propagation of the mmW [20], [21].

C. Massive MIMO Antennas

The MIMO antenna schemes enhance the data rate, reduce latency, boost radiated energy efficiency, improve fidelity on the wireless interface, and also avails a simplifies multiple access of control layer. The sender and recipient decide to transmit large stream of data along the multiple antennas then Massive MIMO is impactful. [22], [23]. The massive MIMO technology combined with the mmW then it provides the large throughput of Gb/s traffic and it improves the link reliability [24].

D. WiGig Attachment Point

The 5G network has the ability to perform high data rate ranging from 1 to 7 Gb/s. That includes more than 1Gb/s date rate can be provided to the user by the last distribution point of a wireless LAN. The standard of IEEE 802.11ad works as indoor mmW AP at 60 GHz for WiGig [25], which ables the multigigabit transmission rate. The beamforming technique has been found to overcome the issues of non-line-of-sight can be overcome by the beamforming technique and it also improves energy efficiency [26]. WiGig APs are the best suitable inside the compartments of the HST.

E. IP Address and Mobility

The IPv6 address is a combination of physical and logical IDs, which represent host and network interface IDs, respectively. Fig. 4.1 illustrates the IPv6 structure, which shows how the device can identify itself through its IPv6 address.

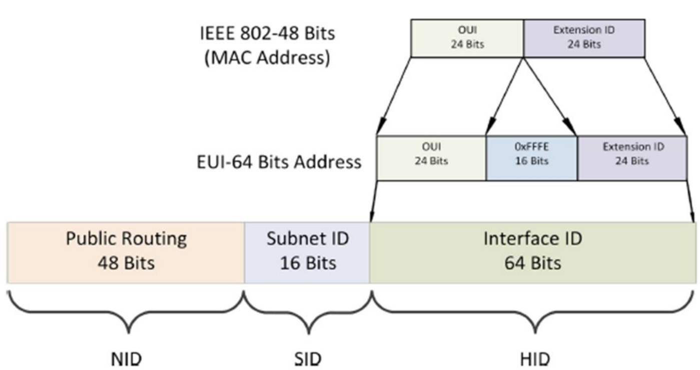

Fig4.1 IPv6 Structure

Fig.4.1 shows the three parts of the IPv6 [27-28] given as follows.

1) *Network Identifier (NID):* it consists of 48 bits and gives the public topology (public routing).it is considered as the parent of the SID.
2) *Subnetwork Identifier (SID):* It consists of 16 bits and it provides the site topology (local routing) The SID is the child of the NID. The NID and SID combined represents the global routing prefix of an IPv6. They both together gives the indication of the location.
3) *Host Identifier (HID):* It is 64 bit long and represents the interface attachment port of a device. The IPv6 address is a combination of the NID, SID, and HID that is used by a device to be an end-to-end identifier. The HID can be worked as an indication for the mobile device position.

The information of the geographic locations of the mobile device is provided to the network operator of all the sub networks. The IP address provides the location of the mobile device by calculating the previous location knowledge of the subnet which serves the device [29].

The structure of the system, as shown in Fig. 4.2, it consists of three principal parts.

a) The main domain (operator network).
b) The subdomains (subnetworks or subnets).
c) The train (its AP and triggering signal).

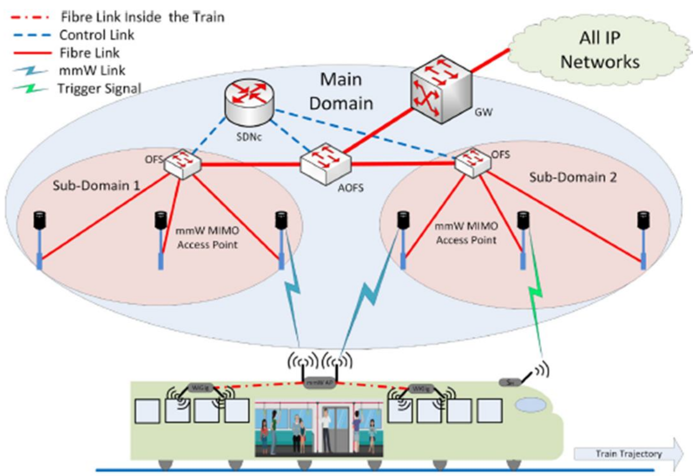

Fig 4.2 System Architecture

F. *Main Domain*

The main domain consists of the following:

1) The SDN controller.
2) Gateway (GW).
3) Aggregator OpenFlowswitch (AOFS).
4) OFSs in each domain.

The SDN controller acts the directing guide for the AOFS and OFSs and routes the packets of data to the destination. The SDNc look up table consists of the links of the devices which helps in the routing of the data. The SDNc controls the traffic flow in the main and sub domains. The SDN controller gives the instructions to the switches that with route the data to the destination based on the saved information from the SDNc lookup table. The SDNc look up table consists of the network indicator (NID), subdomain identifier (SID), virtual local area network (VLAN) that gives the train identifier.

The VLAN ID represents the topology of the local network of an access point that connects to the train under the coverage area. The Internet Gateway acts as a switch to connect the AOFS to direct the data packets from one subdomain to another. That means when the train moves from one subdomain to another subdomain the AOFS changes its direction of the packet route to the destination access point by using the SDN controller look up table. The AOFS are responsible for the packet path change. When the train moves in the same domain then the AOFS doesn’t changes the direction of packet flow. All IP networks that are installed outside the main domain should be connected the GW. The routing process is done according to the rules SDN controller fixes.

G. Subdomains

Subdomain comprises of at least one OFS and several APs. The data plane is used for the communication between the OFS and AOFS. THE OFS forwards the data according to the rules of SDN controller. The NID does changes when the train moves within the main domain whereas, SID changes. The train AP is the HID and so APs work as the VLANS i.e., network topology.
The NID, SID and HID together makes the train IPv6 address.

H. Trigger Signal and Train AP

A triggering signal is sent to the next access point from the running train. TO send the triggering signal, antenna is connected at the train head and the signal is sent to the next location of the train. The triggering signal consists of the HID and the current access point and the train speed. This information is sent to the next access point, which helps the SDN to control the data forwarding. So, the routing changes the direction based on the triggering signal information.
The main important purpose of *SH* is to give information to the SDNc to govern the flow of packet flow. The SDN controller modifies the direction of the packet flow based on the SH signal. dictate to the OFSs and AOFS to change the flow direction. Fig. 4.3 shows the hierarchical architecture of the proposed scheme for forwarding packets. Also, Fig. 4.3 NID (red), SID (green), and HID (blue) points the parts of the IPv6 address for the train. The SH received will urges the SDN controller to start the layer2 handover procedure and the APn will be prepared to take over the connection even though the train is still connected with the APc. The distance between train and the APn is calculated based on the parameter received signal strength indicator (RSSI).

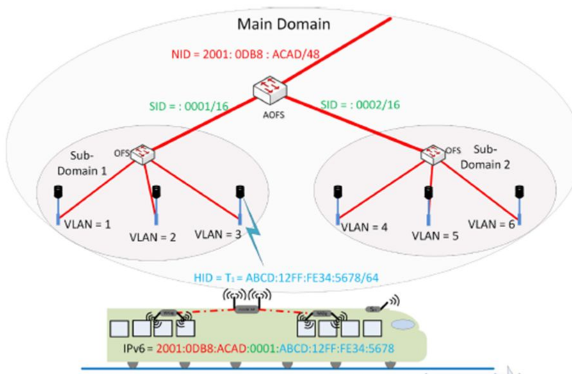

Fig4.3 Proposed SDN IPv6 hierarchy structure

I. Packet Flow Forwarding Scenario

When the train moves within the main domain then the IPv6 address of 64bits does not change. As the train moves from one AP to another, the layer2 handover takes place but due the transition of train in same domain that makes the handover without any change in the address so it reduces the latency.

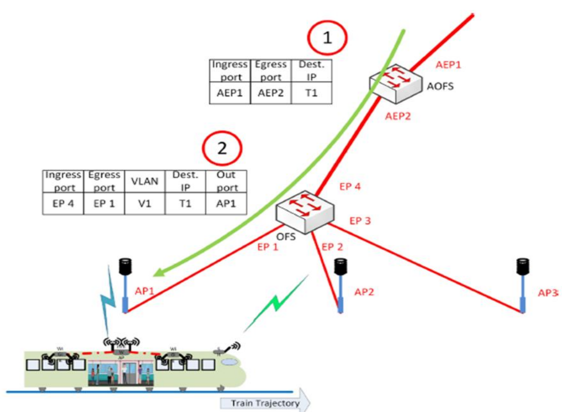

Fig. 4.4. Packet forwarding based on the flow table within one subdomain.

Figure. 4.4 gives the clear view of the packet flow when the train moves within the same main domain. Figure. 4.5 and 4.6 shows that the information provided by the SH to the APn will makes the SDN controller govern the traffic flow of the AOFS and OFS.

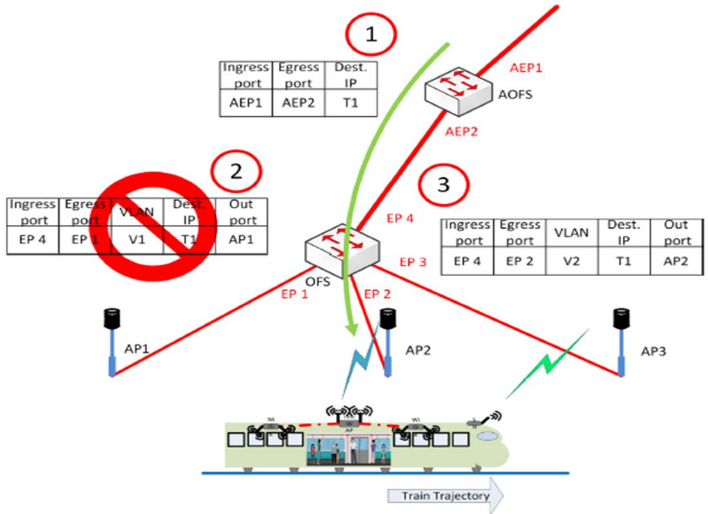

Fig. 4.5. Packet forwarding based on the modified flow table within one subdomain.

Fig. 4.5 shows that the flow table entries will change once the train moves to the next subdomain and the right time is calculated by the SDN controller.

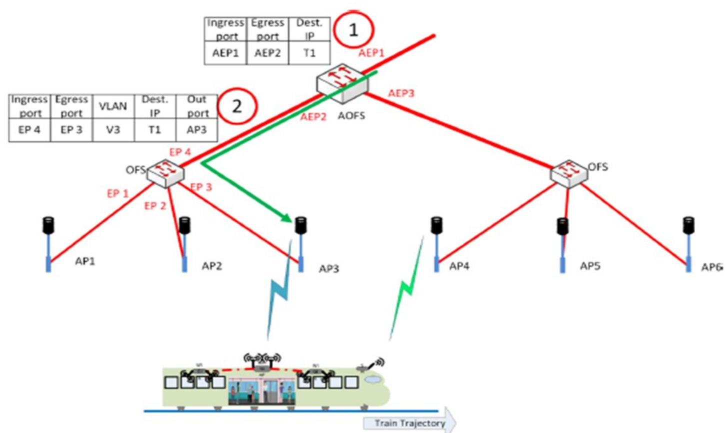

Fig. 4.6. Packet forwarding based on the flow table between adjacent subdomains.

Fig. 4.6 gives a view of the result after the information of the train location is passed to the SDNc by the APn.

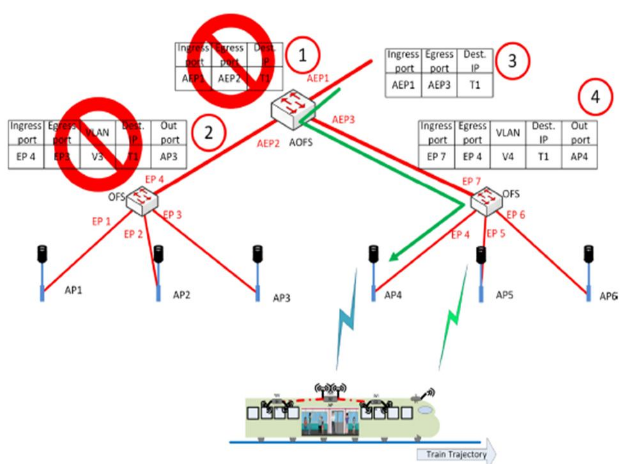

Fig. 4.7. Packet forwarding based on the modified flow table between adjacent subdomains

V. OPEN STACK

The entire process is performed by using open stack flow model. The process performed by open flow and open stack is same but the only difference is switching of signals in software defining networks. The switching plays a key role in communicate the access points. The access points need to get the signal in right time. The results obtained using open flow and open stack is been compared. Open-Stack is an open-source cloud computing management platform project that combines several major components to accomplish specific tasks. Open-Stack covers many aspects like network, virtualization, operation system, and server. If we consider open stack the results have been improved in all terms like average delay, packet loss etc... Integrating SDN controllers into Open Stack gives promising results.

VI. RESULTS AND DISCUSSION

A. SDN- Open Flow

Software defined networks will be the key to the traffic routing in the networks. AS it occupies the position of brain and makes routing process as central routing. It separates the data link layer and the control layer. The measurements done by the SDN is based on the train header signal which gives the information about the train to the next access point.

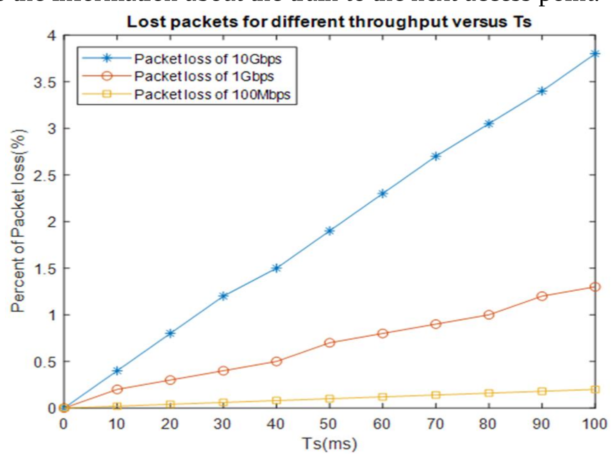

Fig6.1 Packet loss w.r.t train speed

From fig 6.1 it shows that the rate of lost packets depends on the capacity and the channel bandwidth. That means the packet loss increases with the increase in the train speed and the channel bandwidth. As the rate of data that the passengers' usages increases then the percentage loss in data also increases and the train speed also effect the packet loss. As the channel band width is 10Gbps the packet loss when train speed 50ms is 2% when bandwidth is 100Mbps at 50ms the loss is 0.7%.

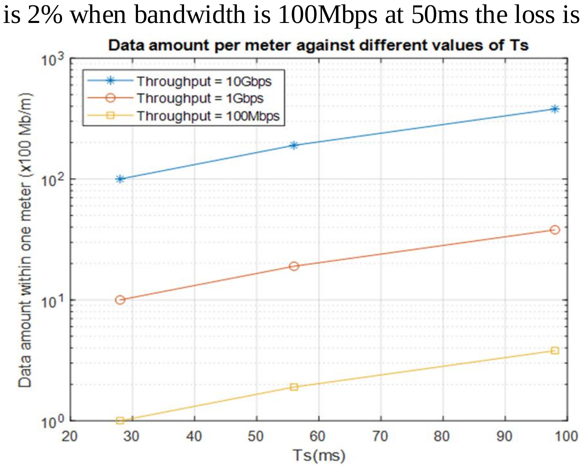

Fig 6.2 Loss of data w.r.t train speed

From fig 6.2 it gives that the loss in data is directly proportional to the channel throughput. In the figure the data loss jumps as the train speed increases *Ts* (as proposed 28, 56, and 98 m/s) leads to an increase in the number of meters that are traversed by the HST within 50 ms.

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From fig 6.3, the graph gives the received data vs train speed. The separation between the APc and APn will considered as the handover process takes place and the delay occurs.by using the SH received data is 93%, 90% and 89% at 40m overlap distance at Ts 28m/s, 56m/s and 98m/s respectively. Without using S_H the HST received data of 60%, 50% and 40% at 40m overlap distance at Ts 28m/s, 56m/s and 98m/s respectively.

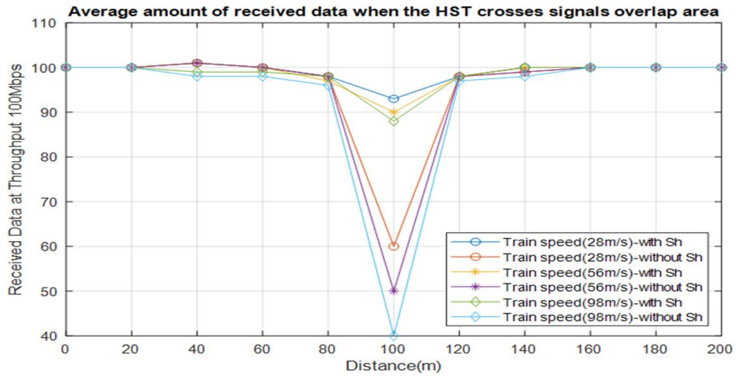


Fig 6.3 Received data w.r.t train speed

B. SDN- Open Stack

The above results are simulated using SDN-Open flow. If we consider open stack the results have been improved in all terms like average delay, packet loss etc... Integrating SDN controllers into Open Stack gives promising results. The simulated results using MATLAB software tool is shown below.

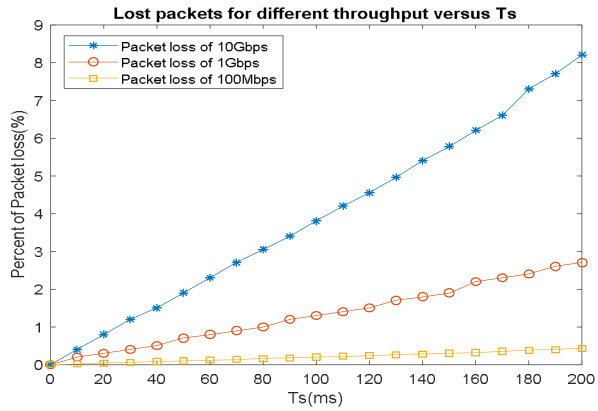


Fig 6.4Packet loss w.r.t train speed

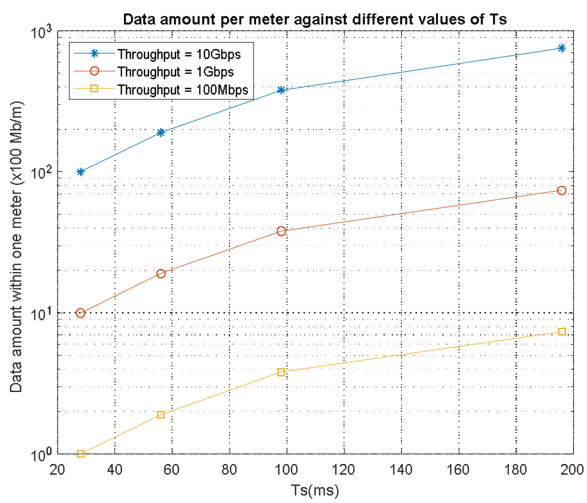


Fig6.5 Data loss w.r.t data speed

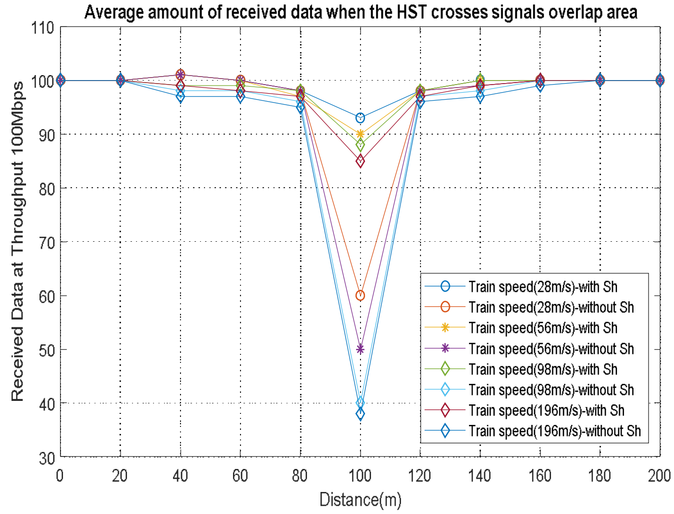


Fig6.6 Receiver Data w.r.t train speed

The comparison of open flow SDN and open stack SDN in terms of packet loss, data loss and receiver data in following table.

VII. CONCLUSION

The virtualization and the SDN combination are better for networking and the mobile data processing and the transition allows us to use the cloud computing for better results. We observed that the trigger signal will makes the handover process more effectively. The results also give clarity about that topic. Moreover, our technique results in a decrease in the number of lost packets during the handover procedure in both the cases of increasing the channel bandwidth capacity and the train speed. The comparison is done for SDN-Open Flow and SDN-Open stack. The SDN with open stack gives promising results.

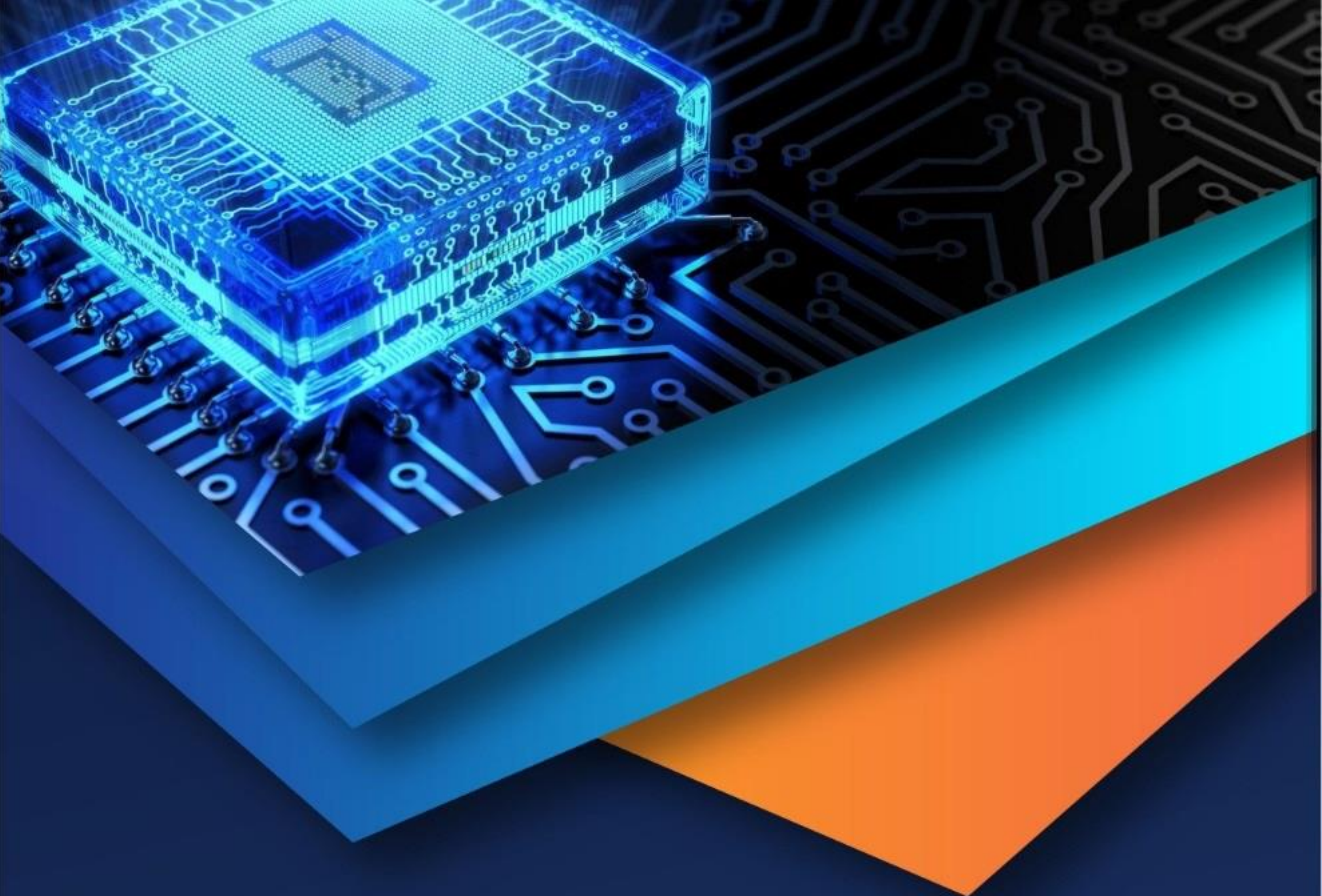
VIII. FUTURE WORK

In future this method can be implemented for bullet trains as the speed of train increases than the normal high-speed trains. When the train speed increases the communication network tracking becomes a bit difficult since the user changes from one access point to next point in quicker time. The adjustment for obtaining receiver signal strength will be increased.

REFERENCES

[1] D. Johnson, C. Perkins, and J. Arkko, “Mobility support in IPv6. IETF, request for comments: 3775, June 2004,” 2004.
[2] R. Koodli, “Fast handovers for mobile IPv6,” 2005.
[3] H. Soliman, C. Castelluccia, K. El Malki, and L. Bellier, “Hierarchical mobile IPv6 mobility management (HMIPv6),” 2005.
[4] S. Gundavelli, K. Leung, V. Devarapalli, K. Chowdhury, and B. Patil, “Proxy mobile IPv6,” 2008.
[5] H. Yokota, K. Chowdhury, R. Koodli, B. Patil, and F. Xia, “Fast handovers for proxy mobile IPv6,” 2010.
[6] J.-H. Lee, J.-M. Bonnin, I. You, and T.-M. Chung, “Comparative handover performance analysis of IPv6 mobility management protocols,” IEEE Trans. Ind. Electron., vol. 60, no. 3, pp. 1077–1088, Mar. 2013.
[7] H. Modares, A. Moravejosharieh, J. Lloret, and R. B. Salleh, “A survey on proxy mobile IPv6 handover,” IEEE Syst. J., vol. 10, no. 1, pp. 208–217, Mar 2016.
[8] W. Luo, X. Fang, M. Cheng, and Y. Zhao, “Efficient multiplegroup multiple-antenna (MGMA) scheme for high-speed railway viaducts,” IEEE Trans. Veh. Technol., vol. 62, no. 6, pp. 2558–2569, Jul. 2013.
[9] J. Kim, H.-S. Chung, I. G. Kim, H. Lee, and M. S. Lee, “A study on millimeter-wave beamforming for high-speed train communication,” in Proc. Int. Conf. Inf. Commun. Technol. Convergence, 2015, pp. 1190–1193.
[10] M. Karakus and A. Durresi, “Quality-of-service (QoS) in software defined networking (SDN): A survey,” J. Netw. Comput. Appl., vol. 80, pp. 200–218, 2017.
[11] G. Faraci and G. Schembra, “An analytical model to design and manage a green SDN/NFV CPE node,” IEEE Trans. Netw. Service Manage., vol. 12, no. 3, pp. 435–450, 2015.
[12] J. Doherty, SDN and NFV Simplified: A Visual Guide to Understanding Software Defined Networks and Network FunctionVirtualization. Reading, MA, USA: Addison-Wesley, 2016.
[13] P. A. Morreale and J. M. Anderson, Software Defined Networking: Design and Deployment. Boca Raton, FL, USA: CRC Press, 2014.
[14] J. Costa-Requena et al., “SDN and NFV integration in generalized mobile network architecture,” in Proc. Eur. Conf. Netw. Commun., 2015, pp. 154–158.
[15] F. Anwar, M. H. Masud, S. Bari, and S. A. Latif, “Enhanced handoff latency reduction mechanism in layer 2 and layer 3 of mobile IPv6 (MIPv6) network,” Aust. J. Basic Appl. Sci., vol. 7, no. 6, pp. 658–671, 2013.
[16] A. I. Sulyman, A. T. Nassar, M. K. Samimi, G. R. MacCartney, T. S. Rappaport, and A. Alsanie, “Radio propagation path loss models for 5G cellular networks in the 28 GHz and 38 GHz millimeter-wave bands,” IEEE Commun. Mag., vol. 52, no. 9, pp. 78–86, Sep. 2014.

[17] T. S. Rappaport et al., “Millimeter wave mobile communications for 5G cellular: It will work!” IEEE Access, vol. 1, pp. 335–349, 2013.
[18] T. S. Rappaport, J. N. Murdock, and F. Gutierrez, “State-of-the-art in 60-GHz integrated circuits and systems for wireless communications,” Proc. IEEE, vol. 99, no. 8, pp. 1390–1436, Aug. 2011.
[19] S. Rangan, T. S. Rappaport, and E. Erkip, “Millimeter-wave cellular wireless networks: Potentials and challenges,” Proc. IEEE, vol. 102, no. 3, pp. 366–385, Mar. 2014.
[20] K. Sakaguchi et al., “Millimeter-wave wireless LAN and its extension toward 5G heterogeneous networks,” IEICE Trans. Commun., vol. 98, no. 10, pp. 1932–1948, 2015.
[21] S. Hur, T. Kim, D. J. Love, J. V. Krogmeier, T. A. Thomas, and A. Ghosh, “Millimeter wave beamforming for wireless backhaul and access in small cell networks,” IEEE Trans. Commun., vol. 61, no. 10, pp. 4391–4403, Oct. 2013.
[22] E. G. Larsson, O. Edfors, F. Tufvesson, and T. L. Marzetta, “Massive MIMO for next generation wireless systems,” IEEE Commun. Mag., vol. 52, no. 2, pp. 186–195, Feb. 2014.
[23] T.-T. Tran,Y. Shin, and O.-S. Shin, “Overviewof enabling technologies for 3GPP LTE-advanced,” EURASIP J. Wireless Commun. Netw., vol. 2012, no. 1, p. 54, 2012.
[24] Z. Gao, L. Dai, D. Mi, Z.Wang, M. A. Imran, and M. Z. Shakir,“MmWave massive-MIMO-based wireless backhaul for the 5G ultra-dense network,” IEEE Wireless Commun., vol. 22, no. 5, pp. 13–21, Oct. 2015.
[25] D. Wang and C. H. Chan, “Multiband antenna for WiFi and WiGig communications,” IEEE AntennasWireless Propag. Lett., vol. 15, pp. 309–312, 2016.
[26] S.Wyne, K. Haneda, S. Ranvier, F. Tufvesson, and A. F. Molisch, “Beamforming effects on measured mm-wave channel characteristics,” IEEE Trans. Wireless Commun., vol. 10, no. 11, pp. 3553–3559, Nov. 2011.
[27] T. Reshmi and K. Murugan, “Light weight cryptographic address generation (LW-CGA) using system state entropy gathering for IPv6 based MANETs,” China Commun., vol. 14, no. 9, pp. 114–126, 2017.
[28] S. Hagen, IPv6 Essentials. Sebastopol, CA, USA: O’Reilly Media, 2006.
[29] J. Davies, Understanding IPv6. London, U.K.: Pearson Education, 2012.
[30] S. Banerjee, M. Hempel, and H. Sharif, “Decoupled U/C plane architecture for HetNets and high speed mobility: Research directions & challenges,” in Proc. 14th IEEE Annu. Consum. Commun. Netw. Conf., 2017, pp. 1–6.
[31] P. Dong, T. Zheng, S. Yu, H. Zhang, and X. Yan, “Enhancing vehicular communication using 5G-enabled smart collaborative networking,” IEEE Wireless Commun., vol. 24, no. 6, pp. 72–79, Dec. 2017.
[32] H. Zhang, N. Liu, X. Chu, K. Long, A.-H. Aghvami, and V. C. Leung, “Network slicing based 5G and future mobile networks: Mobility, resource management, and challenges,” IEEE Commun. Mag., vol. 55, no. 8, pp. 138–145, Aug. 2017.
[33] L. Lei et al., “Stochastic delay analysis for train control services in next-generation high-speed railway communications system,” IEEE Trans. Intell. Transp. Syst., vol. 17, no. 1, pp. 48–64, Jan. 2016.
[34] K. Banerjee, S. M. R. Islam, Z. I. Tahasin, and R. Uddin, “An efficient handover scheme for PMIPv6 in IEEE 802.16/WiMAX network,” Int. J. Elect. Comput. Sci., vol. 11, no. 5, pp. 8–16, 2011.
[35] C. Makaya and S. Pierre, “An analytical framework for performance evaluation of IPv6-based mobility management protocols,” IEEE Trans. Wireless Commun., vol. 7, no. 3, pp. 972–983, Mar. 2008.
[36] M.-S. Chiang, C.-M. Huang, D.-T. Dao, and B.-C. Pham, “The backward fast media independent handover for proxy mobile IPv6 control scheme (BFMIH-PMIPv6) over heterogeneous wireless mobile networks,” J. Inf. Sci. Eng., vol. 34, no. 3, pp. 765–780, 2018.
[37] X. Li et al., “Novel resource and energy management for 5G integrated backhaul/fronthaul (5G-crosshaul),” in Proc. IEEE Int. Conf. Commun. Workshops, 2017, pp. 778–784.
[38] X. Wang, G. Wang, R. Fan, and B. Ai, “Channel estimation with expectation maximization and historical information based basis expansion model for wireless communication systems on high speed railways,” IEEE Access, vol. 6, pp. 72–80, 2018.
[39] Kang MW, Chung YW. An Efficient Energy Saving Scheme for Base Stations in 5GNetworks with Separated Data and Control Planes Using Particle Swarm Optimization. Energies.2017; 10(9):1417
[40] Liu, Z., Wu, J., Yuan, Y. et al. Robust Power Control for 5G Small Cell Networks with Sleep Strategy. Wireless Pers Commun 116, 2205–2222 (2021).
[41] Y. S. Soh, T. Q. S. Quek and M. Kountouris, "Dynamic sleep mode strategies in energy efficient cellular networks," 2013 IEEE International Conference on Communications (ICC), 2013, pp. 3131-3136,
[42] Yousefi, Marziye & Omid, Mahmoud & Rafiee, Sh & Ghaderi, S.F.. (2013). Strategic planning for minimizing CO2 emissions using LP model based on forecasted energy demand by PSO Algorithm and ANN. International Journal of Energy and Environment. 4. 1041-1052.
[43] C. Liu, Y. Wan, L. Tian, Y. Zhou and J. Shi, "Base Station Sleeping Control with Energy- Stability Tradeoff in Centralized Radio Access Networks," 2015 IEEE Global Communications Conference (GLOBECOM), 2015, pp. 1-6, doi: 10.1109/GLOCOM.2015.7417363.



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