utilizations of all the systems but none of them were high enough and hence, the network was likely to be the bottleneck. For the first case, the throughput flattens out for about 250 concurrent UEs, whereas in the second case, for a data rate of about 55 Mbps per UE. In both the cases, the maximum throughput achieved is between 500 to 600 Mbps in spite of having 1 Gbps links. This is because of IP-in- IP encapsulations as well as physical layer header overheads. The number of data packets sent by the UEs are large compared to that in case of 100 Mbps links, thus leading to higher overheads.

:

V. CONCLUSIONS

We have implemented a prototype of LTE EPC Gateways -S-Gateway and P-Gateway, based on the concepts of SDN. We integrated it with SDN based MME and HSS. For only data traffic the maximum number of concurrent UEs handled by the setup before the network becomes the bottleneck is close to 90 (for 100 Mbps links and 1 Mbps rate per UE) and around 250 (for 1 Gbps links and 2 Mbps rate per UE). For mixed traffic (long duration data), the maximum number of concurrent UEs handled by the setup before the network becomes the bottleneck is about 100 (100 Mbps links, 1 Mbps data rate per UE and data traffic duration of 20 sec).

References

[1] Van Giang Van Giang Nguyen and Younghan Kim, "*Proposal and evaluation of sdn based mobile packet core networks*," EURASIP Journal on Wireless Communications and Networking, 2015(1), 2015.

[2] Basta, Arsany and Kellerer, Wolfgang and Hoffmann, Marco and Morper Hans Jochen and Hoffmann,"*Applying NFV and SDN to LTE Mobile Core Gateways, the Functions Placement Problem*," Proceedings of the 4th Workshop on ALL Things Cellular: Operations, Applications & Challeneges. Pp.33-38

[3] *S. B. H. Said and M. R. Sama and K. Guillouard and L. Suciu and G. Simon and X. Lagrange and J. M. Bonnin, "New control plane in 3GPP LTE/EPC architecture for on-demand connectivity service*," in 2013 IEEE 2nd International Conference on Cloud Networking (CloudNet), pp. 205-209

[4] L. E. Li, Z. M. Mao, and J. Rexford, "*Toward software-defined cellular networks*," 2012 European Workshop on Software Defined Networking. 2012.

[5] Junguk Cho, Binh Nguyen, Arijit Banerjee, Robert Ricci, Jacobus Van der Merwe, and Kirk Webb, "*Smore: Software-defined networking mobile offloading architecture*," In Proceedings of the 4th Workshop on All Things Cellular: Operations, Applications and Challenges, 2014.

[6] Brent Hirschman, Pranav Mehta, Kannan Babu Ramia, Ashok Sunder Rajan, Edwin Dylag, Ajaypal Singh, and Martin McDonald, "*Highperformance evolved packet core signaling and bearer processing on general-purpose processors*," IEEE Network, vol. 29, no. 3, 2015.

[7] http://www.tutorialspoint.com/lte/lte network architecture.htm

[8] http://www.netmanias.com/en/post/techdocs/6108/detach-emm- lte/emm-procedure-2-detach