A Virtual Network Placement Algorithm for Radio Access Network

D. Jeyakumar, C.Rajabhushanam

Abstract: ***Network functions virtualization (NFV) is a contemporary theme in telecommunication industry in the recent past and It is the main instrument of major transformational changes in the modern days network.NFV gives flexibility to network service and reduce enormous amount of time to deploy new network services without any hurdles. It can be achieved through various recent technologies such as cloud computing, Industry Standard High Volume Servers, Software Defined Networking (SDN).Mobile network highly exploited NFV because of cost effective. In this study, we proposed combination of window based VN embedding algorithm with Simple Lazy Facility Location to compute the optimal virtual network placement on radio access network. Comparing with the SLFL algorithm and ILP algorithm, the average link utilization is well connected. It can be noticed that approximately 4 -5 per cent increase in link utilization compared with existing algorithm***

Keywords : Network Function virtualization,Software Defined Network, SLFL

I. RESEARCH BACKGROUND

Network Virtualization enables the cost effective realization of data centers that spread across the world. In network virtualization, the main element is virtual network. A virtual network comprises of network nodes and network links on the substrate. The physical infrastructure provider manages the physical infrastructure which is called "Substrate". In order to be functional, it has to assign the substrate resources to virtual networks [1]. Schalffrath et al [2] have redefined and added new the roles to the network virtualization which helps to plays important role in business decision. The service provider (SP) uses the virtual network to offer service. It offers two types of service: a) application service b) Transport service. Virtual network provider (VNP) handles the responsibility of organizing the virtual resources to form virtual topology. Virtual network operator (VNO) handles installation and operation of the established virtual topology.

In any wireless or wired network, a large network operation was performed by dedicated hardware application and software. The role of network function virtualization helps in migrating a network function from the hardware instance to software instances that running on the virtual environment. This process of network softwarization is expected to play a vital role in the fifth and six generation mobile networks [3, 4]. Due to advance in virtualization network, many mobile network operators (MNO) enabled to use their Network infrastructure as a service to tap new revenues from various mobile virtual network operators (MVNO). For better understanding, MNO owns spectrum license from their national Government and radio access network whereas MVNO provides mobile subscription service to the end user without having mobile network infrastructure [5, 6].

Ahmed et al [7] have analyzed comprehensively about the virtual machine migration schemes. To optimize the virtual machine migration, three important areas should be optimized: a) Bandwidth optimization b) DVFS enabled power optimization c) storage optimization. Ghaznavi et al [8] addresses the unaddressed problem in the virtual function placement and their proposed model minimizes the operating cost in offering virtual network services. The main challenge is to find a tradeoff between the host and resource consumption.

Chowdhury et al [9] have proposed a heuristic based algorithm to isolate between the node and link mapping phase. The heuristic algorithm called ViNEYard, which establishes better coordination between the node and link phase. A generalized window based VN embedding algorithm (WiNE) to evaluate the look ahead on the virtual network. Many researchers [8, 10] have worked on the virtual network function placement problem and provided relative solutions. Whereas Riggo et al [11] addresses the new problem of virtual radio function placement. In this seminal work, the researchers demonstrated the NFV management and orchestration frame work for wireless network. In this research work, we used combination of window based VN embedding algorithm with Simple Lazy Facility Location to compute the optimal virtual network placement on radio access network.

The remaining of this paper is organized as follows. In section II, Network Model for the virtual function network. In section III, Proposed VNP algorithm, In section IV, Evaluation parameters and followed by conclusion of the work.

II. NETWORK MODEL

A simple substrate is illustrated as shown in the Figure 1. In the network, there are eight different nodes and are interconnected. It comprises of four different radio access nodes and four switches.

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The virtual network model coordinates three virtual resources namely, forwarding, forwarding with processing and forwarding the radio access. All these nodes assumed to zero that assumed to be pure packet forwarding, pure packet processing and pure radio access nodes. Generally, the weight associated with pure packet processing node reflects processing, memory and storage resources. Further, the weight corresponding to the radio access network node represents wireless resources available on the node.

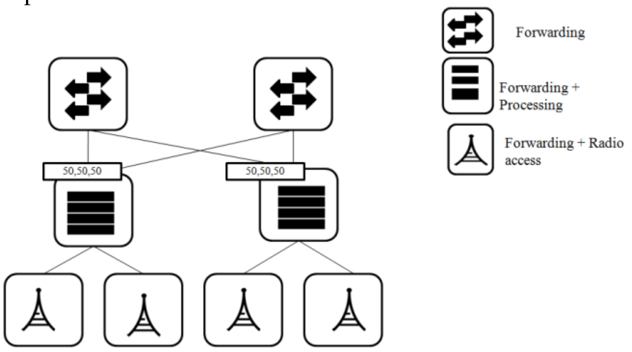

Figure 1 Virtual Network Infrastructure model [11]

The users send request to the service function chain as a directed graphs to activate virtual nodes and virtual links. The virtual node with service function chain request (SC) represents virtual network function which packets should undergo. To initiate provisioning the radio resources in the virtual network, it can be implemented either by accessing the available radio resources or in terms of bandwidth. The most of researchers addressed the node in terms of either resources or bandwidth, whereas Roberto Riggio et al [11] were the first to investigate that SFC request which combines both bandwidth based and resource based model.

In any mobile network, the available bandwidth strength is a time varying factor which also causes channel fading. When the throughput of the virtual network node is above the threshold, expected bandwidth is reserved. When two users requested SFC to access their resource bandwidth, if the channel condition is said to be good, the users receive bandwidth demands, whereas if the channel condition is said to be bad, one of them experiencing the complete bandwidth while the other user's bandwidth demand not met. The service chain request is illustrated in the Figure 2.

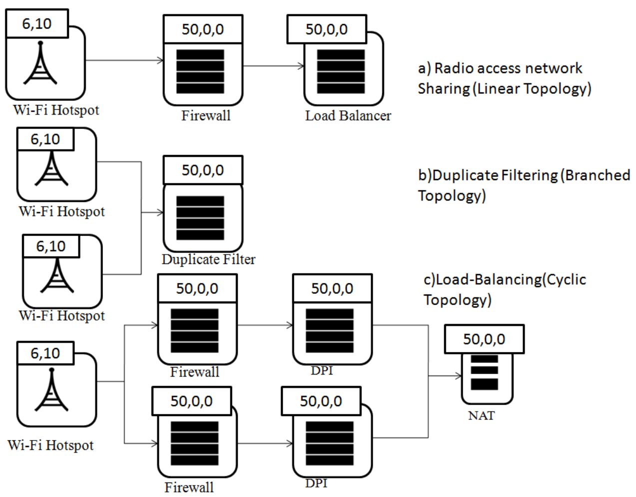

Figure 2. Service function chain request: a) linear b) Branched c) cyclic

The service function chain consists of three virtual functions that are WiFi Hot spot, a firewall, and a load balancer. When the radio access network is sharing the linear topology and further duplicate filter is employed with two branched WiFi Hotspot. In cyclic topology, two WiFi hotspots are connected to firewall configuration of the virtual network. When the user requests the SFCs, equal resource allocation has to be maintained. From the observation, there should be a continuous path between the node and link phases.

III. SLFL ALGORITHM

In this section, we use the Simple lazy Facility Location (SLFL) to optimize the virtual network placement function. In the time of demand request from the user, Service chain function is directed and it is addressed with combination of installation and migration.

Algorithm 1: Migration potential of SLFL [8]

Function
Step 1: potmig (v, n, r)
Step 2: $C \leftarrow$ *Transportation cost of Dv;*
Step 3: $C* \leftarrow g \times flow\ (n, Dv \cup \{d\}, R,) + \lambda \times kv;$
Step 4: return $(C - C*)$ *if* $(C*$ *is not* $\infty)$
Step 5: end function

The two potential metrics to access the minimum transportation cost are migration and installation potential. The migration potential is defined as the difference between the present transportation cost and cost after placement. The algorithm shows the migration potential of SLFL. Secondly, the installation potential is defined as operational cost before and after installing the virtual network function. By estimating the transportation cost, SFC request should be placed close to each other and that helps to optimize the virtual placement function.

Algorithm 2: On demand arrival of SLFL

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Function

Step 1. Demand on arrival;

Step 2: D ⟵ D ∪ {d};

Step 3: vasn ⟵ arg minv∈V{flow (nv, {d}, ∅)}

Step 4: pasn ⟵ g × flow(nvasg , {d},R ∗ asg);

Step 5: (vmig, nmig) ⟵ argmaxv∈V :n∈F{potmig(v, n, ∅)};

Step 6: emig ⟵ potmig(vmig,R∗mig);

Step 7: nins ⟵ argmaxn∈F/NV{potins(n, ∅)};

Step 8: (eins,Dre) ⟵ potins(nins,R ∗ins);

Step 9: if (eins > −pasn) and (eins ≥ emig) then

Step 10: u ⟵ install a facility at nins;

Step 11: Reassign ∀d ∈ Dre and assign d to u;

Step 12: Route related traffic based on R∗ins;

Step 13: V ⟵ V ∪ {u};

Step 14: else if emig > −pasn then

Step 15: Migrate vmig to node nmig;

Step 16: Assign d to vmig;

Step 17: Route traffic based on R∗mig;

Step 18: else

Step 19: Assign d to vasn;

Step 20: Route traffic based on R∗asg;

Step 21: end if

Step 22: end function

IV. RESULTS AND DISCUSSION

In this section, the proposed placement heuristic algorithm SLFL is evaluated in three different topology VNF request. As we discussed in the previous section, three different VNF request are linear, branched and cyclic. The reference substrate network is K-ary fat-tree with K= 10, 12 and 14. In this experimental set up, in order to be deterministic fixed number of SFC requested are generated and in the each trial, generated request is about 50. In this work, we carried out radio node and link utilization to evaluate the performance across three different virtual and substrate topologies.

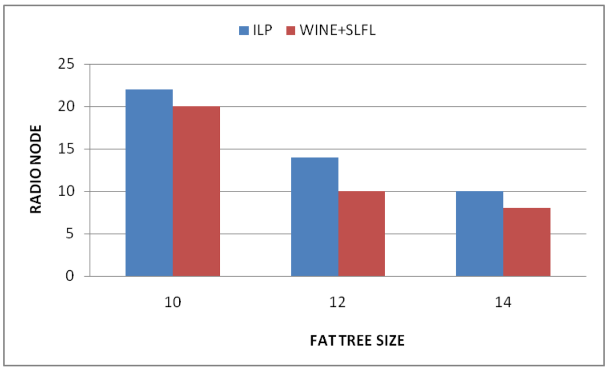

Figure 3. Average Radio Node utilization using linear topology

Figure 4. Average Radio Node utilization using Branch topology

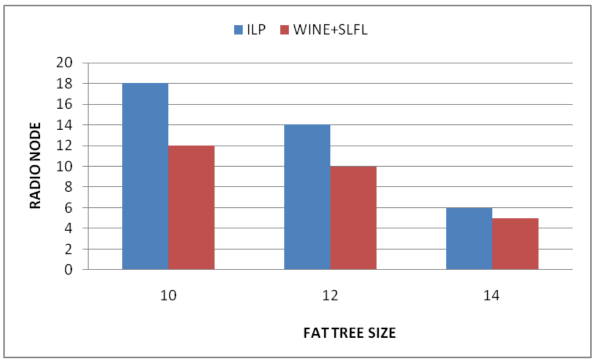

Figure 5. Average Radio Node utilization using Loop topology

From the Figures 3, 4 and 5, it can be observed that in terms of node utilization the ILP algorithm outperforms our proposed algorithm across three different virtual and substrate topologies. From the result, it can be inferred that K-ary fat-tree with K= 10 performs better across three different virtual and substrate topologies. Specifically, in the Branch VNF request, the average radio access utilization is maximum and when K-ary fat-tree with K= 14, in the loop VNF request, the average radio access utilization is overall minimum. Comparing with the ILP algorithm and SLFL algorithm, the average radio node is utilized by the existing ILP algorithm. This shows that ILP is more efficient in mapping the incoming requests. Further, by increasing the K ary fat tree values for about 100, it has to be evaluated. From the results, it can be noticed that in linear topology for the K= 10, the SLFL performs relatively lower than the ILP algorithm.

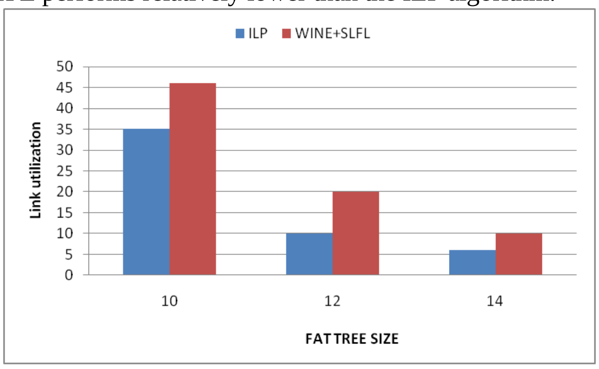

Figure 6. Average link utilization using linear topology

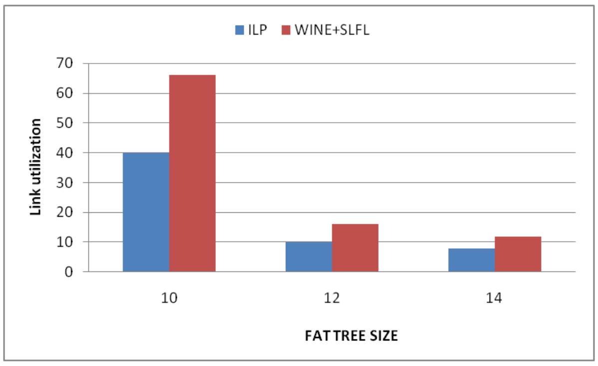

Figure 7. Average link utilization using branch topology

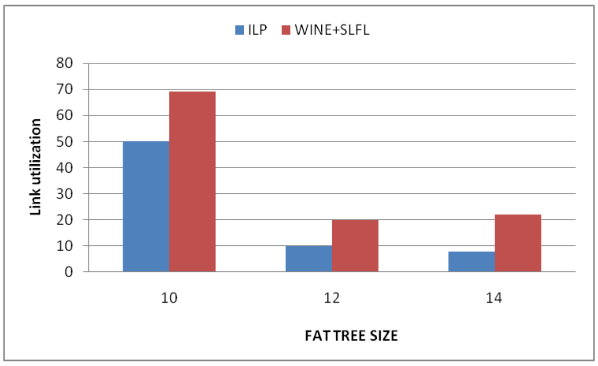

Figure 8. Average link utilization using loop topology

From the Figures 6, 7 and 8, it can be observed that in terms of node utilization the SLFL algorithm outperforms ILP algorithm across three different virtual and substrate topologies.. From the result, it can be inferred that K-ary fat-tree with K= 10 performs better across three different virtual and substrate topologies. Specifically, in the loop VNF request, the average link utilization is maximum and when K-ary fat-tree with K= 14, in the branch VNF request, the average link utilization is overall minimum. Comparing with the SLFL algorithm and ILP algorithm, the average link utilization is well connected. It can be noticed that approximately 4 -5 per cent increase in link utilization compared with existing algorithm. This observation shows that the SLFL is efficient in terms of handling the link utilization. Further, by increasing the K ary fat tree values for about 100, it has to be evaluated. From the results, that in linear topology for the K= 10, the ILP performs relatively lower than the SLFL algorithm. From the above results, for the efficient operation of virtual function placement, both the radio utilization and link utilization are important.

V. CONCLUSION

The role of network function virtualization is to help in migrating a network function from the hardware instance to software instances that running on the virtual environment. In order to deploy and operate the Network function virtualization in the mobile networks, it is necessary to investigate the VNF placement problem for radio access networks. In this research, we proposed the combination of window based VN embedding algorithm with Simple Lazy Facility Location to compute the optimal virtual network placement on radio access network. It can be observed that in terms of node utilization the SLFL algorithm outperforms ILP algorithm across three different virtual and substrate topologies. From the result, it can be inferred that K-ary fat-tree with K= 10 performs better across three different virtual and substrate topologies.

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