Topology-Aware Placement of Virtual Network Functions (VNFs) in Autonomous Response Networks

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Topology options for deploying **NFV**

ETSI

"NFV aims to transform the way that network operators architect networks by evolving standard IT virtualization technology to consolidate many network equipment types onto industry-standard high-volume servers, switches and storage, which ***could be located in data centers, network nodes, and in the end–user premises****.*

According to ETSI – NFV (a priori solutions)

1. Centralized NFV Topology
2. Service Edge NFV Topology

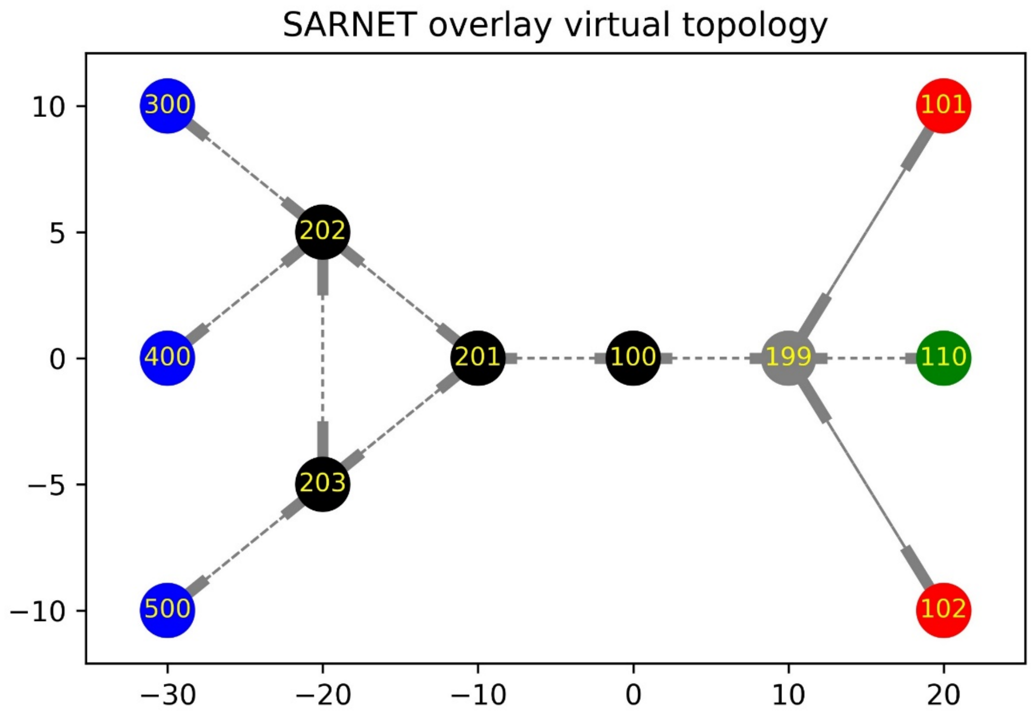
Centralized NFV Topology

Advantages

- OPEX (i.e. deployment and cooling costs) for implementing each virtual service is low, and re-use of resources is maximized.
- Compute and storage resources can easily be added to the centralized location.

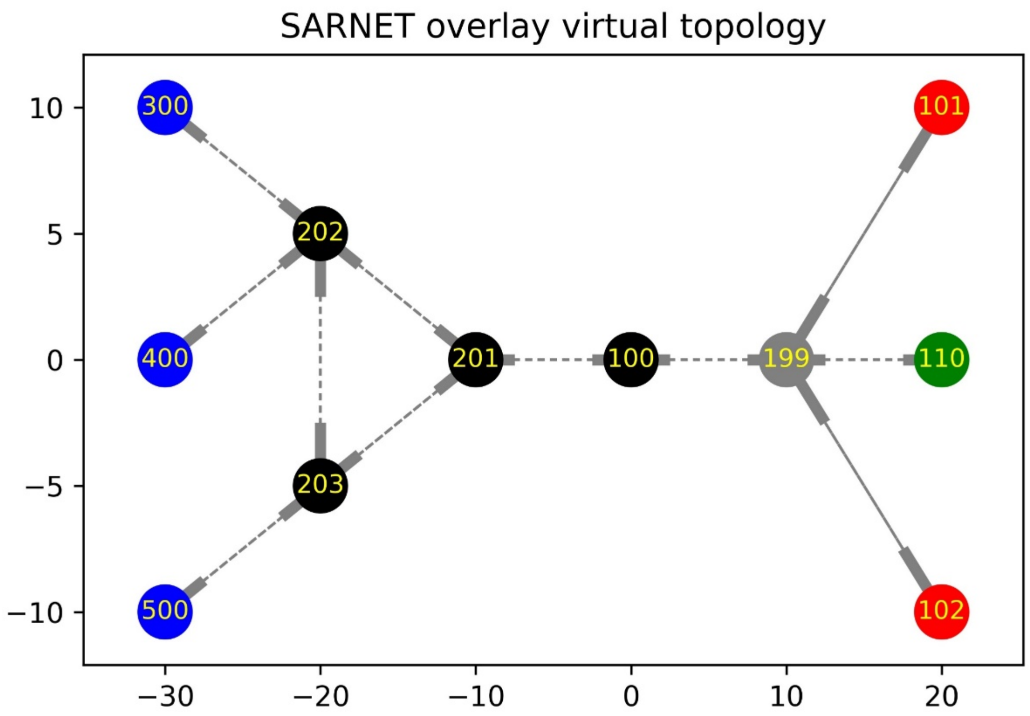
Disadvantages

- No support of services where particular functionality is needed at the service edge
  - e.g. - the most effective DDoS defense scheme is to block attack traffic close to the source [1]
  - e.g. - latency-sensitive applications, deploying 5G networks where network functions are the most sensitive to latency, thus they need to be located as close as possible to end---user devices



[1] *T. Peng et al.* - ACM Computing Surveys, Vol. 39, No. 1, Article 3, Publication date: April 2007

Service Edge NFV Topology



Advantages

- Enables services that are not possible to deploy in a centralized model

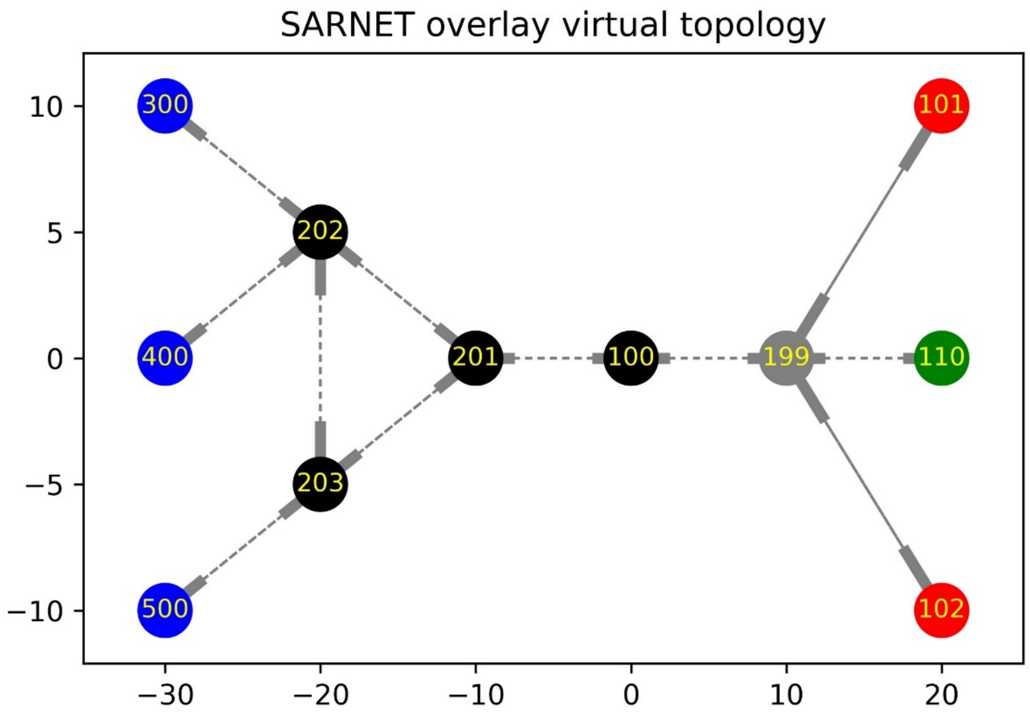
  e.g. - effective security defense schemes at the edge for DDoS

  e.g. - latency-sensitive applications

Disadvantages

- Ability to add additional services or scale is limited by the installed resources - this limitation is overcome using a chained approach

Chained NFV Topology



Advantages

- One advantage of the chained model over the service edge model is the ability to add virtualization resources without having to upgrade the service edge.
- The chained model can support all of the advanced applications that are available with the service edge model.

Disadvantages

- Requires advanced orchestration to combine physical and virtual resources

On going research…

Main Tasks

To design a topology-aware heuristic algorithm to efficiently allocate VNFs in a NFV/SDN environment

Specifics

1. Modeling of the network function placement and chaining problem by means of an ILP model, taking into account the topology awareness (i.e. for a given infrastructure) – for small networks size and service demands.

2. Designing an heuristic algorithm to efficiently place the VNFs for a specific scenario (i.e. DDoS, load balancing, etc).

3. Evaluating the results of the proposed solution with the results obtained using an optimal placement (i.e. ILP model).

4. Determining network metrics and parameters to compare the results of the heuristic algorithm against other topology option (i.e. centralized and service edge NFV topology).

Modeling **network function placement** and **chaining problem** (1/3)

PHYSICAL NETWORKS --> infrastructure

_P is used to denote whether variables refers to physical resources.

G = (N, E) --> unidirectional network graph (cloud infrastructure, physical network, etc…)

N_P [n]: network nodes

E_P [i, j]: network links for (i, j) in E

C_P [n]: CPU capacity in % of each node (n in N)

B_P [i,j]: Bandwidth capacity of each (i,j) in E

D_P [i,j]: Delay of each (i,j) in E

Modeling network function placement and chaining problem (2/3)

NETWORK FUNCTIONS

F [f]: denote the set of possible VNFs that may be instantiated/placed in the infrastructure.

U [f]: denote the number of times that each network function can be instantiated, due to licensing purchases.

F_CPU [f, inst]: each instance (inst in U) provides a limited amount of resources to process demands. This enables our model to represent instances of the same VNF with different capabilities.

F_DELAY [f]: each function (f in F) has a processing delay associated to it.

Modeling **network function placement** and **chaining problem** (3/3)

SERVICE FUNCTION CHAININGS (SFCs) --> VNFs requests

_S is used to denote whether variables refers to demand of services.

S [q]: denote the set of service functions chains (q in S).

E_S [k,l]: virtual edge (k,l) between functions requested in the service chain k, represent the topology of the SFCs

C_S [k, f]: CPU capacity required by function f in chain k

B_S [k,l]: Bandwidth requested for each virtual edge (k,l) in E_S

D_S [k,l]: Delay requested for each virtual edge (k,l) in E_S

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