Towards a Service-Oriented Virtual Evolved Packet Core

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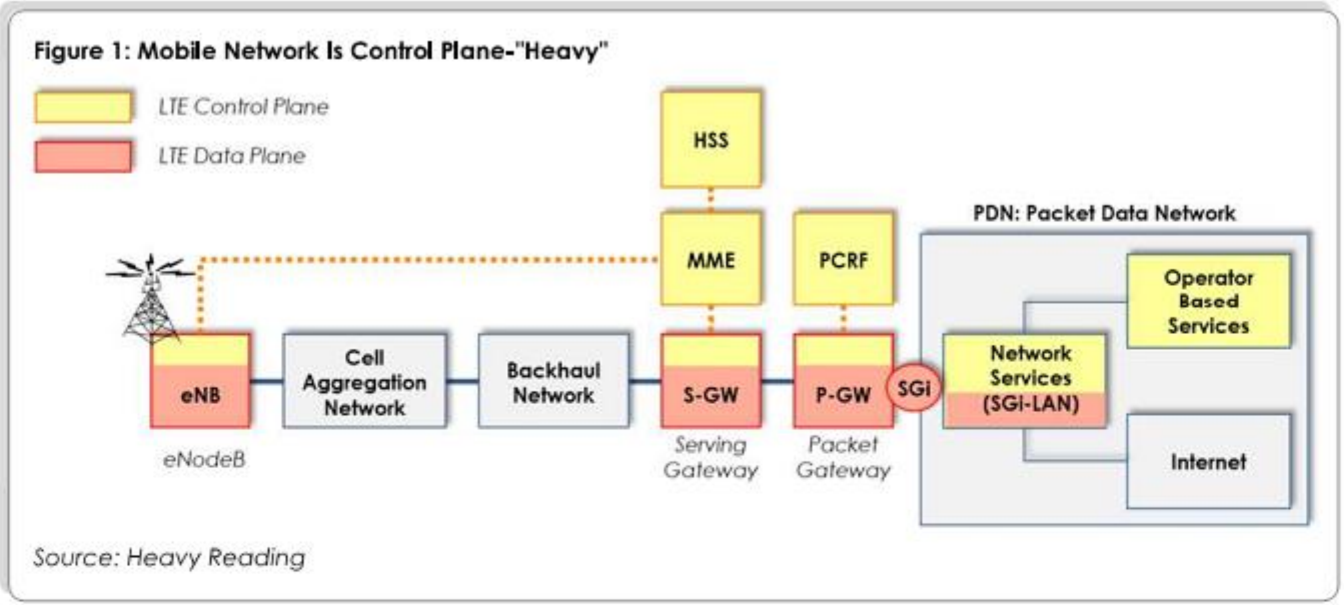
3GPP Evolved Packet Core

- **The 3GPP Evolved Packet Core (EPC) is an increasingly complex platform which is in constant need of optimization for content delivery and security**



[1]W. John et al., "Research Directions in Network Service Chaining"
[2]White Paper – Heavy Reading, "Commercializing Virtual EPC at Scale: Why, What and How?"

Motivation for Service-oriented vEPC using NFV

- **Software-centric network strategy**
- **Time to market and flexibility**
- **Investment and refresh cycles**
- **Monetization opportunities : SCEF (Service Capability Exposure Function) – allows the operator to expose network capabilities, such as charging location and QoS, to third parties to enable new services.**
- **NFV in mobile core is focused around**
  - ❖ **the EPC**
  - ❖ **The IP Mutimedia Subsystem (IMS) core – for call control in VoLTE and video.**
  - ❖ **Network services deployed in SGi-LAN**

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[2]White Paper – Heavy Reading, “Commercializing Virtual EPC at Scale: Why, What and How?”

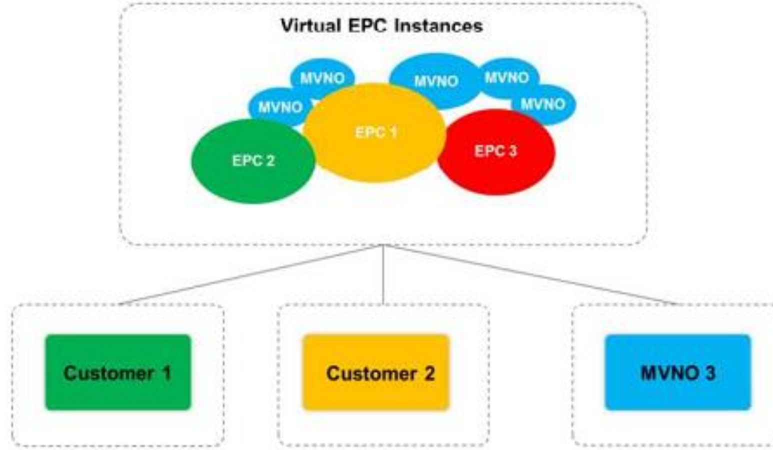
Virtual EPC Use Cases

Figure 2: Virtual EPC Use Cases

DEPLOYMENT MODEL	DESCRIPTION/ADVANTAGES
Capacity Relief/ Cap-and-Grow/ Pooling	• Deploy alongside "classic" EPC to absorb subscriber and traffic growth • Both classic EPC and vEPC capacity is pooled into a common core • Cap investment in classic product and migrate to vEPC over time
Internet of Things	• Deploy virtual P-GW or GGSN for M2M services • Able to optimize the gateway for traffic profile (e.g., transaction-oriented config.)
MVNO	• Operator hosts virtual core for MVNO customers • MVNO can control its own core instance independently via a portal • The operator can offer a full suite of hosted BSS, voice services, etc.
Enterprise Virtual Core	• A virtual P-GW tailored and scaled to the enterprise user needs • Can combine with additional security and optimization services • Services can be customer-programmable via a portal
Smaller Markets	• For operators with smaller or subsidiary markets, such as islands • Also suitable for later-adopting LTE markets and LTE greenfield
Gi-LAN	• Connect "classic" EPC to virtualized Gi-LAN environment • Modernize "service complex" ahead of vEPC rollout • Virtualized Gi-LAN is well suited to the cloud edge environment
Main EPC Replacement	• Replace aging EPC or packet-switched core with modern equivalent • Future-proof investment made in core network refresh • Prepare for growth and LTE Advanced/4.5G

Source: Heavy Reading

Figure 4: Multiple vEPC Instances

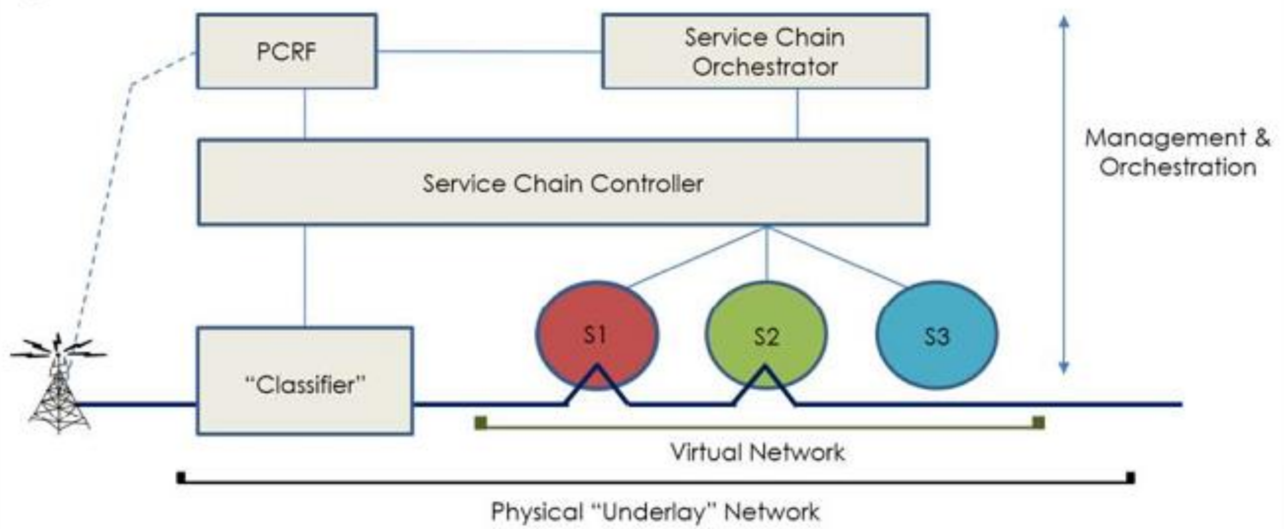


Source: Heavy Reading

Virtual Gi-LAN Architecture

- **This has to be the first step in virtualization of the mobile core**
- **Low risk implementation when compared to vEPC**
- **Functions are well-suited for NFV**

Figure 5: Virtual Gi-LAN



Source: Heavy Reading

[2]White Paper – Heavy Reading, "Commercializing Virtual EPC at Scale: Why, What and How?"

More on the SGi-LAN

- **"Gi-LAN (3G)/ SGi-LAN (4G) refers to small dedicated dedicated networks that may be inserted, providing additional functions, given that they are fully complaint to the internet protocols used over that point"[3]**

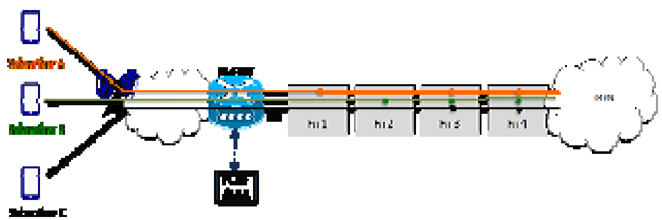


Figure 2 SGi-LAN Service interface and middle-boxes

C. Related Work

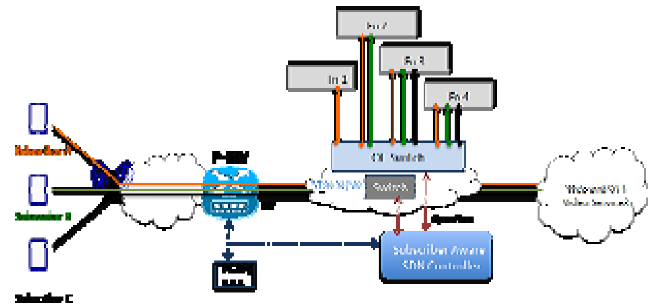


Figure 3 SGi-LAN Service interface implementing a switched service graph

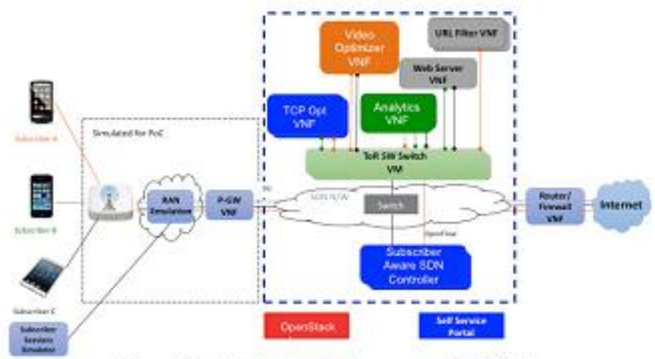
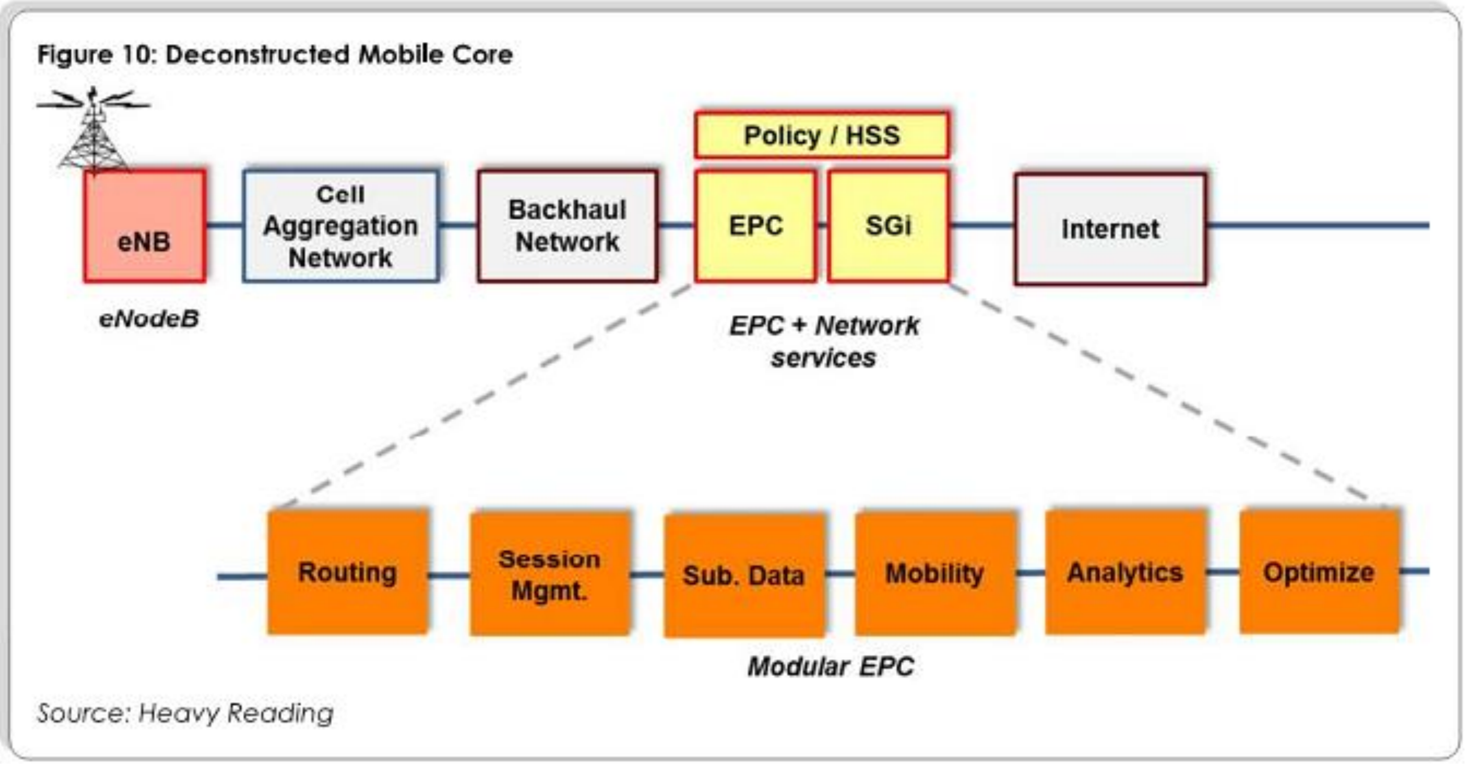


Figure 5 Logical network view mapped to VNFs

[3] Ariel Noy et al., "A solution for SGi-LAN Services Virtualization using NFV and SDN"

Future EPC Architecture



[2]White Paper – Heavy Reading, "Commercializing Virtual EPC at Scale: Why, What and How?"

EPC details - 1

- **EPC based on customized hardware using static config.**
- **These network entities are tightly coupled in 2 dimensions :-**
  - **Software and Hardware**
  - **Control and User planes**

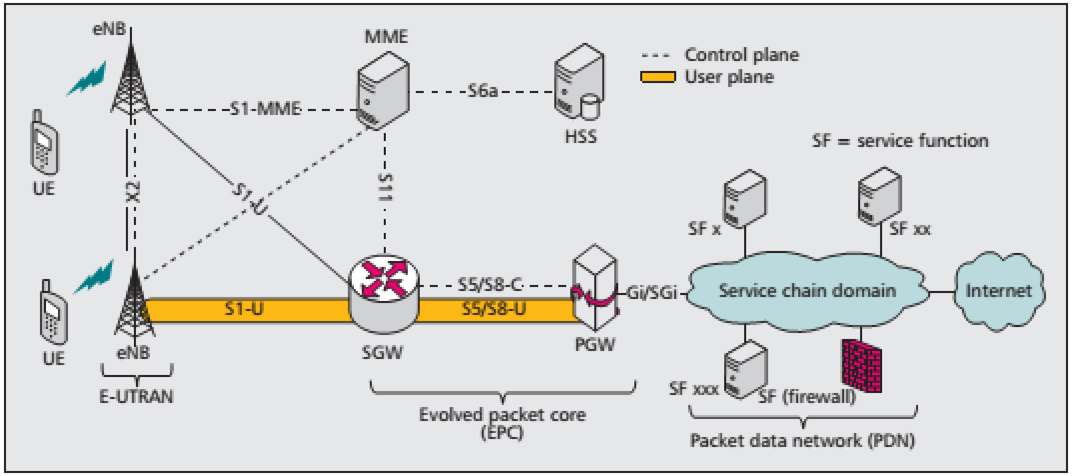


Figure 1. A mobile operator network.

[4] Malla Reddy Sama et al., "Software-Defined Control of the Virtualized Mobile Packet Core"

EPC details - 2

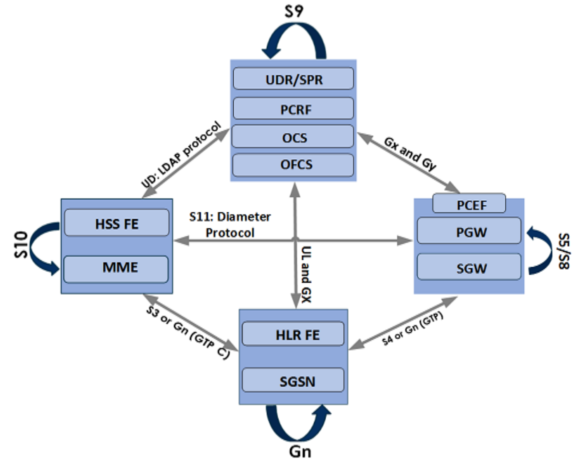


Figure 5: vEPC Entities Grouping

Groups	Entities	Benefits
Segment one	- HSS front-end (HSS FE) - Mobility Management Entity (MME)	- Interactions between HSS and MME occur locally. - Fewer networking transactions through Vswitches. - Network transactions use the LDAP protocol, which is an efficient protocol for database information querying.
Segment two	- Home location register front end (HLR FE) - Serving general packet radio service support node (SGSN)	- Supports combining existing SGSN with the Gn interface to the EPC system - Interactions between HLR and SGSN occur locally. - Fewer networking transactions through Vswitches. - Network transactions use the LDAP protocol, which is an efficient protocol for database information querying.
Segment Three	- Packet data network gateway (PGW) - Policy and charging enforcement function (PCEF) - Serving gateway (SGW)	- Minimizes the number of data-plane processing nodes (flat architecture principle) - Helps to overcome data-forwarding and network bottlenecks - better data monitoring and charging
Segment Four	- User data repository (UDR). - On-line charging system (OCS). - Off-line charging system (OFCS). - Policy and charging rules function (PCRF)	- Unified user database; less fragmentation. - PCRF interacts locally with UDR to generate policies. - Local interaction between OCS and PCRF - Central interaction point for OSS/BSS - Fewer networking transactions through Vswitches.

Table 2: Grouping of EPC Entities in NFV Environment.

[5] Hassan Hawilo et al., "NFV: State of the Art, Challenges and Implementation in Next Generation Mobile Networks (vEPC)"

PAPER REVIEW

Mobile Core Network Virtualization: A model for combined Virtual Core Network Function Placement and Topology Optimization

Andreas Baumgartner, Varun S. Reddy, Thomas Bauschert
Chemnitz University of Technology, Chemnitz, Germany

Objective and parameters

- The combined optimization of the virtual mobile core network topology (graph) and its embedding onto a physical substrate network
- Topology, link capacities and node (processing, storage and throughput) resources of the physical substrate are given
- Mobile Core VNFs – SGW, PGW, MME and HSS
- Explicit single path routing is assumed
- Optimization target is to minimize the cost of occupied node and link resources
- Number of services chains are fixed in advance and are assumed to be equal to the number of traffic aggregation points (TAP)

[6] A. Baumgartner et al., "Mobile Core Network Virtualization: A Model for combined Virtual Core Network Function Placement and Topology Optimization"

Service Chain – User plane and Control Plane

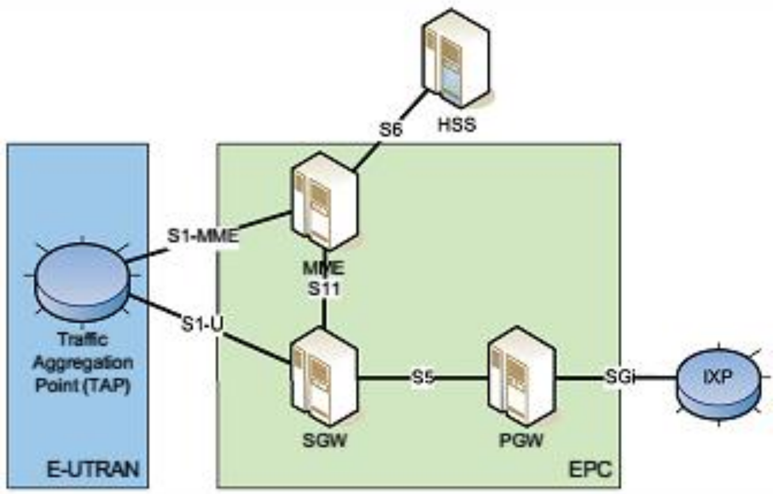


Figure 1. 3GPP LTE system architecture

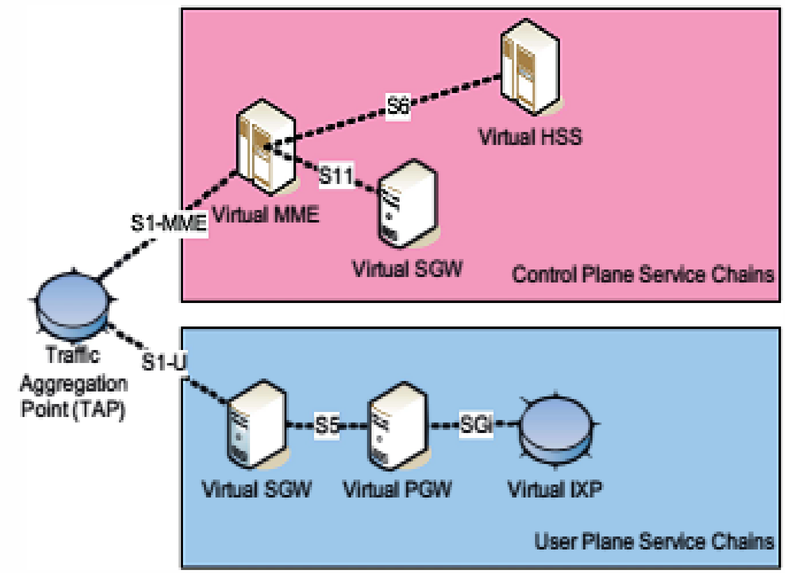


Figure 2. User and control plane core network service chains

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[6] A. Baumgartner et al., "Mobile Core Network Virtualization: A Model for combined Virtual Core Network Function Placement and Topology Optimization"

Simulation details

- Service chain is further decomposed into a user plane service subchain (TAP - SGW - PGW - IXP) and several control plane service subchains (TAP - MME), (MME - HSS), (MME- SGW).
- All service subchains are considered separately for upstream and downstream traffic.
- The processing, storage and throughput requirements of a VNF that belongs to a particular TAP are given.
- Also the bandwidth requirements between the VNFs is dependendent on the TAP. (also takes care of protocol overheads)
- Cost based on three parameters
  - Basic Cost : Cost of placement of a VNF on a physical substrate
  - Cost per unit of physical resource on a node
  - Cost per unit of capacity on a physical link
- Consider embedding of only one virtual mobile core network
- All nodes are capable of hosting functions.

Results for Polska Network

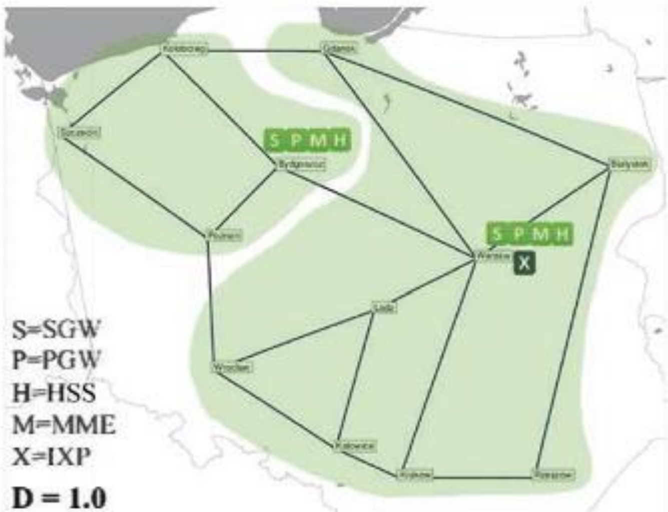

Figure 3. Core VNF placement and gateway catchment areas for $D = 1$ - Polska Network.

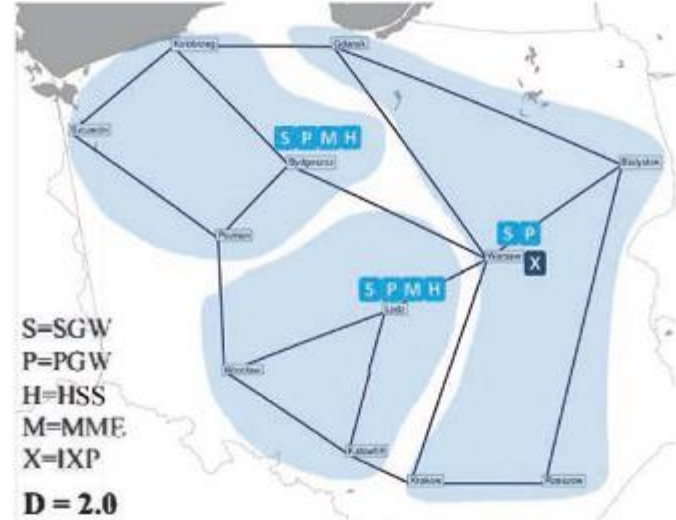

Figure 5. Core VNF placement and gateway catchment areas for $D = 2$ - Polska Network.

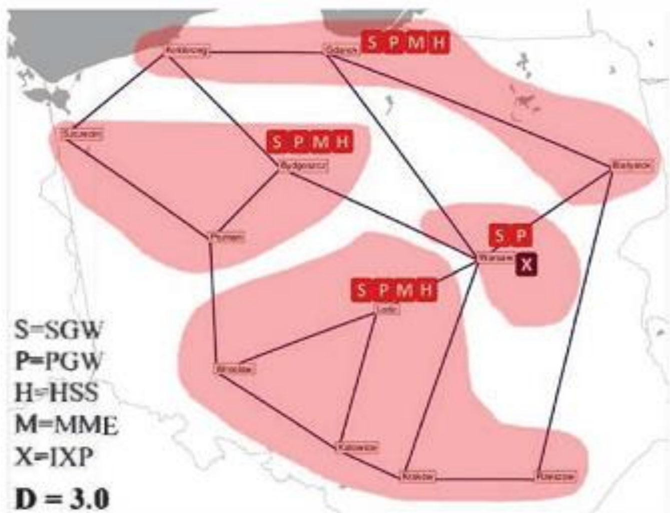

Figure 7. Core VNF placement and gateway catchment areas for $D = 3$ - Polska Network.

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[6] A. Baumgartner et al., "Mobile Core Network Virtualization: A Model for combined Virtual Core Network Function Placement and Topology Optimization"

Results for Germany50 Network

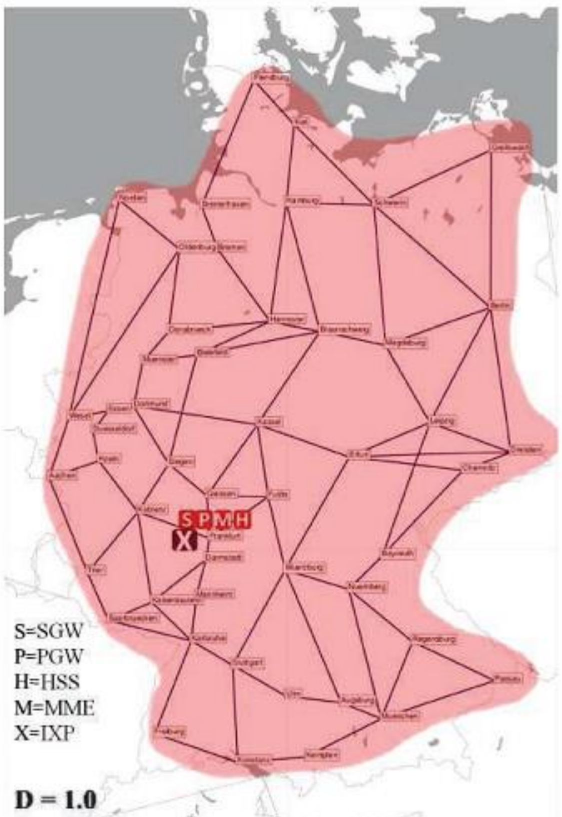

Figure 4. Core VNF placement and gateway catchment areas for $D = 1$ - Germany50 Network.

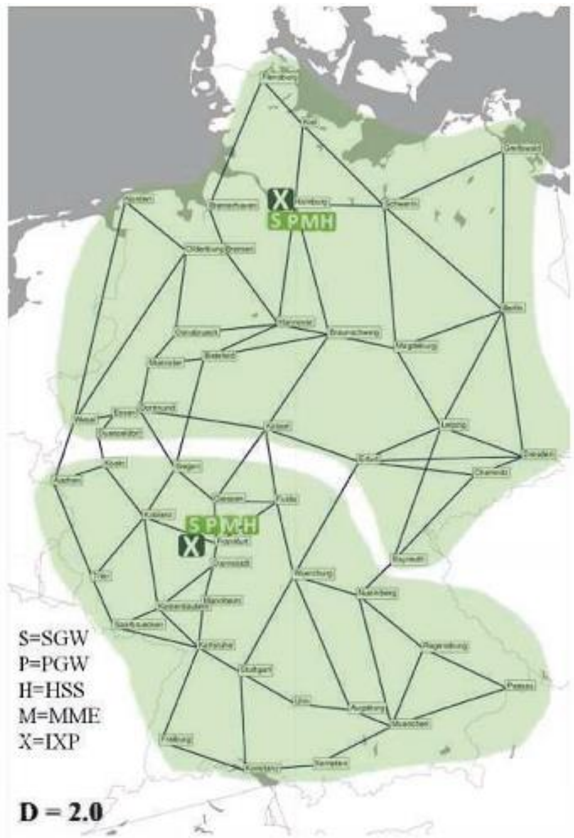

Figure 6. Core VNF placement and gateway catchment areas for $D = 2$ - Germany50 Network.

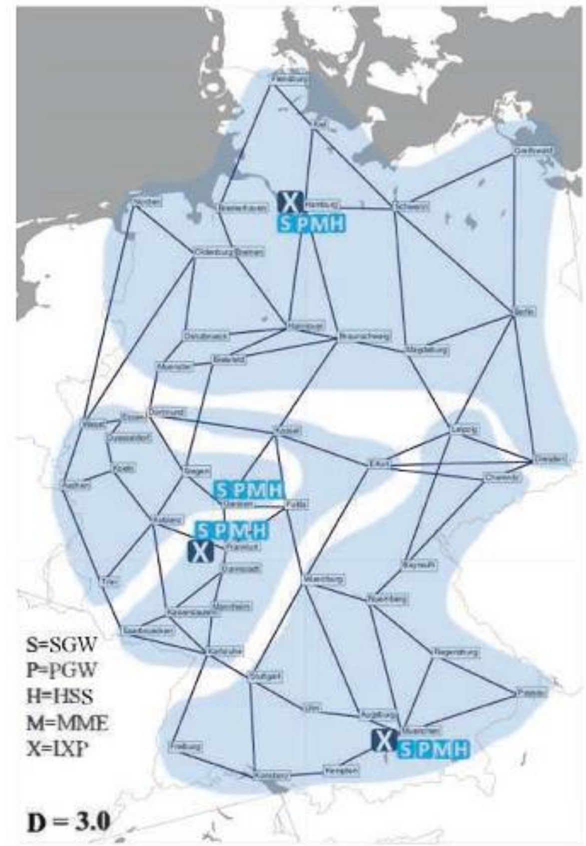

Figure 8. Core VNF placement and gateway catchment areas for $D = 3.0$ - Germany50 Network.

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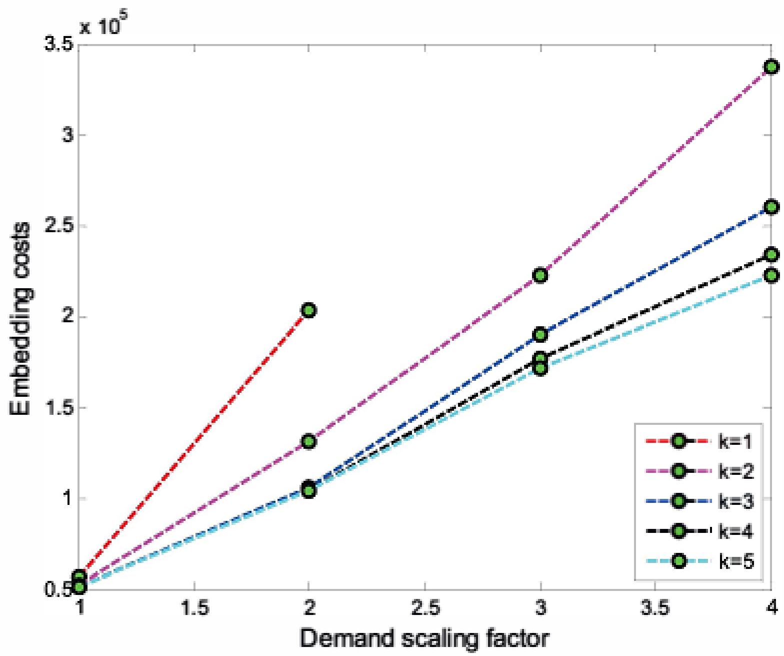
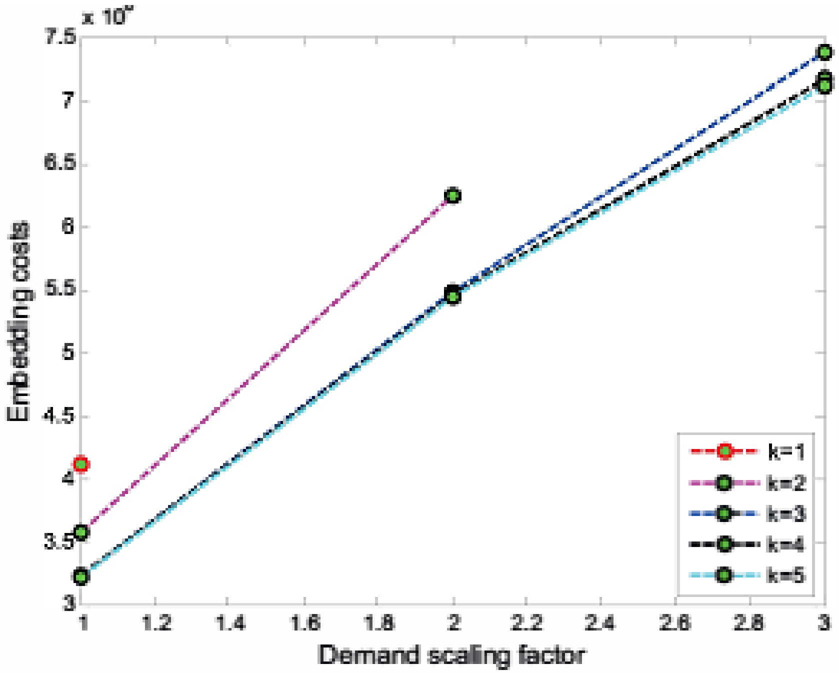
[6] A. Baumgartner et al., “Mobile Core Network Virtualization: A Model for combined Virtual Core Network Function Placement and Topology Optimization”

Embedding cost for different D and k



Polska Network



Germany50 Network

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[6] A. Baumgartner et al., “Mobile Core Network Virtualization: A Model for combined Virtual Core Network Function Placement and Topology Optimization”

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