virtual Evolved Packet Core as a Service (vEPCaaS)

BY
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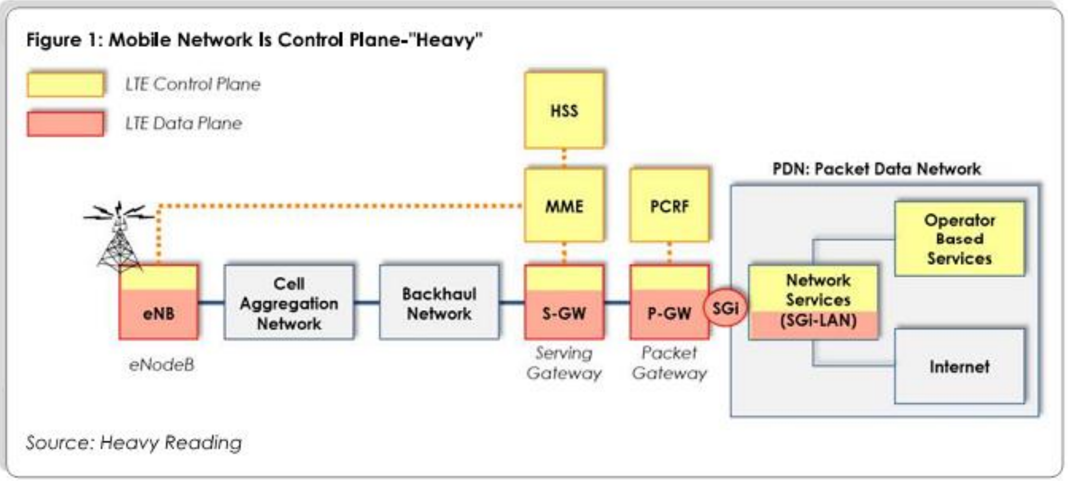
3GPP Evolved Packet Core (EPC)

- 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?”

[3]EASE: EPC As A Service To Ease Mobile Core Network Deployment Over Cloud

Tarik Taleb, Marius Corici, Carlos Parada, Almerima Jamakovic, Simone Ruffino, Georgios Karagiannis, and Thomas Magedanz

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Simone Ruffino is with Telecom Italia.
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Introduction

- EPC is designed as a flat all-IP architecture supporting only packet-based services
- “EPC is the next generation mobile aggregation network developed by 3GPP for fixed and 4G mobile broadband services[4]”
- EPC aims to provide seamless Internet connectivity between User Equipment (UE) and applications and separates between user and data planes

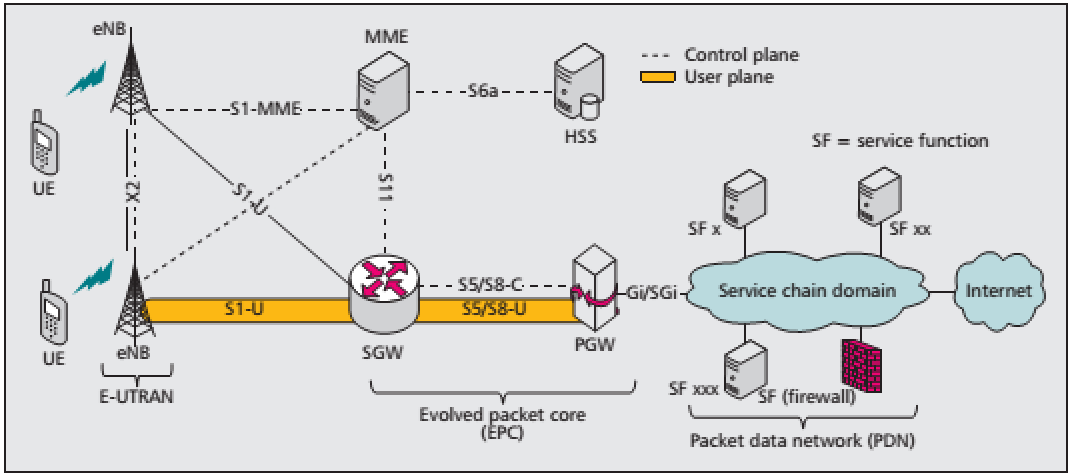


Figure 1. A mobile operator network.

[4] “General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access” Release 9, 3GPP, TS 123.401, 2010
[5] Malla Reddy Sama et al., “Software Defined Control of the Virtualized Mobile Packet Core”

EPC functions

- Aggregate traffic from different fixed and mobile access networks to a single Internet gateway router, the Packet Data Network Gateway (PDN Gateway)
- Handle terminal mobility management between base stations covered by the mobile access networks connected to the EPC through Serving Gateways
- Manage bandwidth and congestion in order to provide better than best effort QoS for applications, such as real-time voice and video
- Handle authentication, authorization, and accounting for user traffic within the EPC

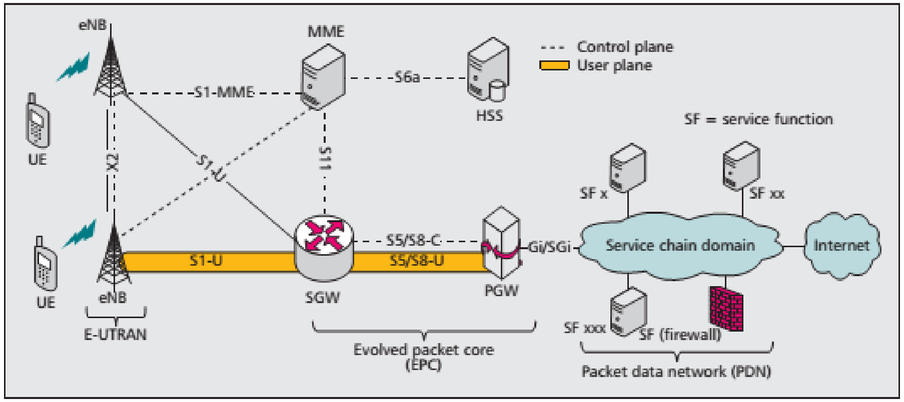


Figure 1. A mobile operator network.

[5]

EPC entities

1. Mobility Management Element (MME)

2. Serving Gateway (SGW)

3. Packet Data Network Gateway (PGW)

- These entities are responsible for forwarding user traffic to and from the network, by creating one or more channels with end user called **bearers**

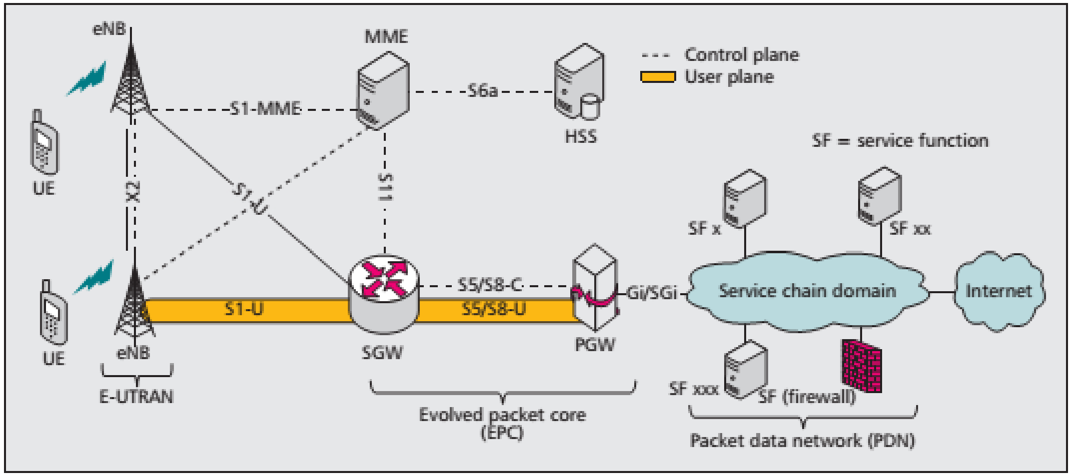


Figure 1. A mobile operator network.

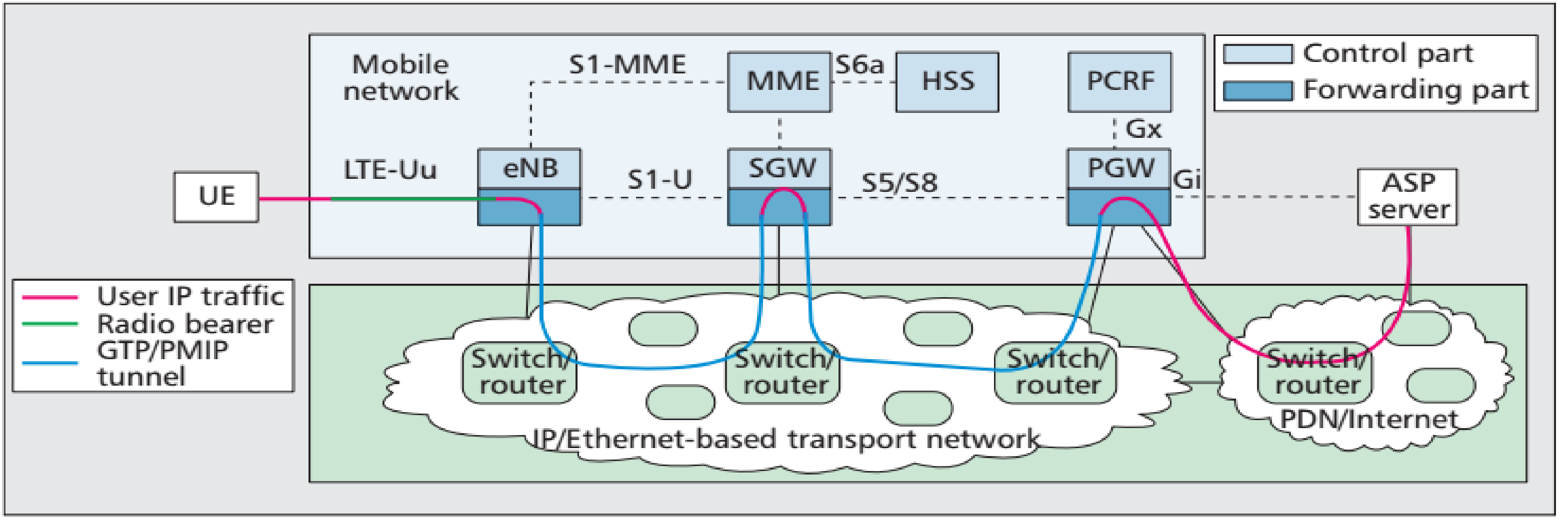
[5]

GPRS Tunneling Protocol (GTP)

- **GPRS Tunneling Protocol (GTP)** and **Proxy Mobile IP (PMIP)** are main communication protocols in EPC architecture

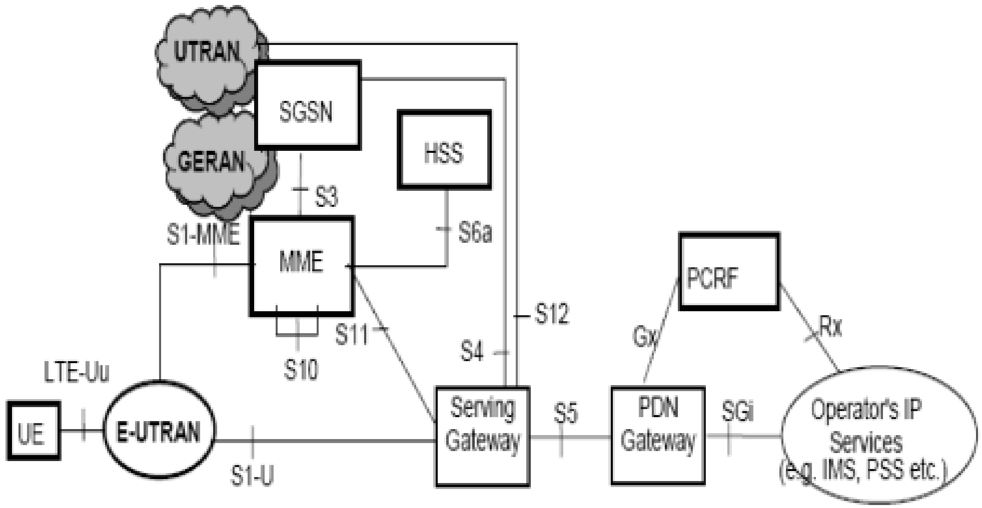
- GTP supports 2 main components:
  1. GTP–U
  2. GTP-C

- MME uses the S1-AP protocol over the S1-MME interface to transfer radio and GTP tunneling parameters to eNB's



Continued…

- EPC utilizes IP routing of overlay tunnels to handle mobility
- Tunnel management is centralized in EPC, while IP routing which decides tunnel routing is distributed



[6] James Kempf et al., "Moving the mobile evolved packet core to the cloud." *IEEE WiMob 2012*

vEPCaaS implementations

- 1:1 Mapping
- 1:N Mapping
- N:1 Mapping
- N:2 Mapping

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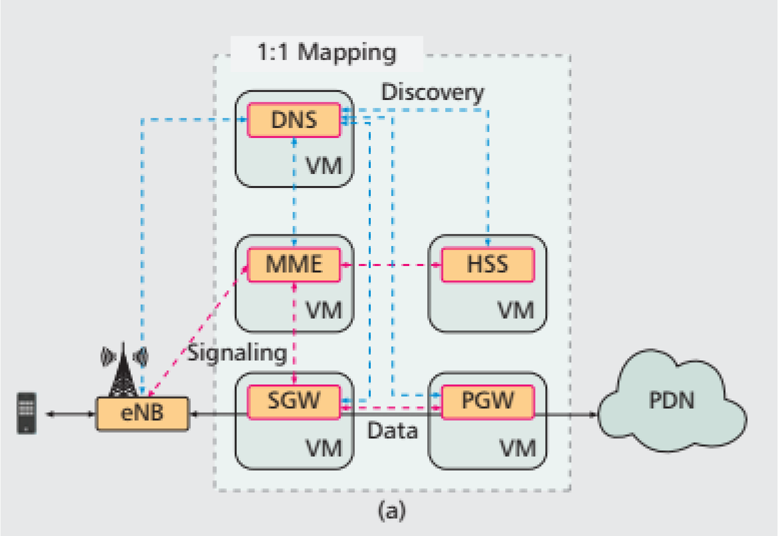
1:1 Mapping



- Advantages
  - Simple
  - Already realized

- Disadvantages
  - Automatic configuration of virtual EPC components
  - Adding new instances of components has an impact on external nodes
  - Turning virtual components off is a complex operation
  - Large number of instances will pose a scalability challenge

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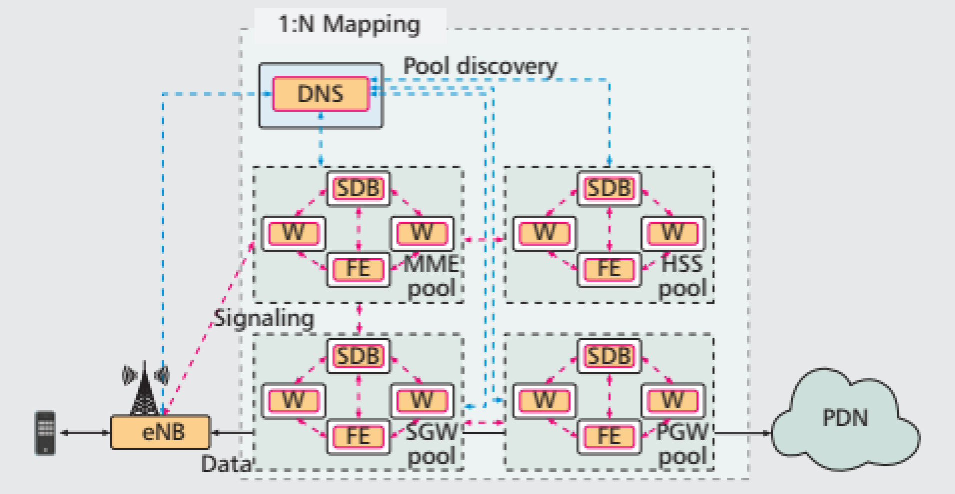
1:N Mapping



- Each 3GPP EPC network function is decomposed into multiple elements of 3 types:
  1. Front End (FE) – communication interface to other entities
  2. Worker (W) – Stateless virtual component
  3. State Database (SDB) – User session state
- Each VNF of EPC becomes a virtual component pool
- Advantage: one configuration per pool, increases availability of vEPCaaS
- Disadvantages: synchronization issues, longer processing delays, design is complex

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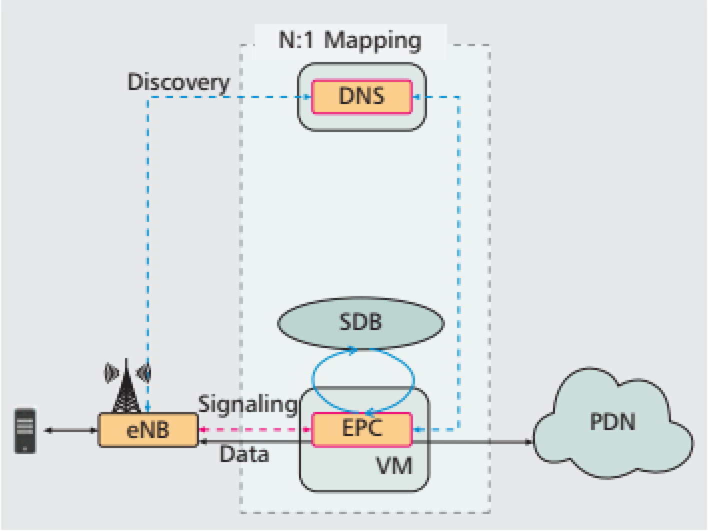
N:1 Mapping



- All components collapsed into one virtual component
- Each subscriber/group of subscribers is served by one merged-EPC
- Advantages:
  - Easier to optimize internal processing/control
  - Makes reference state machine (S11,S5 etc), communication protocol state machine (diameter, GTP, and S1-AP) and encoding/decoding messages redundant
- Disadvantages:
  - High number of virtual components to manage
  - Subscriber data management is highly complicated
  - Interfaces become internal

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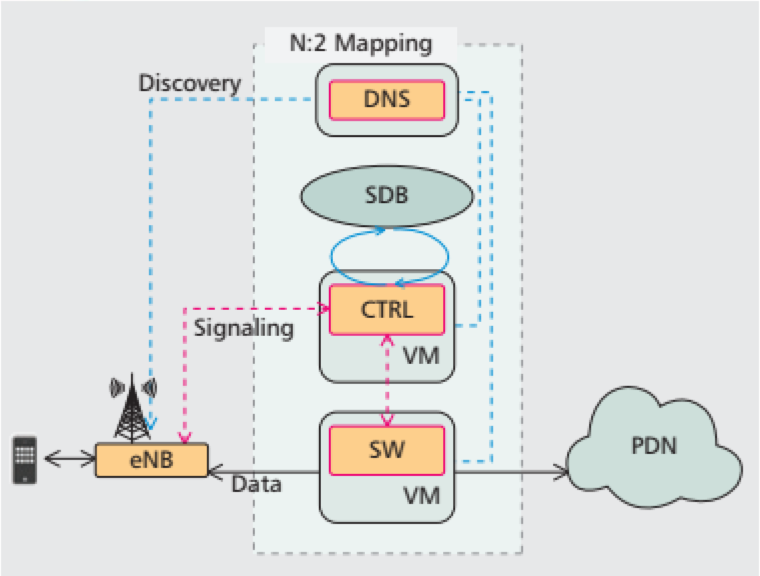
N:2 Mapping



- Has similar restrictions as N:1 for user-pale components

[7]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

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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)

Service Chain – User plane and Control Plane

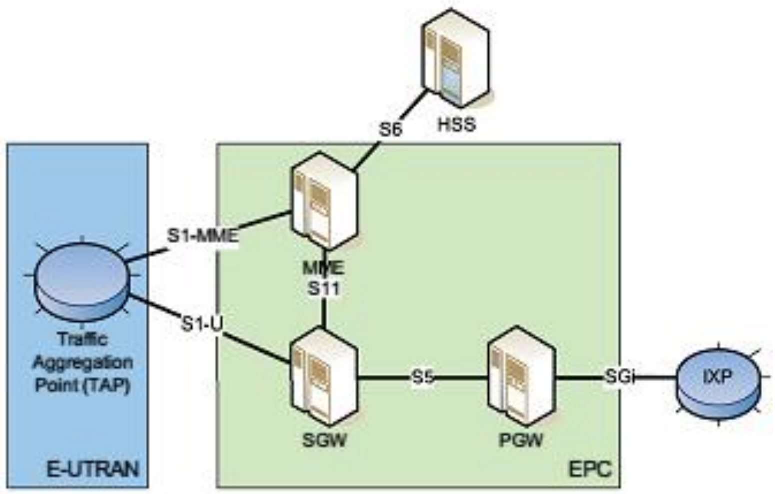

Figure 1. 3GPP LTE system architecture

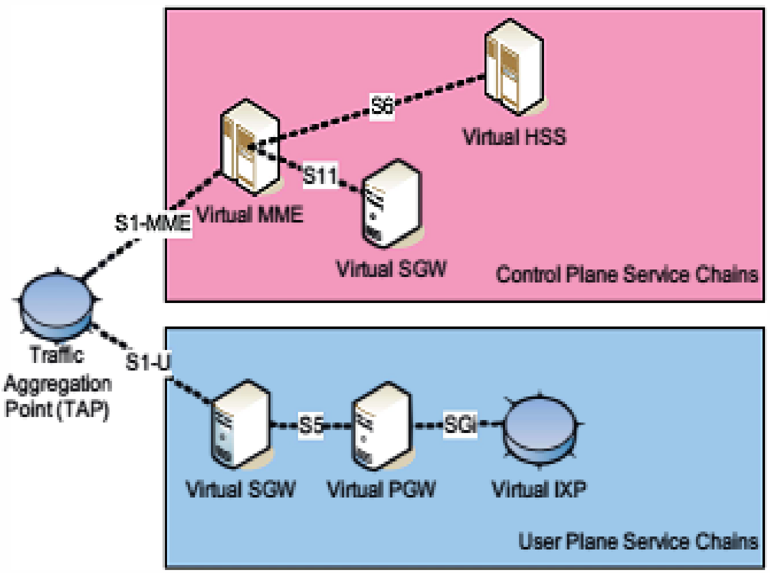

Figure 2. User and control plane core network service chains

Simulation details

- Service chain is further decomposed into a user plane service sub-chain (TAP - SGW - PGW - IXP) and several control plane service sub-chains (TAP - MME), (MME - HSS), (MME- SGW)
- All service sub-chains 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 dependent 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

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Results for Polska Network

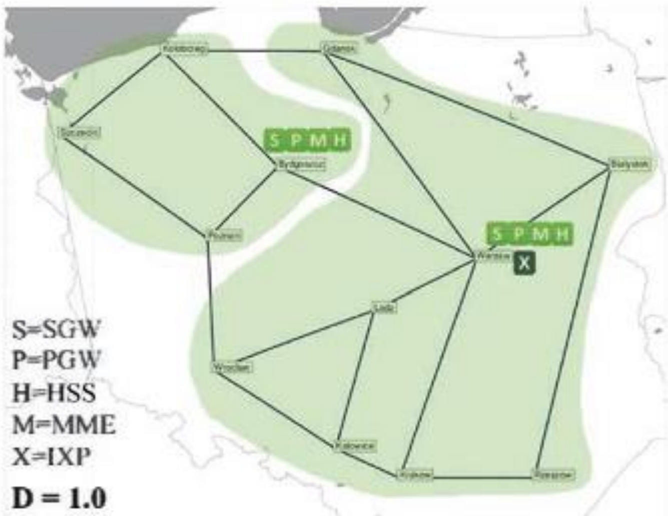

Figure 3. Core VNF placement and gateway catchment areas for $D = 1$ - Polska Network.

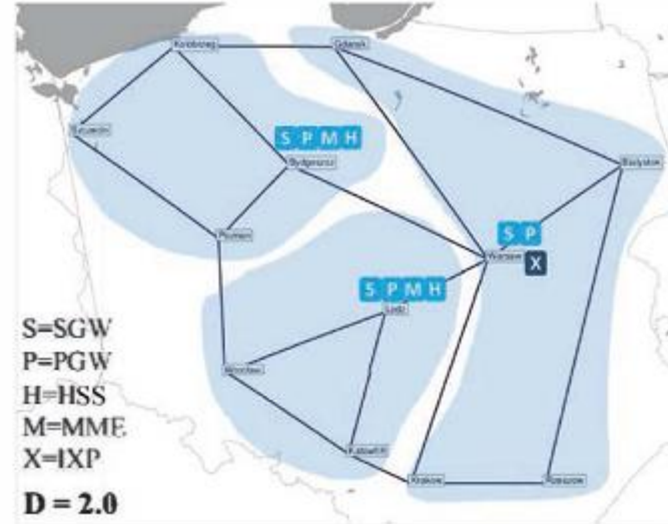

Figure 5. Core VNF placement and gateway catchment areas for $D = 2$ - Polska Network.

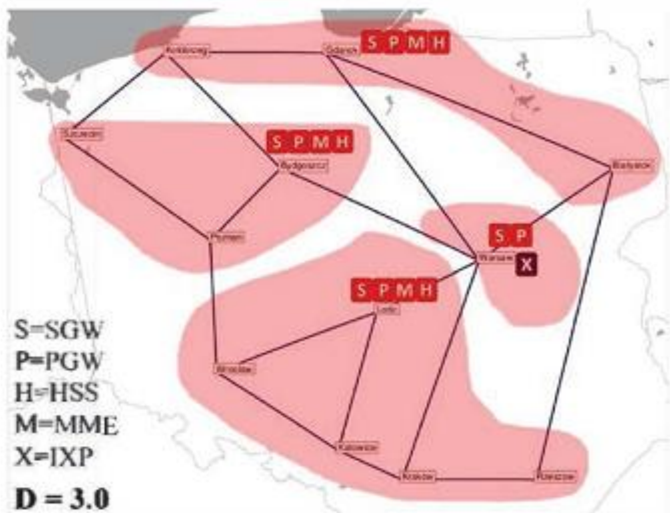

Figure 7. Core VNF placement and gateway catchment areas for $D = 3$ - Polska Network.

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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

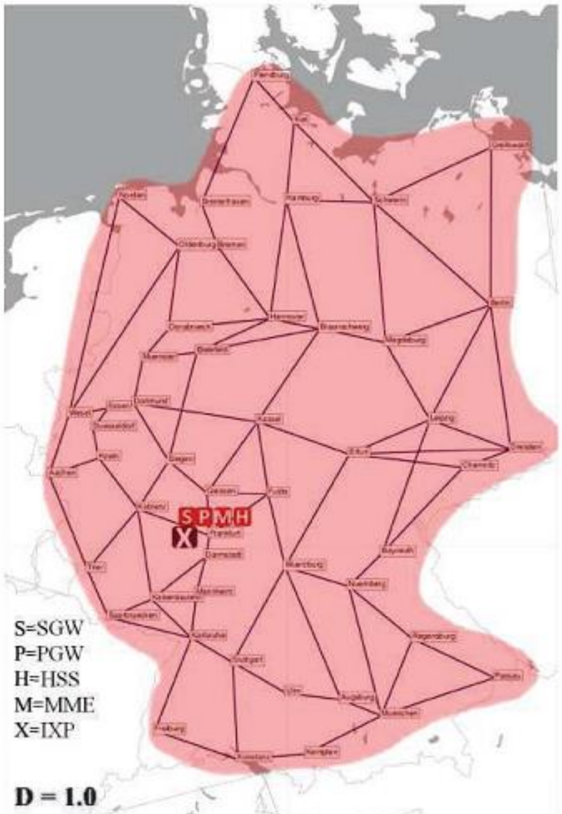

Figure 4. Core VNF placement and gateway catchment areas for $D = 1$ - Germany50 Network.

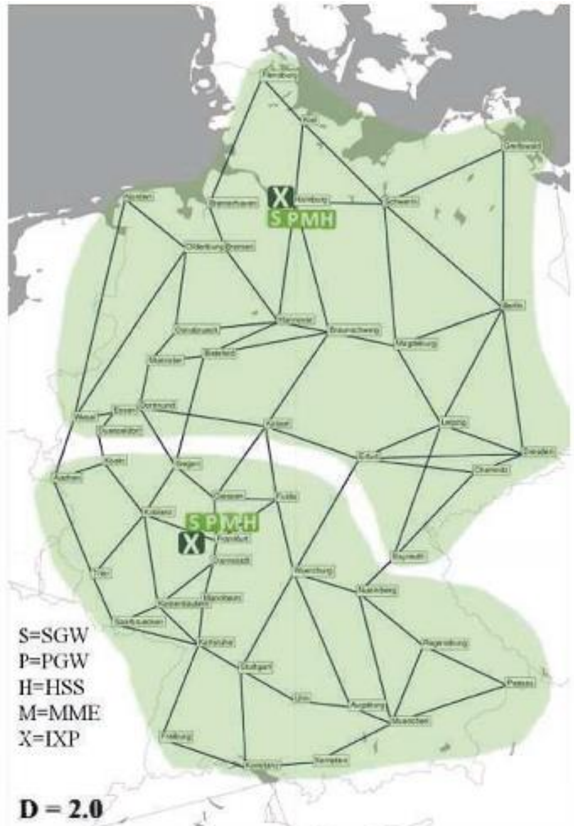

Figure 6. Core VNF placement and gateway catchment areas for $D = 2$ - Germany50 Network.

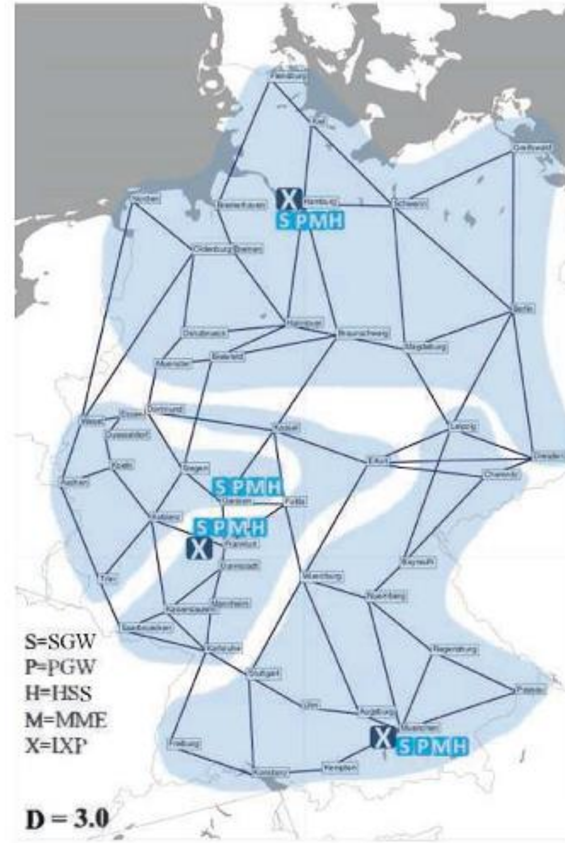

Figure 8. Core VNF placement and gateway catchment areas for $D = 3.0$ - Germany50 Network.

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Our Goal

- The optimal placement and routing of traffic of traffic through a virtual EPC
- What is the objective?
  - Reduce bandwidth consumption? How critical is it?
  - Reduce the latency to the EPC? How critical is it?
- How to reduce the bandwidth consumption?
  - Does having distributed instances of the EPC help?
  - What about the management overhead for large deployments?
- How relevant is the backhaul in this context? Willa pure IP perspective be too simplistic?

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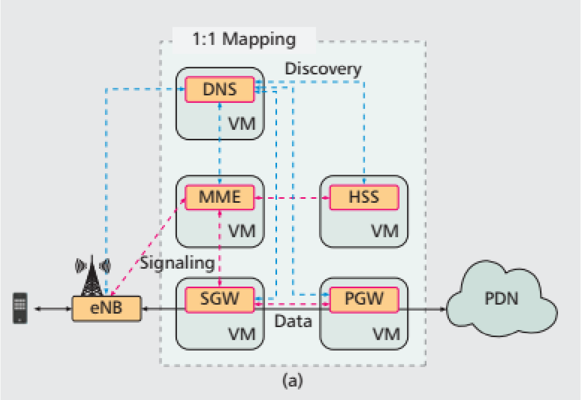
Given

- Network Topology
  - A core network topology which includes metro rings (access too?)
- Traffic flows
  - Should we be dealing with per-subscriber traffic?
  - Aggregated traffic makes more sense?



- Service Chains (EPC) to be deployed
  - Service chain for upstream traffic
  - Service chain for downstream traffic
  - Details of exact traversal of EPC components to better design these chains
- Stateless and Stateful VNF differentiation
  - Stateless VNFs will follows CPU core-to-throughput relationship
  - Statefull VNF will have CPU core-to-connections relationship, also has to much more real-time and hence, have stricter latency constraints on operation

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