SVEUČILIŠTE U ZAGREBU
Fakultet elektrotehnike i računarstva

Master Programme Computing

Advanced Architectures of Telecommunication Networks

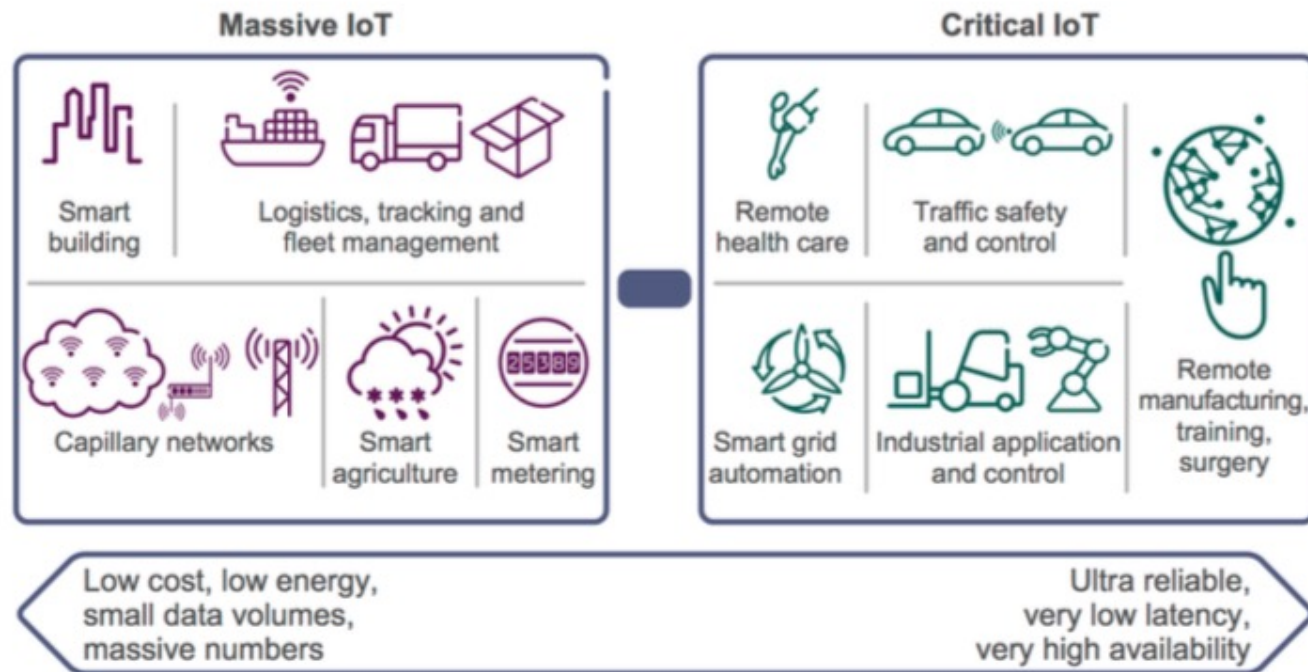Ac. year 2022/2023

Towards network softwarization

What is softwarization?

- Try and replace network devices in form of „black boxes" with programmable components to allow more flexibility and openness

- Think of an old, monolithic software solution vs. microservice-based solutions in the cloud
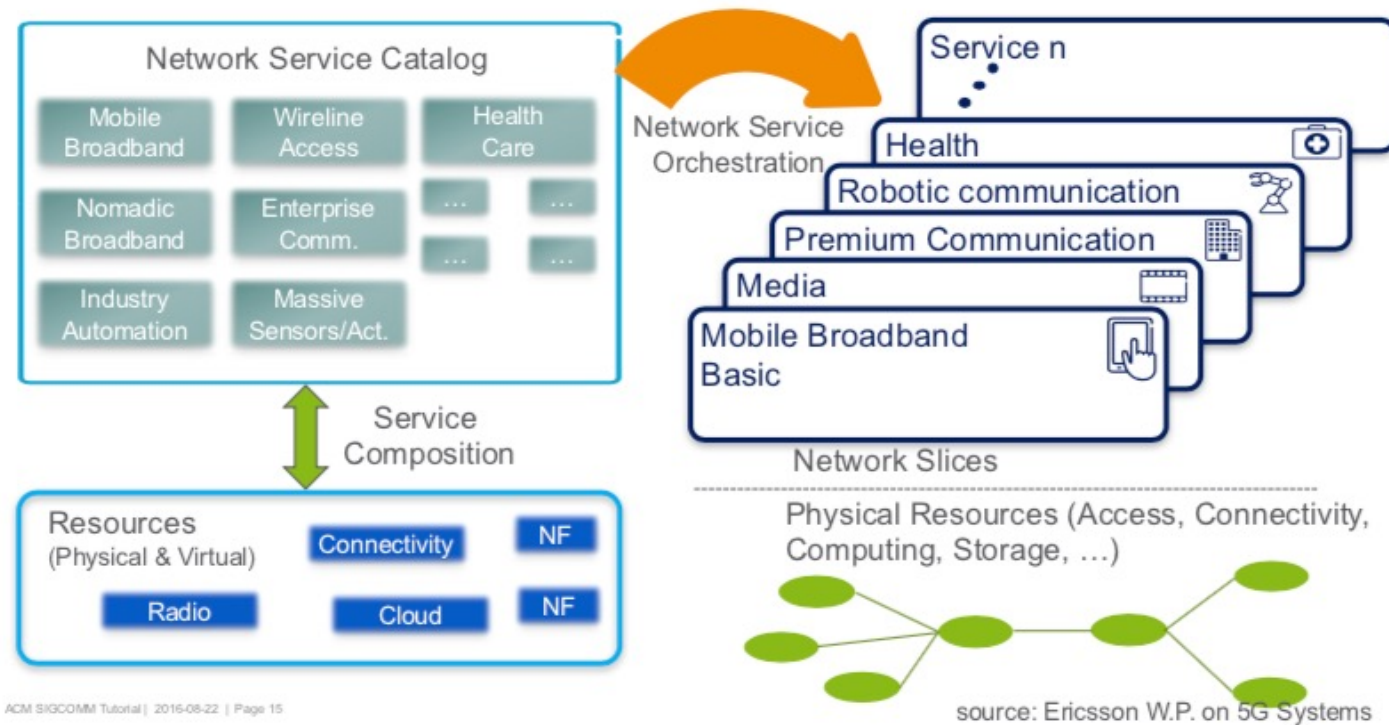 - Similar "evolution" with similar motives and benefits!

Why softwarization?

- IoT and 5G requirements
  - One network for multiple services with different requirements

"SDN, NFV and their role in 5G", https://www.dca.fee.unicamp.br/~chesteve/ppt/SIGCOMM16-Tutorial-5G-SDN-NFV-part1.pdf

Why softwarization?

- Service deployment and orchestration

"SDN, NFV and their role in 5G", https://www.dca.fee.unicamp.br/~chesteve/ppt/SIGCOMM16-Tutorial-5G-SDN-NFV-part1.pdf

Why softwarization?

- Goals:
  - High level of flexibility and programmability in individual domains (mobile core, radio access network and transport network)
  - Cross-domain programmability and orchestration.

- To provide better…
  - Service Agility
    - Shorten the time for service creation and service adaptation (e.g., scaling).
  - Service Diversity
    - Share a single infrastructure among multiple services with wide range of requirements.
  - Resource Efficiency
    - Dynamically allocate the right amount of resources when and where needed

Ultimate goal of softwarization?

- So, what is the ultimate goal?
  - Example 1: I want to build a farm with 1000s of sensors and automate everything
    - I need connectivity, routing, cloud monitoring…
  - Example 2: I am an IPTV provider
    - My subscribers need to have high QoS and QoE
- Could I do any of these with traditional, monolithic networks?
  - Yes, but it would be more complex (and expensive)
- This is what network softwarization enables
  - among many other things!

When comparing with other domains...

- IaaS, SaaS, PaaS - and now: NaaS

On-site	IaaS	PaaS	SaaS
Applications	Applications	Applications	Applications
Data	Data	Data	Data
Runtime	Runtime	Runtime	Runtime
Middleware	Middleware	Middleware	Middleware
O/S	O/S	O/S	O/S
Virtualization	Virtualization	Virtualization	Virtualization
Servers	Servers	Servers	Servers
Storage	Storage	Storage	Storage
Networking	Networking	Networking	Networking

■ You manage   ■ Service provider manages

https://www.leanix.net/en/wiki/saas/iaas-vs-paas-vs-saas
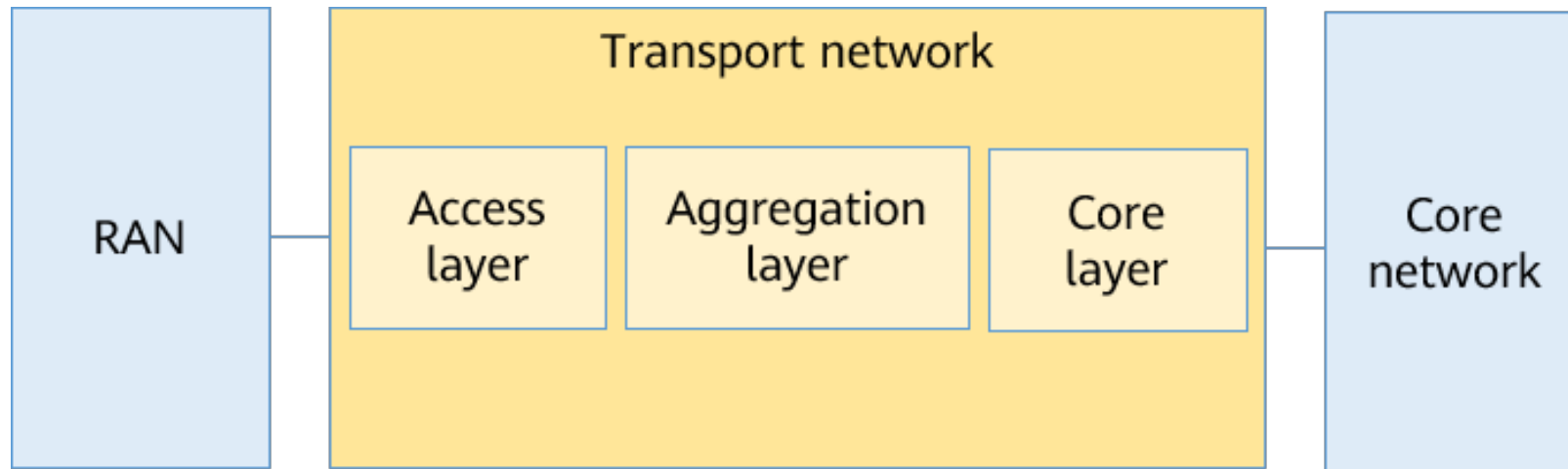
(this is actually the evolution of cloud, services)

Where can softwarization be applied?

- Core network
- Access network
- Transport network

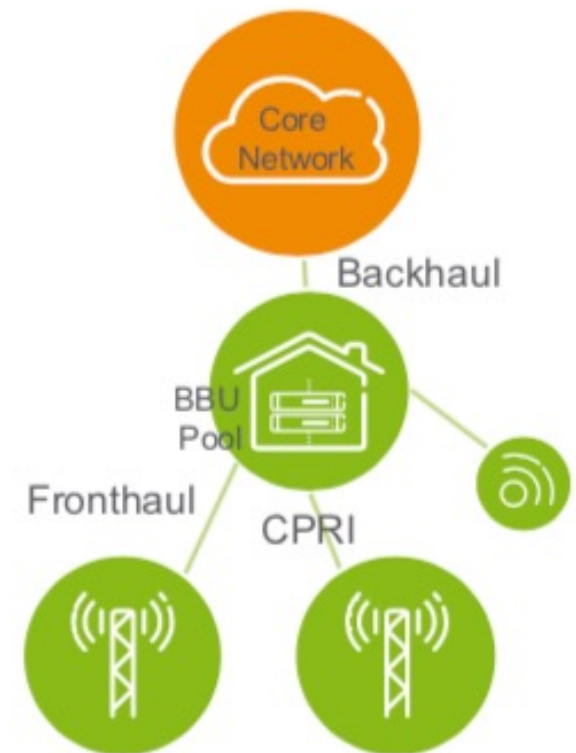# Core network softwarization – current problems

- Without softwarization:
  - single network architecture for multiple services
  - control and user functions mixed!
- Difficult to customize (remember different service requirements!)
- Difficult to scale

- What we need is flexibility in core network
  - Easier adoption to new services with various requirements
  - What about new/additional/specific hardware?
  - On-the-go (more or less) adaptation

Core network softwarization – what do we need?

- Separation of control and user- plane functions
- Separation of functionalities
  - E.g. remember software development and „separation of concerns" -> higher granularity of core functions
- Functionalities virtualization
  - Better scalability
  - Adaptation on-the-go, per service/network slice
- Treat services as separate entities
  - Customization for each service
  - Per service scaling – selective
  - Flexibility
- But also:
  - Centralized control
  - Use of cloud and services in cloud!

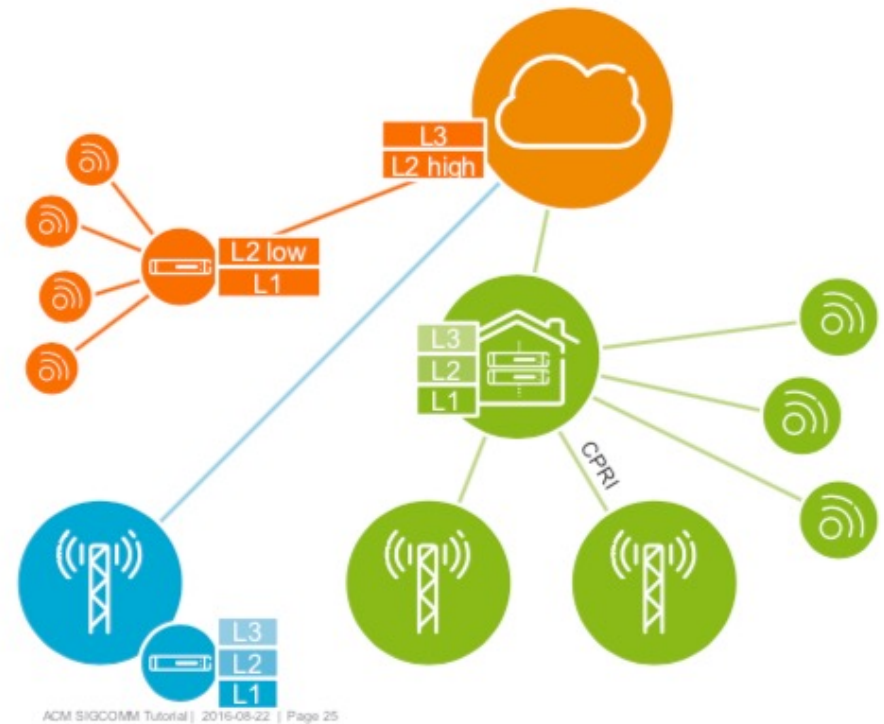# Access network softwarization – current problems

- IP connectivity (remember previous lectures)
- Scaling for new scenarios?
- Imagine IoT requirements
  - How to segment access network
  - Edge services – example
    - Farming IoT service over the same access netowork as other services
    - Different bandwith, latency, data requirements

"SDN, NFV and their role in 5G",
https://www.dca.fee.unicamp.br/~chesteve/ppt/SIGC
OMM16-Tutorial-5G-SDN-NFV-part1.pdf

Access network softwarization – what do we need?

- Resource pooling
  - Serve multiple „tenants" with provisional and scalable services
  - Softwarized services (also in the cloud)
- Centralized network management
- Centralized coordination of services and accesses for different services
- „Cloud-RAN"

"SDN, NFV and their role in 5G", https://www.dca.fee.unicamp.br/~chesteve/ppt/SIGCOMM16-Tutorial-5G-SDN-NFV-part1.pdf

Transport network softwarization – current problems

- Monolithic realization of network functions
  - Difficult and manual adaptation, segmentation, scaling
  - Main functions: control and forwarding
- Proprietary Interfaces
  - Interconnection of different equipment?
- Inefficient Resource Utilization
  - No „resource pooling", as-is
  - Optimization difficult, especially in near-real-time
- „Application Unaware"
  - Difficult to adapt to different applications and services (remember e.g. IoT requirements)

Transport network softwarization – what do we need?

- Provide (clearly) separated control and forwarding functions with defined interfaces
- Enable softwarization of control plane and functions
- Automatized delivery and configuration of network and services
- Dynamic creation and configuration of (virtual) connections or tunnels
- Resource optimization operation in order to fully use the available links
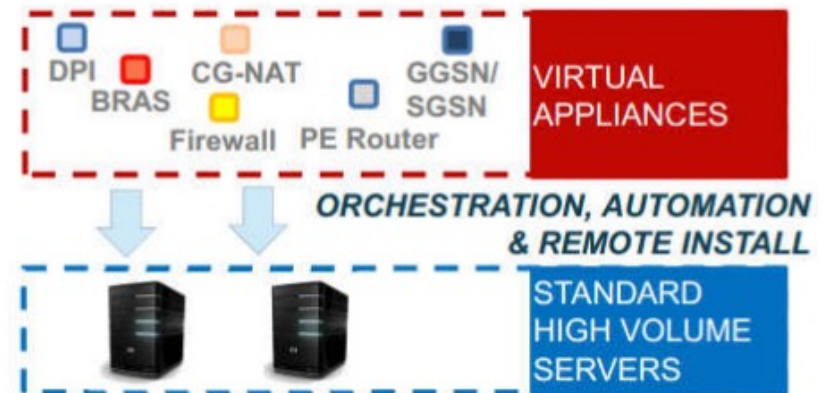
From traditional to softwarized network model…

- In short: minimize hardware dependancies and maximize software dependancies!

https://www.dca.fee.unicamp.br/~chesteve/ppt/2016-open-source-network-softwarization.pdf

Network Softwarization = SDN & NFV
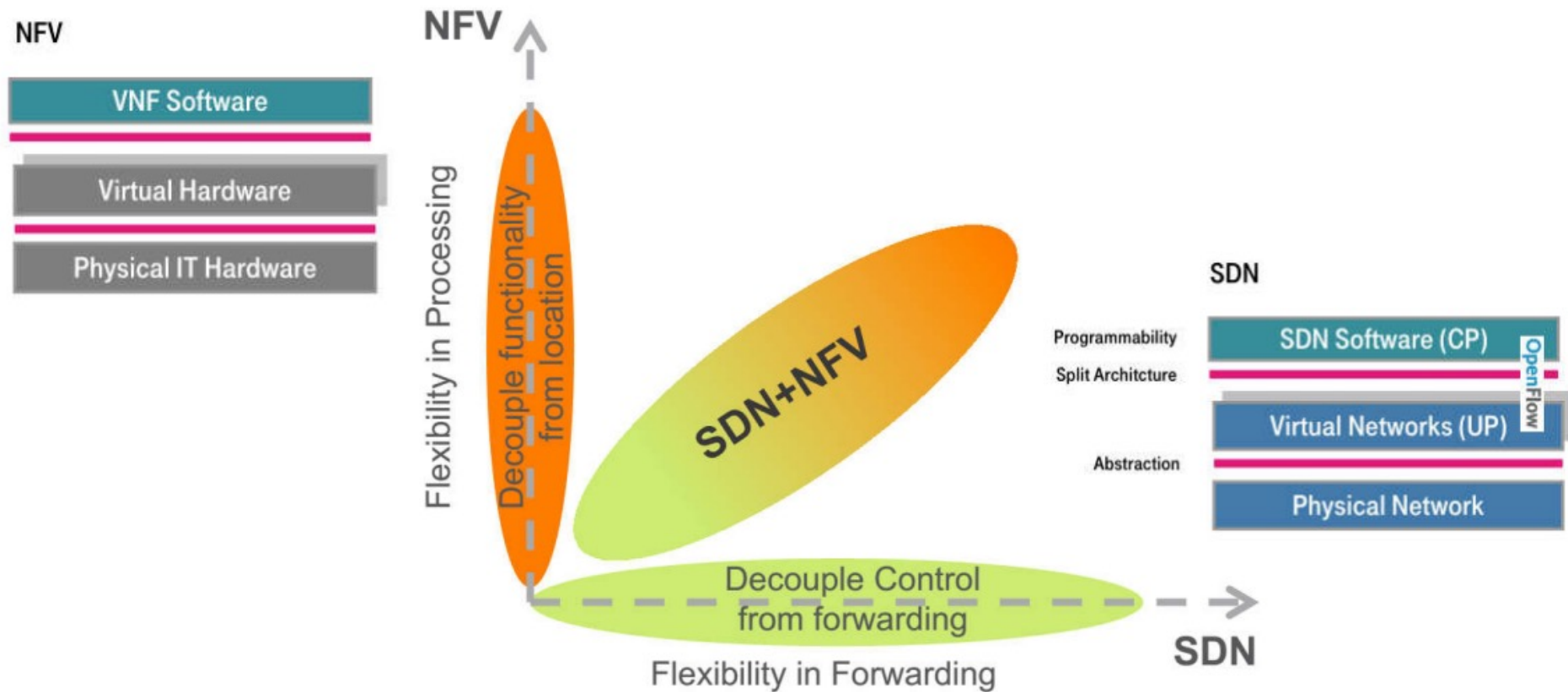
Ahmad Rostami, Ericsson Research (Kista) and Uwe Michel, T-Systems
(adapted from https://www.dca.fee.unicamp.br/~chesteve/ppt/2016-open-source-network-softwarization.pdf)

NFV and SDN are means of network softwarization!

- Software Defined Networking
  - flexible traffic „steering" in a physical or virtual network environment
  - Network part

- Network Function Virtualization
  - flexible placement of virtualized network functions across the network & cloud
  - Application / appliance part

- SDN & NFV are complementary tools for achieving full network softwarization!

Evolution of network softwarization
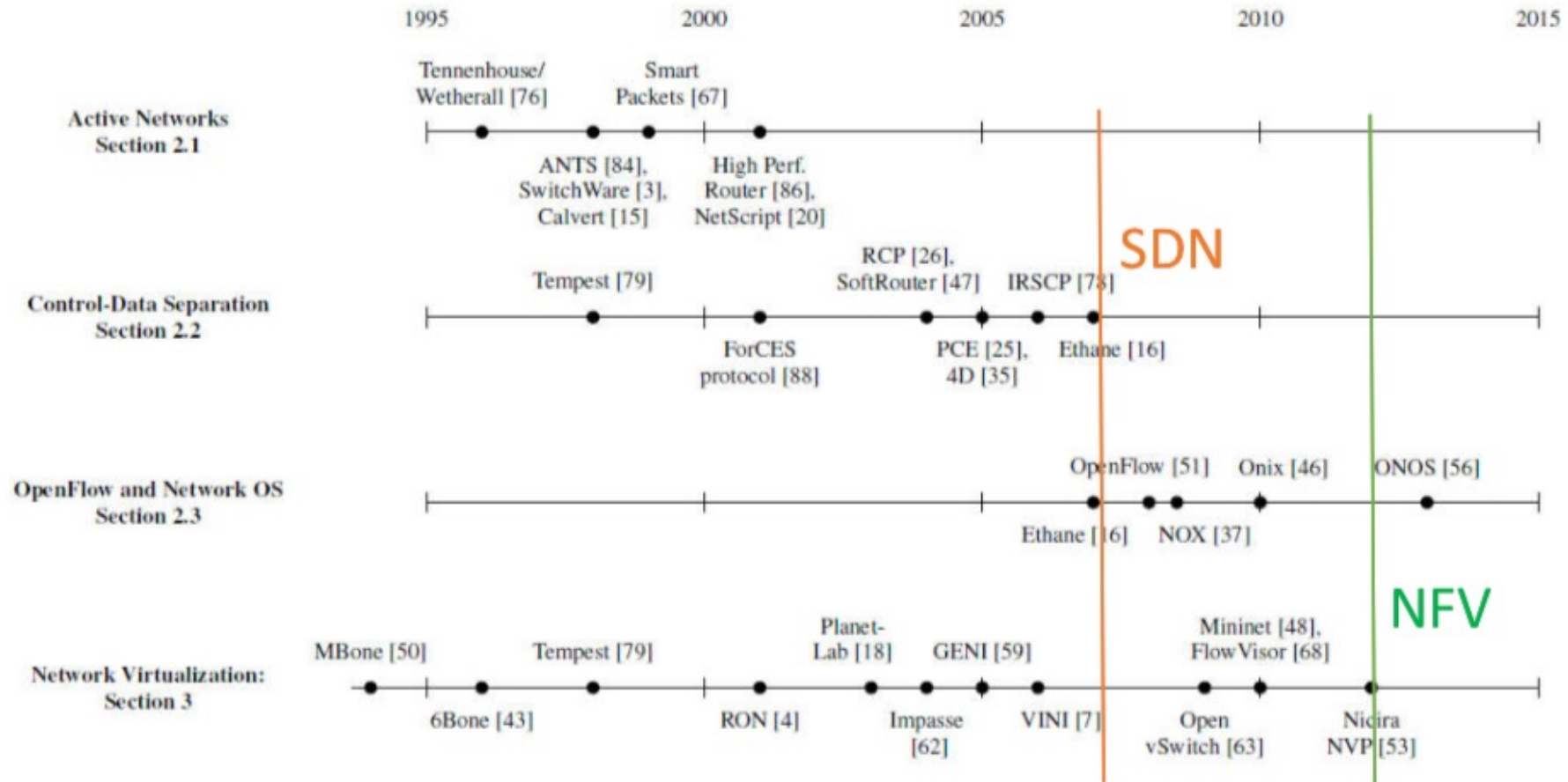
Source: N. Feamster, J. Rexford, E. Zegura. The Road to SDN: An Intellectual History of Programmable Networks.
http://gtnoise.net/papers/drafts/sdn-cacm-2013-aug22.pdf

Benefits when using softwarized networks (1/4)

- Virtualization
  - use network resources without worrying about where it is physically located, how it is organized, etc.
  - configure, deploy, and update services and functions in (near) real-time
  - Example: virtualized router, firewall, lawful interception…
- Orchestration
  - manage thousands of devices
  - prepare for IoT and required mass orchestration
  - Example: smart home and IoT
- Programmability
  - update, setup, (re)configure „everything" in (near) real-time
  - „edge", „fog", „mist", „dew" computing – bring services closer to the users
  - Example: off-load the core network

Benefits when using softwarized networks (2/4)

- Dynamic Scaling
  - change size, quality, quantity based on service requirements
  - possibly in near real-time – „proactivity"
  - Example: resource allocation during football game in mobile network
- Automation
  - As autonomous as possible
  - e.g. automatic updates, adaptation to increasing requirements, automatic resource allocation…
  - Example: automated software updates on network devices

Benefits when using softwarized networks (3/4)

- Visibility
  - better and easier resource monitoring
  - detecting issues in the network, rogue nodes etc. (security also!)
  - Example: reference to SIEMs – why monitoring is important?
- Performance
  - optimize network device utilization
  - Throttling – lowering bandwith for some traffic types?
  - Example: network neutrality problem
- Multi-tenancy
  - Slice the network for different customers (as-a-Service)
  - Important: enable different configurations and environments for different „tenants" while even using the same underlying hardware
  - Example: IoT mixed with video-on-demand

Benefits when using softwarized networks (4/4)

- Service Integration
  - OSS and BSS (operations support system and business support system) should integrate and „work" with network operations
  - Easily integrate business and operational domain requirements into services
  - Example: activating additional GBs on your mobile device using service activation platform from call-center
- Openness
  - Telecommunication vendors are typically very "closed" which limits new services, while telcos want to sell services themselves
  - Openness is very important in this sense – it enables telcos but also third-party service providers (!) to offer new services based on open standards, interfaces and software!

Next lectures

- SDNs and OpenFlow
- NFVs

- Both as basis of network softwarization
- Remember: it enables everything we are actually using nowadays!