What is driving the network requirements?
Application, people and things

Service Experience

Massive broadband
Industry 4.0
IoT
Services and workloads evolve

1. From bare-metal to VM
2. to container in VM
3. to container in BM
4. to functions/processors/instructions
Operations and life-cycles evolve
Radically reduce cycle time for higher value capture and faster time-to-market

DevOps
Methodologies and processes for business agility

1. Up to 10x fewer network failures
2. Up to 10x faster time-to-market
3. Up to 10X operational efficiencies
How do we deal with all of this? Let’s take a step back – key principles

Principle 1

- Physical + virtual equipment
- Network management and control
- Decoupling from the equipment
- Centralized intelligence

Transport – service decoupling

Principle 2

Provision the edge and don’t touch the core
What is an Edge?

Physical

- Leaf switch
- PE
- BNG
- User Plane
- DC-GW
- Peering

Virtual

- Packet core
- vBNG
- User Plane
- Cloud RAN
- Cloud Access
- vswitch
Where is the Edge?
Central or distributed?

Access Sites
4G/5G RAN

Edge Sites
Application
Core UP
EPC/5GC UP & CP, SDM,
Policy & Charging, Security

Central Sites
EPC/5GC UP & CP, SDM,
Policy & Charging, Security

Ping/RTT 11 ms
Helsinki
UE
PGW
Server

Ping/RTT 20 ms
Helsinki
UE
PGW
Server

Ping/RTT 29 ms
Oulu
UE
Server

Oulu
PGW

Helsinki
PGW
Let’s look at the network?

Observations

- Many touch points
  - Different workloads – physical/virtual
  - How to provide a dynamic service in such environment
  - How to optimize the service in this environment
  - How to provide an E2E view of the service in this environment
  - How to handle insight driven automation
Introducing NFIX

An IP fabric with an API

- Built on the basis of seamless MPLS
- Provision the edge, don’t touch the core
  - Edge: pNF, vNF, cNF, etc
- SLA/KPI represented by network instruction set (segment routing)
- Central control through an API to provision services provide fabric insights, measure KPI(s), optimize when needed, etc
  - Day-1/2 operation
NF-IX: Network Functions Interconnect Architecture
Cloud-speed service provisioning with guaranteed SLAs

Build on Open standards build in IETF – evolution from seamless MPLS

- MP-BGP control plane for IP/Ethernet VPNs
- Segment Routing – PCEP/SR-TE policy
- Service chaining
- Netconf/GRPC – Yang
- Telemetry

Any service interconnect with guaranteed SLA(s)
NF-IX: Network Functions Interconnect Architecture
An IP Fabric with an API

Network Fabric (Any topology, DC+WAN, E2E Traffic Engineering/Network optimization)
5G Business Drivers & Applications

Using a set of E2E features to cost-effectively tailor network capabilities for a specific service

Technical aspect

Business aspect

- Fixed Wireless Access
- Smart city
- eHealth
- Consumer experience
- Public safety
- Connected vehicle
- Critical automation
- Industry 4.0
Example: Ports - Leveraging technology to enhance productivity

Challenges by 2025
- 18 Million containers per year
- Several 10K trucks on harbour area streets every day
- Self driving/flying vehicles (public, private, enterprise)

100,000+ sensors connected
- Sharing data between ships & shippers, trucks, port operators
- Emission measurement
- Cargo maintenance: Real-time info on location, temperature, humidity

- Better traffic/process flow
- Enhanced experience & security (e.g. incl. AR & cruise ship passengers)
- Improved pollution control
Insight-driven automated networking
Closing the loop between intent and outcome

Controller
- Service automation
- Network/Application optimization

Data analytics
- Correlate and deduce
- Collect and aggregate

Smart IP fabric
- Software programmability
- Model-driven telemetry
Introducing and automating services faster
Transport realization using NF-IX

Problem
How to dynamically adjust transport network resource needs to match fluctuating service demands

Solution
NF-IX automatically creates connectivity between PNF/VNF nodes across clouds & WANs

Benefits
• Fast service provisioning
• Guarantee transport SLAs for each service
• Optimize network resources as load conditions change

Transport Slicing is a combination of multiple services with assurance and KPI(s)
Optimizing services in real time
Closed-loop action to intelligently place paths to meet SLA

Problem
Inefficient operations impact end user QoE and resources

Solution
Centralized, instant network resource control with real-time visibility

Benefits
• Increase network utilization
• Avoid congestion
• Enhance network resiliency
• Improve service performance (latency, packet loss, jitter…)

Latency increase
Controller
Tunnel Re-routed
End user
Content, service, app

Insight
Action
Slicing

NFIX is simplifying network slicing with insight-driven automation
End-to-end Network Slices

RAN Slices

Transport Slices *

Core Slices

- **E2E network slice orchestrator**

- **RAN slice controller**

- **Core slice controller**

**Tenants**

- Infotainment
- HD maps
- Automated driving

**Automated driving**

**Public safety**

**Video surveillance**

**5G Edge**

**Operator-x**

**5G Core**

E2E network slices = **NS1** **NS2** **NS3** **NS4** **NS5**

* Also called Transport Sub-Slices and Transport Slice-Subnets

**BMW infotainment**

**BMW HD maps**

**Multi-source artificial intelligence**

**PS video surveillance**

**Public and private clouds**
Management and Control of E2E Network Slice and Transport Slices

Each controller/orchestrator performs:
1. Automation (aka creation)
2. Monitoring and analytics
3. Optimization

E2E Network Slice Orchestrator

RAN Slice Controller

Transport Slice Controller

Core Slice Controller

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Transport Slice Automation

1. Transport Slice Connectivity Request (with SLA/SLO)

2. Realize Transport slice
   - Find resources
   - Map the request to any Service/Tunnel/Path models (e.g. IETF and NF-IX)

3. Realize using various models for Services/Tunnel/Paths (e.g. IETF, NF-IX)

4. In addition to Automation, Monitoring and Optimization of Transport Slices should be addressed

Higher System (e.g. e2e network slice orchestrator)

Transport Slice Connectivity Request

Transport Slice Controller

Transport slices

Network Fabric (Any topology, DC+WAN, E2E Traffic Engineering/Network optimization)
Key Takeaways

1. NFIX enables ubiquitous connectivity (Access, Core, Cloud) with SLA(s)

2. Transport slice controller provides a programmable framework for insight driven automation and assurance

3. This framework is built upon IETF standards, Open and multi-vendor
NOKIA