Evolutionary trends in operators' networks for beyond 5G

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The role of computing in the post 5G-era: Architectures and enabling technologies
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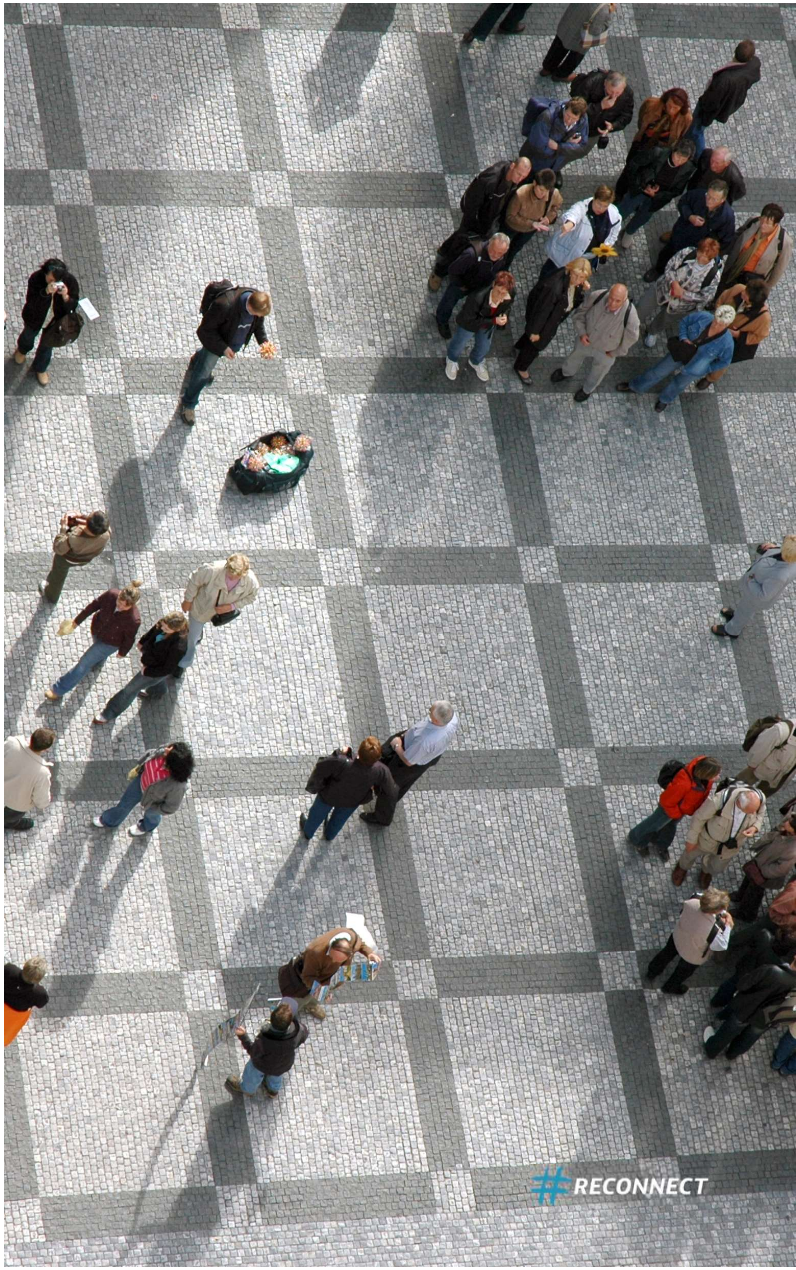


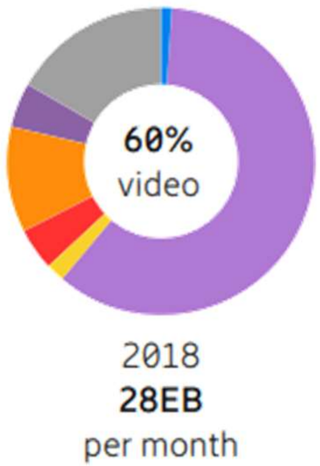
Agenda

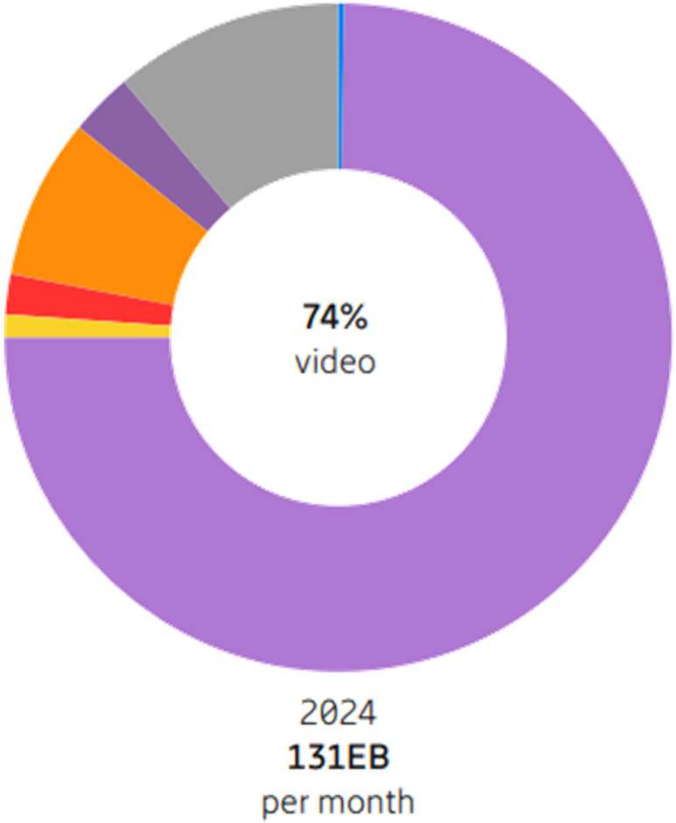
- Trends → Where do we go?
- Network evolution → What is being done?
- Economic context → How make it happen?
- Conclusions → Wrap up

Trends

Mobile data traffic by application category per month (percent)

Similar trend is observed nowadays in (fixed and mobile) networks



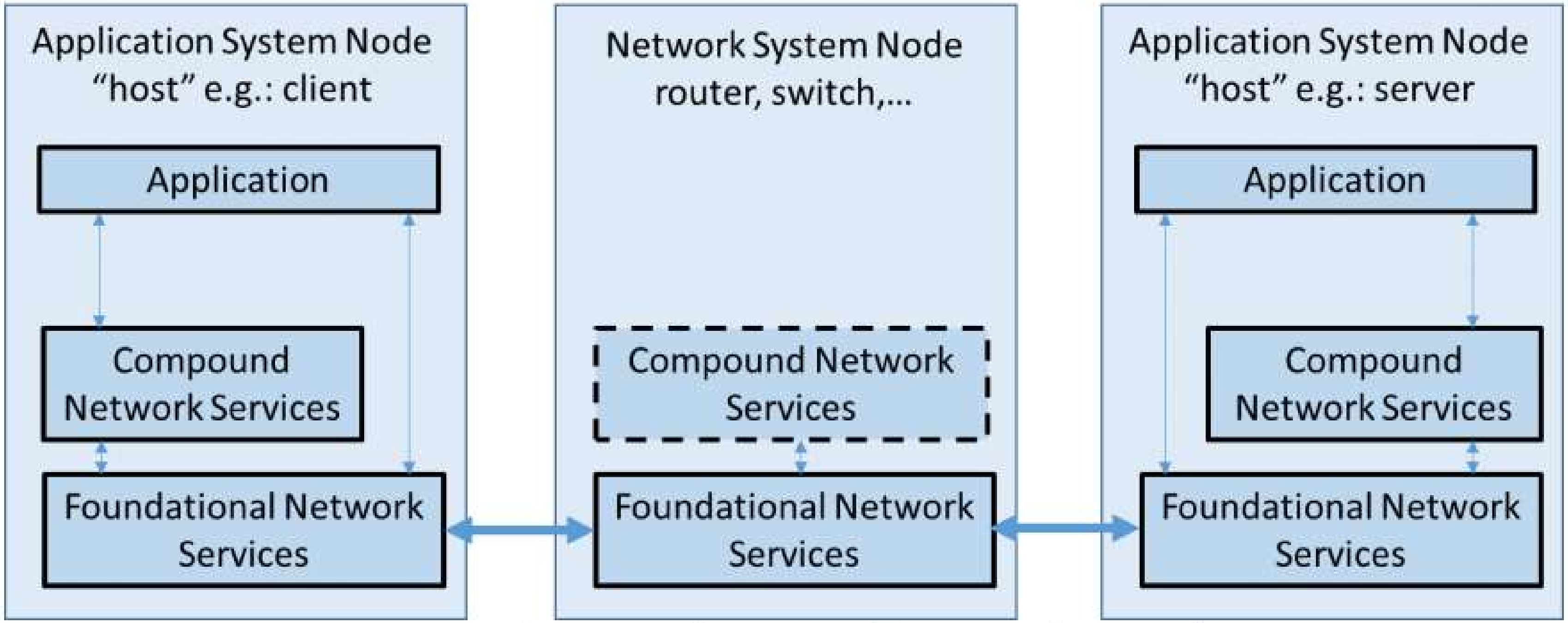


Main drivers for video traffic growth

- Video part of most online content (news, ads, social media, etc.)
- Growth of VoD services
- Video streaming services
- Changing user behavior – video being consumed anywhere, any time
- Increased segment penetration, not just early adopters
- Evolving devices with larger screens and higher resolutions
- Increased network performance through evolved 4G deployments
- Emerging immersive media formats and applications (HD/UHD, 360-degree video, AR, VR)

Source: Ericsson Mobility Report, June 2019.

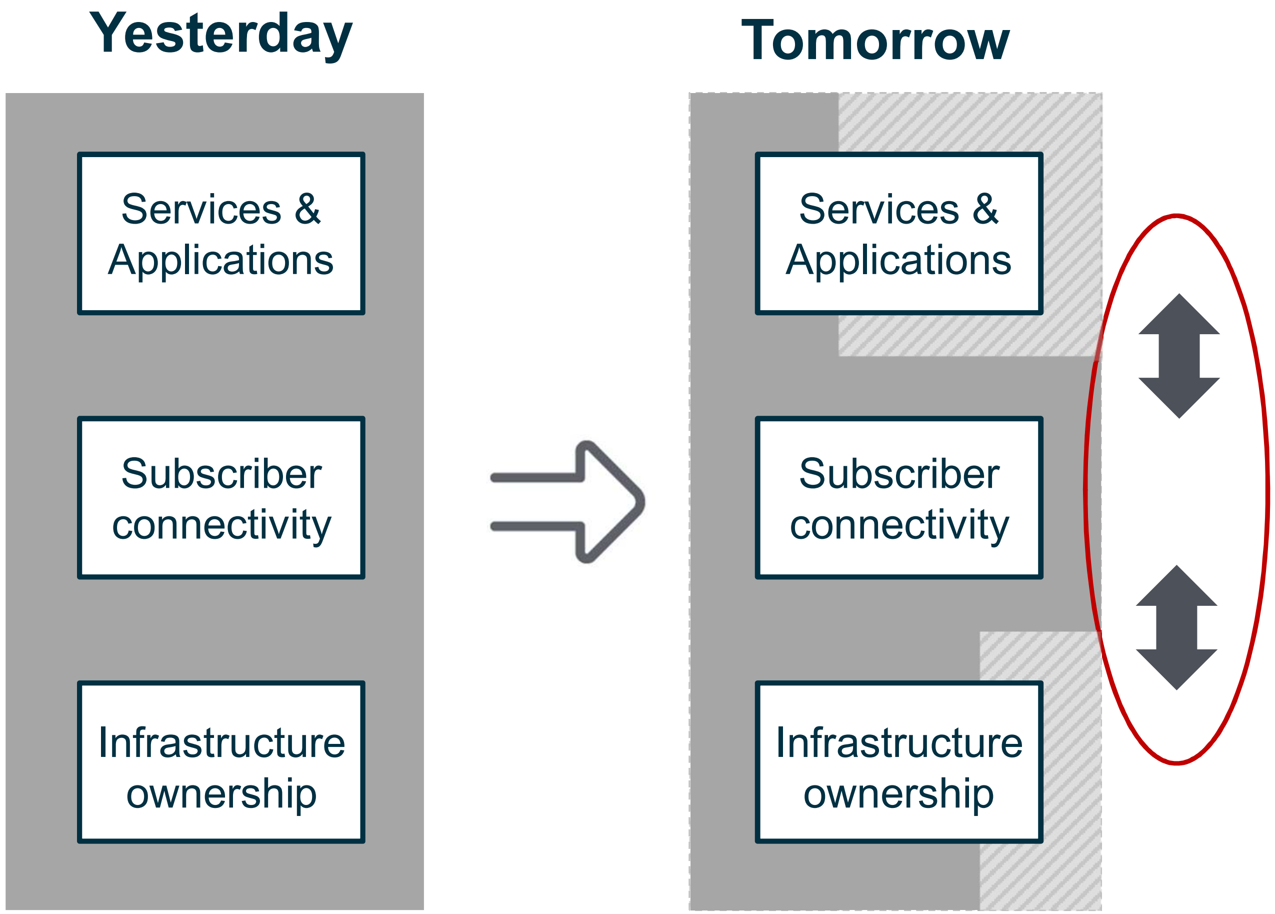
Net2030 - Foundational and Compound Network Services



New network-layer services on the data plane: High-Precision Communications (in-time, on-time), Qualitative communications, Coordinated communications, etc.

Source: ITU-T FG NET2030, Sub-G2 - New Services and Capabilities for Network 2030: Description, Technical Gap and Performance Target Analysis, October 2019.

Multiple actors involved



- Future services will be **richer** and **more immersive** and **interactive** than the ones existing today.
- This evolution means that both Services & Applications and Infrastructure are **not** completely **under control** of the Network operator.
- Integrating and controlling both for satisfying the requirements of future services has **several implications** (see next slides)

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Network operator footprint

#RECONNECT

Infrastructure ownership

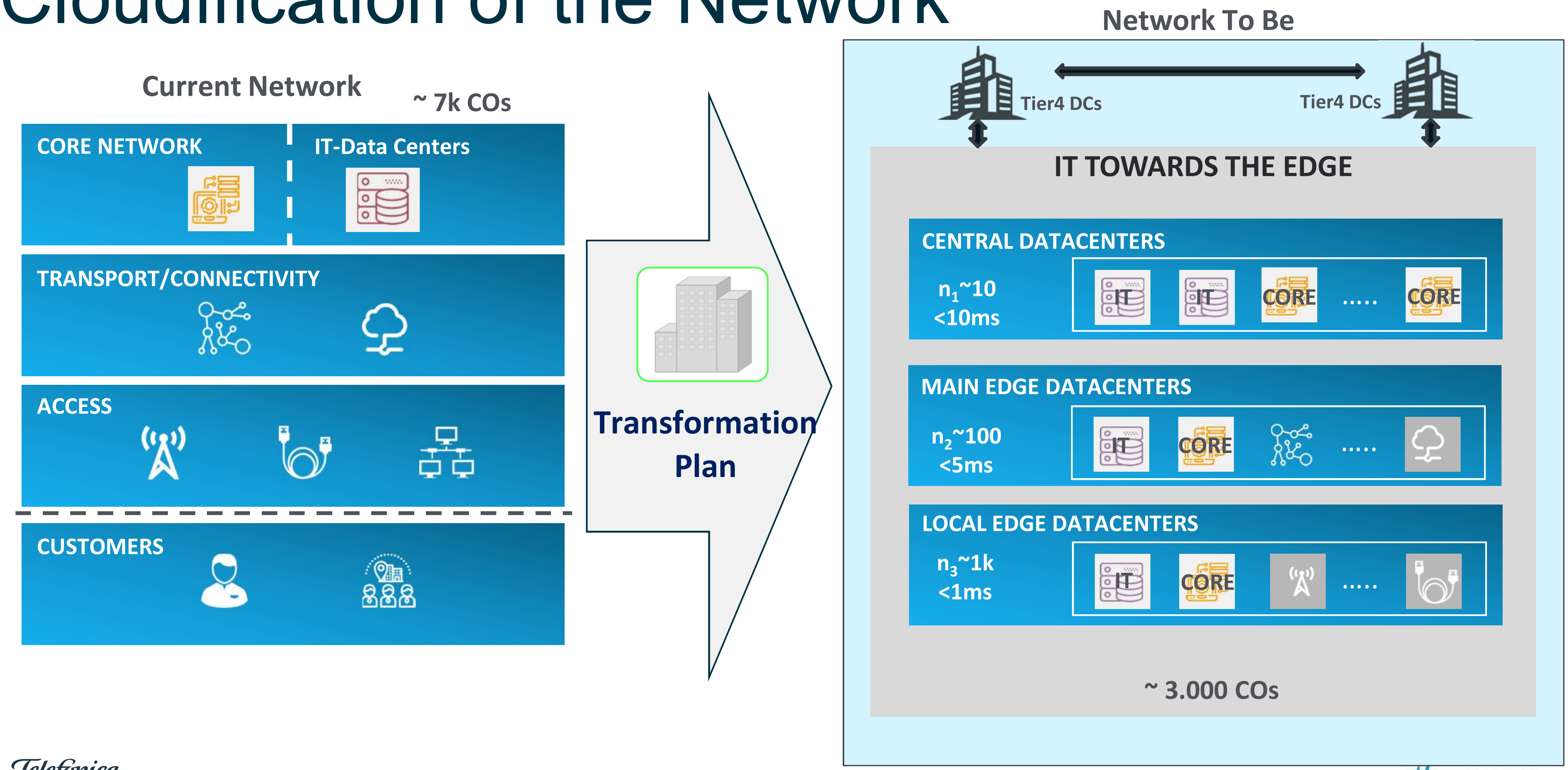
- **Multi-domain:** different levels of interaction with multiple infrastructures at international, regional, national and local levels (~ *fractal* scenario). Several schemas with different governance and operational models, such as sharing, alliance, full federation, etc.
- **Capillarity:** need to complement the coverage either temporary or permanently.
- **Abstraction:** normalized mechanisms for acting on heterogeneous resources and devices.
- **Information exposure:** way of interchanging information of resources, capabilities or even services (e.g., by means of catalogues and APIs).
- **Private Networks:** vertical industries deploying and operating their own infrastructures but requiring additional external services.
- **Disaggregation:** separation of SW and HW at all levels.

Services and applications

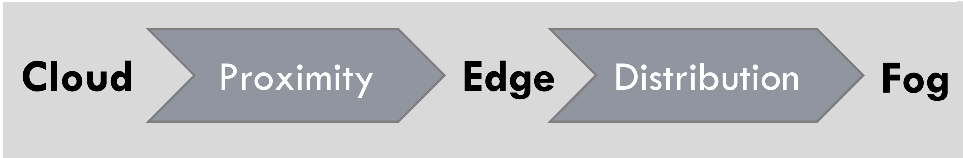
- **Applications and Network integration:** both cannot longer exist without a tight coordination; collaboration mechanisms have to be developed.
- **Introduction of new protocols:** new protocols will require to evolve existing equipment for supporting advance functionalities just after a cycle of investment for supporting 5G services.
- **Orchestration and programmability:** tailored treatment of resources (network and compute) and flexible placement of service functions.
- **Service segregation:** extension of the idea of slicing for segregating services from distinct applications, incorporating mechanisms in new protocols.
- **Planning:** smart planning and adaptation (in-operation network planning).
- **Testing:** need for experimenting services and applications on different execution environments, usually involving multiple actors and Network conditions.

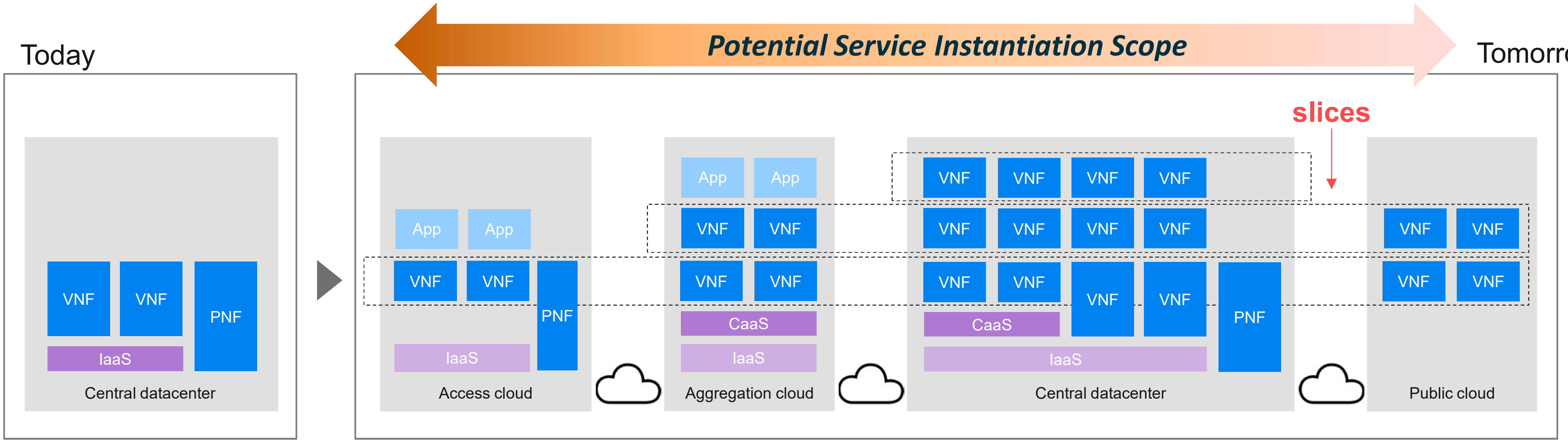
Network evolution

Cloudification of the Network



Extending the reach





Single data center with **semi-automated operations**

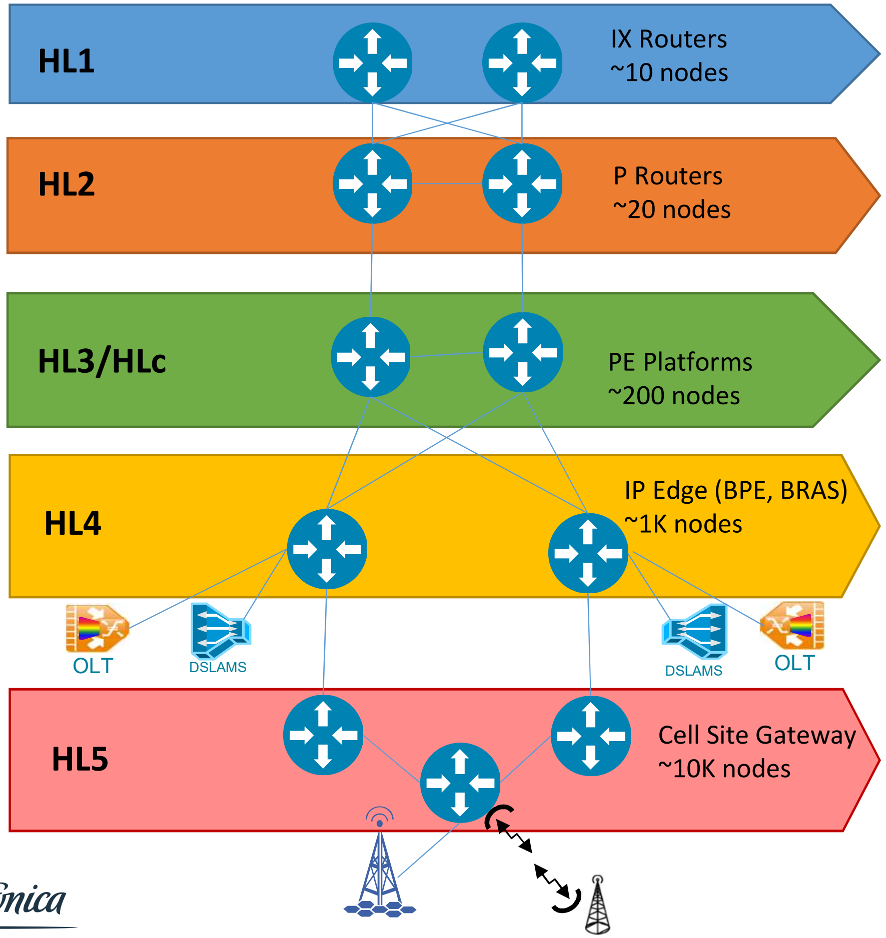
Automated and Optimized Workload placement across Distributed Data Centers in a **multi domain**, **multi technology** and **multi vendor** environment

- ❑ Orchestration, Assurance & Analytics are essential to support a hybrid network increasingly becoming real-time
- ❑ Where to deploy? *Service* Edge vs *Physical* Edge (*)

(*) L.M. Contreras, J. Baliosian, P. Martinez-Julia, J. Serrat, “Computing at the edge, but what edge?”, *IEEE/IFIP Network Operations and Management Symposium (NOMS),* Budapest, Hungary, April 2020.

Telefonica IP FUSION Architecture

FUSION topological levels



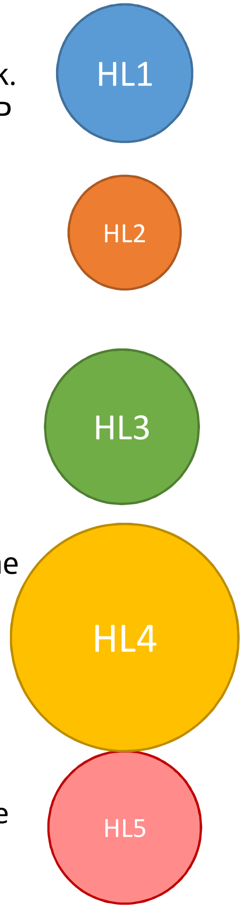
HL1. Located at the top level of the IP network. Interface between IP network and Internet/ISP providers

HL2. Located after the HL2 routers and aggregate traffic to/from the HL3s routers.

HL3/HLc. Provide connectivity to platforms

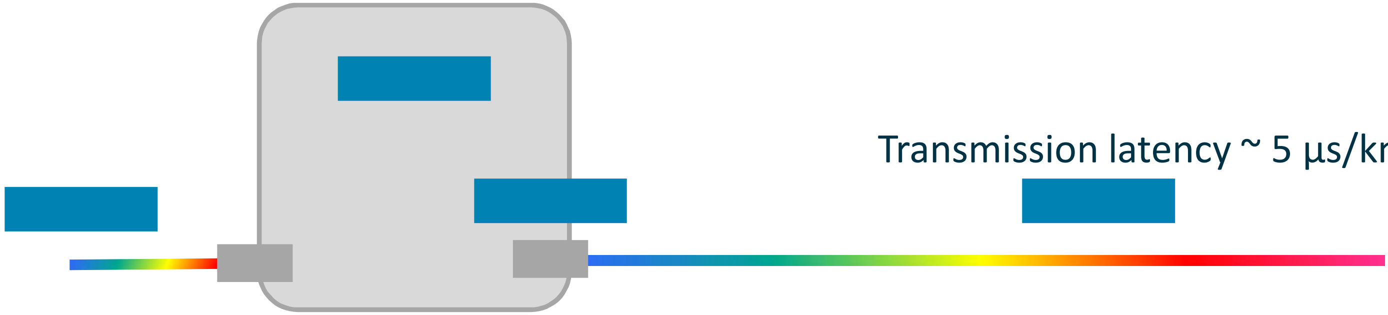
HL4. This is the IP Edge of the network with the Business PE and BRAS functionalities. HL4s aggregate the traffic of the fixed and mobile customers.

HL5. They are in charge of aggregate the mobile traffic and some fixed customers



Typical latencies in transport network

Avg device latency ~ 36 µs
one hop, no congestion



Transmission latency ~ 5 µs/km

Serialization delay < 12 µs
time in putting the packet on the line
1 Gbps line speed, 1500 bytes datagram = 12 µs

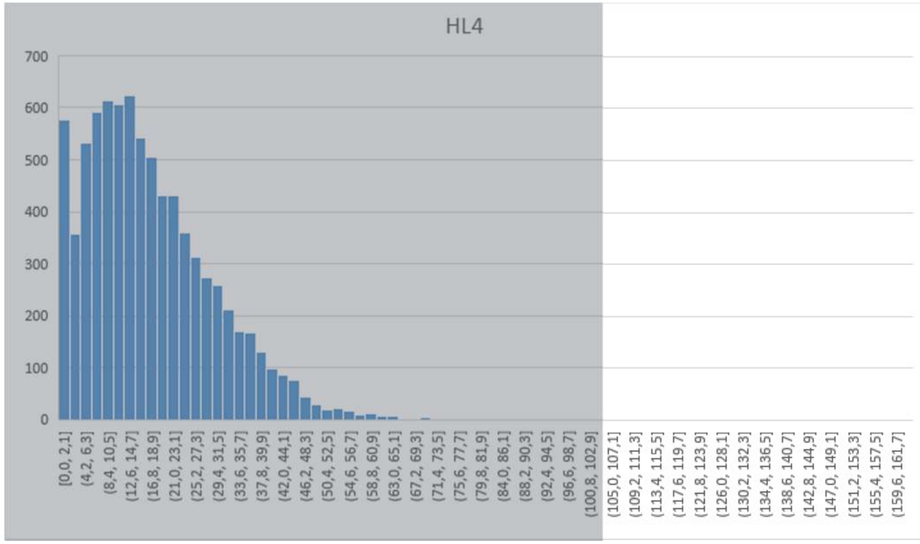
Typical **RTT latencies** for one hop between routers distant 50 /100 Km can be **bounded by 1 ms** per router

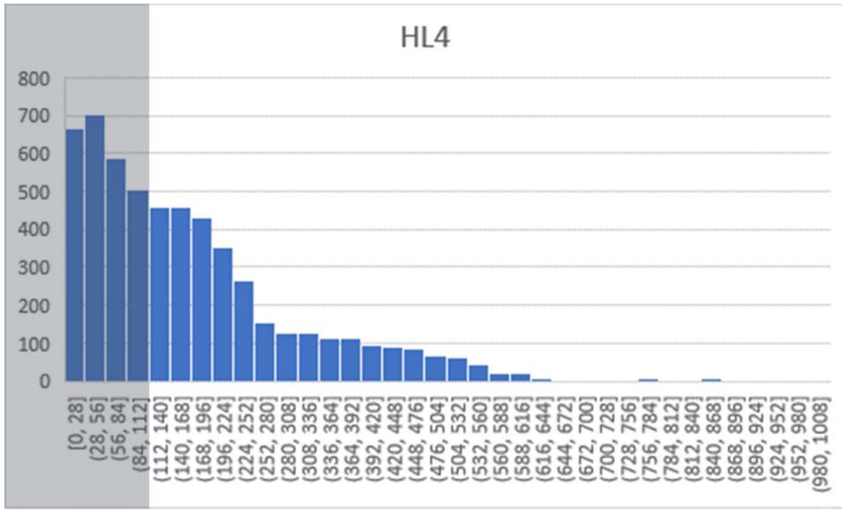
Additional latencies have to be considered for e2e service characterization

- Latency due to the access technology (interleaving, protection schemes, maximum bandwidth, etc)
- Latency due to data plane processing (PGW, coding, BRAS, etc)
- Latency due to service platforms (DNS lookup, etc)

Extract from 3GPP, “Service requirements for next generation new services and markets,” TS 22.261

Scenario	End-to-end latency	Jitter	Traffic density
Discrete automation – motion control	1 ms	1 µs	1 Tbps/km^2
Discrete automation	10 ms	100 µs	1 Tbps/km^2
Process automation – remote control	50 ms	20 ms	100 Gbps/km^2
Process automation – monitoring	50 ms	20 ms	10 Gbps/km^2
Electricity distribution – medium voltage	25 ms	25 ms	10 Gbps/km^2
Electricity distribution – high voltage	5 ms	1 ms	100 Gbps/km^2
Intelligent transport systems/ infrastructure backhaul	10 ms	20 ms	10 Gbps/km^2
Tactile interaction	0,5 ms	TBC	[Low]
Remote control	[5 ms]	TBC	[Low]





Economic context

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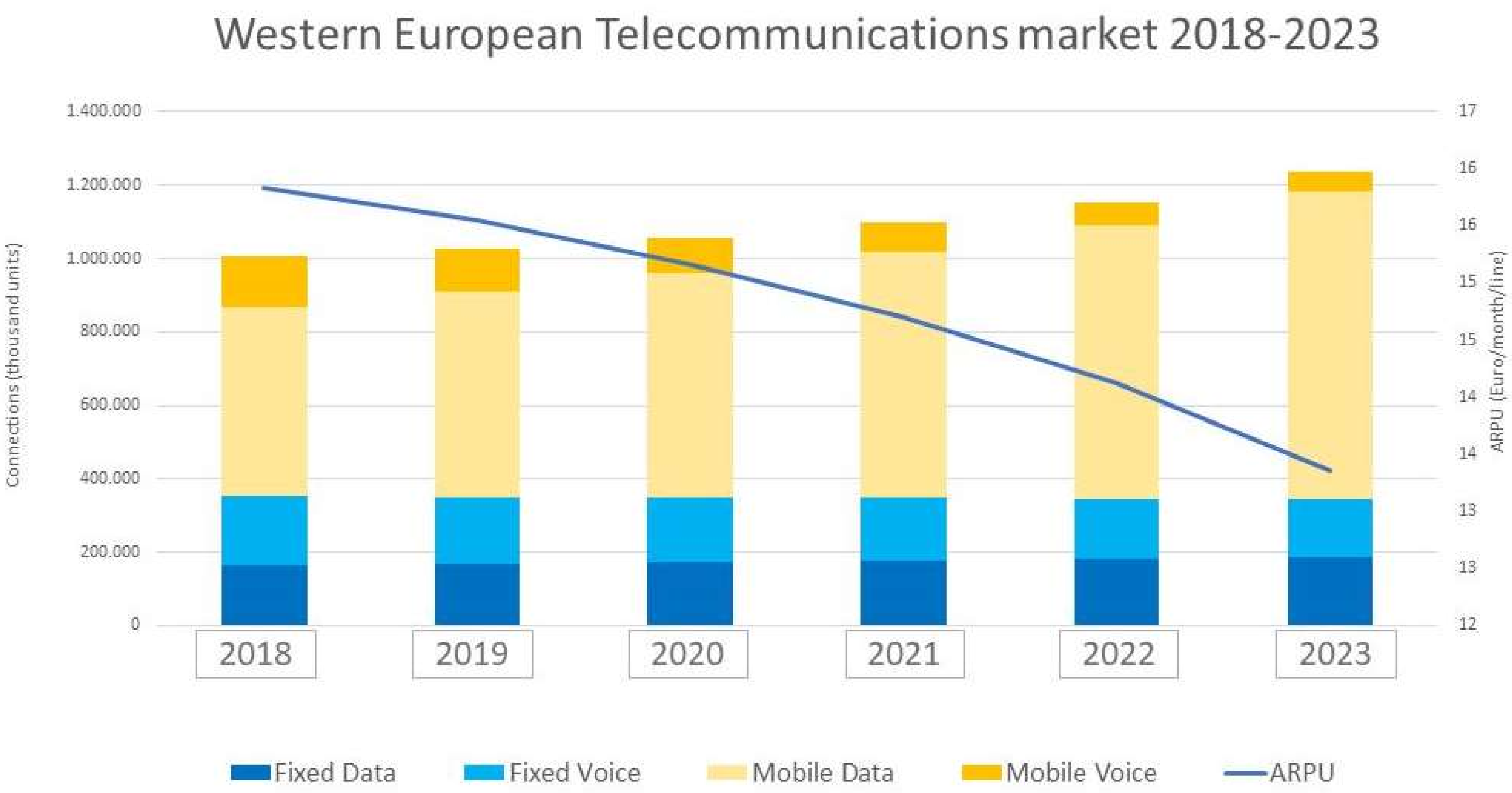
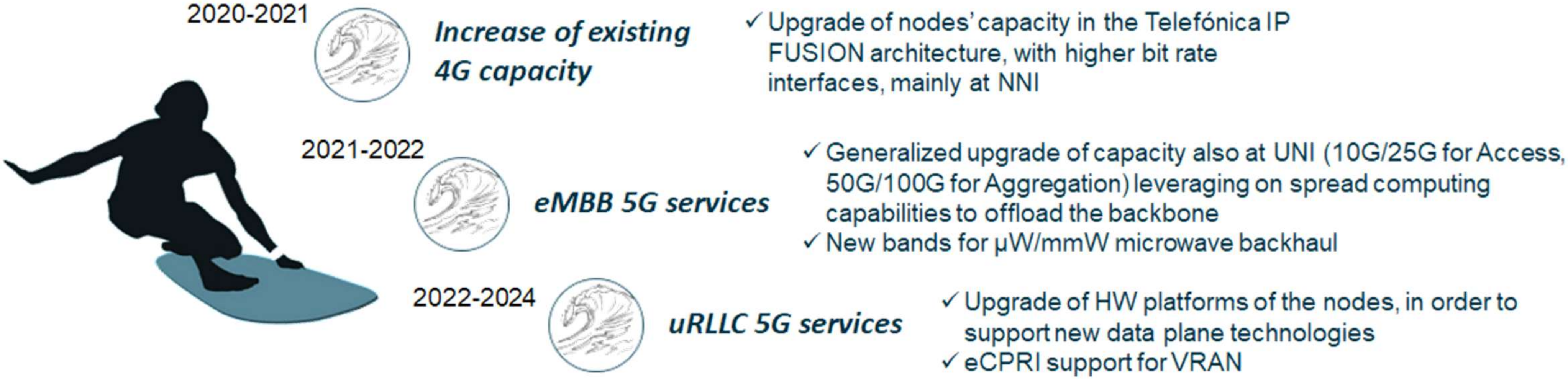


- From 2018 to 2023 the **ARPU** will **decrease** at a **rate of 3%,** despite the growth of the number of connections.
- The evolution of the **ecosystem** is becoming complex, **constantly changing** and with **new actors** appearing.
- New **monetization** schemas should be defined in order to make the situation sustainable, **otherwise investments** can **slow down** and delay the evolution of the Networks towards the post 5G-era.

Source: IDC

What is the forthcoming investment cycle

- Multi-annual investment plans, typically for 3 – 5 years, for network simplification and rationalization



- Beyond-5G will probably force (again) the change of HW platforms, together with the need of consolidating standard abstraction models
- Pre-B5G solutions could start being incorporated in the second cycles from now, according to market development

Conclusions

Conclusions

- The trend in the new telecommunications ecosystems is the interaction and integration with third parties for services, applications and infrastructures
  - Several technical implications can be identified in advance that should be solved for making post-5G services to have success
- Novel post-5G services will imply (most probably) some change of the network operator assets.
  - New HW & SW capabilities will be required for new kind of services (e.g., high precission, qualitative services, etc).
  - Investment cycles will be stressed by the need of renewing the Networks to support 5G in an scenario of decreasing ARPU
- Technical advances should come accompanied by new schemas for sustainability

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