Smart Networks In The Context of Next Generation Internet

(European Technology Platform NetWorld2020 Final Report)

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Outline

- Smart networks

- Network architecture and control

- Optical networks

- Human-Centric services

- Future emerging technologies

Smart Networks

Smart Networks

- Foundation of human centric Internet

- Energy-efficient and high-performance infrastructure for NGI

- Intelligent software: AI/ML

- Decentralized and automated management, data analytics

- Shared contexts and knowledge

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Network Architecture and Control

Network Architecture and Control
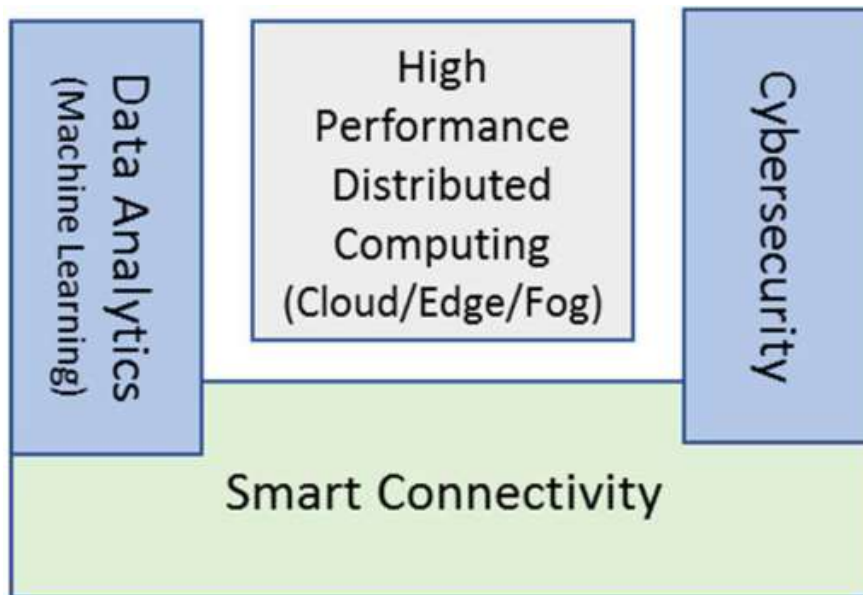
- Vision: Unifying control framework

Network Architecture and Control

- Virtualized network control for increased flexibility
- Integrated fixed-mobile architecture
- Slicing and orchestrators
- Evolution of NFV/SDN and AI/ML-based network control
- Terminal aspects
- Media access control
- Network-based localizzation

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Optical Networks

Optical Networks

- Only choice for submarine, long-haul, metro, and inter/intra DC apps

    ✓ High capacity

    ✓ Energy efficiency

    ✓ Long reach

    ✓ Reliability and EMI immunity

Optical Networks: Flexible Capacity Scaling

- Increasing traffic requires new technologies

- Coherent technologies

- To exceed Shannon's and Moore's laws:
  - ✓ Exploit all dimensions in space and frequency
  - ✓ Open new optical wavelength bands
  - ✓ Consider space division multiplexing

P. J. Winzer and D. T. Neilson, "From Scaling Disparities to Integrated Parallelism: A Decathlon for a Decade," *Journal of Lightwave Technology*, vol. 35, no. 5, pp. 1099-1115, March 2017.

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Optical Networks: New Switching Paradigms

- New switching schemes to meet emerging services (auto driving, AR/VR)

- Strict requirements of capacity and latency: edge and centralized clouds

- Advances in photonics allow packet switching to be practical

Optical Networks: Deterministic Networking

- Traditional Internet: best effort delivery

- Deterministic networking:

  - ✓ Assured end-to-end performance

  - ✓ Controlled physical layer performance

  - ✓ Guaranteed throughput of high-priority services

  - ✓ Guaranteed upper bound in QoS such as latency, jitter

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Optical Networks: Optical-Wireless Integration

- Optica fiber communication: ultra-large bandwidth and capacity but less mobility

- Wireless: coverage everywhere, limited frequency resources, affected by impairments

- Motivation for optical-wireless integration

Optical Networks: Automation

- Software-Defined Optical Networks: SDON

- Intent-based zero-touch provisioning

- Large number of configuration parameters: AI/ML

Optical Networks

- Security for mission critical services

- Privacy

- Ultra-high energy efficiency

Human Centric Services

Digital Service Transformation

- Next network generations brings new service capabilities

- Industry sectors such as healthcare, energy, manufacturing, telecom are experiencing digital transformation

Human-Centric Services

- Humans will be central point

- People are always connected

- Technological solutions must help people more innovative and to help evolution of digitalization

- Users are provided with great level of control, more transparent in interactions with digital services

- Human will be part of networks

- Networks must be adapted to users (i.g., follow me network)

Future Emerging Technologies

Network Infrastructure Transform

- Connectivity is not only functionality of networks

- Intelligent algorithms are part of networks

- Data generated by networks and users need to be used by networks

- Applications

Network Infrastructure Transform
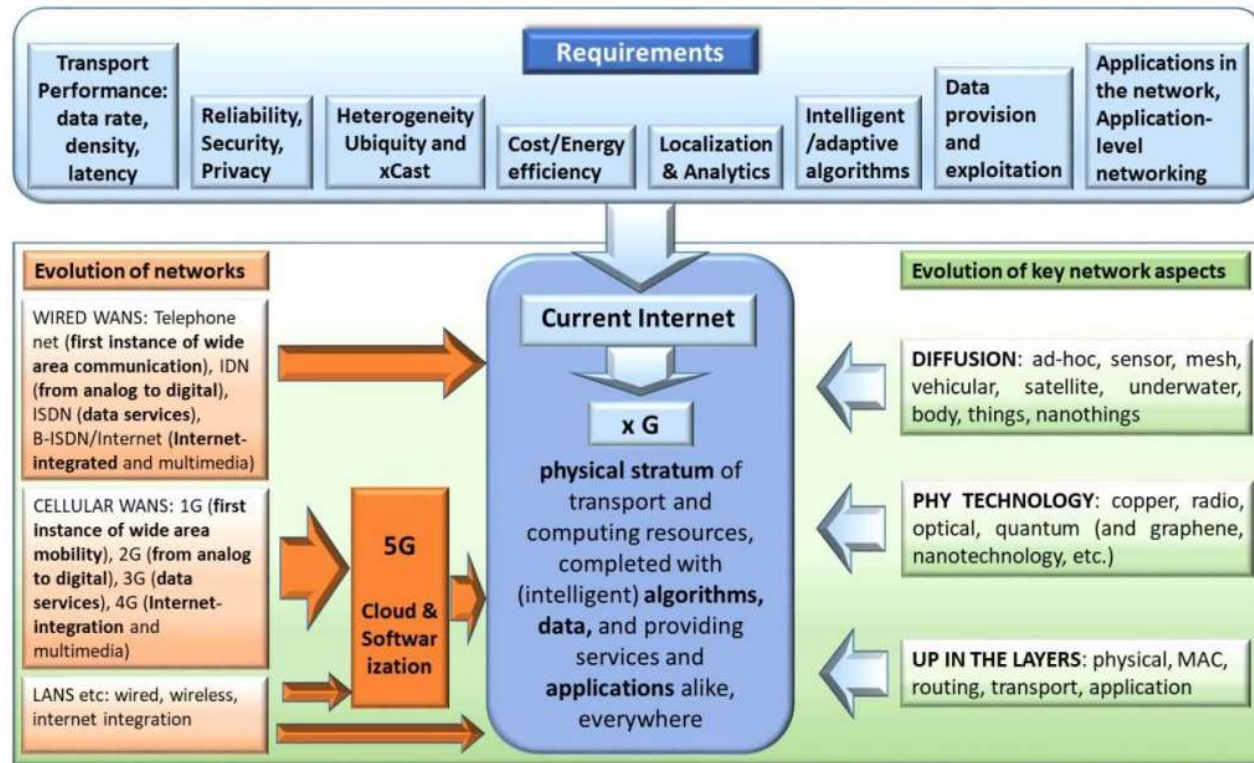
Physical Stratum

- Communication and computing resources

- Nano-thing networking: smart control to molecules and cells

- Bio-nano-thing networking: allowing embedded computing devices

- Quantum networking: connecting quantum computers

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Algorithms and Data

- Impact of AI/ML: motivated by available data and network complexity

- Impact of IoT: seamless integration for applications to access IoT resources

Evolution of Protocols

- Achieving ultra-low latency and throughput as most important goal

- Bottleneck can be at access links or core interconnections

- New access technologies: Visible Light Comm., Millimetre-Wave, WiFi

- New Internet communication pattern: connecting to nearest CDN

- More flexibility of network devices and software

- Security, privacy, and trust is a necessity

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Applications

- Dominant video (AR/VR, Internet TV) traffic: > 75% traffic in 2017
- Real-time sensor data, machine-to-machine networks
- Networking paradigm:
  - ✓ highly distributed content, storage, processing, and delivery
  - ✓ Security challenges are immense
  - ✓ While maintain privacy

In Summary

- Advances in technology and emerging services require us to transform networking paradigms

- Next-generation networks will focus on improving user experience

- Connectivity, intelligent algorithms, data, and applications will be part of networks