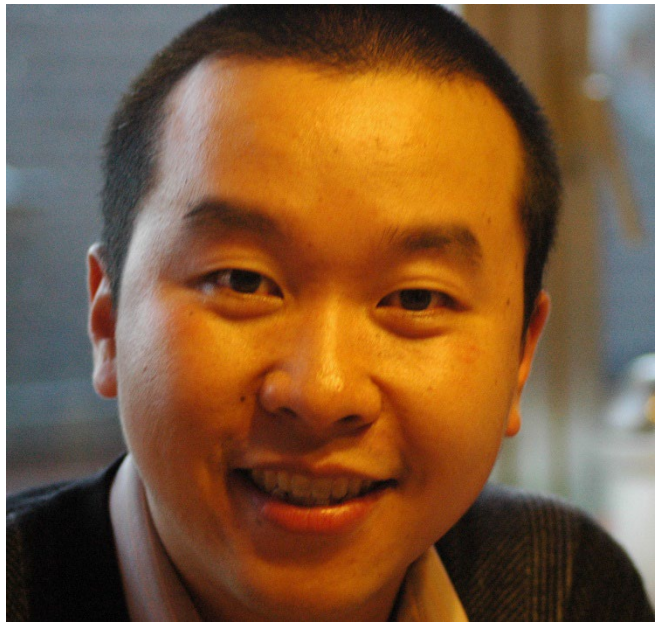
14TH ITU ACADEMIC CONFERENCE

ITU KALEIDOSCOPE
ACCRA 2022

Towards a more flexible networking landscape

7-9 December 2022
Accra, Ghana



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Session 1 – Some Perspectives on Future Networks
Paper S1.3

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Emerging Apps Demanding New NW Capabilities

Mobile Network

5G ready and 6G arises

TABLE 1 A comparison of 5G and 6G KPIs.

Source: 6G THE NEXT FRONTIER

KPI	5G	6G
Traffic capacity	10 Mb/s/m^2	~ 1–10 Gb/s/m^3
Data rate: downlink	20 Gb/s	1 Tb/s
Data rate: uplink	10 Gb/s	1 Tb/s
Uniform user experience	50 Mb/s, 2D everywhere	10 Gb/s, 3D everywhere
Latency (radio interface)	1 ms	0.1 ms
Jitter	NS	1 μs
Reliability (frame error rate)	1–10^{-5}	1–10^{-9}
Energy/bit	NS	1 pJ/b
Localization precision	10 cm in 2D	1 cm in 3D

NS: not specified.

- **New Terminals:** XR, Holographic Teleportation, Autonomous Vehicles, UAVs, for boosted user experiences via senses.
- **Internet of All:** Fully connected intelligent world, with reliable, real-time, high-throughput, agile connectivity.
- **Integrated Many Networks:** Spatial, Aerial, Maritime, and Terrestrial Networks, with global mobility.
- **Security and Privacy:** Human-centric networks with balanced high security and privacy.

Industry Networks

From Best-Effort to SLA-guaranteed Services

Hologram

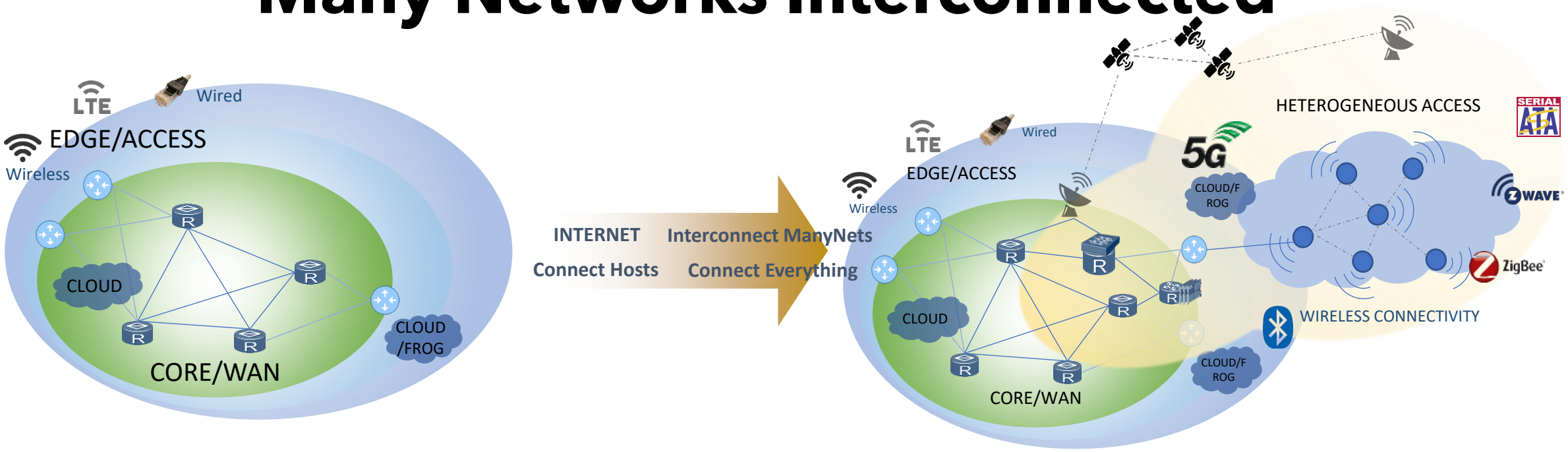
UAV/ITS

Smart Manufacture

Tele-Medical

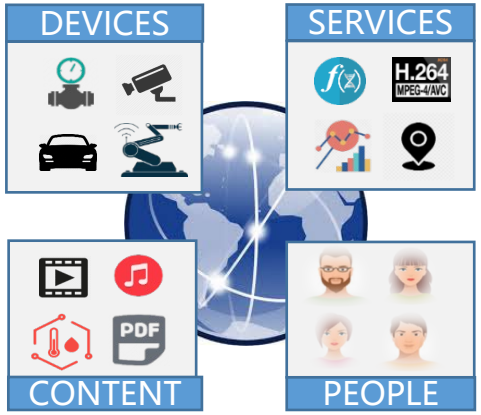
- **Deterministic Services with Guaranteed QoS:** Machined-centric communications demand extremely low latency and real-time data delivery, with AI-powered autonomous functionalities, to achieve SLA guaranteed information exchange.
- **Intrinsic Security:** Immune to existing cyber attacks and intelligent to prevent potential unknown attacks.

Many Networks Interconnected



Ubiquitously connect massive of physical entities, such as smart terminals, sensors, wearables, vehicles, and industrial control devices

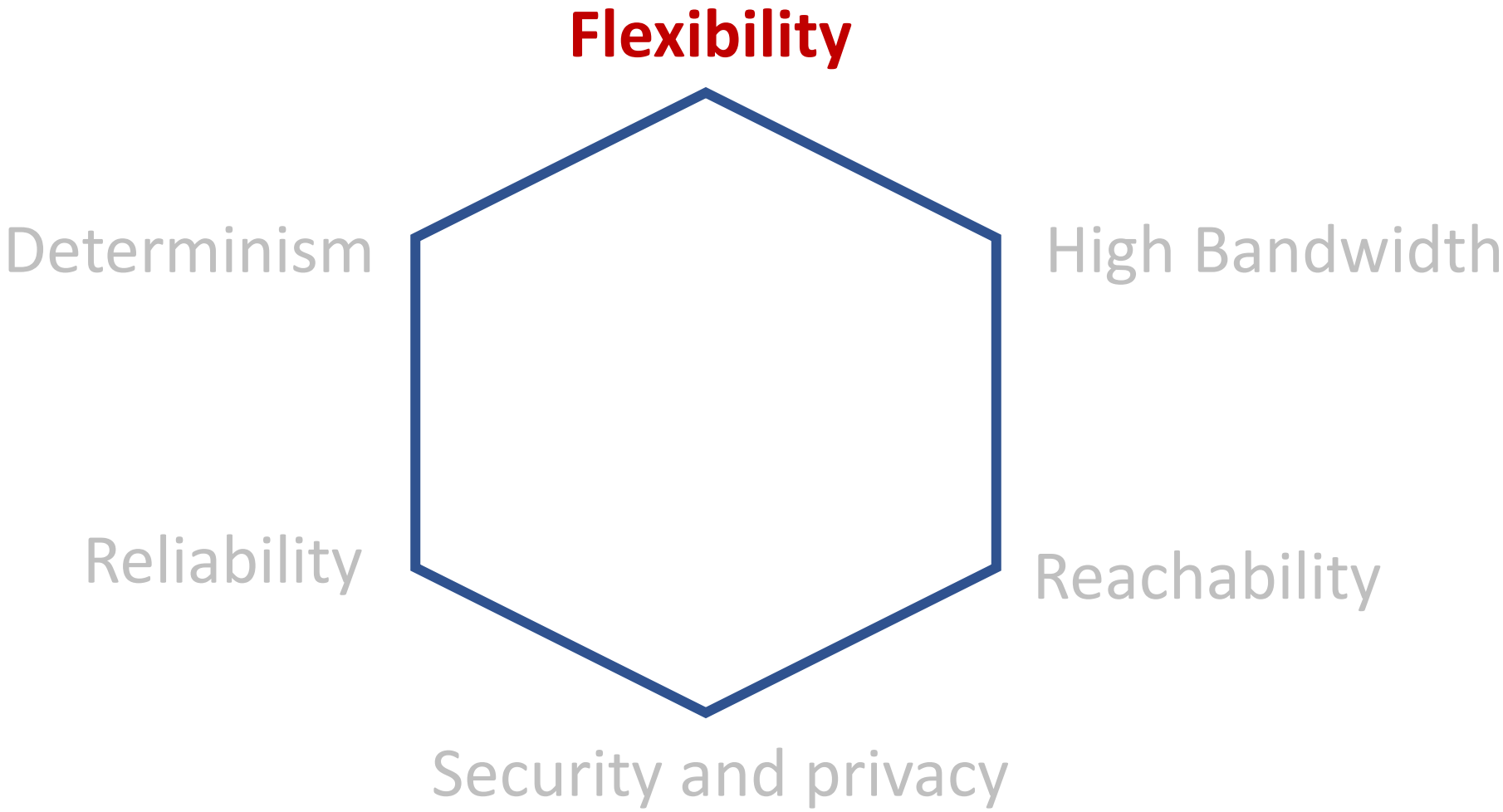
The content in the network acts as an independent communication entity and is no longer bound to specific locations or specific hosts.



The in-network computing and AI technology will let the service resources, such as micro-services, processes, etc, become virtual communication entities

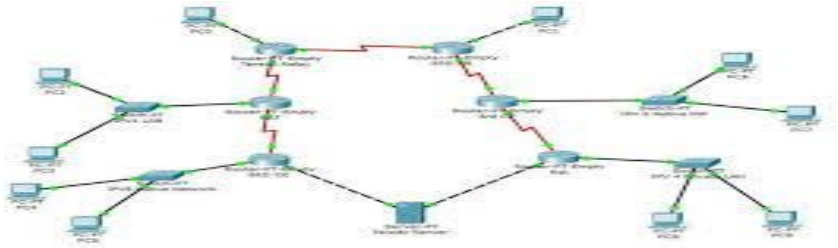
The network needs to provide specific QoS and security policies based on user identity, rather than mapping to something instead.

Network Capability Hexagon

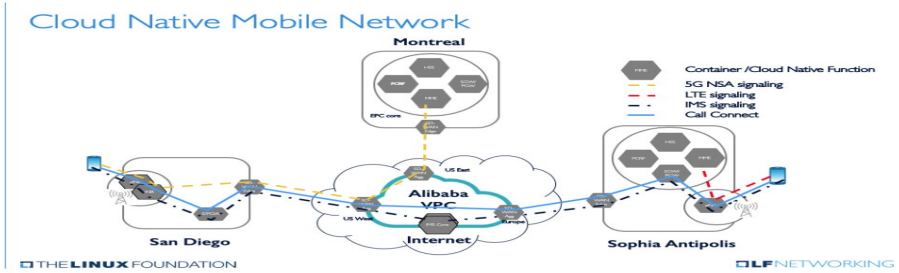


Four Key Areas

Network Configuration and Adaptability

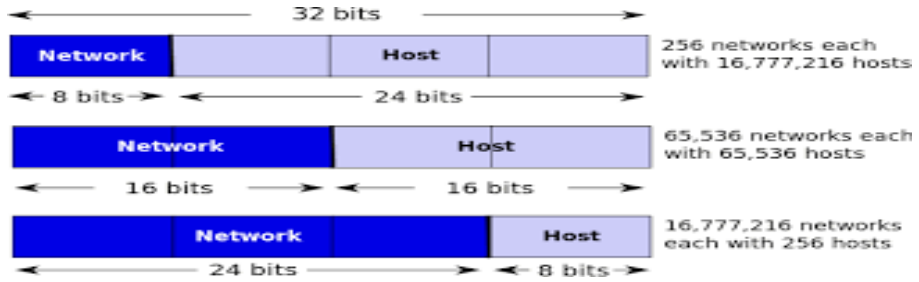


Cloud Native Network



Network Softwarization

Network Addressing



Network Configuration and Adaptability

- Network Automation
  - Although centralization simplifies the implementation of the network management systems, it is less flexible to adopt changes and optimizations
  - Decentralization is required to enable adaptive behavior and realize network automation, as it allows timely detection of events and swift computation and enforcement of appropriate remedy actions
  - Key challenges are to design of light-weigh telemetry mechanisms, striking the right balance between accuracy and overhead
- High Level Programmability
  - Programming control information in the header contains security risks
  - Policy based management technologies are limited to specific domains and patterns
  - SDN C/U separation empowers operators with a highly flexible approach to control the network behavior.
  - Data plane programmability enables more freedom on network programmability, though the P4 language still stays in fairly low level
  - Key challenges
    - A generalized intent decomposition mechanism
    - The incorporation of feedback to ensure the continuous enforcement of intent
    - The automated selection of the most appropriate action(s) to execute for achieving a specific objective
    - Tools to ensure configuration consistency

Cloud Native Networking

- Cloud Computing
  - Cloud computing is elastic and scalable
  - Centrally located clouds imply network and processing latencies, as well as inefficiencies and cost implications of transferring data over large distances
  - It becomes a relative “easy” target for cyber attacks
  - Key challenges
    - Resource management algorithms should treat different resource types jointly
- Edge Computing
  - Edge computing reduces traffic footprint and enables better resilience to failures and attacks
  - There needs to be seamless integration between communication and computation
  - A cloud native approach is needed, hiding the underlying heterogeneous infrastructure by operating on small containers
  - Key challenges
    - Design of models and architectures for effective federation of resources across providers
    - Warrant the confinement of data within the boundaries defined by specific laws and regulations, e.g. GDPR.

Network Softwarization

- Network Function Virtualization (NFV)
  - It replaces network equipment like load balancers and firewalls with software modules running on commodity hardware
  - It allows network functions to be created and migrated according to the needs
  - It enables the dynamic scaling of resources allocated to network functions
- Software Defined Network (SDN)
  - SDN moves control functions outside network devices into dedicated controller entities
  - It simplifies network management tasks and allows advanced network intelligence to be flexibly added to controllers without needing to upgrade network devices
- Key Challenges
  - The design and development of a fully-fledged operating system (OS) for networks
  - Derivation of functionalities and facilities should be common for all services in order to support the reusability.

Network Addressing

- Low Power IoT Networks
  - IPv4 or IPv6 contains large overhead for IoT communication
  - Existing solutions require expensive address translation/mapping and less efficient for outward communication
  - A more flexible addressing scheme with variable length is desired
- Highly Dynamic Network Topologies
  - The existing semantic rigid IP address poses significant challenges to highly dynamic network topologies (e.g. satellite network, vehicle network, etc.)
  - A flexible addressing scheme allowing for richer semantics is desired
- Key Challenges
  - Design of a more elastic and semantic-rich addressing scheme and associated mechanism to support low power and highly dynamic networks

Conclusions

- Flexibility is a key property that future networks should exhibit in order to overcome important limitations of current networking landscape
- In the area of network management and configuration, decentralization and high programmability are key elements to support network automation
- A cloud native approach is desired to hide the underlying heterogeneous infrastructure from network operation
- The design of a fully-fledged network operating system (OS) could further extend the capabilities of SDN and NFV
- A highly flexible addressing scheme is required to support the network communication

Thank you!