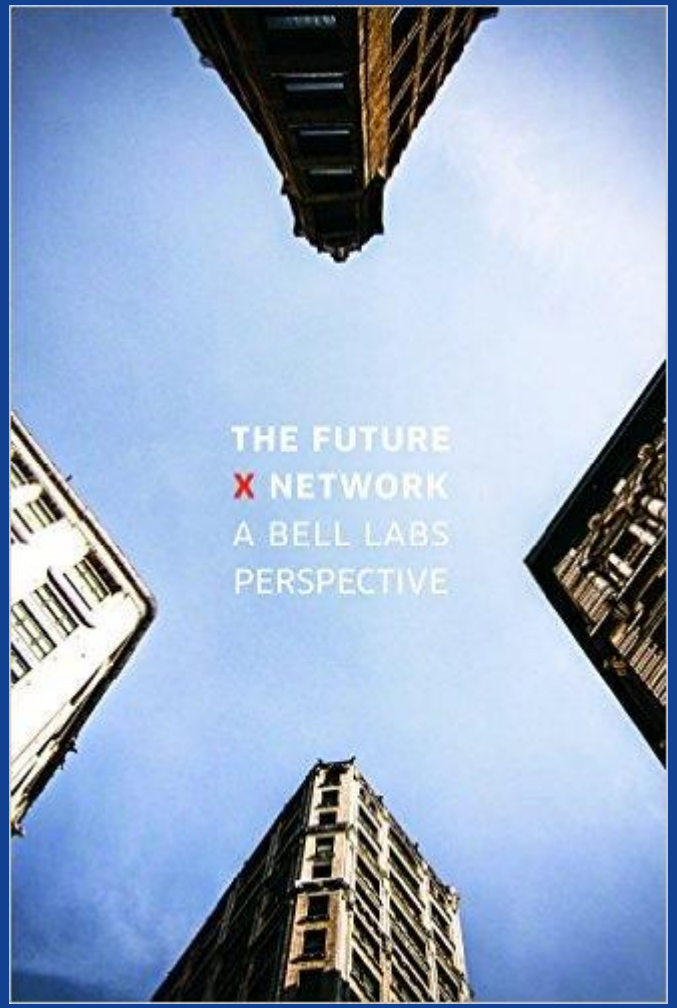
NOKIA Bell Labs

# The Future X Network

## (and its critical role in new value creation)




Marcus Weldon

President of Bell Labs & CTO of Nokia

# The Simple Formula

$$1 + 1 + 1 = 11 \rightarrow 11 + 111$$

# The revolution

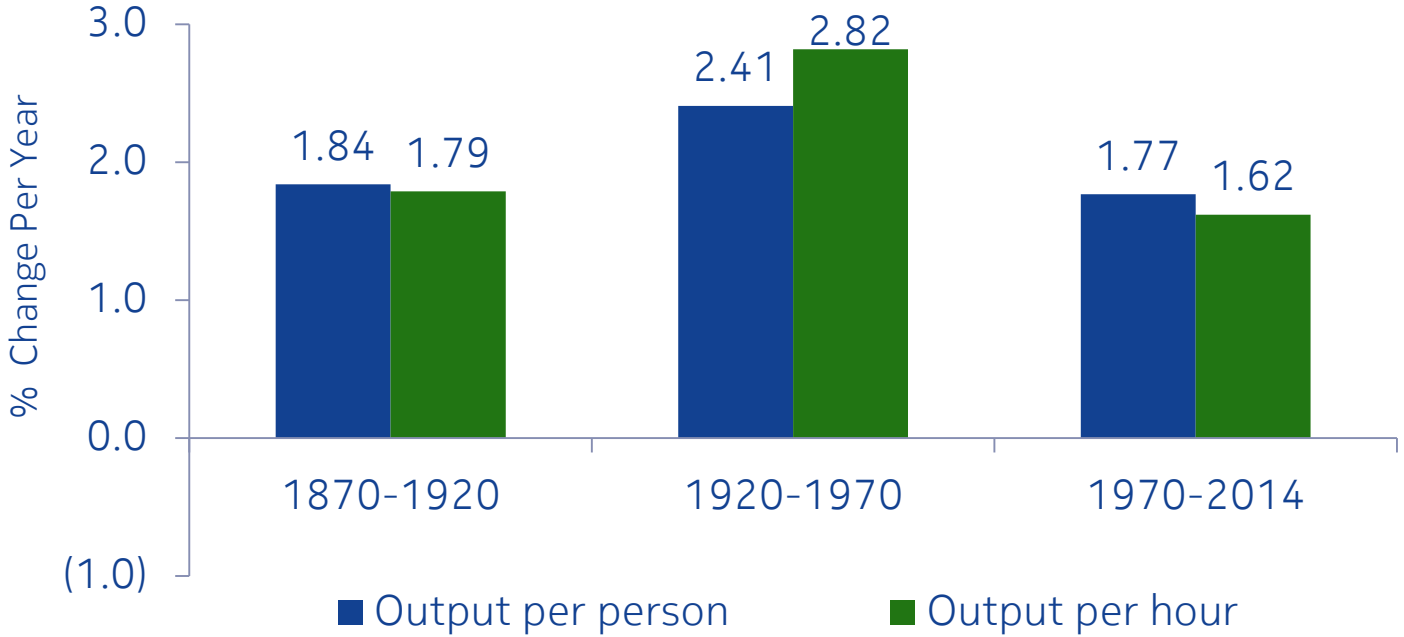
## Technological Revolution (def):

Interconnection of new systems and technologies + capacity to profoundly transform economies & society

| Tech. Revolution | Enabling Technology | Connectivity |
|---|---|---|
| Financial (1600 – 1740) | Stocks & Bonds | Banking & Stock Market Infrastructure |
| 1st Industrial (1780 – 1840) | Steam Engine & Iron Production | Rail and Shipping Networks |
| 2nd Industrial (1880 – 1920) | Steel & Chemicals | Extended Transportation Networks<br>Electricity & Telecom Networks |
| Scientific-Technical (1940 – 1970) | Analog & Digital Signal processing | Digital Communications Networks |
| Information (1985 – 2015) | The Web, Cloud computing & Mobile devices | Internet & Broadband Access |
| **Automation of Everything (2015 –)** | **Digital interfaces & Data analysis** | **Future X Network** |

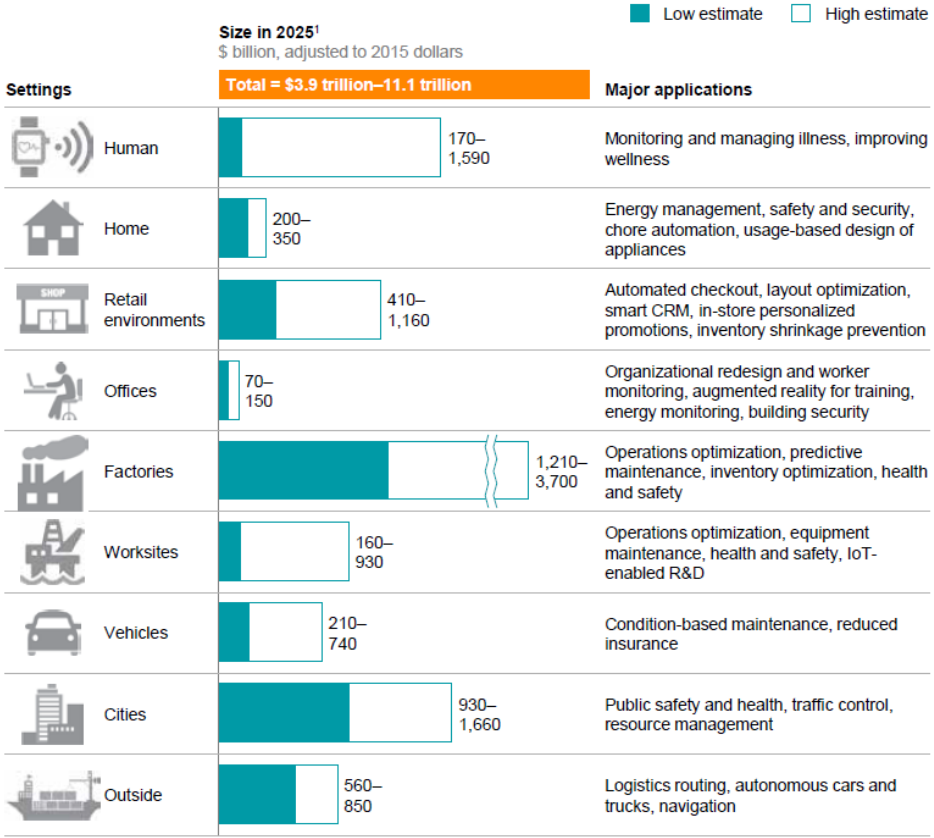
We are here

# The quest for digital value (1/2)




*Source: Robert Gordon, The rise and fall of American growth (adapted by Mark Gordon, Chief Economist, E&Y)*

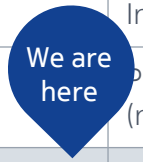
# The quest for digital value (2/2)




*Source: McKinsey Global Institute, The Internet of Things: Mapping the Value Beyond the Hype, June 2015*

# The end and the beginning

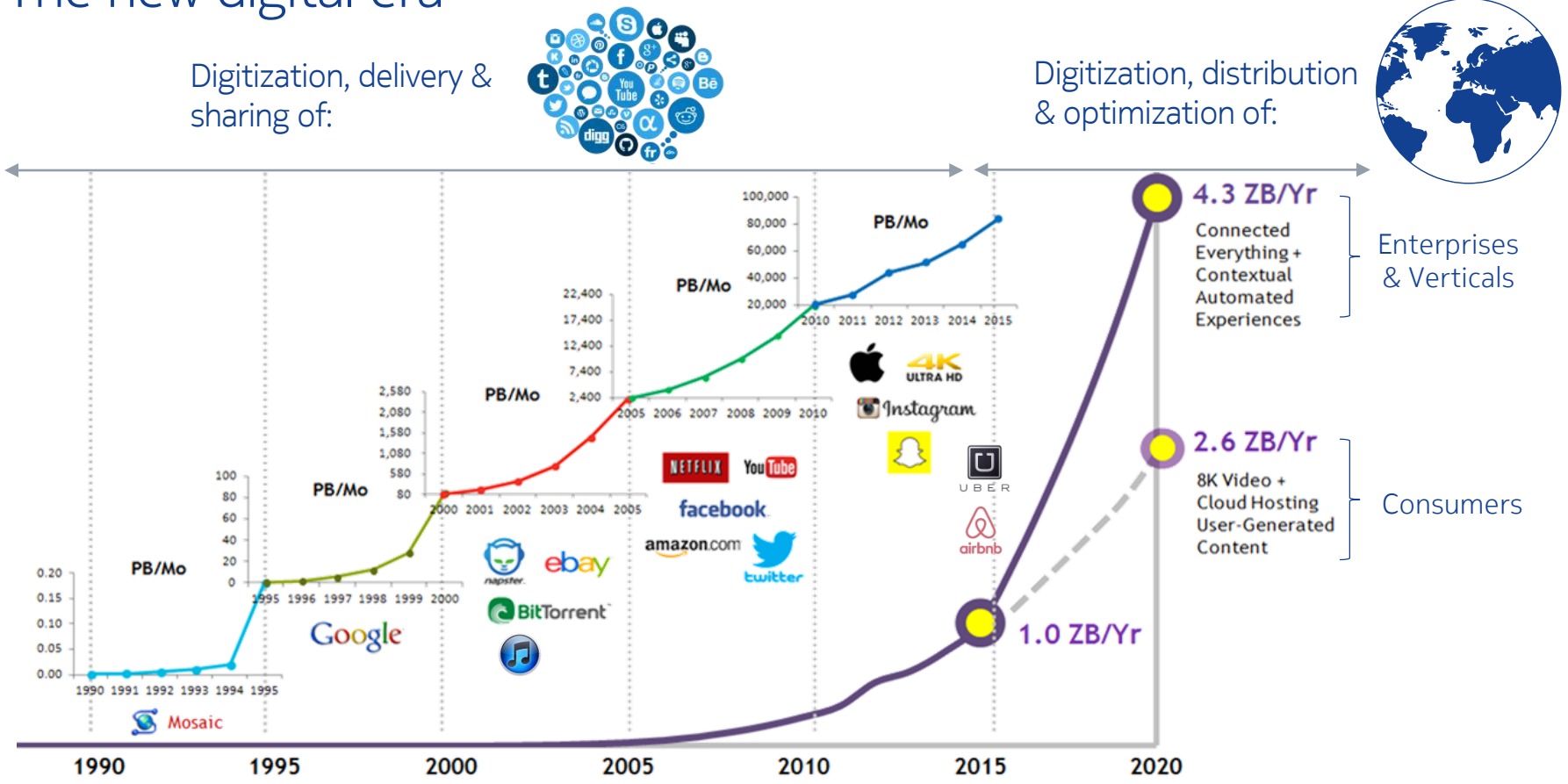
| | | Past/Present | Future |
|---|---|---|---|
| Business | Solutions | Technology-driven | Human/Business-driven |
| | Driver | Consumer (GB) | Industry (BW, Latency, SLA) |
| | Innovation Speed | Per decade<br>(new services) | Per day<br>(new apps) |
| Technology | Architecture | Heavily Centralized (100ms, 10M) | Massively Distributed (1ms, 1G) |
| | Flexibility | Limited<br>(Provisioned) | Large<br>(Software definable) |
| | Sharing | Static and Limited<br>(HW VPNs ) | Dynamic and Infinite<br>(SW Slices) |
| Industry Dynamic | Investment | Singular<br>(Operator only) | Multiple & Cooperative<br>(Many contributors/new players) |
| | Standards | Definitive | Iterative |
| | Partnership | Limited w/APIs | Co-design w/Open specs |



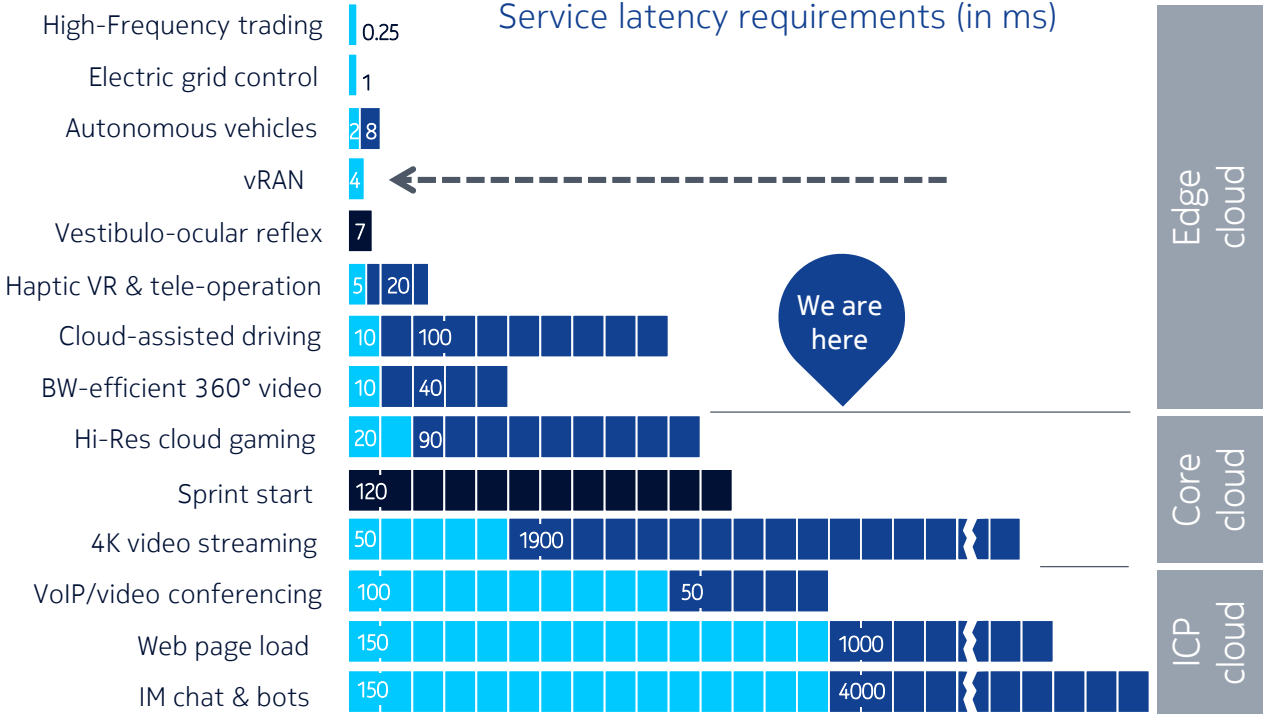


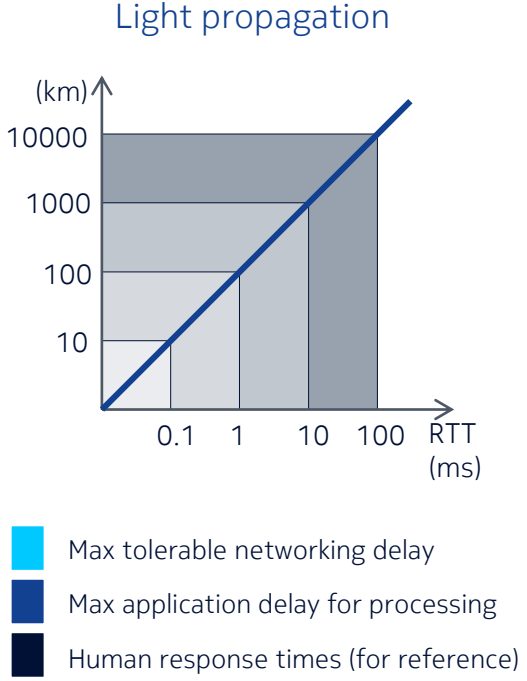

NOKIA

# The new digital era

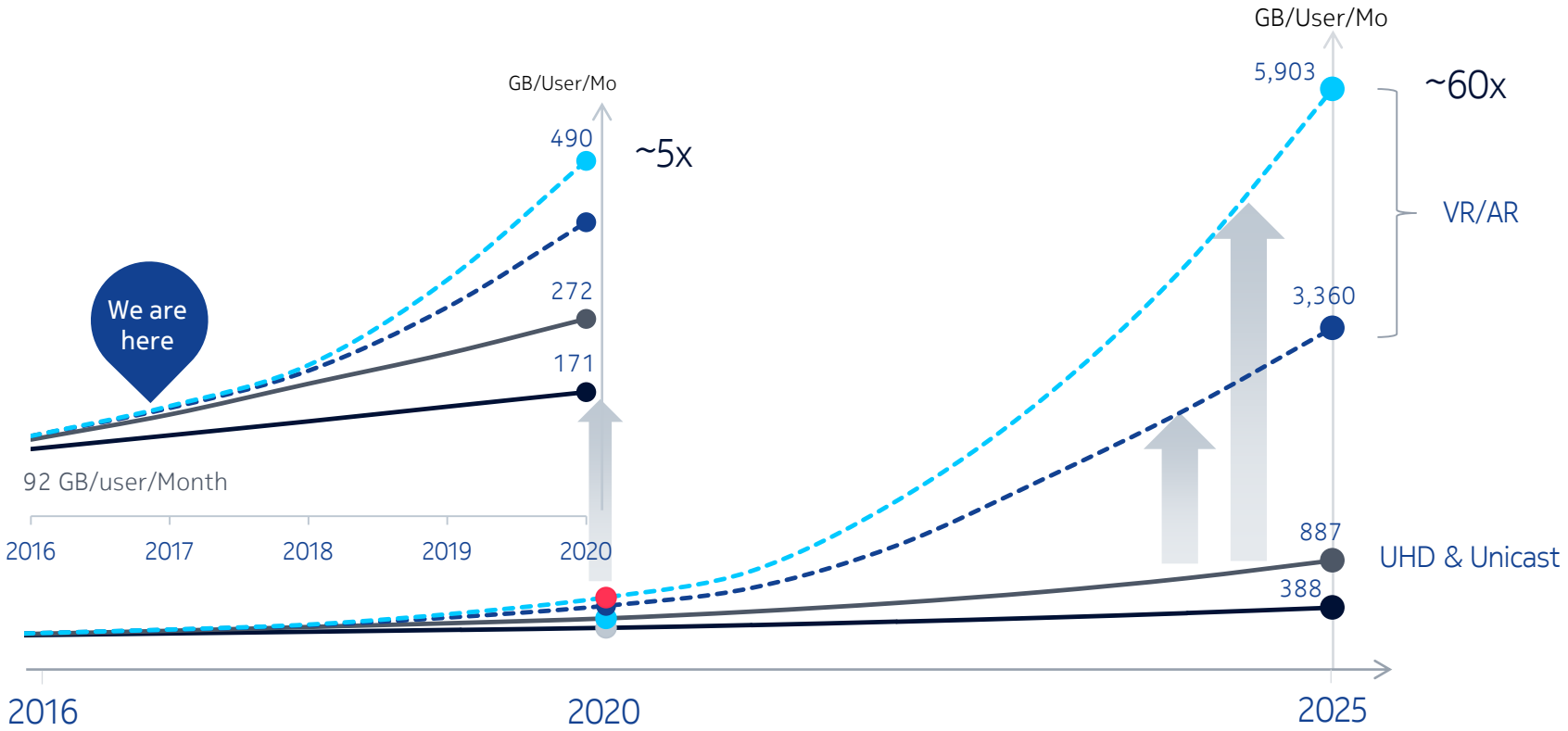


# Latency matters …

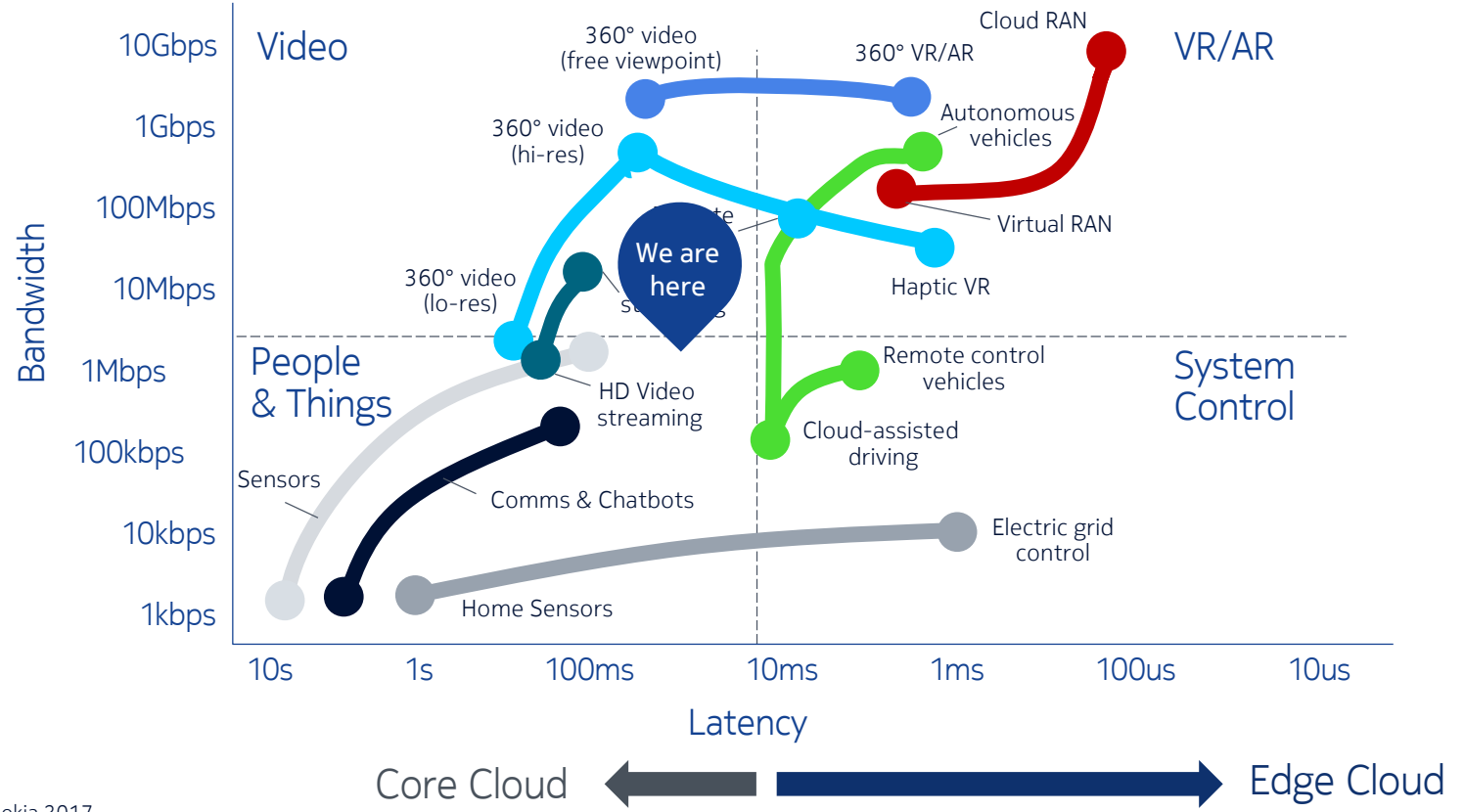


# Bandwidth matters …



# Latency & bandwidth matter …

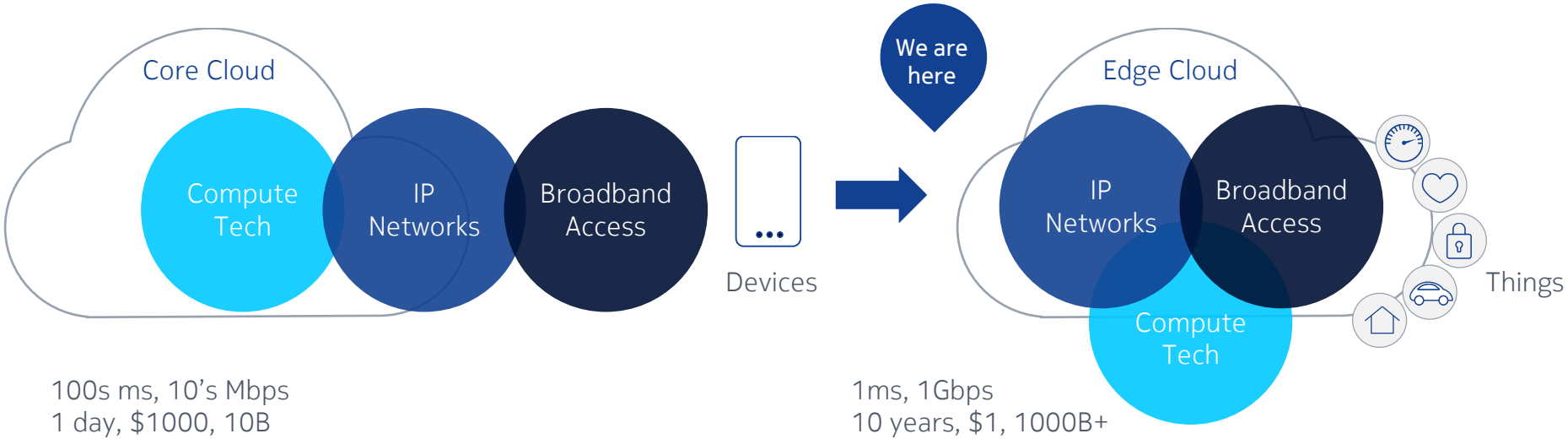


# Summary: The 100yr, 100x shift

**Enabled by:** Global reach and power; SW platforms for business model disruption, stability, non-privacy preserving & inadequately secure

**Enabled by:** Local real estate, fiber, trust, optimized HW/SW network platforms , programmability, privacy preserving, & secure




100s ms, 10's Mbps
1 day, $1000, 10B

1ms, 1Gbps
10 years, $1, 1000B+

NOKIA

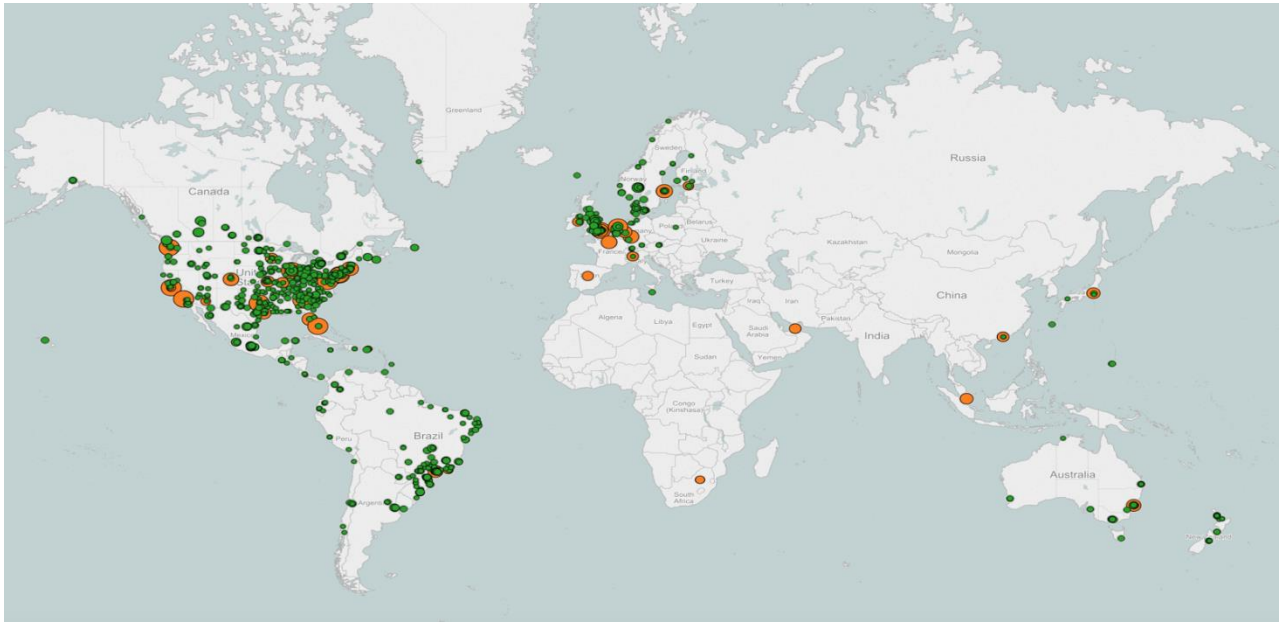
# The shift is underway (but still video centric)

2010: Global/centralized distribution only

2011: Open Connect launched

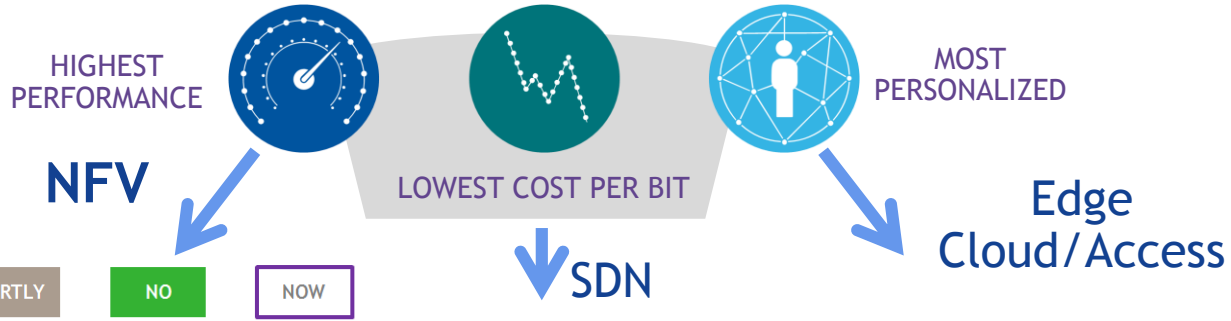
2016: 100% content locally served from ~1000 locations

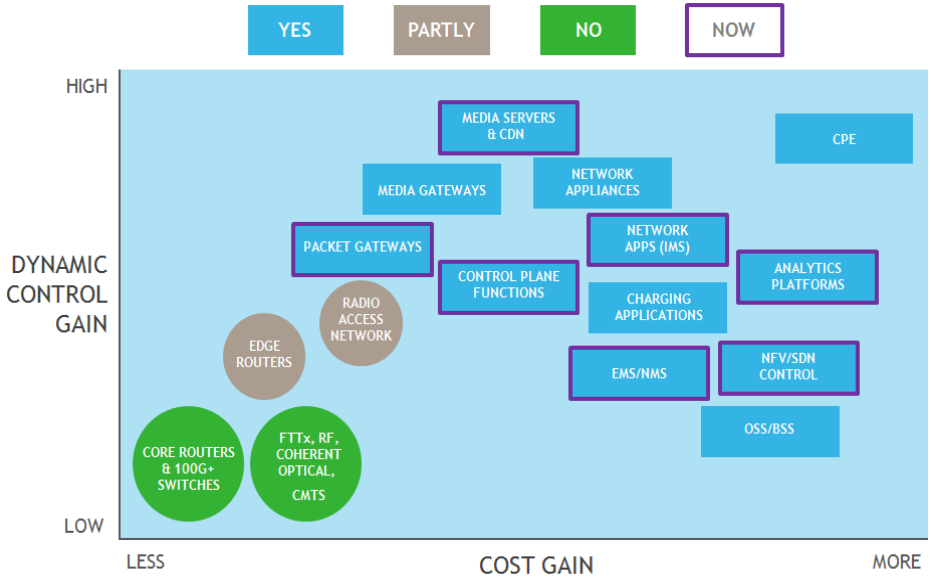
Netflix Open Connect (2011-2016)




*Source: Netflix, "How Netflix Works With ISPs Around the Globe to Deliver a Great Viewing Experience", March 17, 2016*

# Architectural Shift 1: Virtualizing the Network



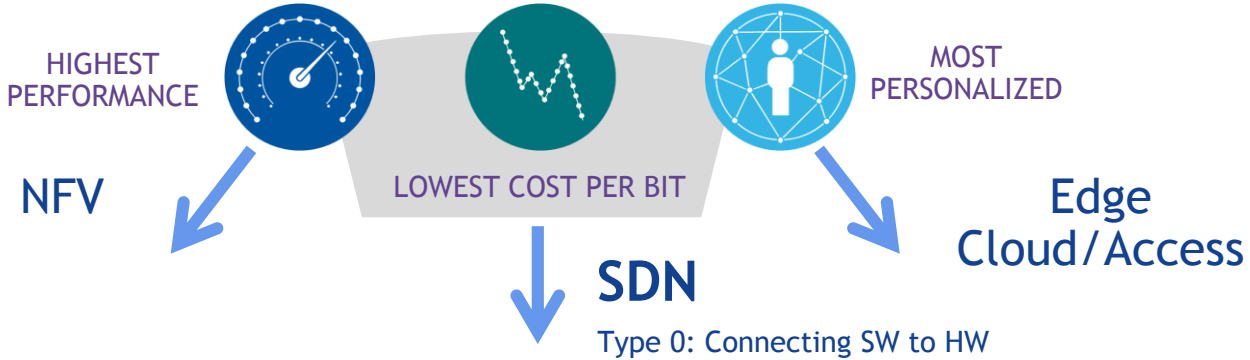

**~40 %**

CapEx & OpEx Savings

NOKIA

# Architectural Shift 2: Software-Defining the Network

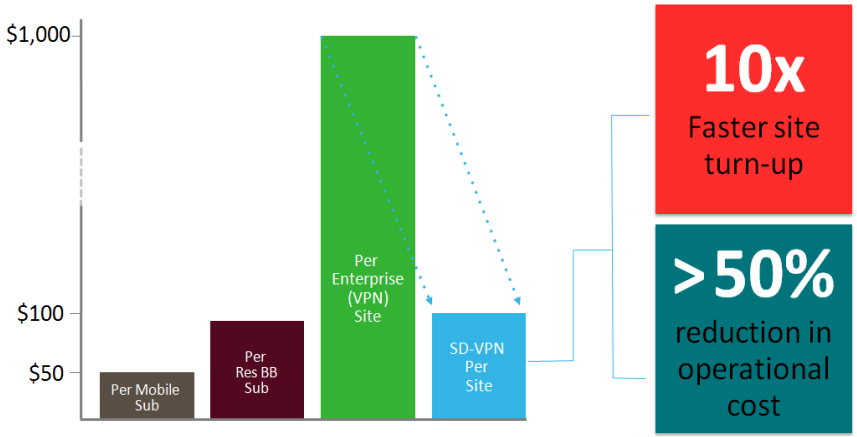



Type 2: Software-define a Network Path

**40 %**

IP + Optical CapEx Savings

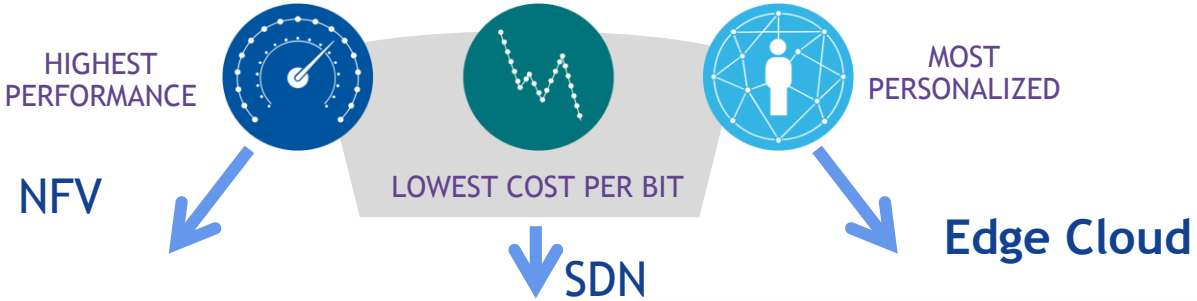
Type 1: Software-define a Service



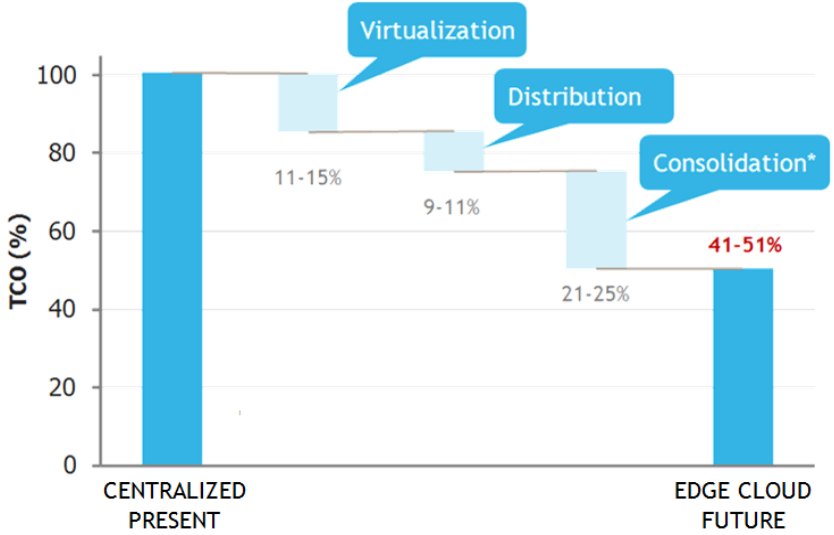
NOKIA

# Architectural Shift 3: Distributing the Cloud…in the Network




**~40 %**

CapEx & OpEx Savings



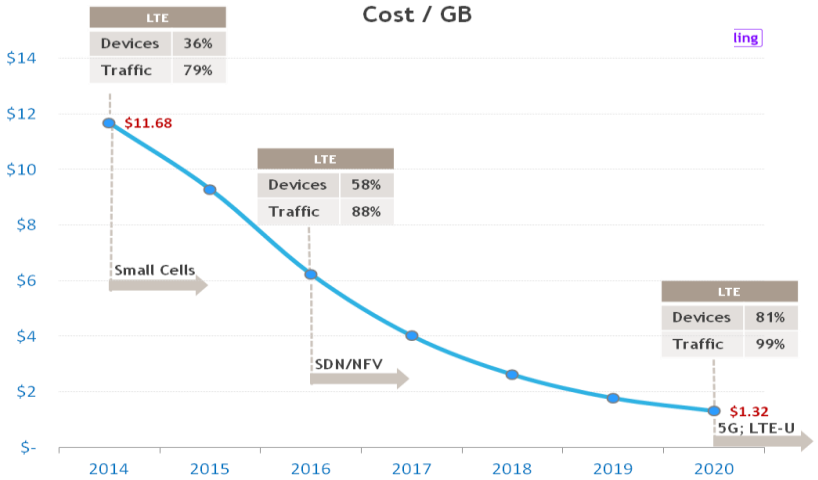

 

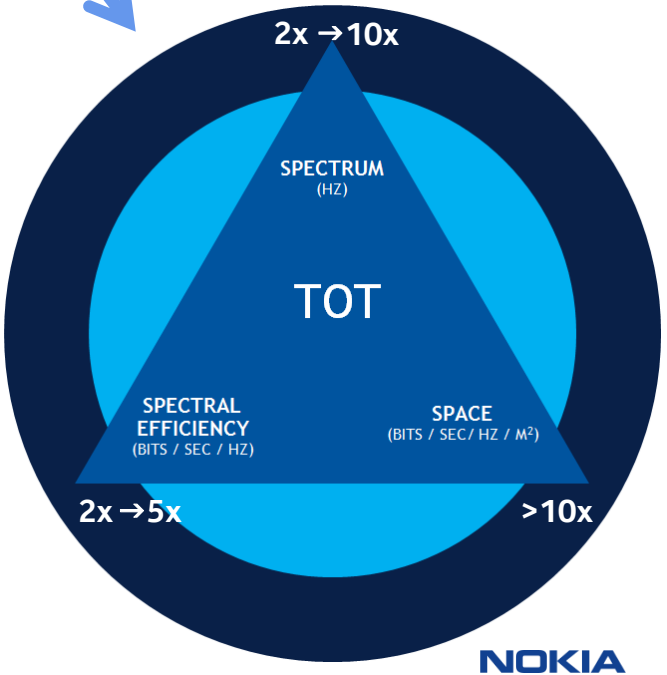
NOKIA

# Architectural Shift 4: Distributing the Access Network


**90 %**

CapEx savings by Small Cells & vRAN

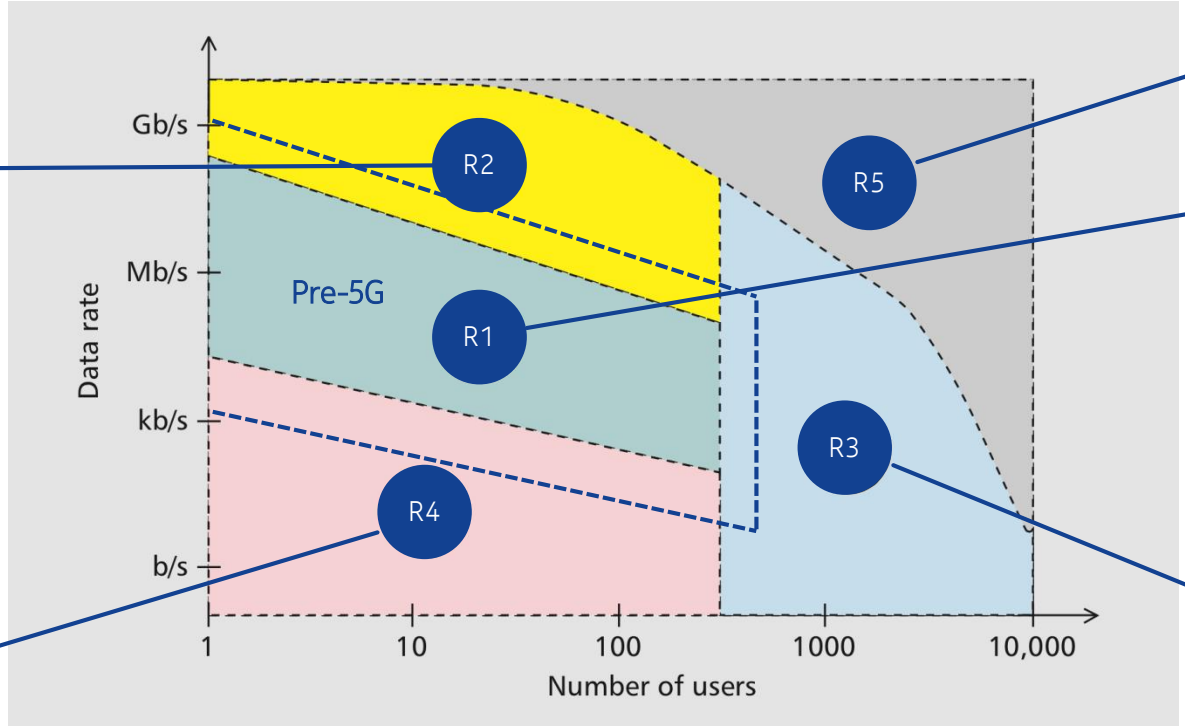


NOKIA

# Perspective on 5G




Ultra-broadband:
"VR/AR"

Forbidden region:
"Shannon Limit"

2G-4G:
"People & Video"

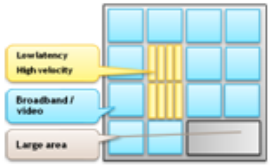
Ultra-narrowband:
"Things"

Ultra-low latency:
"System Control"

*Source: Bell Labs, adapted from F. Boccardi, T. Marzetta, IEEE Comms. Magazine, 201402*

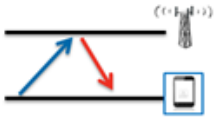
# The Future X Network: The Six Essential 5G Technologies

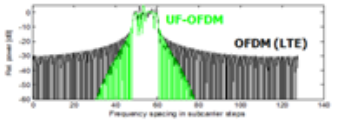
**Modular Framing Structure** for ultra-broadband, ultra-narrowband and ultra-low latency support



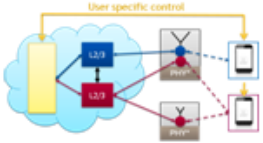

**New Air Interface:** New Waveform and control for flexible multi-service interface

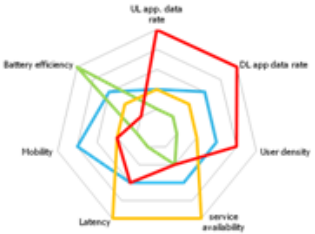
- ~2X battery life
- ~5X lower latency

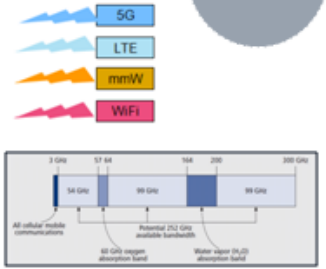





**New Virtualized + Software-Defined Core** for flexible routing through centralized, distributed, gateways optimized for any service mix

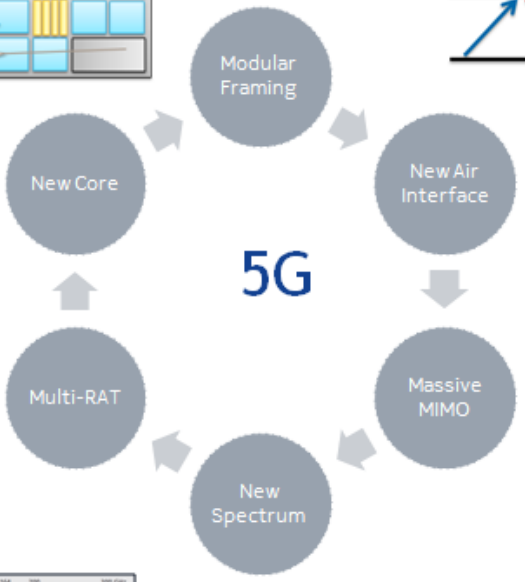


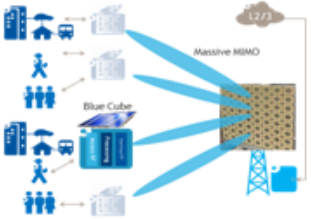

**New "mmWave" spectrum** small cells

- ~10X bandwidth




**Massive MIMO**
Higher spectral efficiency through spatial multiplexing (beamforming)

- ~5X increase in spectral efficiency




**Multi-RAT** with network controlled traffic steering and cell-less architecture

- ~2X increase data rate
- Guaranteed user/service experience

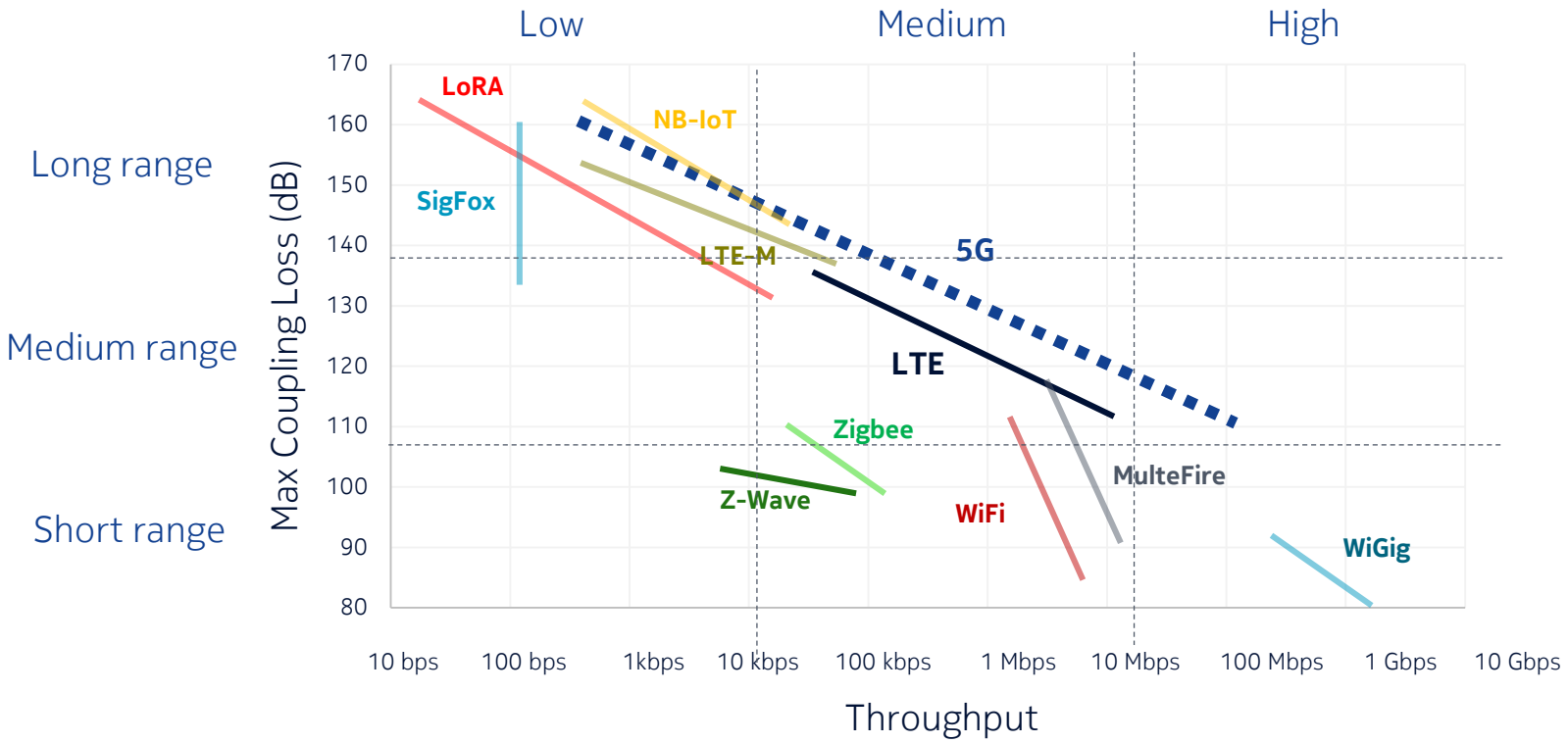






NOKIA

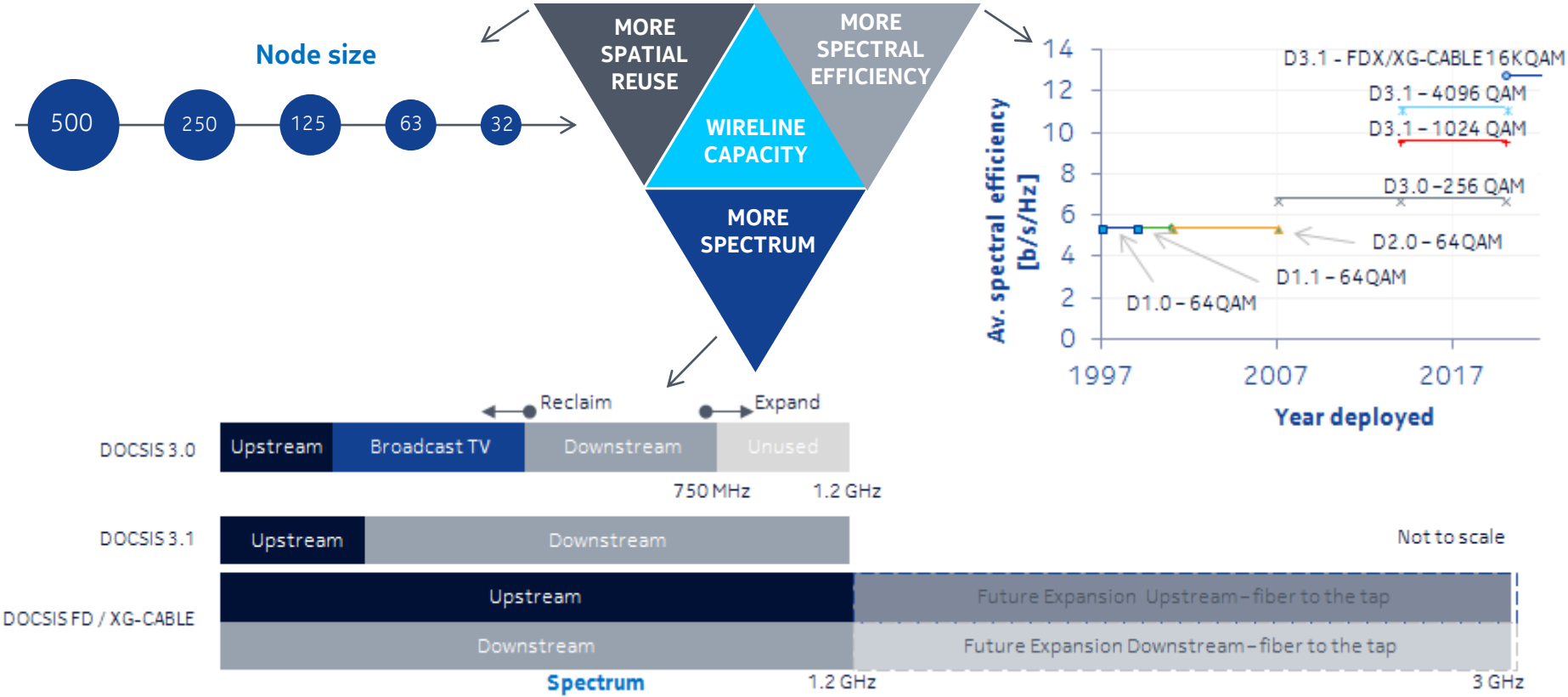
# The Future X Network: IoT technologies



NOKIA

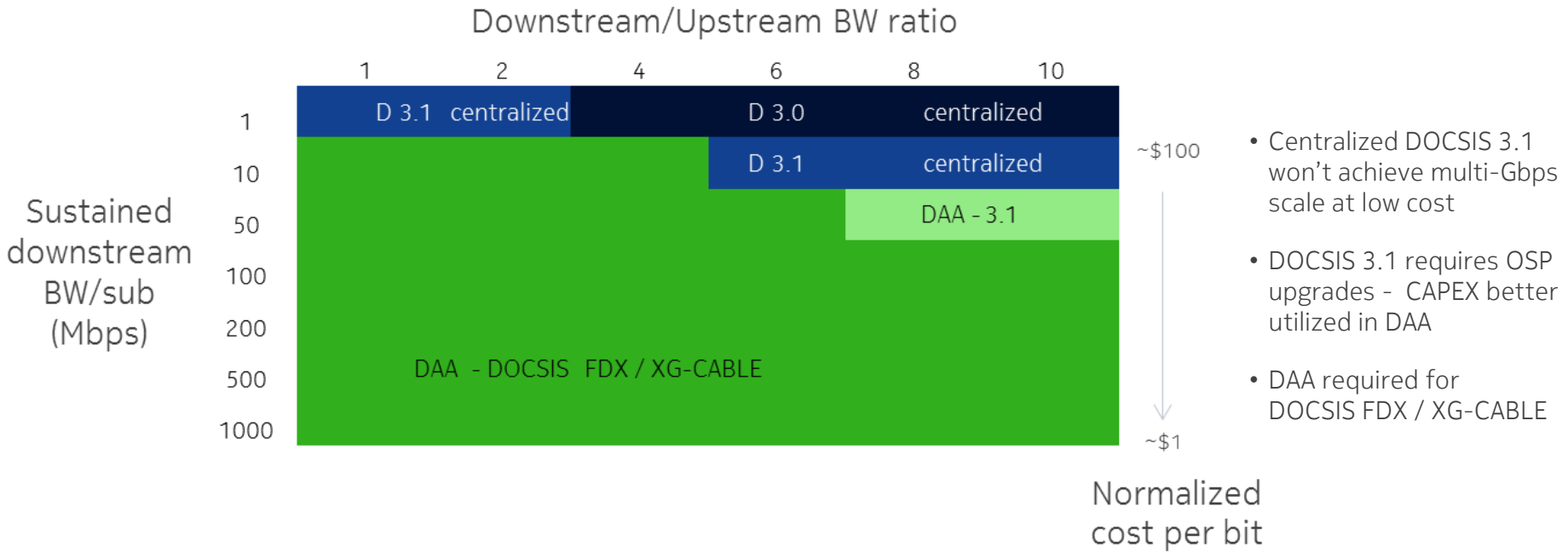
# The Future X Network: Distributing the Cable Access Network



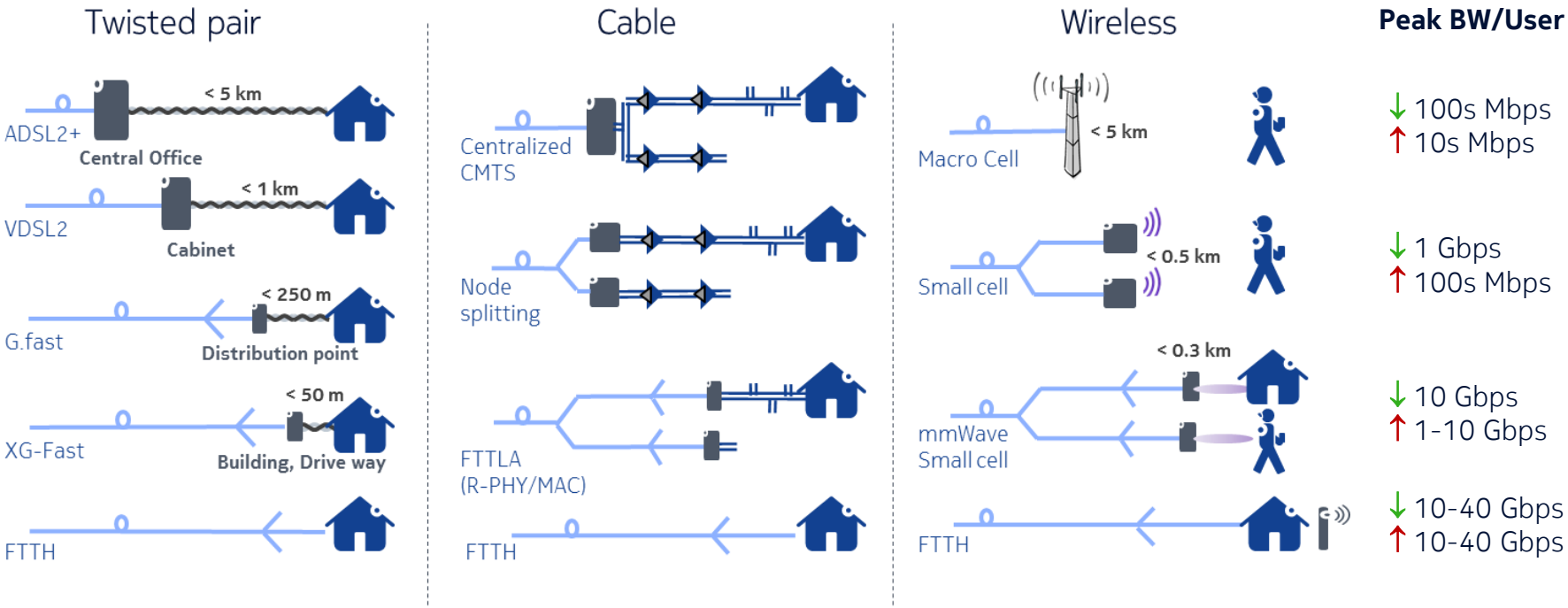
NOKIA

# The Future X Network: Optimizing cost : performance of Cable




- Centralized DOCSIS 3.1 won't achieve multi-Gbps scale at low cost
- DOCSIS 3.1 requires OSP upgrades - CAPEX better utilized in DAA
- DAA required for DOCSIS FDX / XG-CABLE

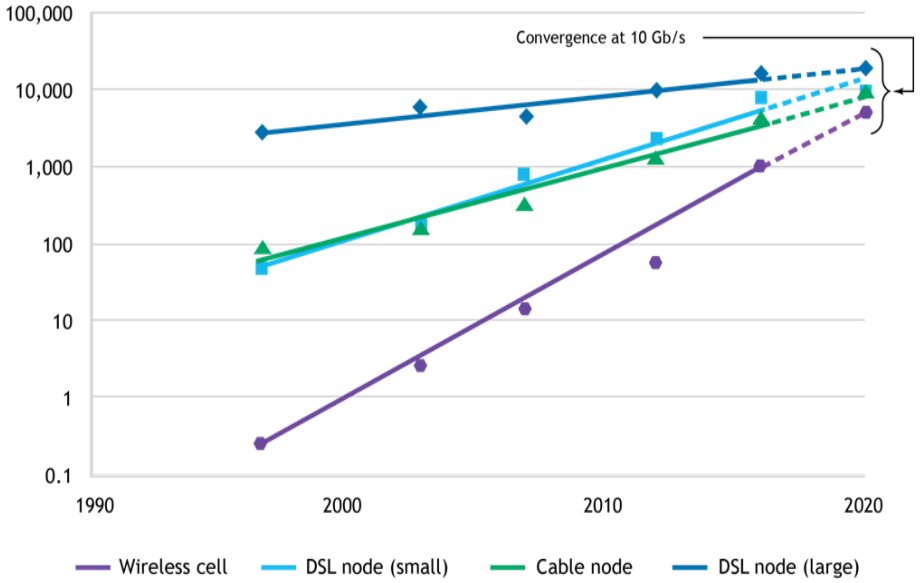
# The Future X Network: Access Convergence - Architecture

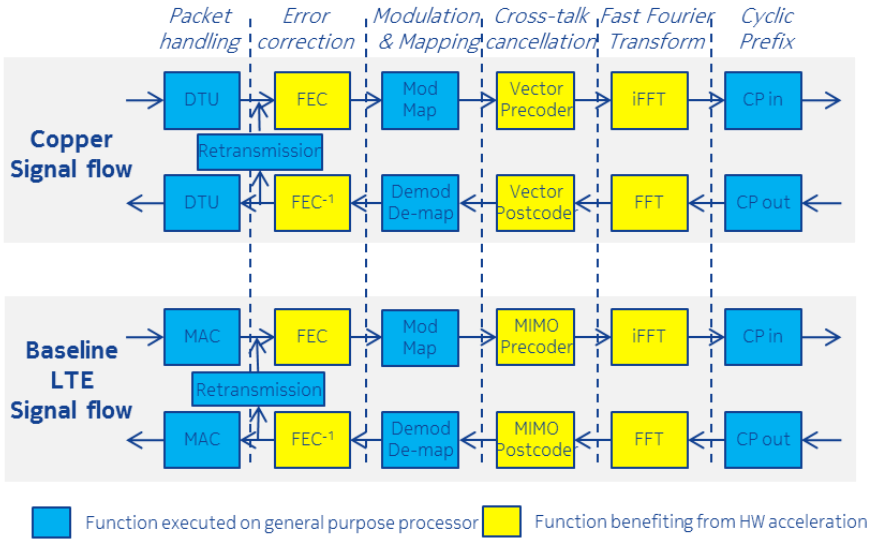


NOKIA

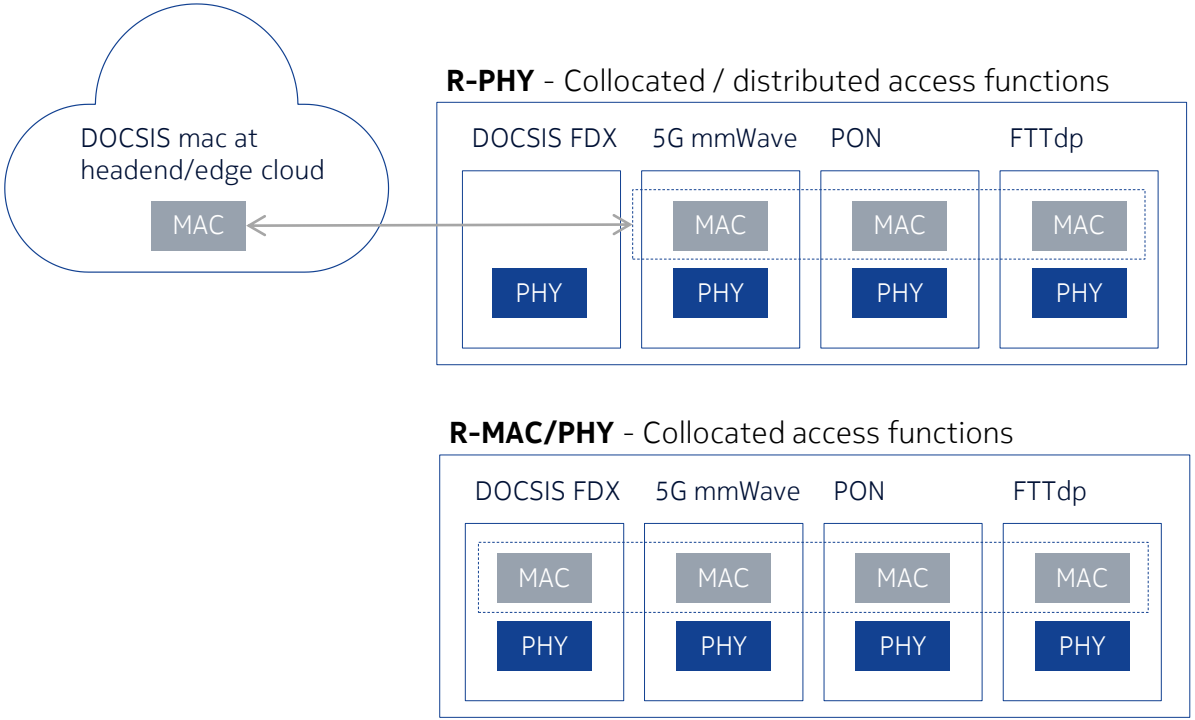
# The Future X Network: Access Convergence – BW & Technology



# The Future X Network: Access Convergence – BW & Technology



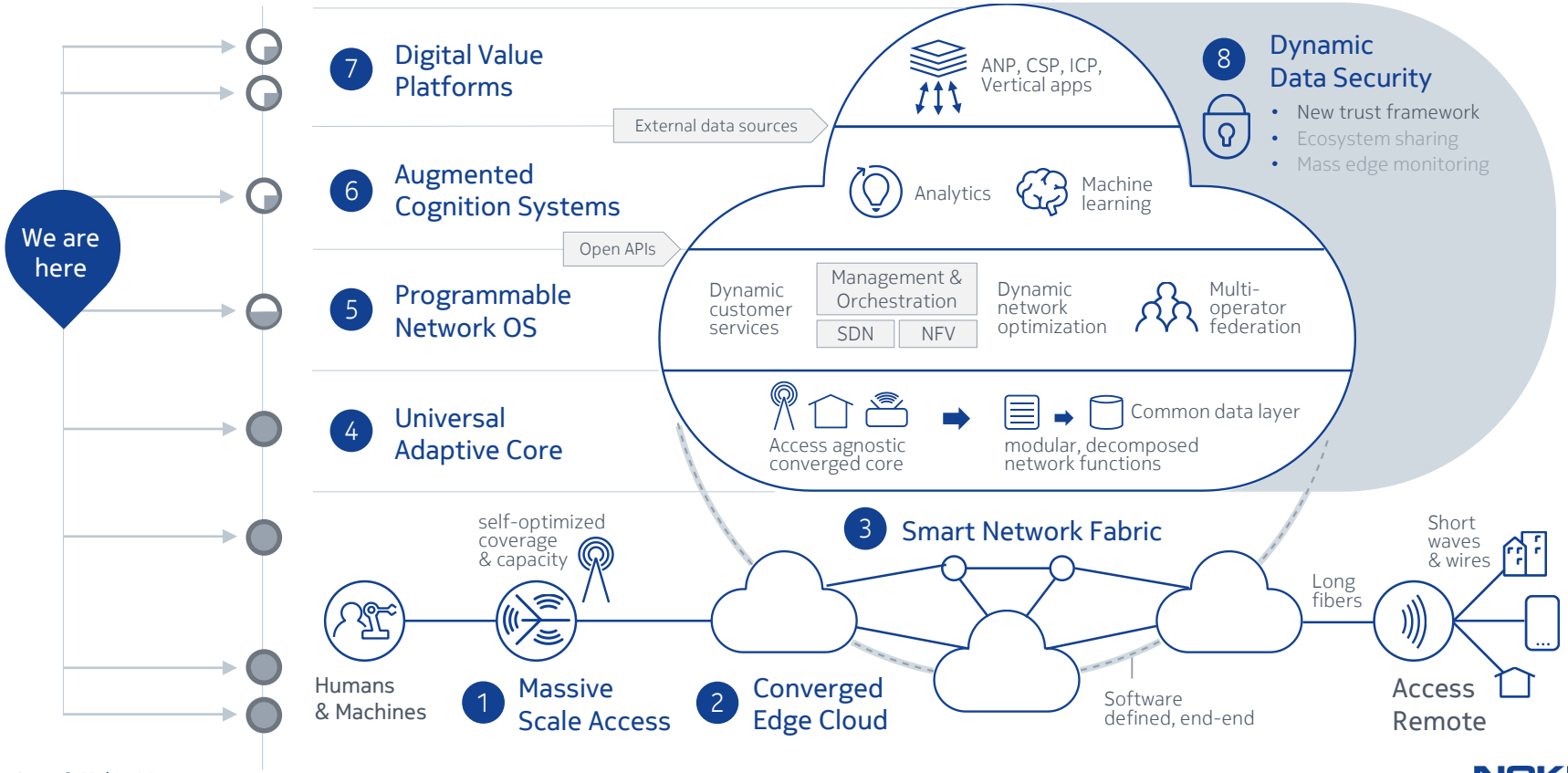

Reduces complexity/functionality in OSP but:

- Remote Phy ↔ Central Mac handshakes may impact seamless coordination/multi-access session continuity
- Potential for multi-access technology scheduling coordination challenges between Macs

Increases complexity/functionality in OSP but:

- Seamless coordination/session continuity between mac layers for multi-access technology use cases
- Future hybrid multi-access CPE with future remote can enable multi-access services

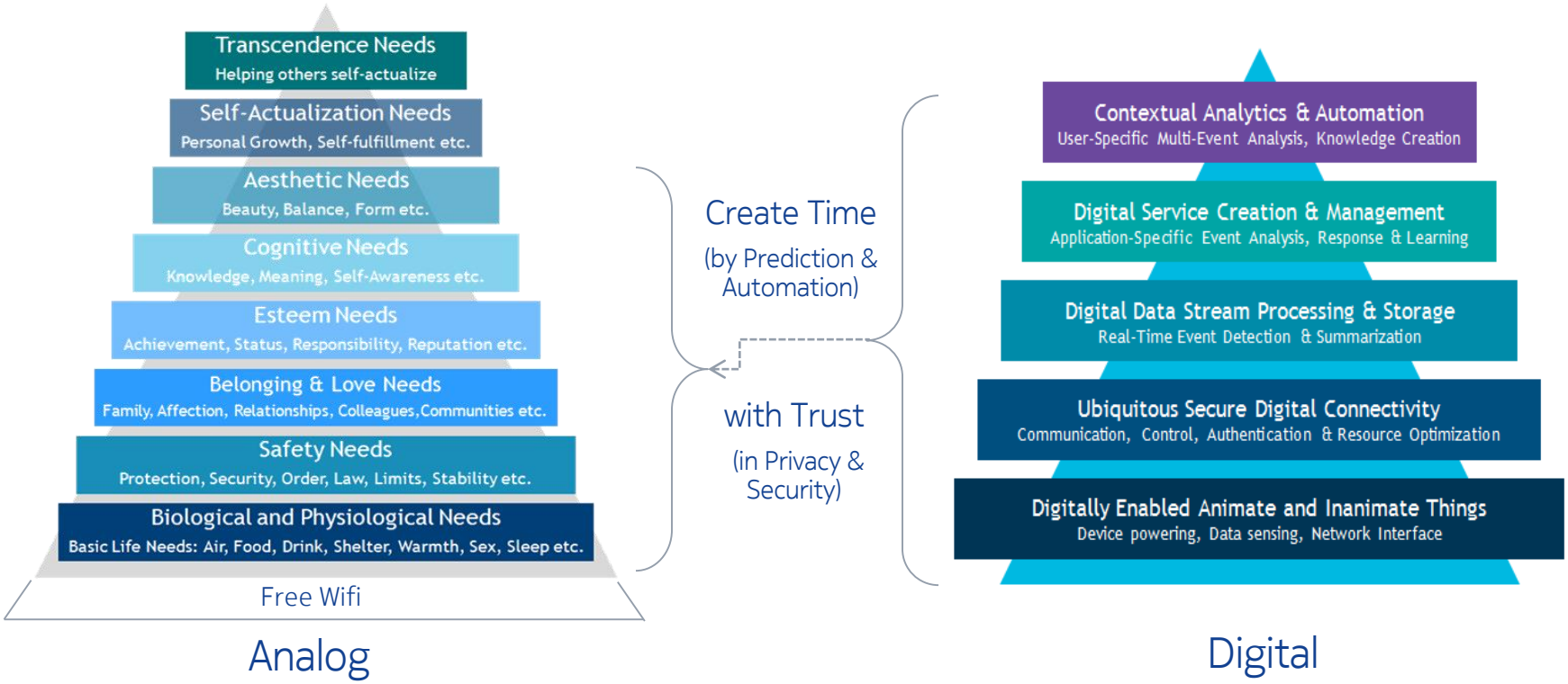
# The New Architecture



NOKIA

# The New Value (1): Time (& Trust)



NOKIA

# The New Value (2): Global-Local Equilibrium

## Local Forces

Optimized **Delivery** of Digital Content

**Trusted Brand** Relationship

**Personalization**

Personal **Privacy Protection**

Economies of **Secure Network Platform**


## Global Forces

Optimized **Discovery** of Digital Content

Massive **Brand Power**

**Generalization**

Personal **Data Monetization**

Economies of **Cloud Platform** Scale



NOKIA

# The New Value (3): Digital Value Platforms

## Media & entertainment

YouTube, hulu, iTunes, Spotify, NETFLIX

**Needs**
- Massive scale content delivery
- Dynamic bandwidth control

## Data & knowledge discovery

Google

**Needs**
- Global network coverage
- Immediate response

## Comms, commerce, context & Content

VoLTE

**Needs**
- Global network coverage
- Uplink capacity for sharing

## Vertical & infra automation

Smart city, Withings Inspire health, Health care, Smart home

**Needs**
- Tera-scale access and core
- Network slicing for verticals

## VR/AR

NETFLIX, magic leap, NEXTVR

**Needs**
- Massive access capacity
- Low latency edge processing

## Expert assistance

IBM Watson

**Needs**
- Global network coverage
- Immediate response

## Supply-demand matching

UBER, airbnb, LendingClub

**Needs**
- Global network coverage
- Network-enhanced trust

## Critical control platforms

Self-driving, Industry, Smart grids

**Needs**
- Latency/reliability constraints
- Control systems in edge cloud



NOKIA

# The Simple Formula

1 + 1 + 1 = 11 → 11 + 111

ms Gbps Tn $Tn GSPs LSPs

NOKIA

# And the winners will be…

## Global Providers

→ Become a DVP company first and foremost

- Create or acquire new digital value platforms
- Create E2E (industry-centric) service offerings
- Create alliance with local providers for edge network slicing & high performance services delivery
- Leverage local value for real time (edge) analytics and security services

## Local Providers

→ Become a high performance Infra company first and foremost

- Create highly optimized, high performance edge-cloud network
- Support massive scale, adaptive network slicing and hosting infrastructure
- Create alliance with global providers for E2E service offerings
- Offer real time (edge) analytics and security services

NOKIA

NOKIA