

5G shaping the ICT ecosystems and Innovation

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NOKIA

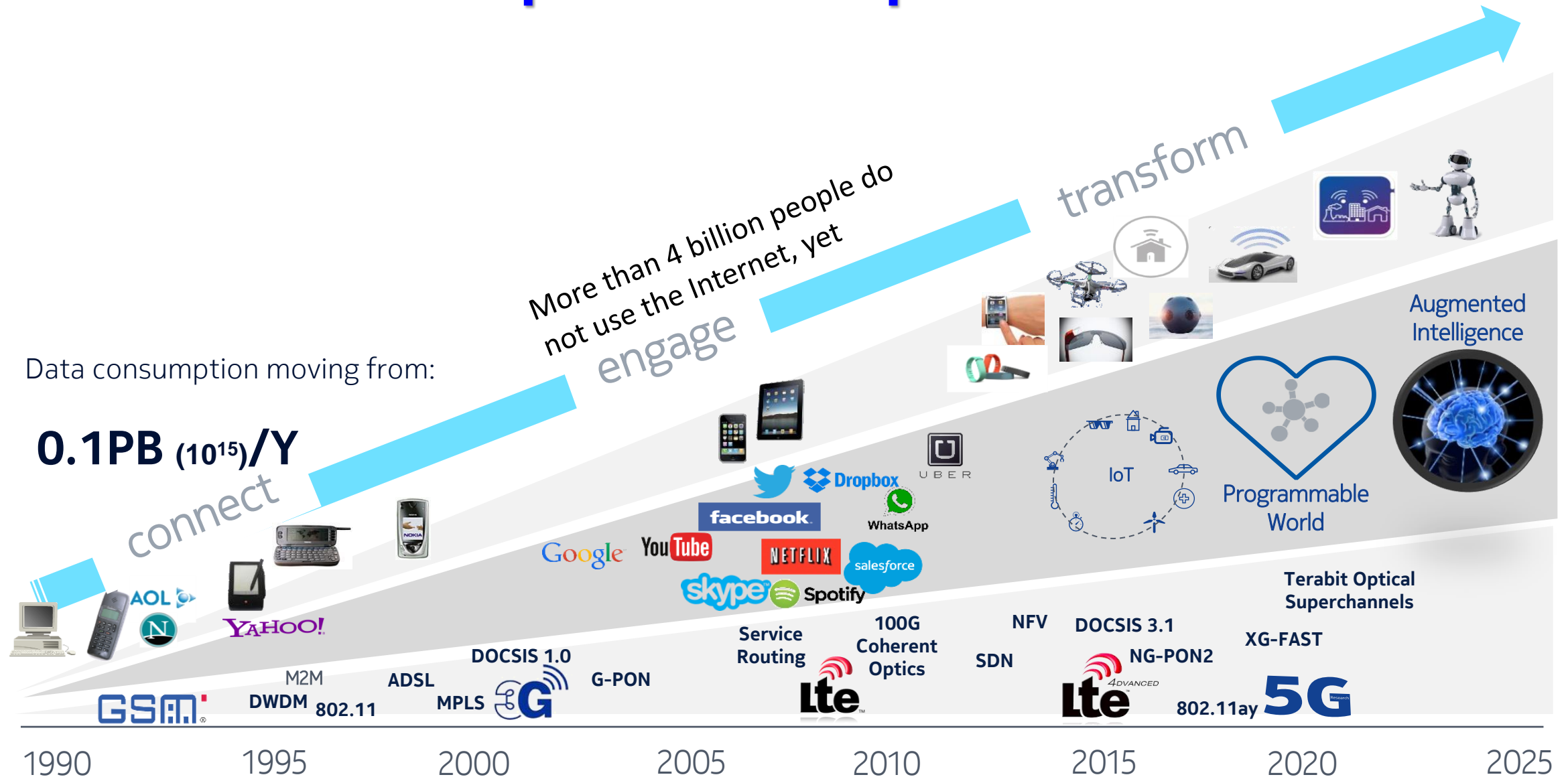
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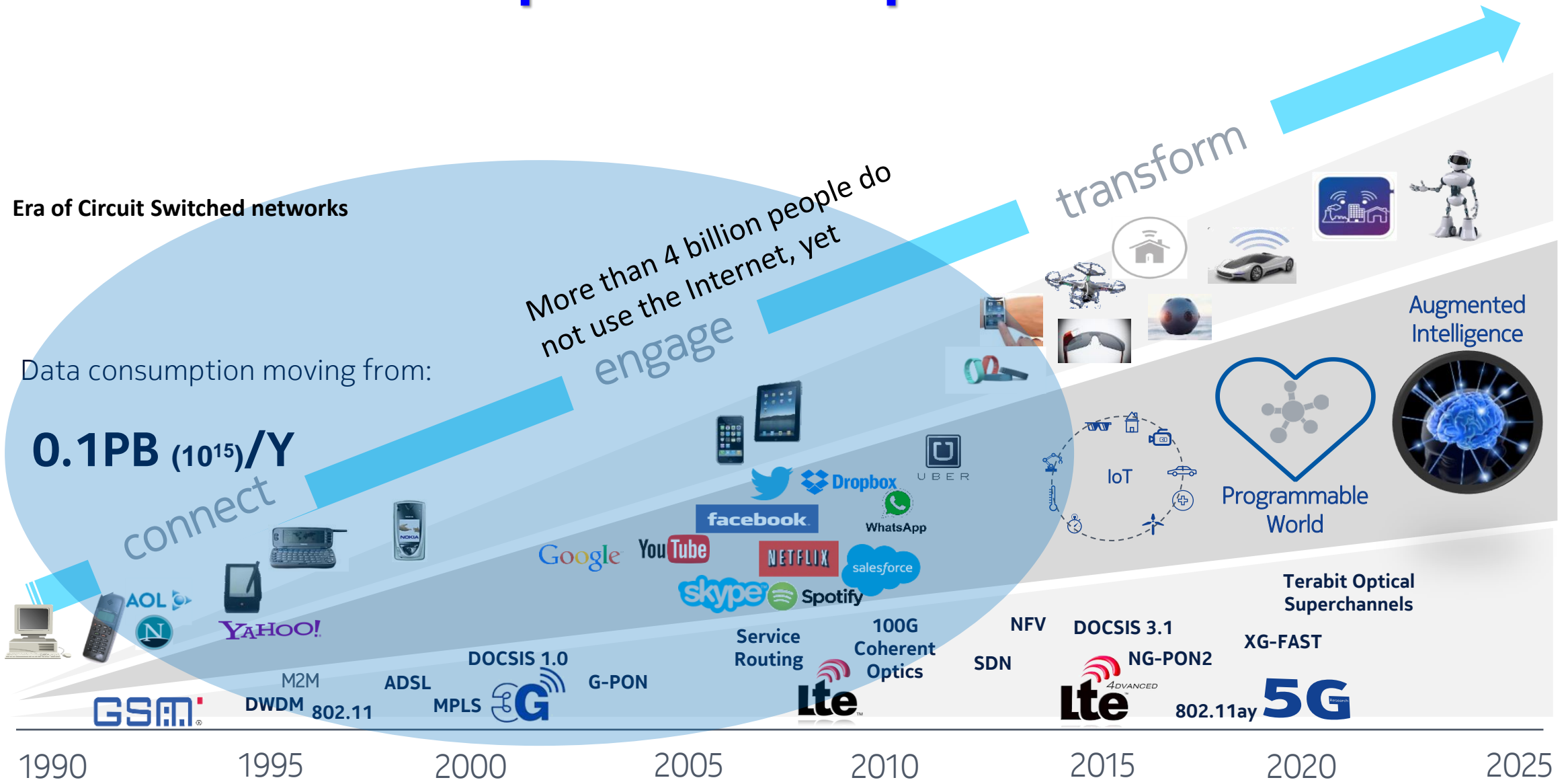
Agenda:

- Focusing on G's
 - Evolutions and revolutions
 - Innovations in 5G
- Drivers of ICT Driven Ecosystems
 - Value creation disruption
 - Structure of ICT
 - Dynamics through Collaboration
 - Platforms and network effects
- Implications
- Discussion

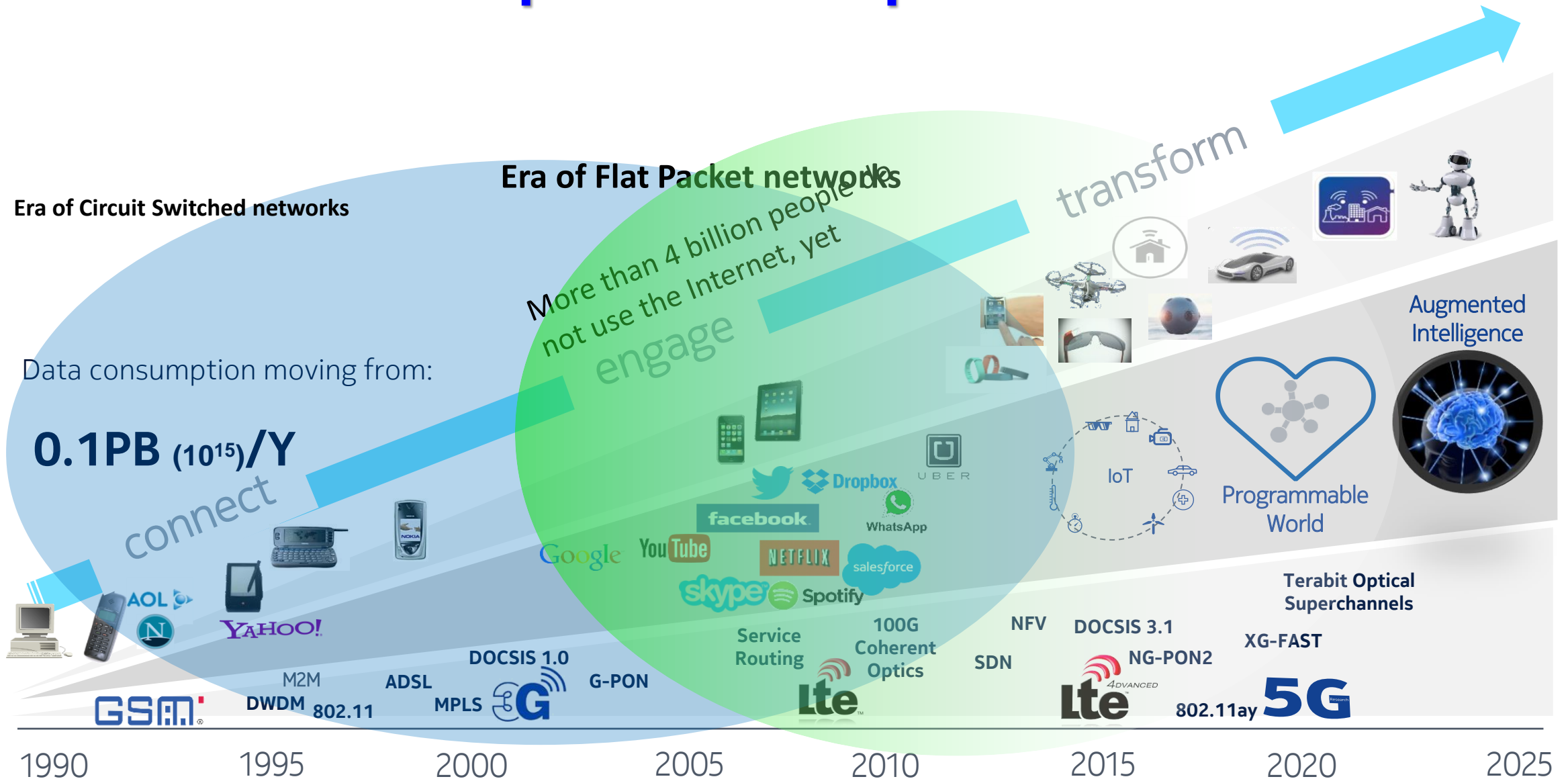
Network technology evolution continues to expand human possibilities



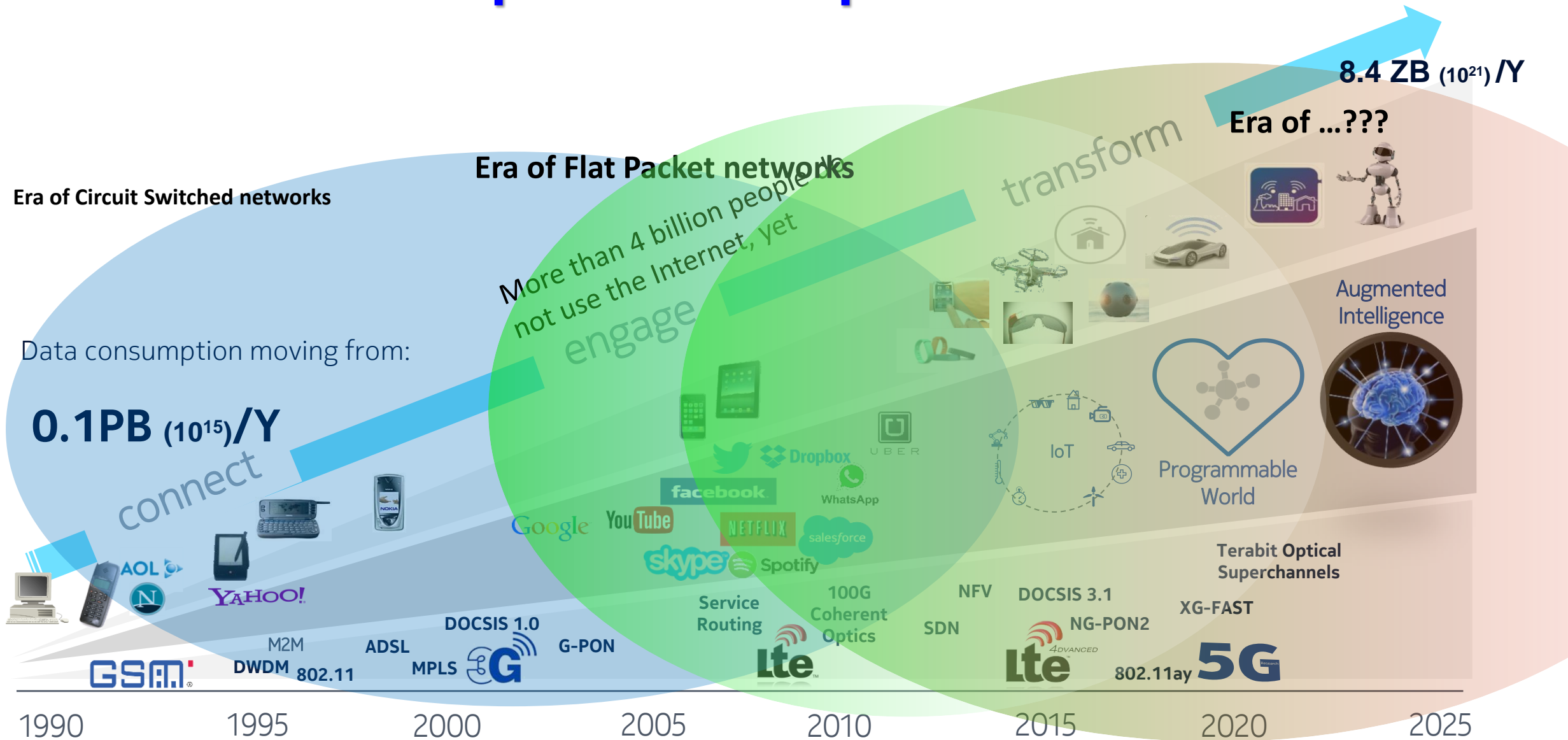
Network technology evolution continues to expand human possibilities



Network technology evolution continues to expand human possibilities



Network technology evolution continues to expand human possibilities



Within the ICT Mobile Communications and Internet have enabled so much new value creation through open collaboration

Interoperability is critical for Mobile Communications

Critical Scarce Resource:
Radio Spectrum



Interoperability is critical for Internet

“Critical scarce Resource”:
IP Addresses

Source: GSMA

Why do we still need to care about the duality of Mobile Communications and Internet today ?

What makes 5G Different ?

It is the power of the 5G technologies

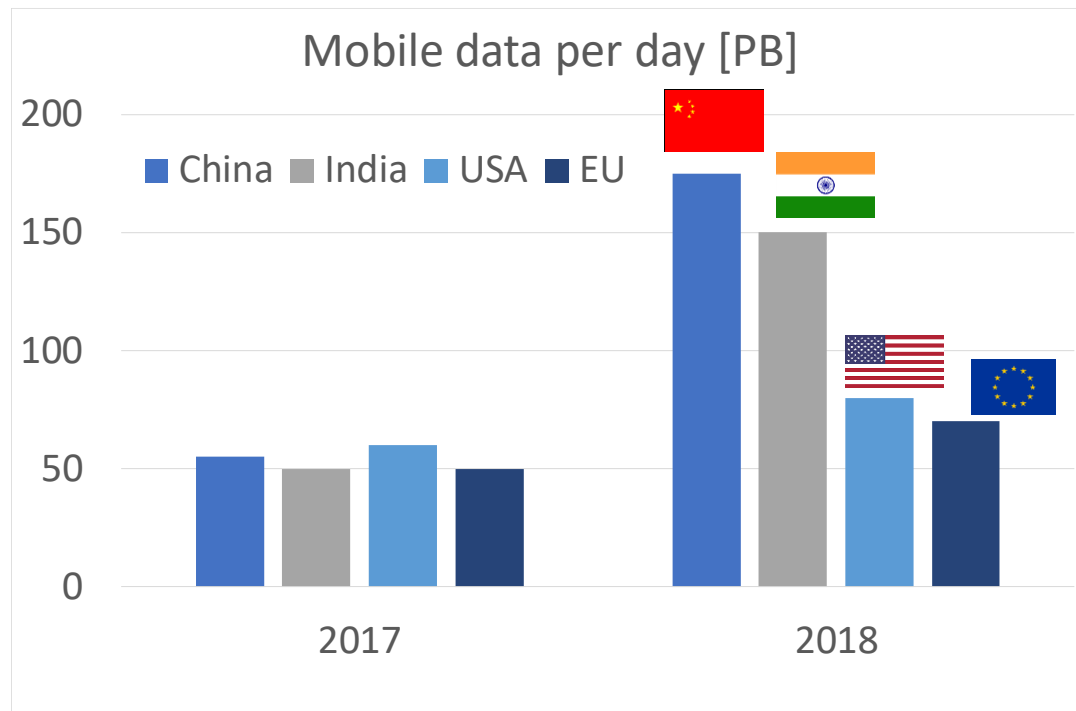


that shape the ICT driven 5G ecosystems

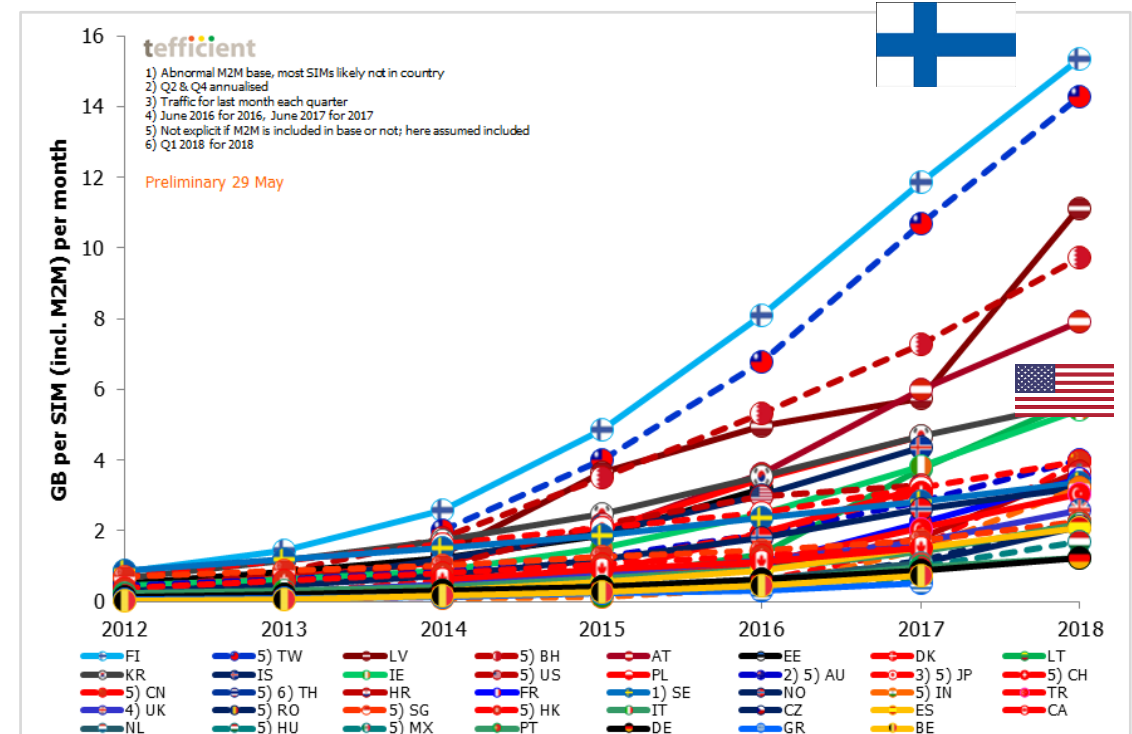
Mobile Broadband

First Motivation for 5G Deployment

Total mobile data traffic >50.000.000 GB/day in leading markets



Finland #1 in globally in terms of mobile data per person >1 GB/person/day



5G Boosts Cell Capacity by 20x with 2.6/3.5 GHz Mid-Band

4x More Spectrum and 5x More Efficiency

Significant amount of technical innovations



LTE1800 2x2
MIMO

LTE

1800 MHz

20 MHz

2 bps / Hz

40 Mbps
cell throughput

20 x

5G

2.6/3.5 GHz

100 MHz¹

10 bps/Hz

800 Mbps cell
throughput

¹80% is downlink



5G 3500 with
massive MIMO
beamforming

A 5G Consumer Use Case (Low latency, High throughput)

Cloud Gaming requires better network than ever before



STADIA

Google Stadia may be the first good use for 5G phones



Five exclusive games

Alongside this, **Hatch** has teamed with the firm to exclusively provide a minimum of five games via streaming. **Nexon** will also begin to offer Kartrider VR.

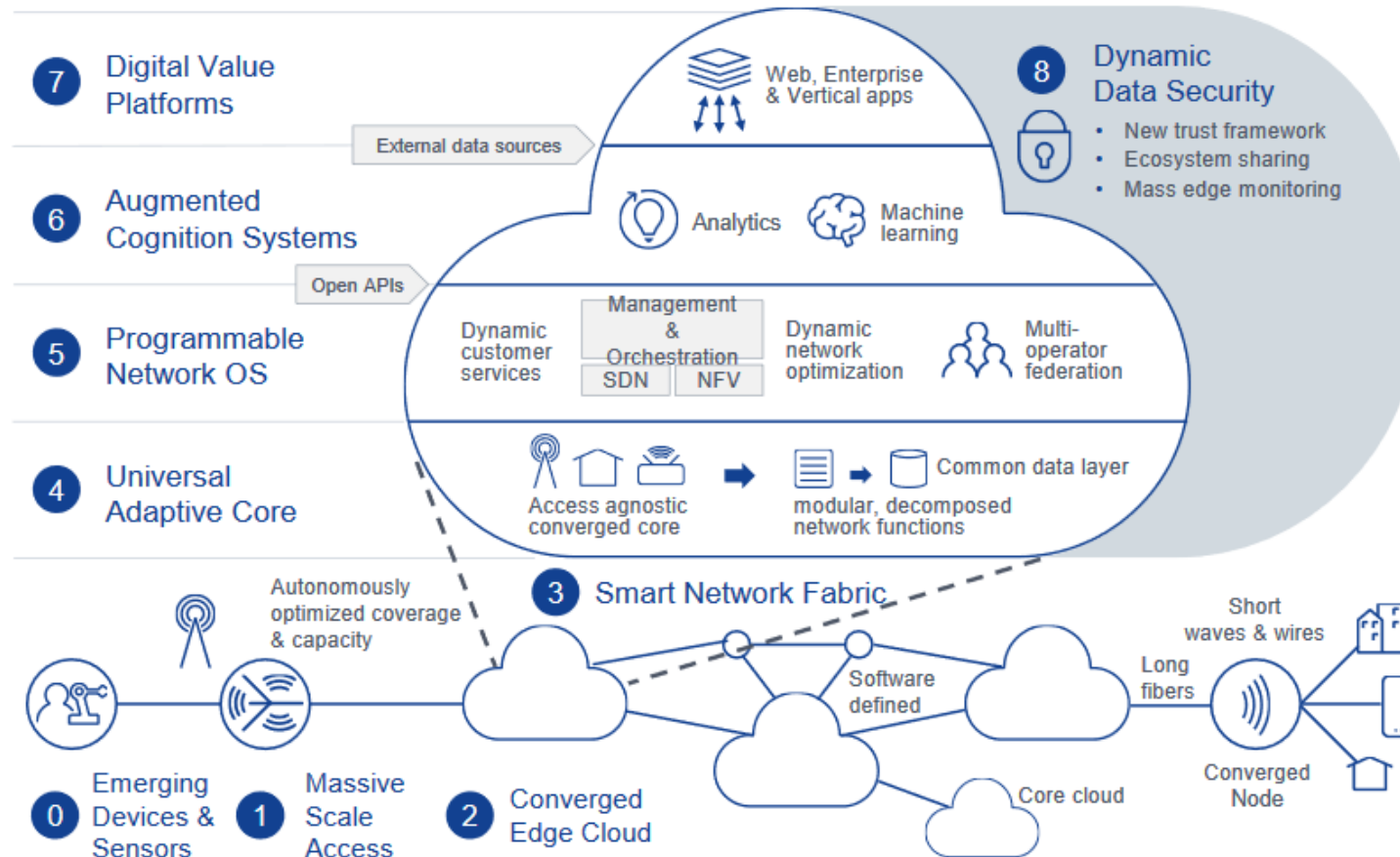
We estimate **one-fourth** all smartphone time worldwide today is spent playing **games**. It is a wildly popular activity.

Network Architecture X is much more than just the radio

Nokia Bell Labs Lead Value System Innovation for all the ICT clusters

The New Value Architecture

Significant amount of further technical innovations



Explore our solutions for....

Analytics

Data center infrastructure

Operations support systems

Security

Business support systems

Fixed networks

Optical networks

Services

Content & video delivery

IP networks

Radio networks

Core networks

Mobile transport (Anyhaul)

SDN & NFV

5G Use Cases for Ultra Reliable Low Latency Communication

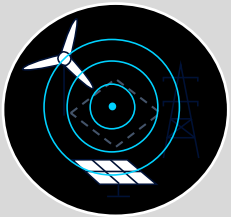
New business opportunities the earlier G's do not support optimally

Significant amount of business innovations

Smart City (wide area)

Smart Grid

- Outdoor
- Stringent requirements on availability, latency, and jitter



Autonomous Vehicles

- Stringent requirements on availability, latency
- Ultra reliable mobility



Factory Automation (local area)

Motion Control

- Indoor
- Most stringent availability, latency, and jitter
- Limited mobility



Mobile Robots

- Indoor & outdoor
- Stringent availability, latency, and jitter
- Ultra reliable mobility



Harbor Automation

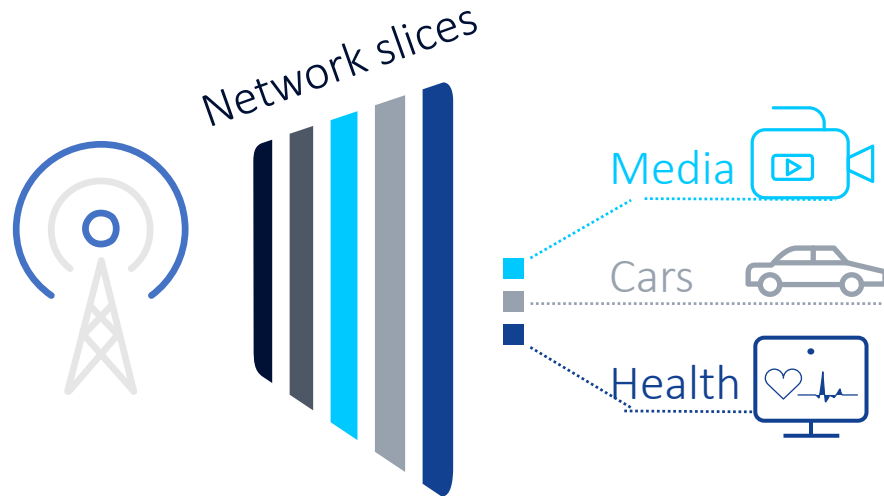
- Remote control of cranes and vehicles
- Indoor & outdoor
- High reliability



5G Ecosystem Options for Providing Critical Connectivity

Option 1: Public networks with slicing

- Guaranteed quality with slicing
- Slice allows different security levels
- Example case: public safety



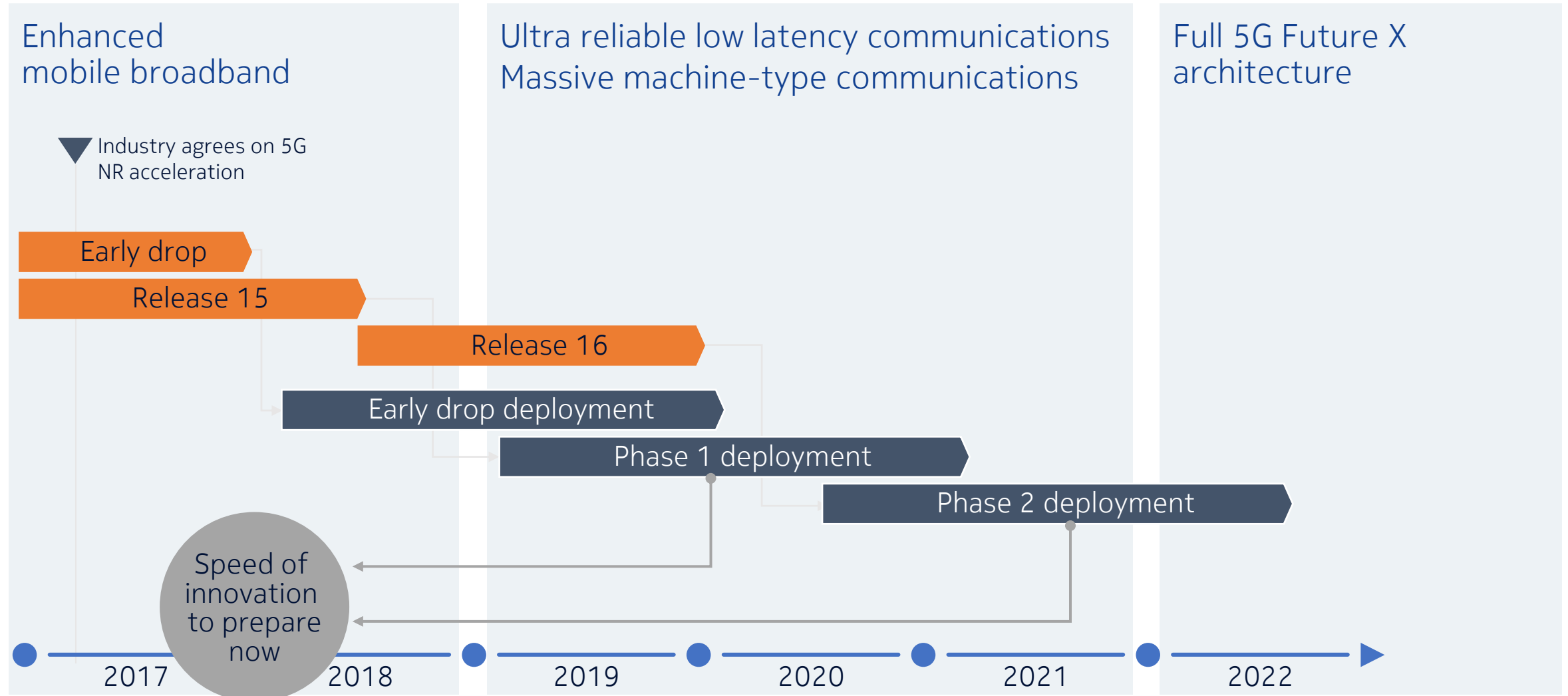
Option 2: Dedicated local network

- Dedicated local network
- Customized security
- Example case: private LTE at Helsinki airport or a mine



5G standardization in 3GPP and related deployment

Focus in licensed mobile communication



5G Technology is neutral – 5G Ecosystems are not



4G evolution

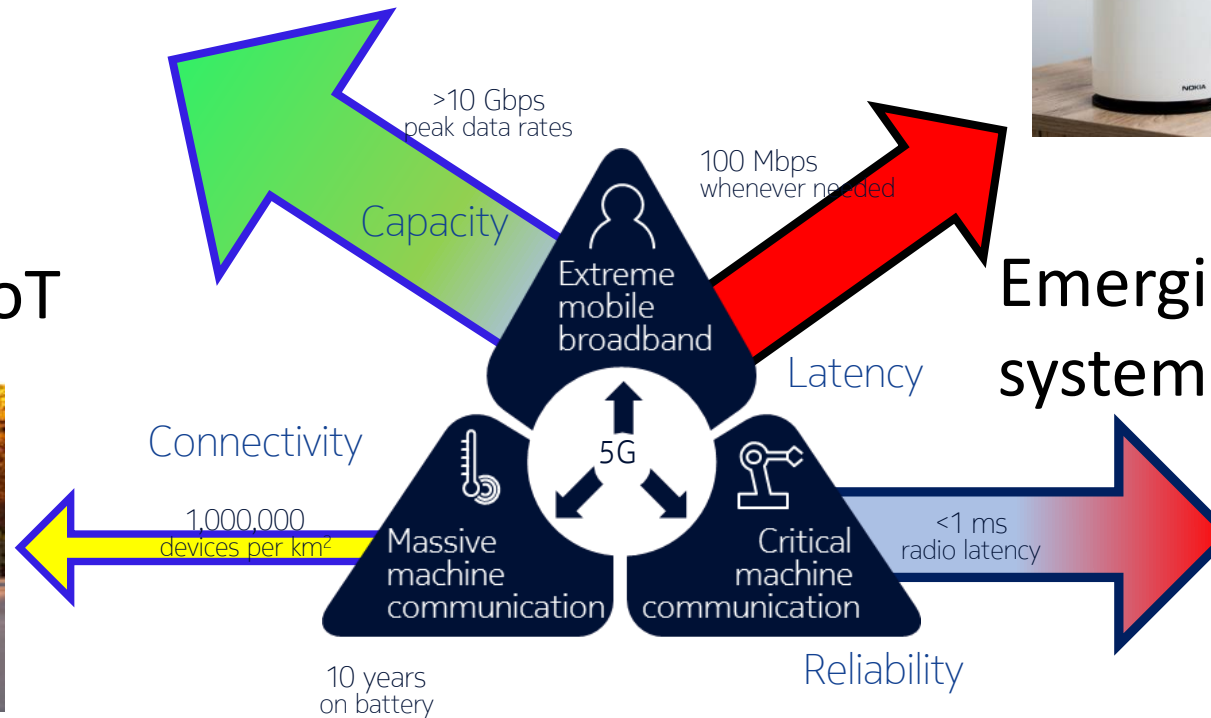
Narrow band IoT



Fixed wireless



Emerging Vertical Business systems



5G serves all use cases



Major Ecosystem Innovations become possible

ICT has unleashed the power of Immaterial Ecosystems and Data based economy

- Moore's law: Exponential growth of processing power
- Enables new economics based on immaterial value creation, capture and sharing



Digitalization is much more than just the network - Unifying Bits, Electrons and Atoms

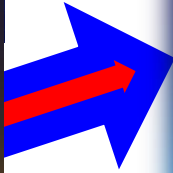
Digital world

Definition of Value: Based on bits and networks
Definition of Work: Innovations related to bits, networking of the content
Goal: Better bits for better decision making and entertainment for the people
Based on thoughts of Negroponte, ...



Materialistic world

Definition of Value: Based on atoms and electrons
Definition of Work: Based on shaping and moving atoms and electrons
Goal: More/better atoms and electrons for basic needs
Based on thoughts of Smith, Marx, ...



New World

Definition of Value: Data based
Definition of Work: Data based

Goal: Better world for each individual person
Based on thoughts of

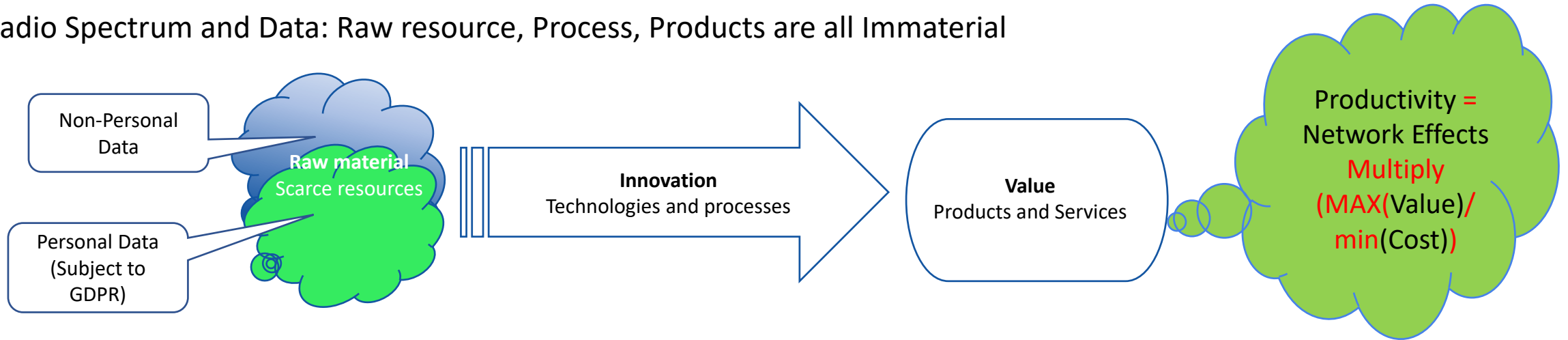


But who defines the rules ?

Mobile Communications and Data Economy

Focus on rules related to raw Immaterial:

Radio Spectrum and Data: Raw resource, Process, Products are all Immaterial



1. **(min)** Data Economy is enabled by Moore's law

- Cost of Storing, Transporting, and Processing of Digital information approaches zero
- Global benefits of economy of scale
- Processing is not only a cost but processing based on AI creates additional new value as the machines learn by doing

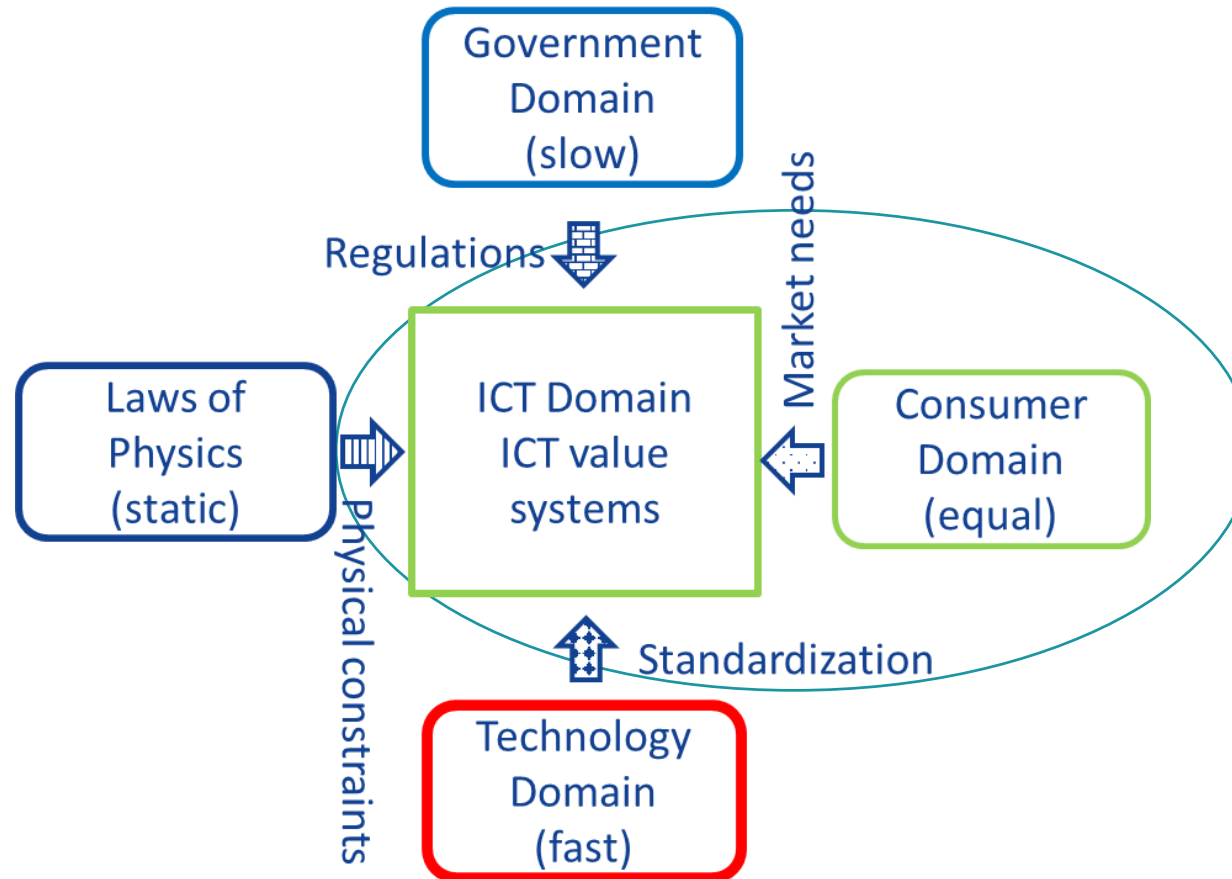
2. **(MAX)** Performance surplus breaks limits: Perfect Differentiation and Perfect Price discrimination become norm

- Fully personalized services maximize the value for the customer
- No need to standardize for variety reduction
- Full information on customer enables personalized pricing

3. **(Multiply)** New value creation through network effects: Multiple Multisided platforms

- Consumer based network effects (downstream)
- Supplier, developers' network effects (upstream)
- Bundling of network effects between the traditional industry sectors (Multiple Multi-sided networks)

Structure of our Value System?



Innovation clusters of the ICT

New Value driven by Innovation

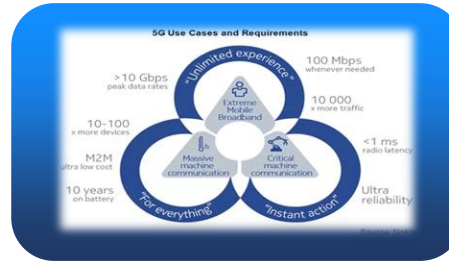
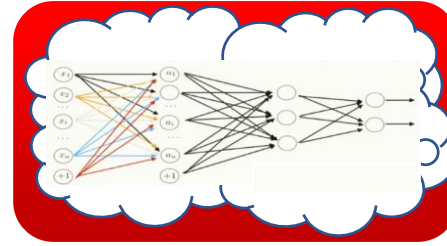
New ICT driven Value systems are emerging in **Health, Transportation, Energy, Smart City and more** and are Utilizing all clusters and their Innovation, IP and Data

Content ~ Big Data
Cloud ~ AI

Network ~ 4G, 5G
Mobile network,
Internet

User Interface ~
Mobile Device,
AR/VR,
Local Connectivity

Things ~ Sensors
and Actuators
Little Data



Openness and centralization controlled by Regulation

Open Internet
Net Neutrality

Open Air Interface
Device Neutrality,
Device Roaming

Open Device
SIM Lock/Unlock

New emerging needs to drive and control the Data based value creation, capturing and sharing

ICT Architecture In Reality

ICT Architecture consists of Four Clusters

=> Six essential Interfaces

=> focus points for Value system considerations

Regulators:

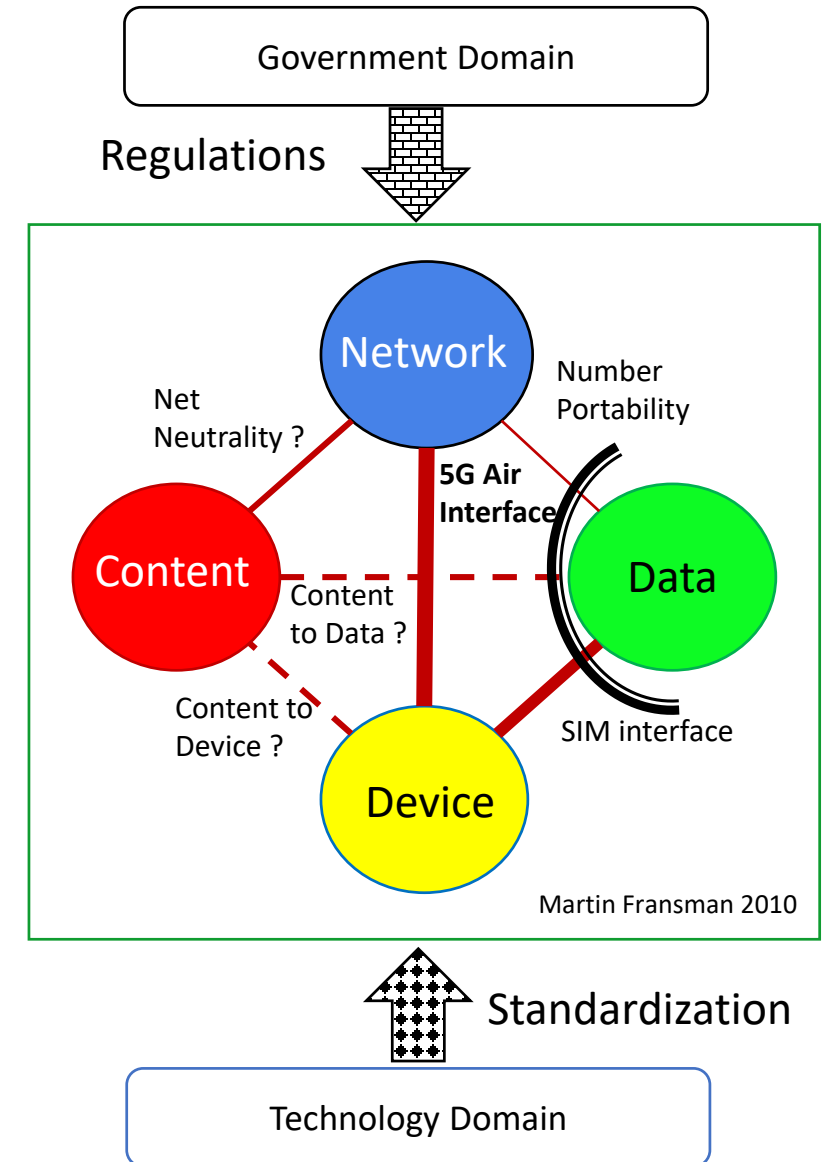
- * Enable access to resources (Radio Spectrum, Data, Real estate, Energy,..)
- * Drive the interoperability (e.g. through Standards)
- * Set rules of competition and collaboration (e.g. Licenses)

- ⇒ Address all the six essential interfaces equally
- ⇒ Focus to interfaces to the data, i.e. to the data of the consumers and citizens
- ⇒ Consider the different options for standardization

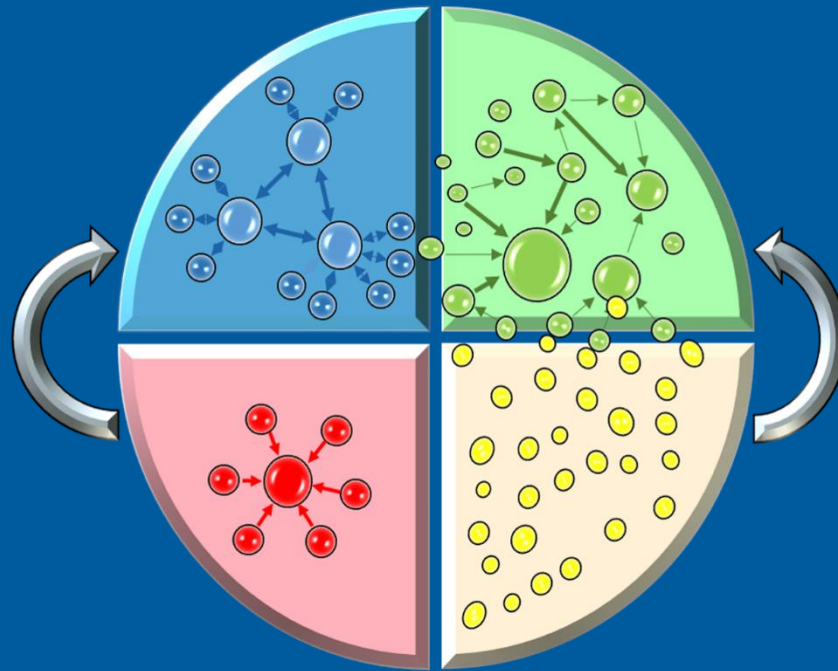
Companies:

- * Get access to resources
- * Utilize interfaces
- * Consider platforms as opportunity and threat

- ⇒ Choose wisely



On Complex Value Systems and their Dynamics



Collaboration for Interoperability in Standardization

Case: Mobile Internet, Convergence of Value systems ?

Historical high level business goal:

- Fully Interoperable Standards for multimode consumer devices and telecommunication networks

Business challenges:

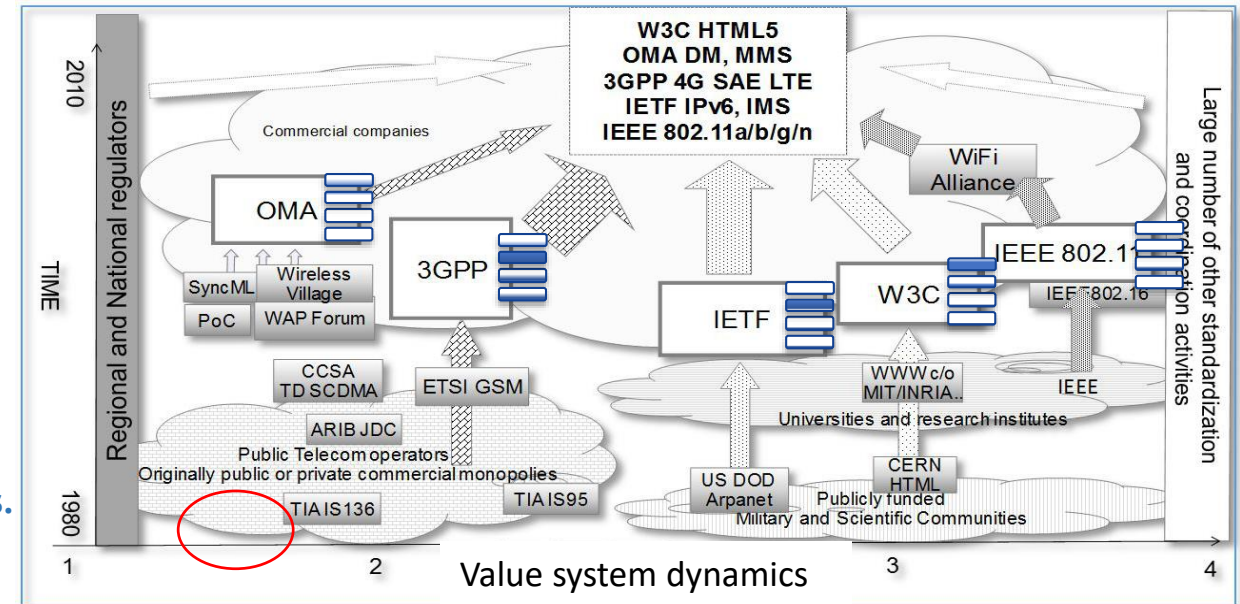
- Value creation, capture and sharing using technologies to exploit limited resources
- Evolution of Value systems
- Convergence of competing Value systems

Standardization Challenges:

- Provide required standards for liberalized use of scarce resources, level the business competition and provide value through interoperability
- Deep collaboration requires deep alignment within the SSOs.
- Each relevant SSO has its own history and own business context

After 40 years of intensive work:

- Highly Successful Mobile Communication and Internet businesses
- Development and Re-use of Technologies is not an issue.
- Re-use of Value system behaviors is an issue



Social Network Analysis makes intuition visible

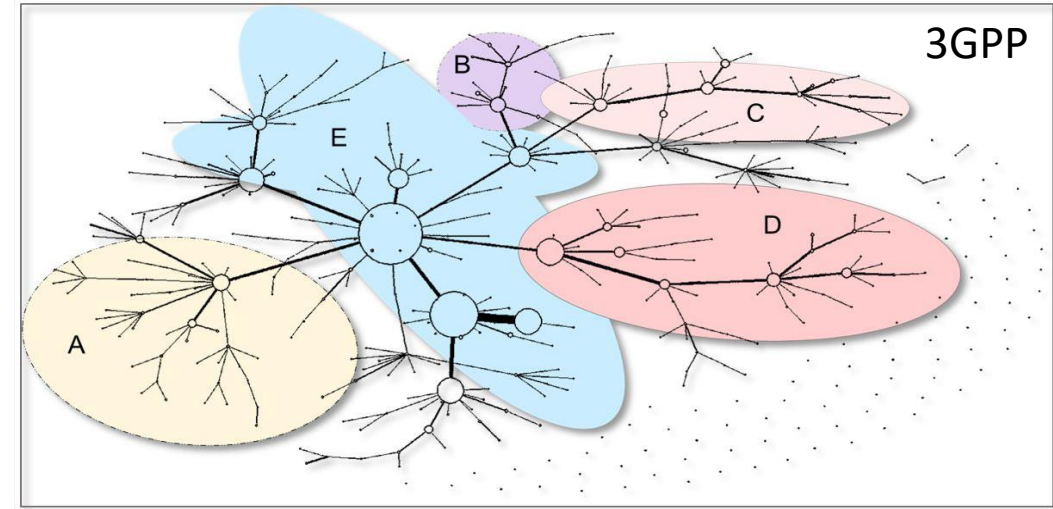
Network Structures

- Active and less active companies
- Collaborative and Competing companies
- Clicks and Groups

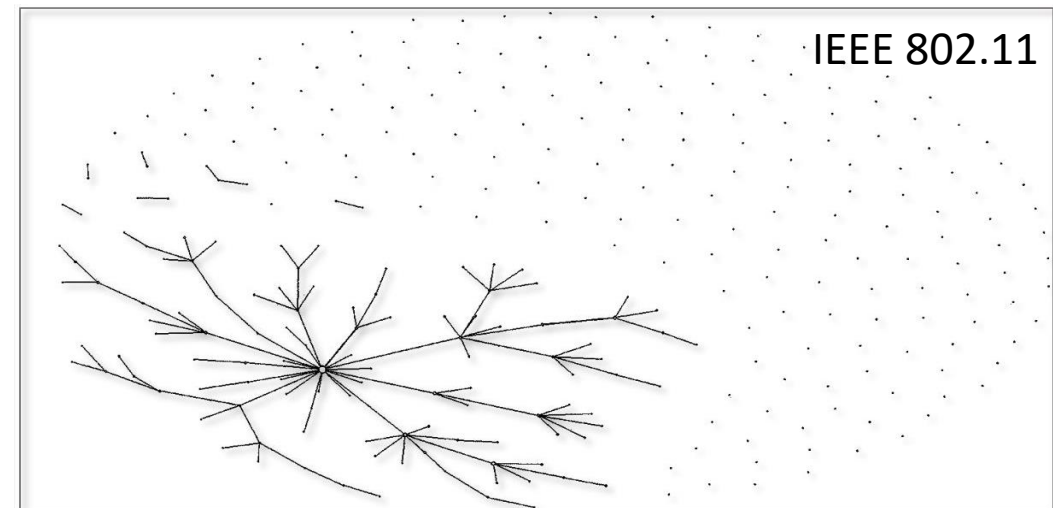
In full alignment with Interviews and experiences

- Strong evidence of the validity of the data for model calibration

Maximum Spanning tree



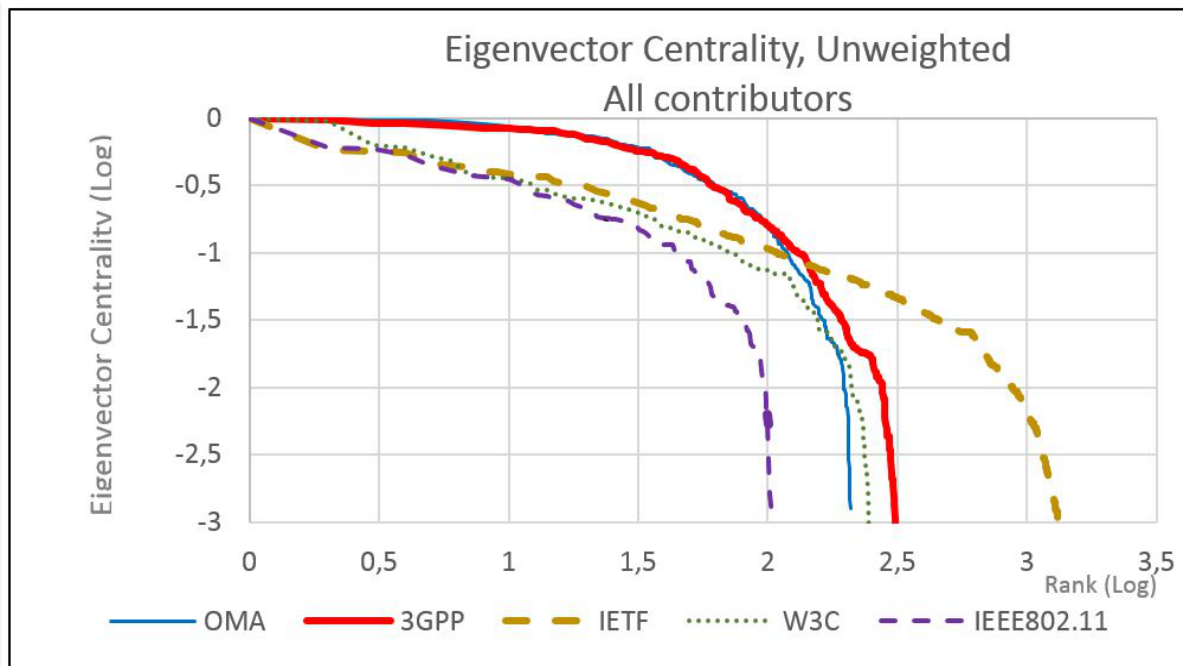
Maximum Spanning tree



Social Network Analysis makes intuition visible - Evaluation

Network Dynamics: Eigenvector Centrality

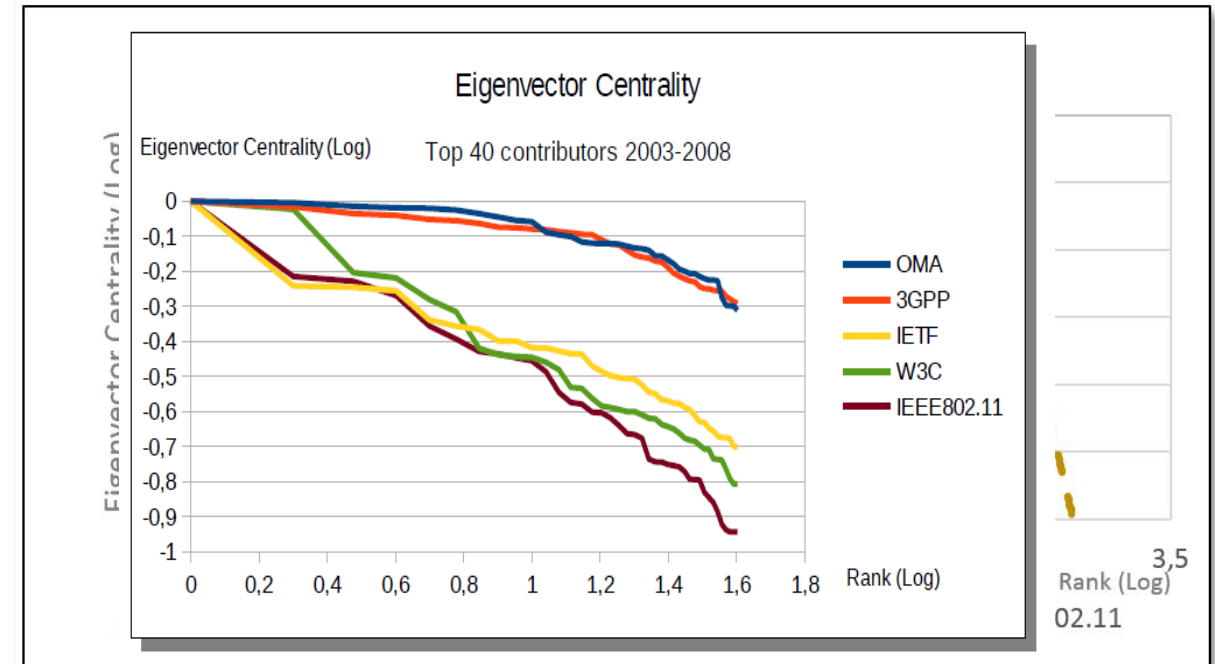
- **Observed behaviors fall into two main groups**
 - Mobile Communications (3GPP, OMA)
 - Internet (IETF, W3C, IEEE802.11)
- **The two groups show different type of collaboration logic**
 - Extensive collaboration and decision making
 - Strong leader driven collaboration
- **Standardization collaboration aligns with the system dynamics indicated through the value system modelling**
 - Regulated through scarce resource and globally agreed interoperability (3GPP)
 - Voluntary collaboration with only few externally set requirements (IETF, W3C, IEEE802.11)
- **Anomaly observed**
 - Without external requirements or resource limitations, extensive collaboration model implemented (OMA)
 - Close collaboration with the 3GPP “synchronizes” the behaviors
 - Root cause of systemic failure of OMA based services



Social Network Analysis makes intuition visible - Evaluation

Network Dynamics: Eigenvector Centrality

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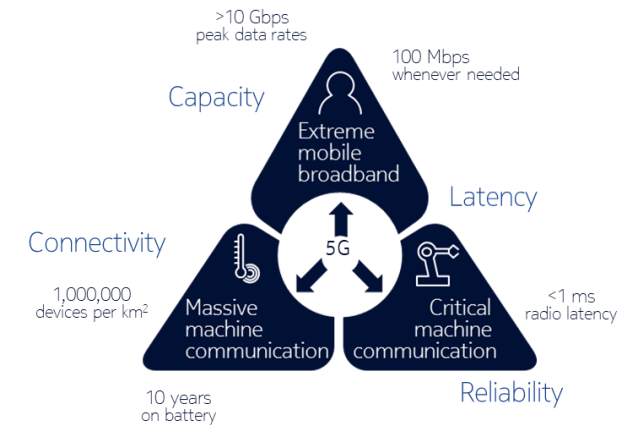


How do we create Standards ?

How do we create Business ecosystems ?

Conway's law ?

FOUR TYPES OF COMPATIBILITY PURSUIT	Mandated/ Non-Collaborative	Openly Collaborative
Driven by a public actor (Government)	1: Mandated de jure standard	2: Licensed de jure standard
Driven by a private actor (Companies)	4: Proprietary dominant design	3: Voluntary de facto standard



5G serves all use cases



**Major Ecosystem Innovations
become possible**

Four ways to choose, Choose wisely

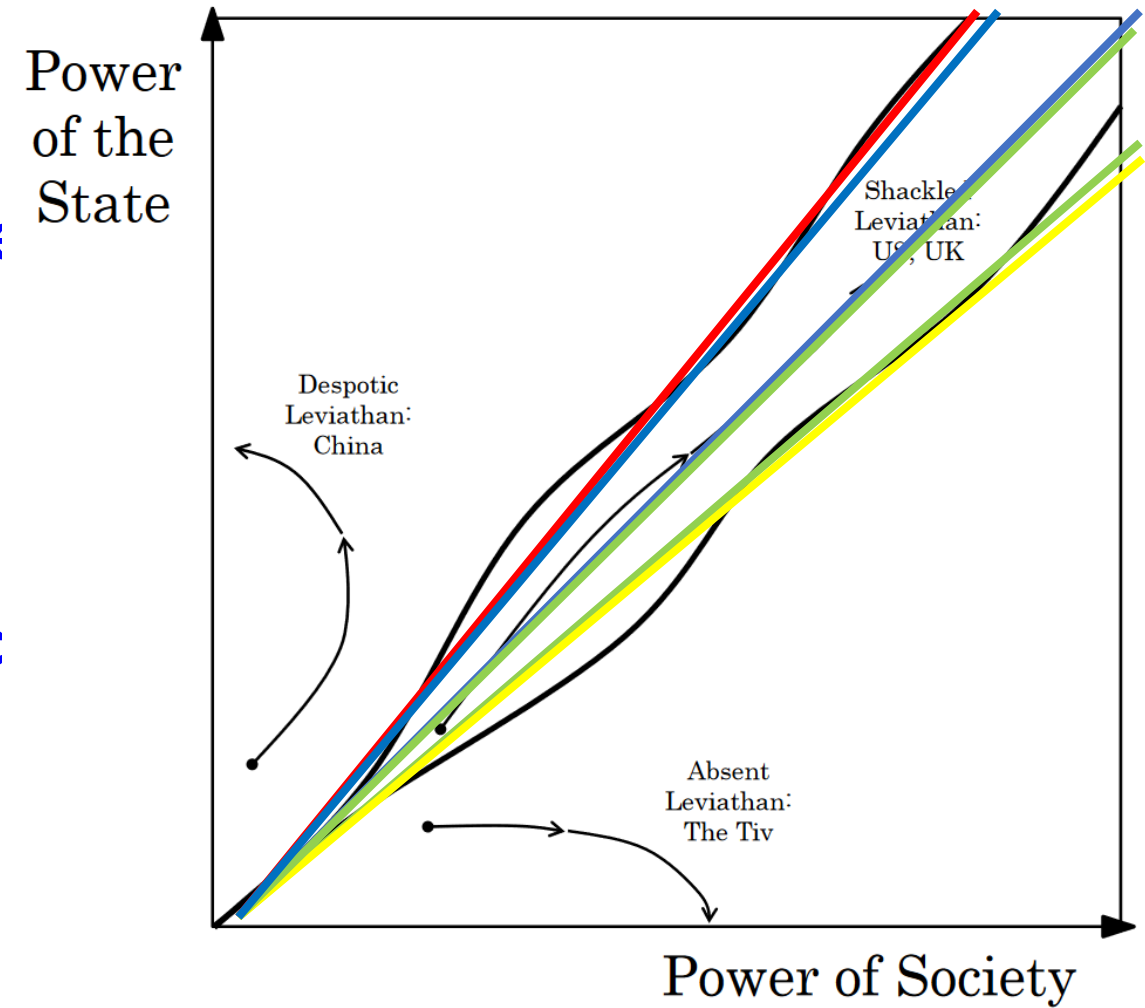
After thought...

Daron Acemoglu: Narrow Corridor

- One more description how the optimum systemic balance is between monopoly and perfect competition.

This research

- ... shows two parallel lanes of traffic in this corridor
- ..and the deep ruts separating all these from each other.



Four generations of platforms

for ever stronger network effects

- **Generation 1: In House Technology Platform (dominant until mid 1990's)**
 - Developed to enable re-use of common parts of the design
 - One directional: Platform owner provides the platform as "common good"
 - Examples: DCT - Nokia Mobile Phone's internal product platform, Open public data (Kansalaisen Karttapaikka)
- **Generation 2: Internal platform converted for external use (dominant until 2005)**
 - Developed by "platform leader" for competing product companies (Katz, Shapiro, Cusumano, Gawer...)
 - Two directional: Platform owner develops the platform in co-operation with platform users on commercial basis
 - Required business model change, platform leader to divest all competing product offerings
 - Examples: Cellular chip sets, Windows SW, WinTel dual platform
- **Generation 3: Two (multi) sided platform (dominant today)**
 - Developed specifically to connect two independent sides of the business through fully controlled information platform (Tirole, Parker, van Alstyne, ... also Zysman, ...)
 - Platform leader combines the network effects of demand and supply side to achieve exponential power gain
 - New roles for developers and end users, Subsidized services
 - Example: Search – Platform – Advertiser
- **Generation 4: Multiple Multi-sided markets on one platform (emerging)**
 - Developed to connect multiple independent sectors of business into one platform
 - Combining multiple two and multi-sided platform businesses into one data based platform (....)
 - Examples: Alphabet, Amazon platforms including services for most of the sectors of society
 - Challenging the structures and services of national states
- **Generation 5: What next ?**

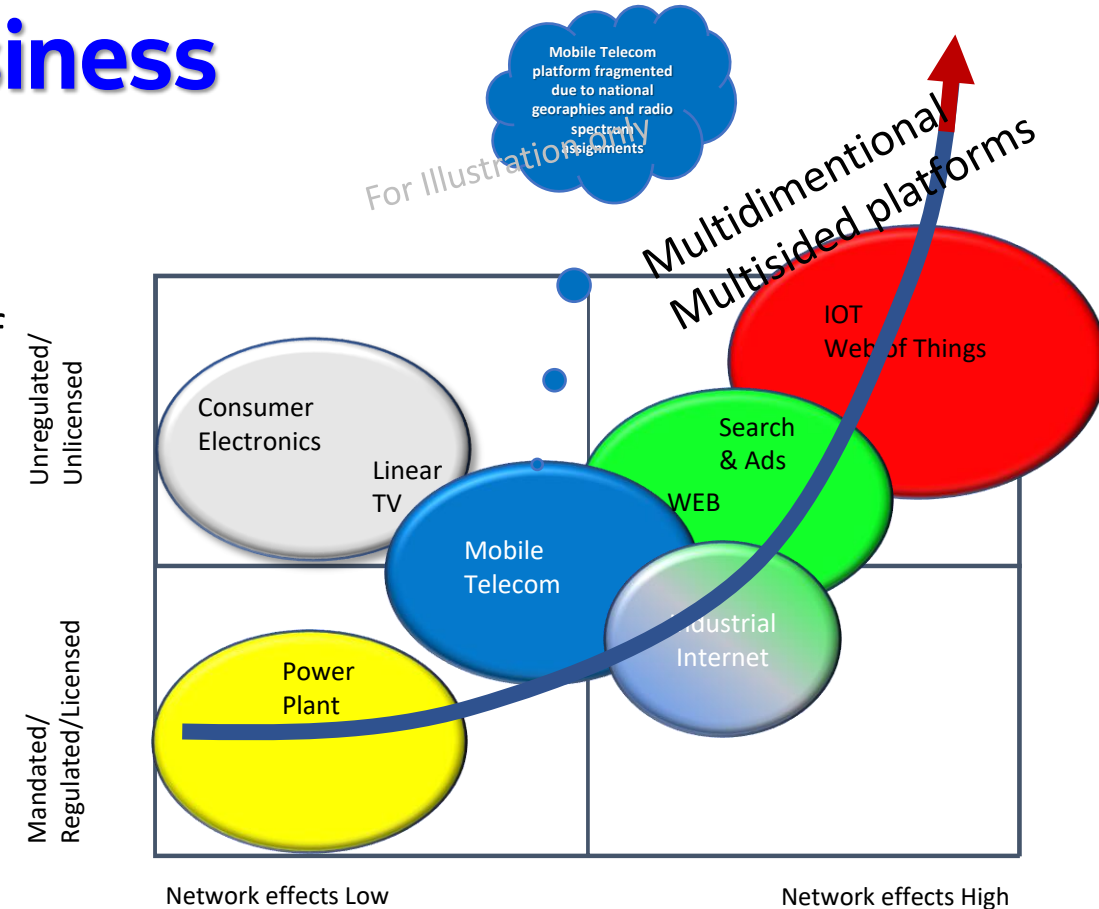


Network effects in Platform Business

Network effects depend on:

- ❑ Internal factors: Competitive and Collaborative actions of the stakeholders, internal open API's and network structures and feedback loops
- ❑ External factors: Regulations, Available resources and technologies

Sarnoff: Value $\sim N$
Metcalfe: Value $\sim N^2$
Reed: Value $\sim 2^N$

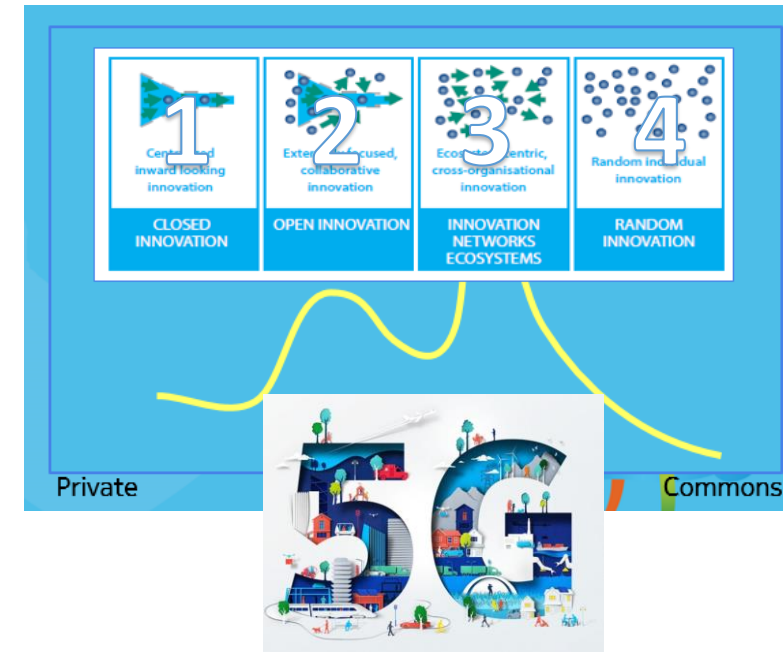


Expected Network effects drive Platform leadership game plan:

- Deeper pockets enable higher stakes
- Temptation to provide technologies for free will grow
- especially when different policies are applied to each critical interface

Concluding Observations

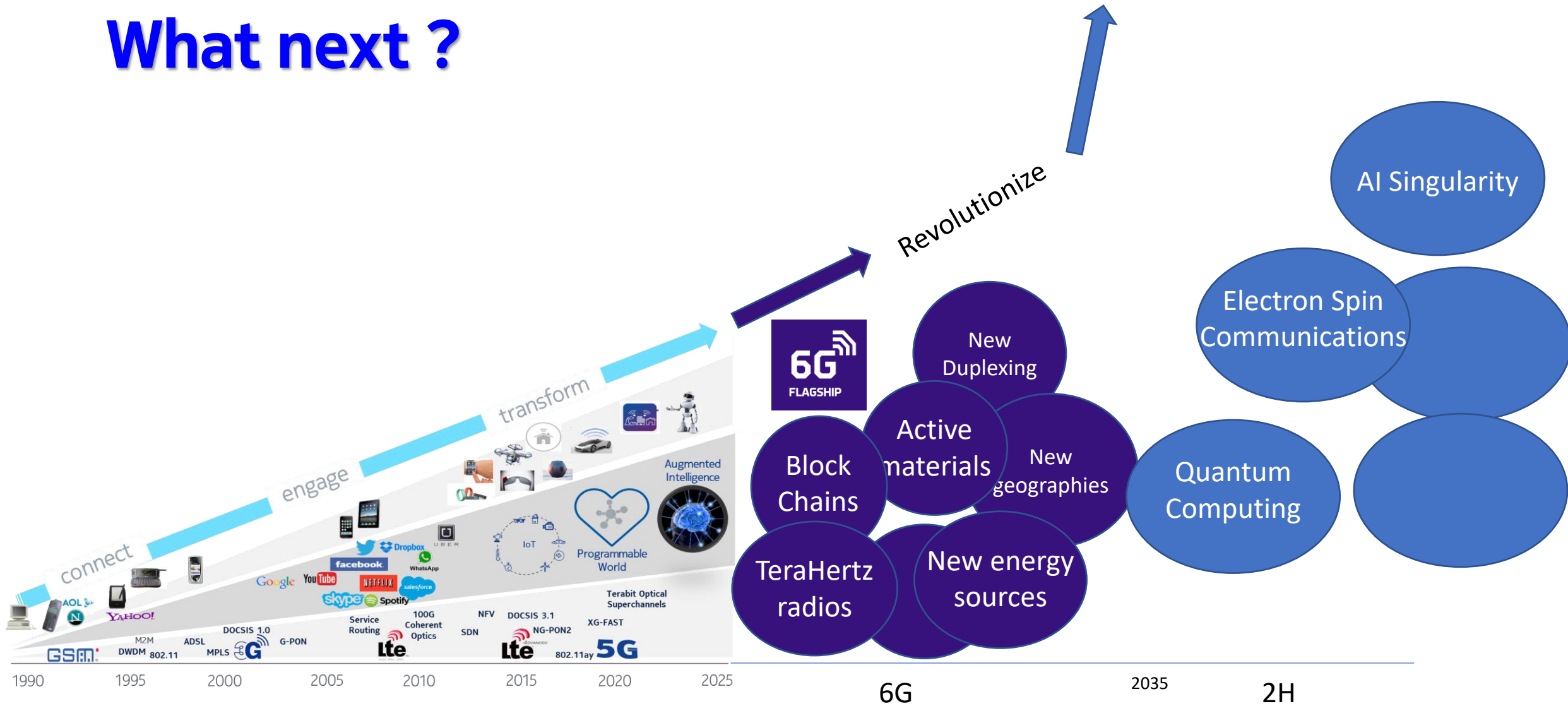
- 5G is The Next Generation of Mobile Communication
 - 5G opens significant new opportunities through 20x better technology and 4x more ecosystem options for value creation, capturing and sharing
 - 5G Technology adoption is well on its way
 - 5G will support a large set of different ways to build business
- => 5G and Digitalization enable Ecosystem disruptions but timing and details are unknown, and often are not even predictable



To define the future, there is no silver bullet. However, some traditional tricks shall be used as a package at all key interfaces of ICT and ICT driven value systems:

- ✓ **Liberty** in accessing the critical resources (radio spectrum, personal data, road capacity, COx emissions...)
- ✓ Dynamic but harmonized Rules for **Equality** in competition and collaboration
- ✓ Well defined local and global **essential Interoperability**, provided for instance by standards
- ✓ Let the people choose the service
- ✓ Beware of Hybris of Hybrids

What next ?



**Managing ICT ecosystems is like gardening:
Harmony and interoperability enable sustainable use of
resources, enable competition and let all the flowers to
blossom – In the proper ways, time and place.**

"These are my principles and if you do not like them, I have other principles." (Groucho Marx)