WIRELESS WORLD
RESEARCH FORUM®

Networking in 2030: A Wireless World Forum (WWRF) Perspective

Dr Nigel Jefferies,
Chair of WWRF

Third ITU Workshop on Network 2030, NPL, Teddington, 18 February 2018

How does WWRF work?

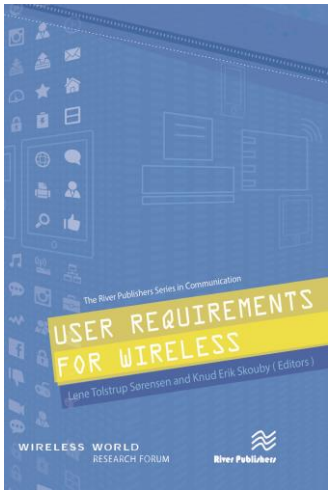
WIRELESS WORLD RESEARCH FORUM®

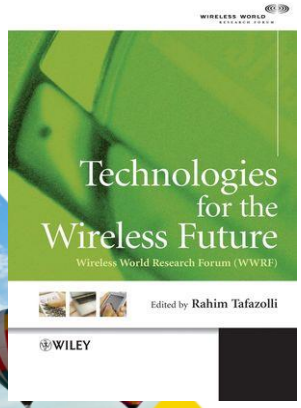
- Vision
- History
- Membership-based
- Steering Board
- Working Groups
- Publications
- Events

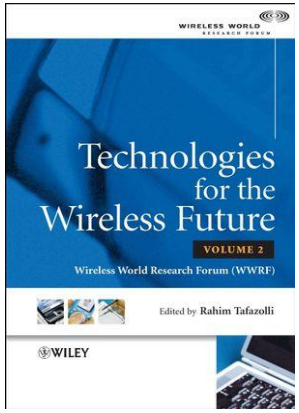
WIRELESS WORLD RESEARCH FORUM®

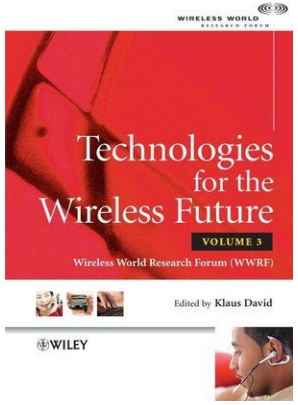
WWRF outputs

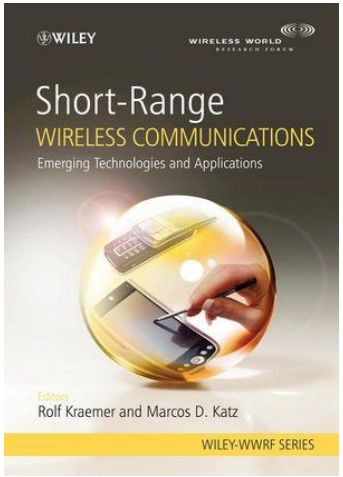
- WWRF Outlook – published version of White Paper
- WWRF Library – proceedings of each meeting
- WWRF – Wiley and River book series











WORKING GROUPS

WGC
New directions in communication architectures and Technologies

Guiding the mobile industry in the use of software, virtualization and cloud computing in future networks (both wireless and wired) by developing end-to-end network architectures, identifying the specific requirements and issues and addressing them by providing solutions that are practical and business driven.

WGA/B
User Needs & Requirements; Services, and Devices, in a Wireless World.

Promoting a secure communications environment across multiple Socio-Economic settings based on user needs and requirements.

WGD
Radio Communication Technologies

Advanced radio technologies and spectrum issues are investigated, to optimise the design of the air interface, medium access and heterogeneous multi-user, multi-RAT systems and identify trends and impact the wireless evolution towards 5g and beyond.

WG HF
High Frequencies (mmWAVE and THz) Radio Communications Technologies

Higher frequency radio communication technologies are expected to enable the vision of wireless transmissions towards the region of 1 Tbit/s. Improved channel modelling and the design of appropriate waveforms, baseband processing, medium access control (MAC) schemes and antenna array configurations are addressed.

WG WAI
AI for Wireless Communications

Artificial Intelligence applied to the wireless communications domain is referred to as Wireless Intelligence (WI). This will be in all sub-systems within the wireless ecosystem. WI is expected by the market to not only reduce operational expenditures (OPEX), but also to increase user quality of experience (QoE) as well as help the introduction of new value chains in an increasingly competitive and complex business environment.

VIP RAIL
Track-to-Train communications

The focus identifying the potential benefits and hurdles for the future adoption of what today is known as 5G by rail transport systems worldwide
Security, reliability, IoT and dependability are playing a focal role in future radio communication systems for efficienttrain operations and safety.

VIP Water
Vertical Industry Platform - 5G for smart water management

A discussion platform about water management and study of the communication requirements, to assess whether 5G can take us faster and further than existing ICTs.

VIP CV
Connected vehicles

Focuses on research that looks five to ten years ahead in order to meet the requirements of the automotive and transport industries based on the next generation wireless technology.

VIP EMW
Ehealth, mobile health and wearables

Developing an e/m-Health and wearables vertical industry paradigm to expose the requirements of such systems to be 5G-enabled

Future Business Models supported and enabled by 5G and Beyond wireless technologies

WIRELESS WORLD RESEARCH FORUM®

Scope

- research that looks five to ten years ahead on Business Models (BM´s) supported and enabled by 5G and Beyond wireless technologies in order to meet the requirements of future Business Model Ecosystems (BMES)
- aimed at the identification of user and business cases for these BM´s and BMES.

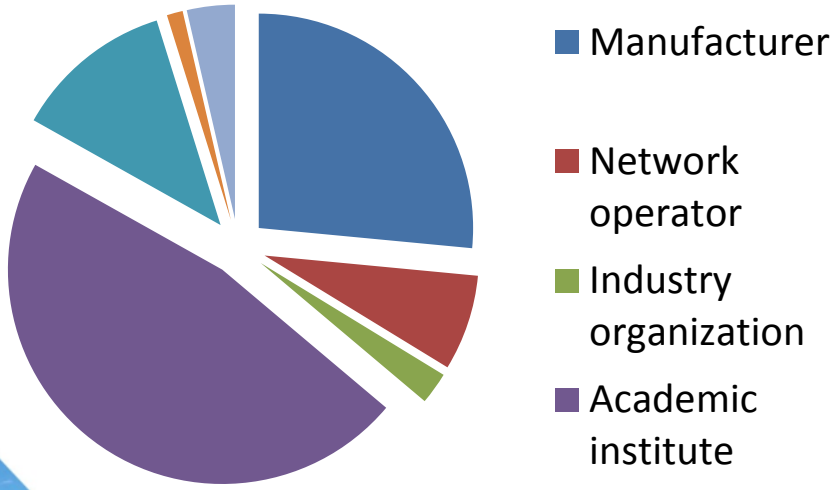
Objectives

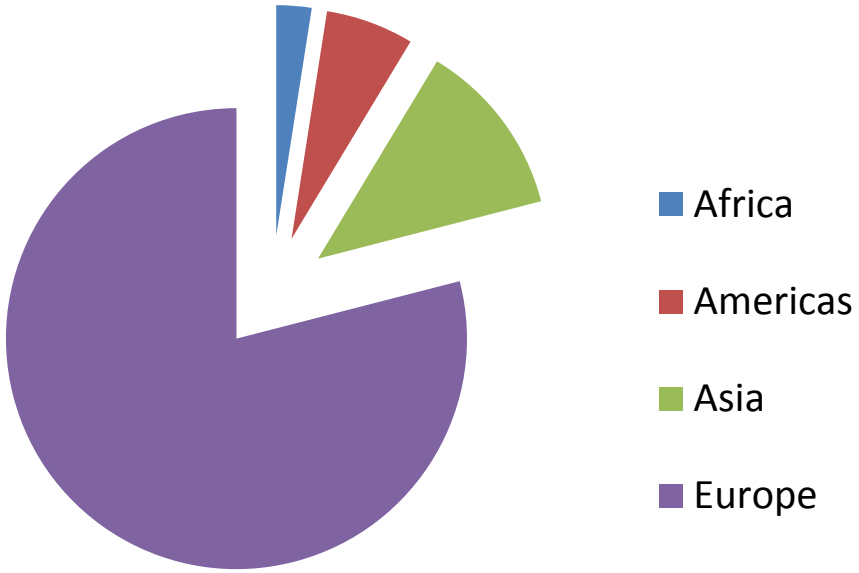
- Leverage academic research to develop technologies for Multi Business Model Innovation (MBMI) that complement developments in standards bodies.
- Provide relevant input to government in order to maximize the advantages of MBMI technologies while addressing concerns with respect to security, privacy, trust, speed of MBMI.
- Create a better understanding of MBMI in Businesses, BMES of the potential, competences needed, capabilities, risks of Business Models and BMES embedded with future wireless technologies.
- Enable the telecom, businesses and representatives from different BMES´s to jointly discuss the vision, usage scenarios, customers, network, requirements and enabling technologies to achieve the targets of future vertical and horizontal BMES business and communications in 5G and beyond.
- Develop use-, business-, BMES cases and study any gaps that may need to be addressed with respect to existing and evolving standards for the support of related BMs, BMESs

Membership

WIRELESS WORLD RESEARCH FORUM®

50 members





WWRF:
Fostering 5G and Beyond Innovation Ecosystem

WIRELESS WORLD RESEARCH FORUM®

- An international “networking platform” between industry and academia
- Long experience in collaboration with research, regulatory and vision developers across continents
- Regular and active collaboration with ITU – contributions made to several WP 5D and WP 5A events
- Active in 5G space from 2012 onwards through WWRF meetings, international workshops and Special Sessions organization
- 5G Huddle events around the globe (5 such event organized so far)
- Academic and industry members (of WWRF) actively working together in the framework of the WWRF IMT 2020 Evaluation Group
  - Performance evaluation of PHY and MAC through simulations is aimed at.

WWRF and ITU

WIRELESS WORLD RESEARCH FORUM®

- Liaison with WP5D, WP5A of ITU
- Presentations to various ITU (IMT 2020) Workshops
  - *5G : on the count of three…… paradigm shifts*
  - *Future of IMT Systems: Wireless World Vision 2020*
- ITU-R WP5D, #13 meeting, WWRF presentation at the WP5D Workshop - Research Views on IMT Technology Evolution, Geneva, Switzerland, 16 July 2012.
- ITU_R WP5A – WWRF organized a Workshop on “Requirements and Technologies for The Next Generation of Mobile Communications”, Geneva, Switzerland, 21 May 2013.
- ITU-R WP5D, #18 meeting, WWRF presentation at the Workshop on Research Views on IMT Beyond 2020, Ho Chi Minh City, Vietnam, February 2014
- Participating in ITU IMT-2020 Evaluation Process

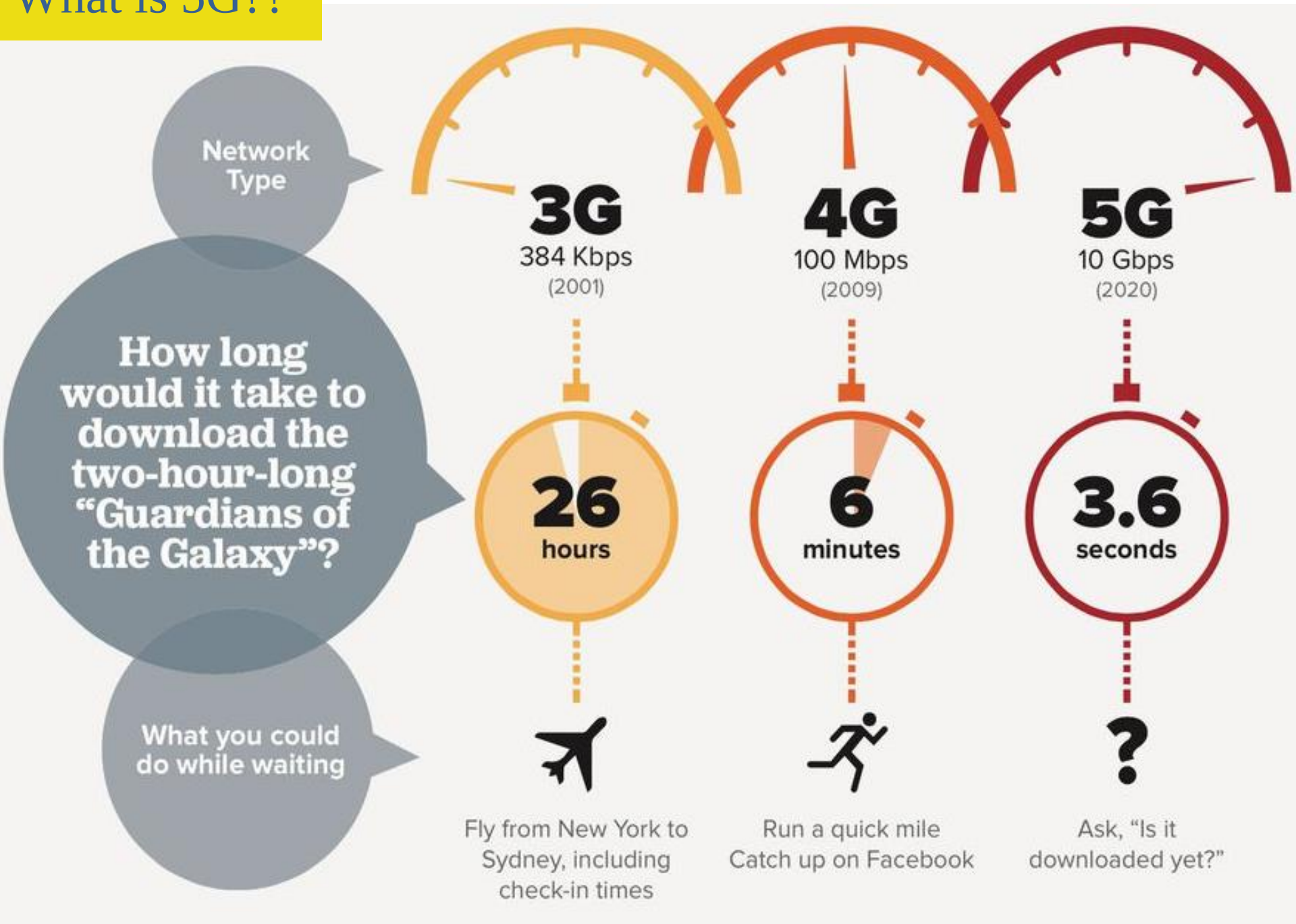
WWRF is looking beyond 5G

WIRELESS WORLD RESEARCH FORUM®

Recent workshop identified the major technology challenges and relevant application and usage scenarios for systems B5G

1. Technology enablers/new air interface
   - THz Communications
   - Large/massive antenna processing
   - Molecular Communications
2. New architectures/system concepts: machine learning, AI
3. New deployment concepts (e.g. islands of BB, ..)
4. New apps/use cases (virtual reality, ..)
5. New and critical challenges: Society impact, ‘endless’ battery life, cost of new technologies,..

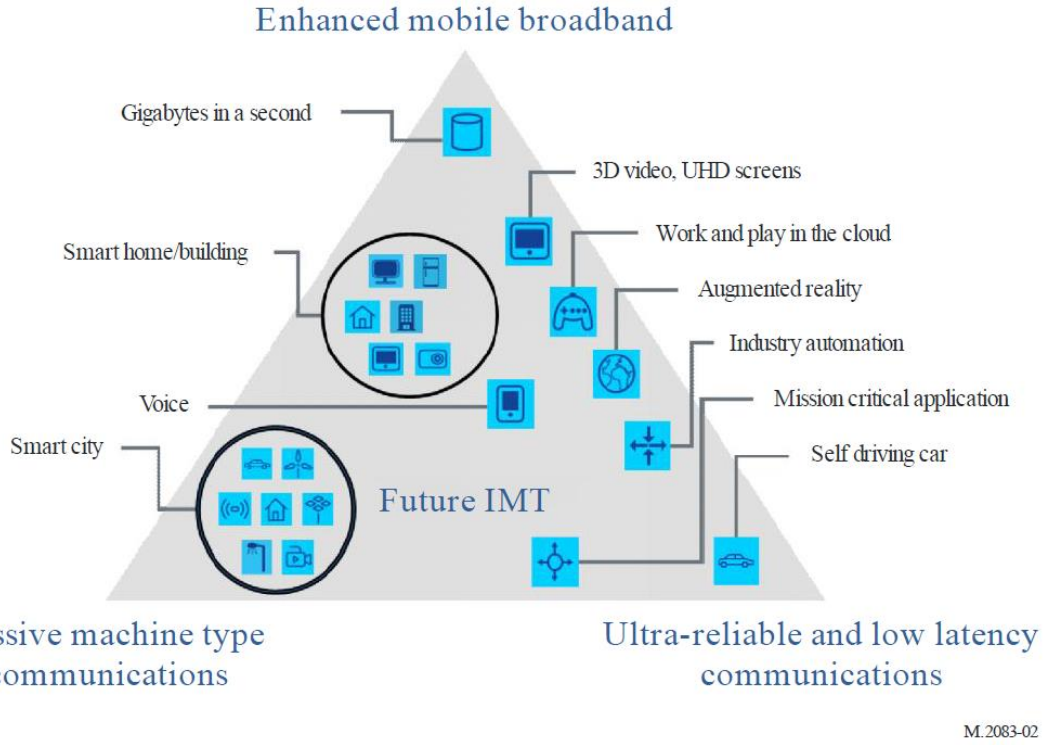
What is 5G??


Network Type
How long would it take to download the two-hour-long "Guardians of the Galaxy"?
What you could do while waiting
3G
384 Kbps
(2001)
4G
100 Mbps
(2009)
5G
10 Gbps
(2020)
26
hours
6
minutes
3.6
seconds
?
Fly from New York to Sydney, including check-in times
Run a quick mile
Catch up on Facebook
Ask, "Is it downloaded yet?"

Target Scenarios and Critical Requirements (1)

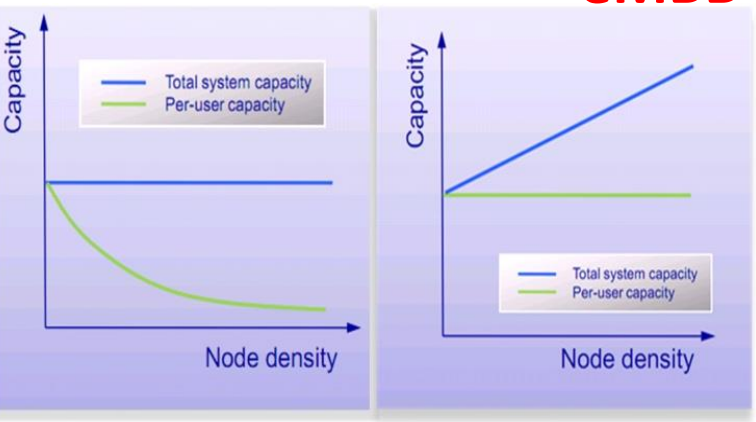
WIRELESS WORLD RESEARCH FORUM®

Usage scenarios of IMT for 2020 and beyond



Target Scenarios and Critical Requirements (2)

eMBB

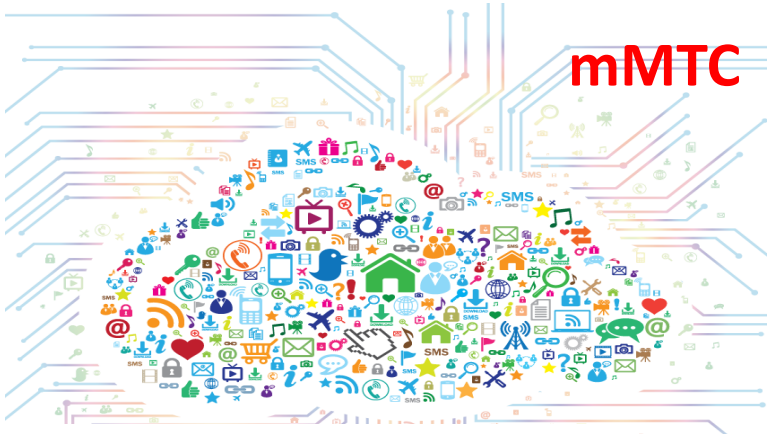


- **Capacity scaling**
  - *massive infrastructure deployment density over large geographical areas that is technologically and financially feasible*
  - *new niche and business opportunities*
  - *introduction of new value chain actors.*

eMBB

- **Crowded Local Access**
  - *massive data local access for dynamic crowds addressed through the interplay of technological and architectural innovations.*

Target Scenarios and Critical Requirements (3)



Source: Business Korea, "SK Telecom Develops World's First Global Standard IoT Platform", J.H. Park, Dec 2014

- **Massively Available Connectivity**
  - *5G will accommodate for bursty IoT communications by providing the necessary infrastructure and operations to handle the vastly diversified QoS requirements.*

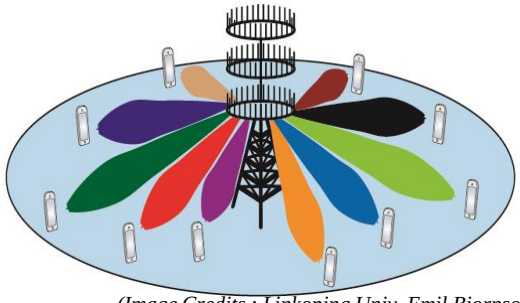
Source: "The tactile internet: IoT, 5G and cloud on steroids", M. Dohler, G. Fettweis, Telecomstechnews, Nov 2014

- **Reliability and Latency or 5G as the 'network of control'**
  - *The realization of Tactile Internet or the Network of Control will open up an "unforeseeable plurality of new applications, products, and services".*(1)

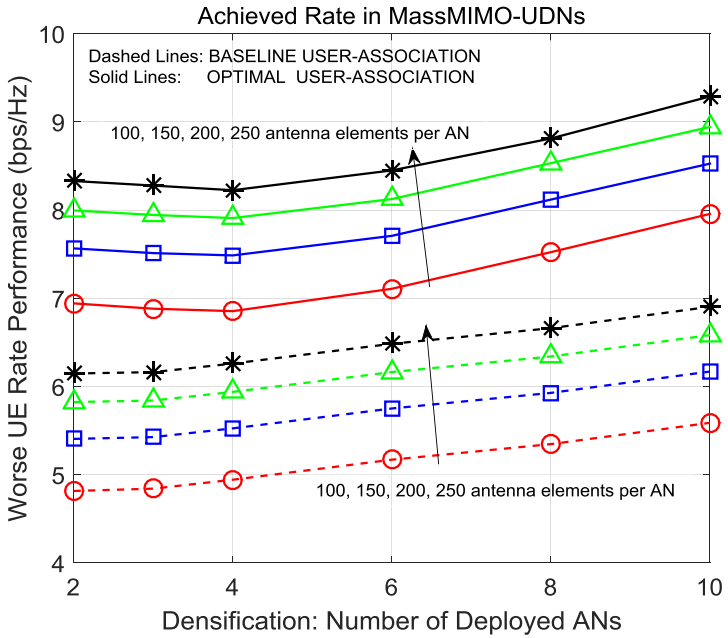
(1) Gerhard P. Fettweis, "The Tactile Internet – Applications & Challenges", IEEE Veicular Technology Magazine, Vol. 9, No. 1, pp. 64 – 70, March 2014

Enablers (1)

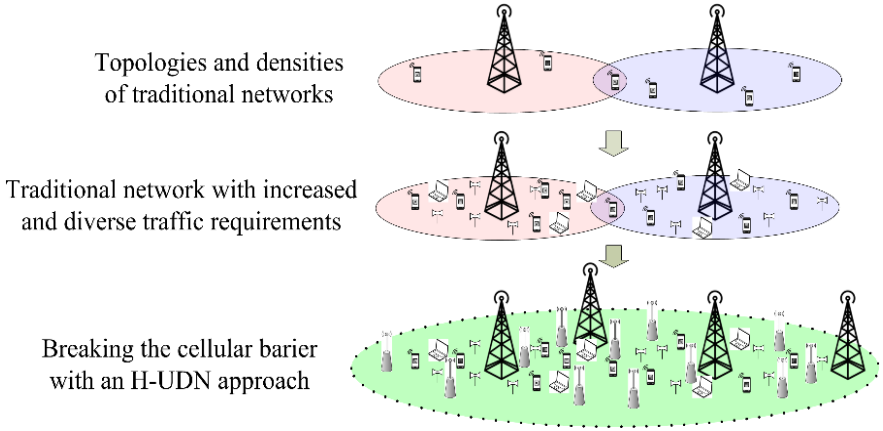
- **Large/Massive/Network-MIMO:**



(Image Credits : Linkoping Univ, Emil Bjornson)



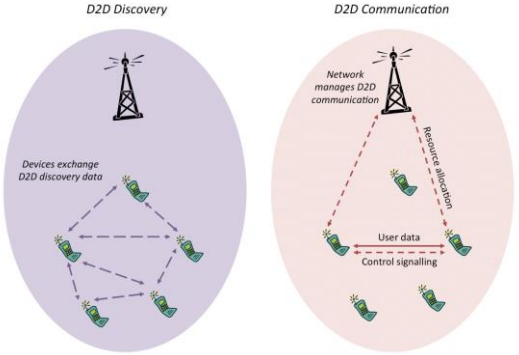
- **Ultra Dense Networks ('Cell-less' wireless)**

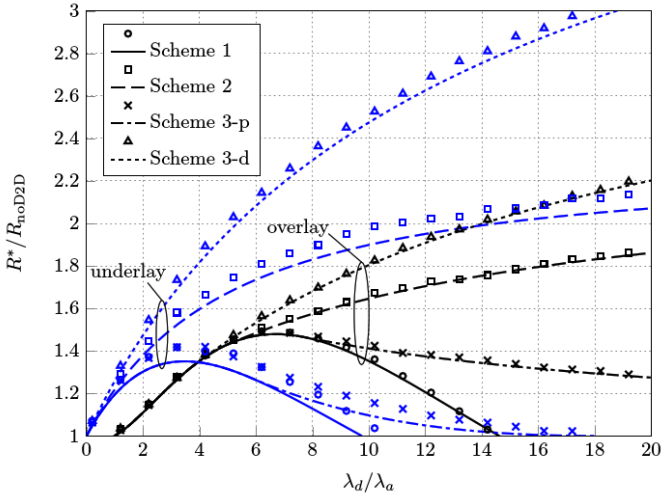


[A. G. Gotsis, S. Stefanatos, and A. Alexiou, "Optimal User Association for Massive MIMO Empowered Ultra-Dense Wireless Networks," IEEE ICC 2015 - Workshop on Advanced PHY and MAC Techniques for Super Dense Wireless Networks (ICC'15 - Workshops 13), Jun. 2015, London UK]

Enablers (2)

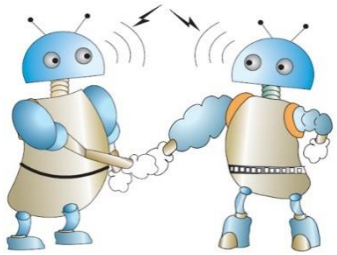
- **D2D**: exploiting intelligence at the edge of the network with Device-to-Device (D2D) connectivity and/or smart caching at the mobile side may offer an excellent network load balancing opportunity.

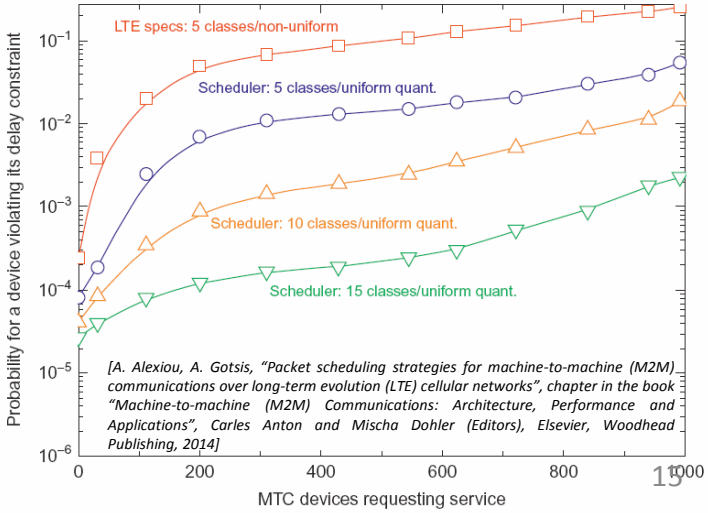




[S. Stefanatos, A. G. Gotsis, and A. Alexiou, "Operational Region of D2D Communications for Enhancing Cellular Network Performance," IEEE Transactions on Wireless Communications, 2015, to appear (available on arXiv)]

- **M2M** supporting a massive number of low-rate devices in the future IoT, in a plethora of diverse scenarios, and very-low-latency data transfers.

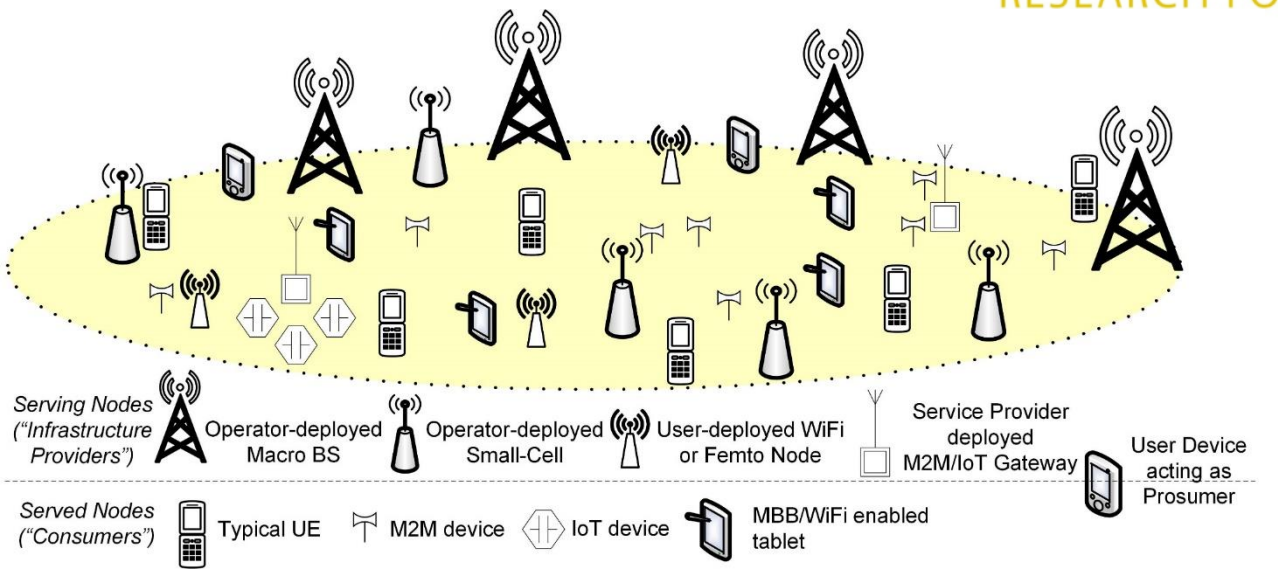




[A. Alexiou, A. Gotsis, "Packet scheduling strategies for machine-to-machine (M2M) communications over long-term evolution (LTE) cellular networks", chapter in the book "Machine-to-machine (M2M) Communications: Architecture, Performance and Applications", Carles Anton and Mischa Dohler (Editors), Elsevier, Woodhead Publishing, 2014]

5G and Beyond Design and Architecture Principle

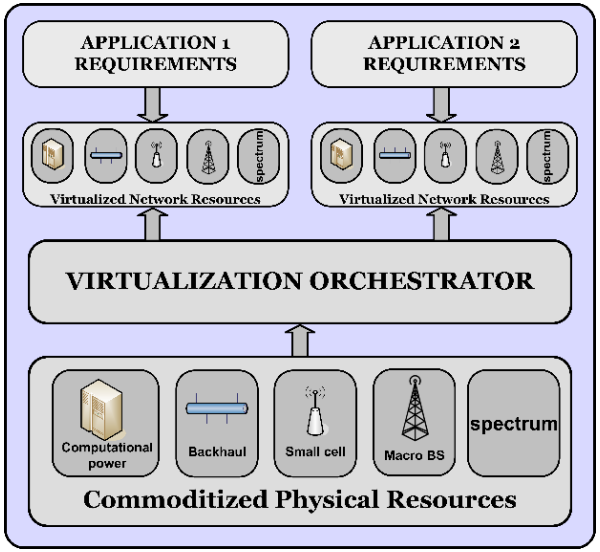
Extreme Network Densification



- The UDN concept introduces a paradigm shift from the well-known small-cell to a cell-less wireless future, by integrating:
  - Operator-driven hyper-dense small-cell deployments, bringing multiple orders of magnitude increase in the number of available infrastructure elements per user;
  - Complementary radio access networks (e.g. WiFi) operated by alternative providers (stadiums, airports, shopping malls);
  - User-deployed home infrastructure, such as wireless routers for internet access, femto-cells, M2M gateways;
  - "Crowdsourced" high-end user devices equipped with various wireless interfaces, and acting as adhoc providers.

5G and Beyond Design and Architecture Principle

Network Softwarization and Virtualization

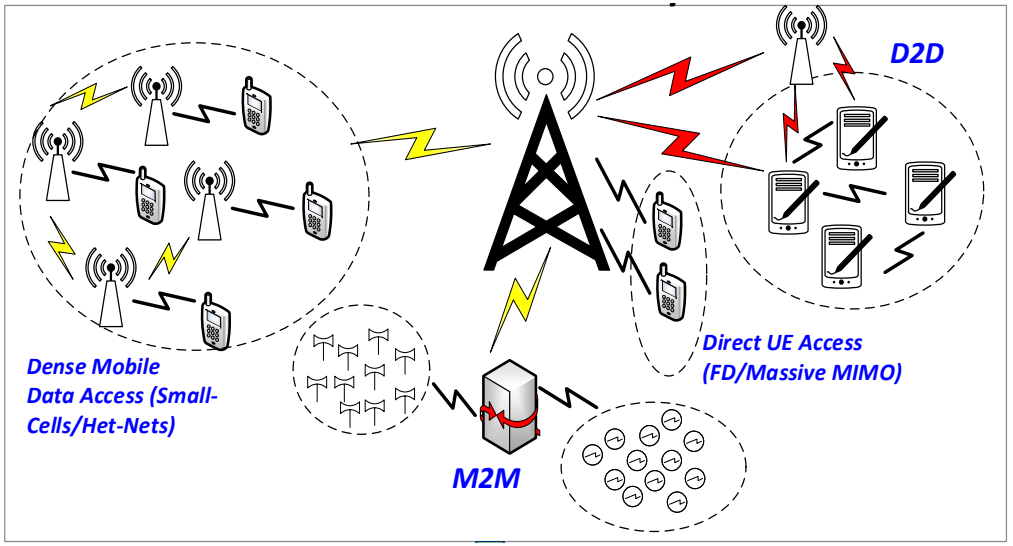


- A paradigm shift based on 'RESOURCES SHARING PRINCIPLE', in order to provide on-demand, cost-efficient and service-oriented networks on-the-fly.
- Decoupling of HW infrastructure and the supported functionalities, by:
  - Leveraging mainly general-purpose hardware and relevant facilities (e.g. IT data-centres);
  - Relying on software implementations for all system functionalities, including baseband processing, radio resources scheduling, network routing;
  - Dynamic on-demand real-time network management, in terms of allocated physical infrastructure and network operations, thus optimizing cost- and energy-efficiency, towards "elastic" network scalability.

Beyond 5G novel system concept

Proximal communications with '2-layer' access

WIRELESS WORLD RESEARCH FORUM®

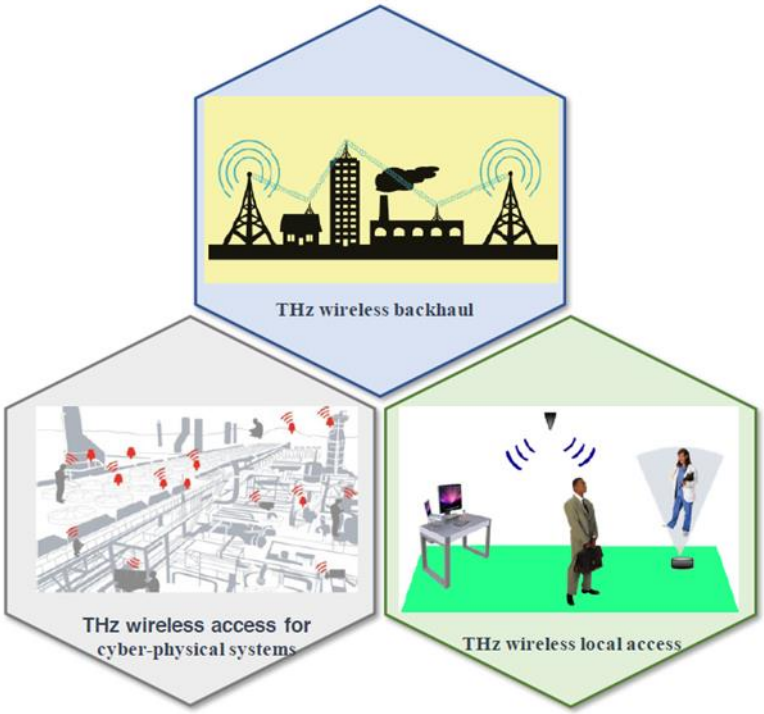


- Basic concept: exploit massive UE densification to access the network via a proximal link (M2M, D2D, SCN, WiFi, ..)
- Main challenge: '2-layer' multiple access, access/fronthaul/backhaul, overlay/underlay, cashing…

Beyond 5G: expectations

Tbps
CPS
AI
…?

WIRELESS WORLD RESEARCH FORUM®



- Inherently support a large dynamic range of novel usage scenarios that combine extreme data rates with agility, reliability, zero response time and AI
- Cost-efficient and flexible provision of high-speed data connections guaranteed, zeroing the ‘digital divide’
- Extend the fibre optic systems QoE and performance reliability to wireless

THz Opportunity and its unique Challenges

WIRELESS WORLD RESEARCH FORUM®

- Bridge the THz ‘gap’
- Tackle the THz propagation characteristics
  - Ultra wideband and extremely directional wireless links
  - Absorption Loss
  - Attenuation with distance

- **Devise a new network information theoretic framework imposed by the new disruptive characteristics of the channel**
- **Design appropriate wireless access technologies, i.e. pencil-beamforming, space synchronization, beam tracking, ..**
- **Design MAC protocols tailored to ‘pencil-beam’ access: challenging initial access/discovery and tracking w.r.t. complexity/delay/reliability/..**
- ict-terranova.eu

Network 2030 (6G) Ultra Radio

WIRELESS WORLD RESEARCH FORUM®

- Selected Access Technologies for Network 2030 (6G) Ultra-Radio
  - Exploiting the Spatial Dimension
    - Advanced MIMO and Massive MIMO
  - Exploiting the untapped spectrum
    - mmWave & Terahertz communication systems
  - Exploiting Cost Efficiency of Cloud and Distributed Computing
    - Multi-Technology HetNets (UDN)
    - Improved Cell Edge Coverage

Technology challenges for Network 2030 (1/4)

WIRELESS WORLD RESEARCH FORUM®

- **Verticals to drive development**
  - Wireless connectivity offers unlimited opportunities
- **Major changes to network architectures**
  - Ultra dense networks (UDNs)
  - Short range connectivity a crucial component of the e2e connectivity
  - Varieties of network deployments
  - Cloud distributed across the network from edge to the core
  - Distributed AI and ML
- **New value chains to appear**
  - Context dependent content
  - Micro operators and virtual operators to be integral part of the eco-system and potentially extending to the end users

Technology challenges for Network 2030 (2/4)

WIRELESS WORLD RESEARCH FORUM®

- **Low cost and affordable network solutions**
  - Connecting the last 4B people
  - Must contribute to sustainable development and society
  - Must address the problem of backhauling to remote areas
  - Seamless integration of terrestrial, satellite and HAP-based networks
- **Networking converges with IT and cloud**
  - Virtualization and cloud the largest disrupters to telecom
  - Software defined mobile network
  - Mobility management moves to edge of the network

Technology Challenges for Network 2030 (3/4)

WIRELESS WORLD RESEARCH FORUM®

- **New spectrum allocation and spectrum refarming**
  - Synergistic collaboration between unlicensed and licensed bands
  - Communication in the THz range
- **Advances in communications fundamentals**
  - Channel modeling and propagation for mmWave and THz systems
  - Short range connectivity a crucial component of the e2e connectivity
  - Adaptive signal processing and beamforming algorithms
  - Analytical modeling and design of UDNs
  - Radio resource management

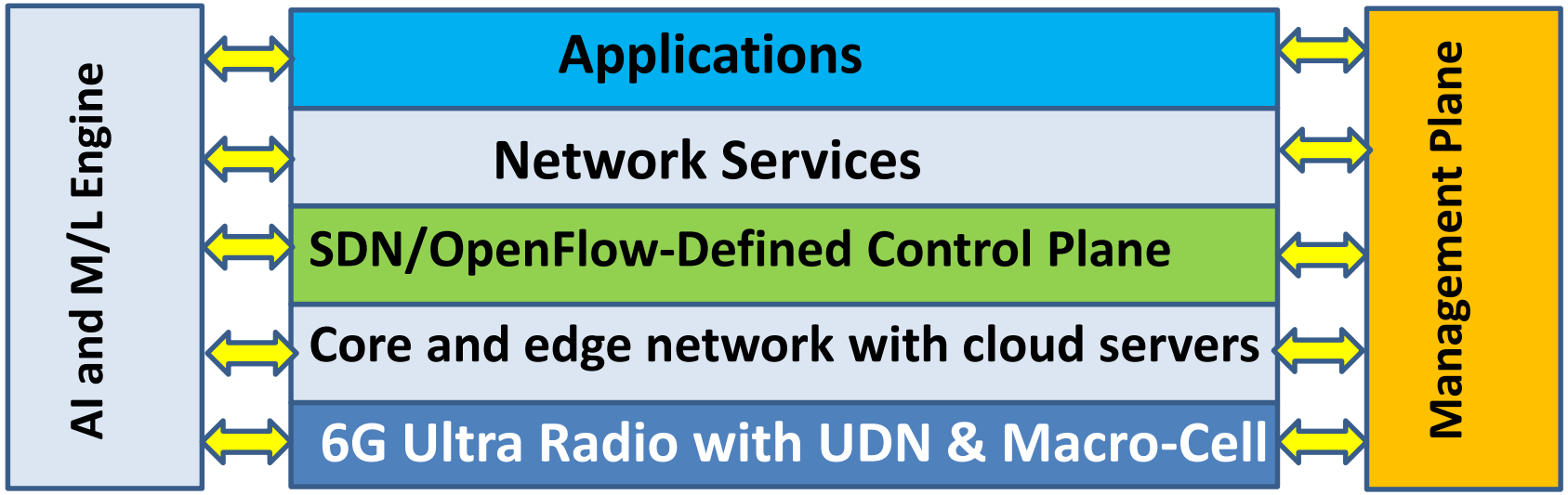
Technology Challenges for Network 2030 (4/4)

WIRELESS WORLD RESEARCH FORUM®

- **Advances in massive MIMO and adaptive near real-time channel estimation**
  - Channel properties and efficient channel learning techniques
  - Deal with imperfections such as antenna coupling effects, pilot contamination

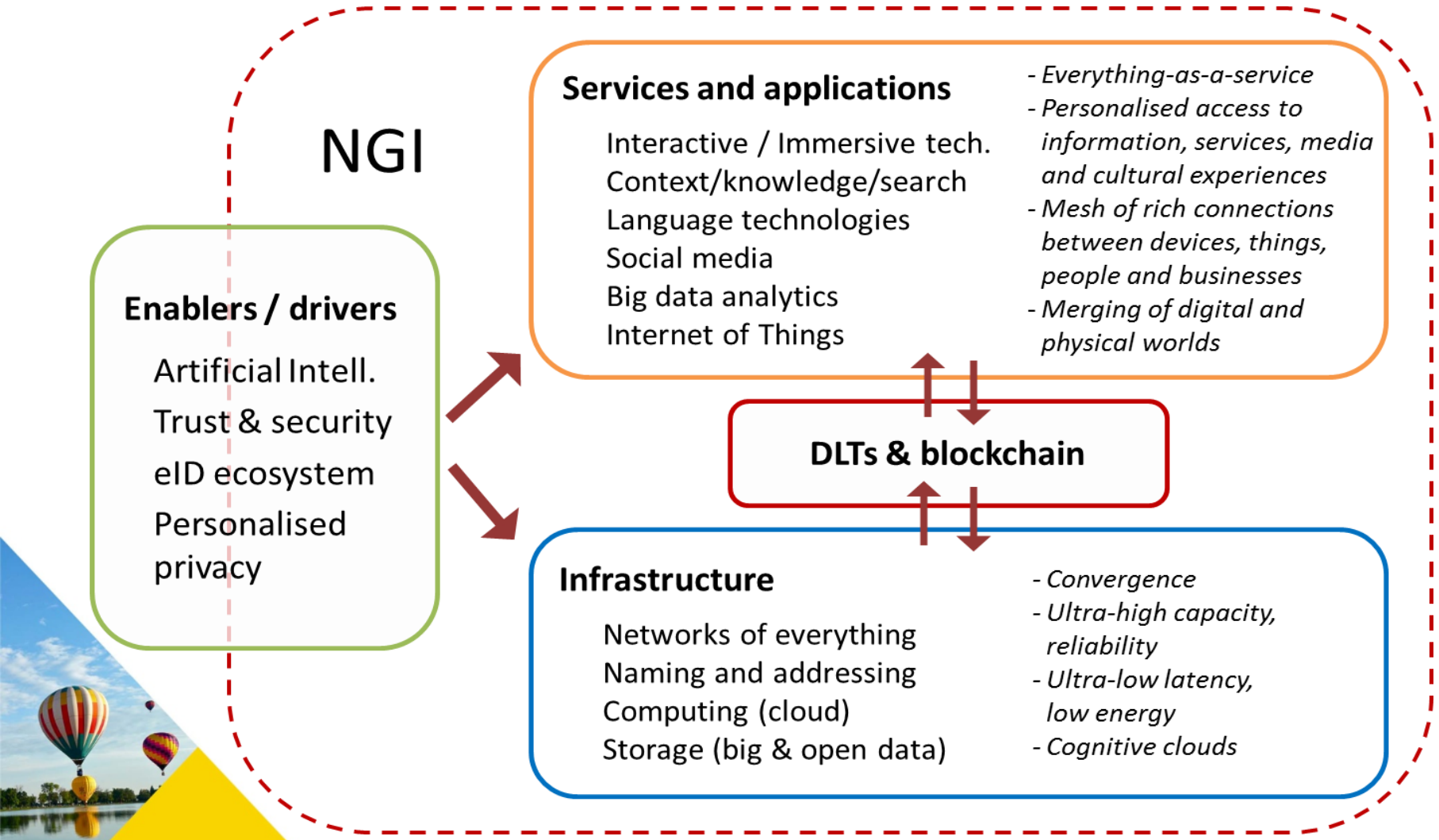
Potential IT-Driven architecture

WIRELESS WORLD RESEARCH FORUM®



NGI Proposed Structure

WIRELESS WORLD RESEARCH FORUM®



6Genesis

WIRELESS WORLD
RESEARCH FORUM®

Flagship

National Flagship on wireless communications

6G Enabled Wireless Smart Society & Ecosystem

- National Flagship for **2018-2026**
- Volume **251M€**
- Operated by **University of Oulu**
- Collaboration with **Nokia, VTT, Aalto University, BusinessOulu, OUAS.**

6Genesis was elected as **Finlands high-tech Flagship,** by **Finnish Government** through **Academy of Finland**

1. 

Wireless Connectivity
Ultra-reliable low-latency communications
Enabling **Unmanned Processes**

2. 

Devices & Circuits
THz communications materials & circuits
Enabling **Unlimited Connectivity**

3. 

Distributed Computing
Mobile edge intelligence
Enabling **Time Critical & Trusted Apps**

4. 

Services & Applications
Multidisciplinary research accross verticals
Enabling **Disruptive Value Networks**

5GIMF
The Fifth Generation Mobile Communications Promotion Forum

WIRELESS WORLD
RESEARCH FORUM®

42nd Wireless World Research Forum (WWRF 42), Tokyo, Japan

Theme: The 5G dream becomes real - will it keep its promises?

Venue: **Aoyama TEPIA**

14-16th May, 2019

Deadline for Abstracts 28th February

Contact

WIRELESS WORLD RESEARCH FORUM®

- Prof. Angeliki Alexiou, University of Piraeus, aalexiou@ieee.org
- Dr Sudhir Dixit, sudhir.dixit@gmail.com
- Dr. Nigel Jefferies, Chair WWRF, chair@wwrf.ch

wwrf.ch