Trends and Challenges in Wireless Innovation for 5G and Beyond

WIRELESS WORLD RESEARCH FORUM®

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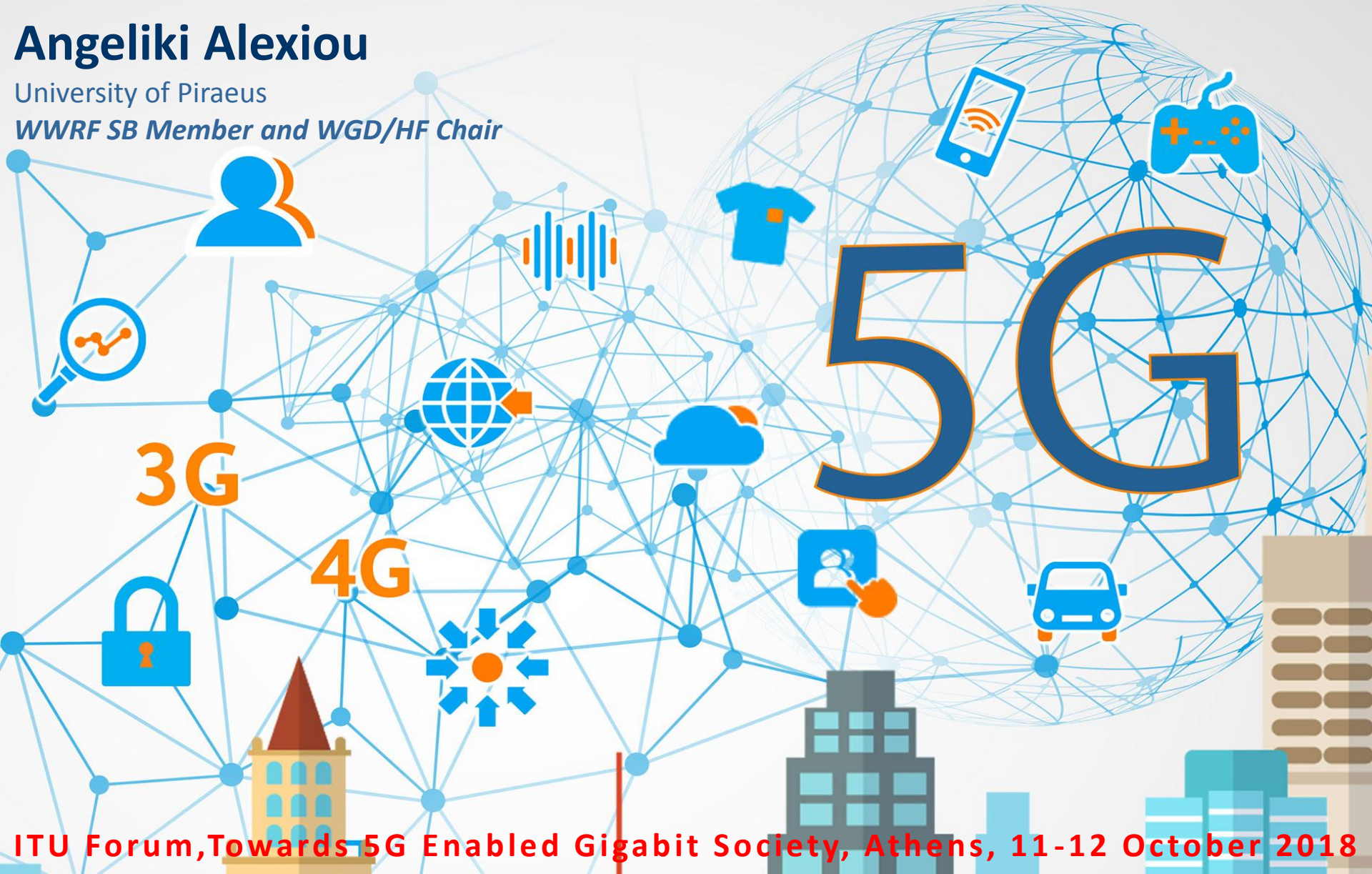


ITU Forum,Towards 5G Enabled Gigabit Society, Athens, 11-12 October 2018

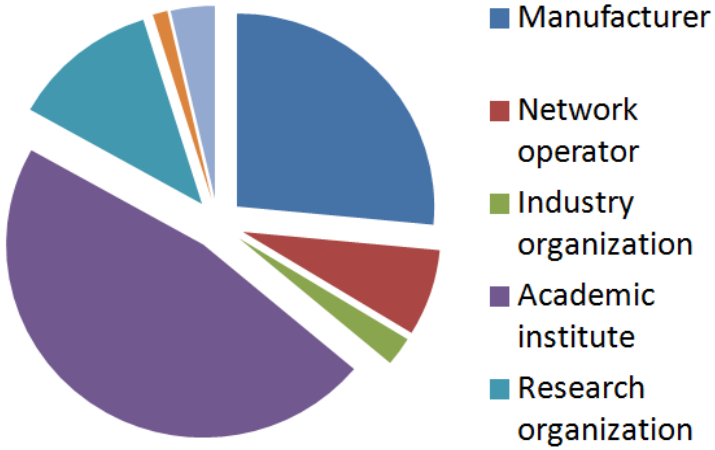
WWRF Overview

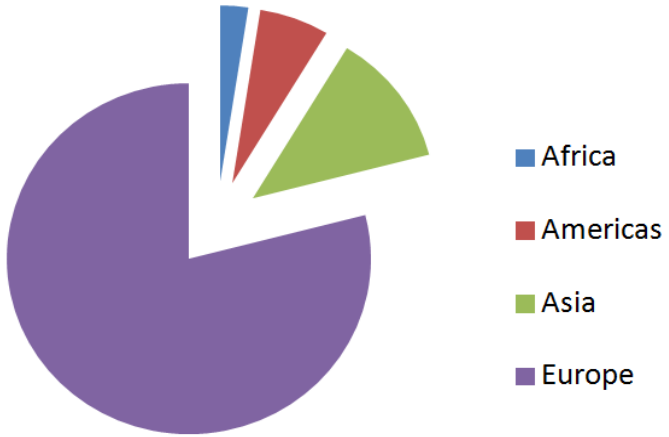
WIRELESS WORLD RESEARCH FORUM®

- Develop future vision of the wireless world
- Bring a wide range of parties together to identify and overcome significant roadblocks to the vision
- Enable / facilitate the translation of vision into reality
- Inform and educate on trends and developments

- Global operation
- Covers every technical field of wireless communications and mobile networking
- Open to all
- Based on membership

60 member organizations





WWRF facts

WIRELESS WORLD RESEARCH FORUM®

- Founded in 2001
- Formed from EU-funded Wireless Strategic Initiative
- Founder members: Nokia, Ericsson, Motorola, Alcatel, Siemens

- Now more global
- Huawei, Nokia, Intel, China Mobile are leading influences on Steering Board
- Many leading universities participate
- Two Forum meetings per year
- 5G Huddle event
- Publications, workshops, etc.

WWRF Working Groups

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- WORKING GROUP A/B: User Needs & Requirements in a Wireless World/Services, devices and service architectures
- WORKING GROUP C: Communication architectures and technologies
- WORKING GROUP D: Radio Communication Technologies
- WG HIGH-FREQUENCY TECHNOLOGIES
- VIP WG 5G E/M-HEALTH AND WEARABLES
- VIP WG THE CONNECTED CAR
- VIP WG TRACK-TO-TRAIN
- WG WIRELESS AI

WWRF and ITU

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- 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 IMT 2020 Evaluation Group Vision and Differentiators

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- Objective> Focus on performing advanced technologies evaluation studies based on realistic channel and system modelling assumptions

- Leveraging> previous 3G and 4G expertise of members, academic excellence and industrial experience, a global technology perspective and a strategic insight on all factors of the wireless evolution technology chain

WWRF IMT 2020 Evaluation Group Technical Approach

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- **Modelling**: Classification of 5G resources, propagation and channel modelling, node topology (geometry, density, ..)
- **Theoretical Tools to formulate and analyze problems**: Stochastic geometry, Information theory, Mathematical Programming
- **Management models & algorithms**: Understanding the fundamental performance levels. Centralized & Distributed approaches for dynamically assigning resources and assessing performance (be means of system level simulations)

WWRF IMT 2020 Evaluation Group Membership and Expertise

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- Members> spanning all stakeholders, bringing in a global perspective, and connecting with all 5G regional initiatives, namely
  - industry (Huawei, Intel, ..),
  - operators (China Mobile, ..),
  - academic research (Carleton University, Canada; CTTC Barcelona; Univ. of Piraeus, Greece; CSIR (South Africa),
  - Europe, North America, Asia, Africa
  - 5GPPP, 5G Forum, 5GMF, ..
- Expertise/experience> advanced technologies research and assessment, ITU-R WP5D procedures, system modelling and requirements specifications, large scale system level evaluations

Most Recent Events: 5th Annual 5G Huddle and WWRF40 meeting

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- Events held in Durban, South Africa, May 29th to 1st June, 2018
  - WWRF First Venture in Africa
  - Interested Countries:
    - Kenya, Tanzania, Burkina Faso, Zimbabwe
- WWRF Members:
  - CSIR – Meraka Institute
  - The Independent Communications Authority of South Africa (ICASA), South Africa

WWRF: Fostering 5G and Beyond Innovation Ecosystem

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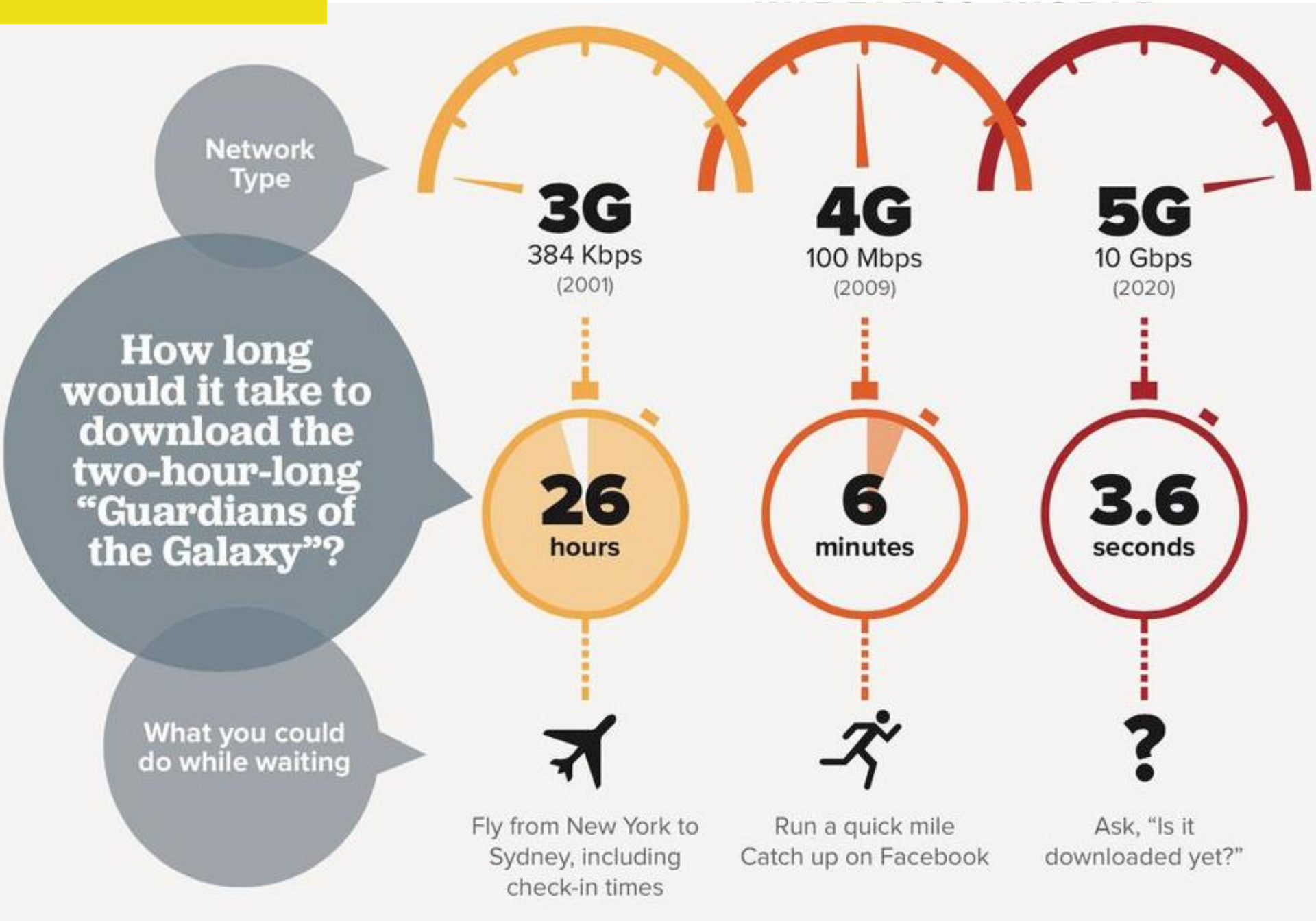
- An international “networking platform” between industry and academia
- Long experience in collaboration with research, regulatory and vision developers across continents
- Regular and active collaboration with ITU – contributions made to several WP 5D and WP 5A events
- Active in 5G space from 2012 onwards through WWRF meetings, international workshops and Special Sessions organization
- 5G Huddle events around the globe (5 such events 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.

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)

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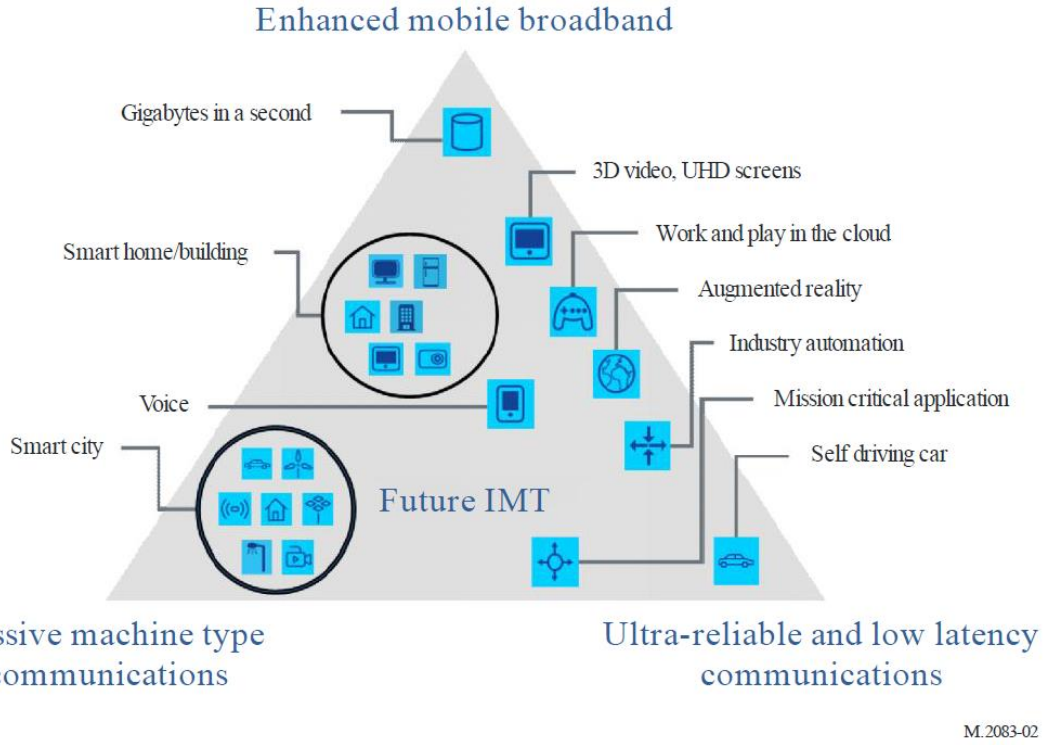
Usage scenarios of IMT for 2020 and beyond



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Target Scenarios and Critical Requirements (2)

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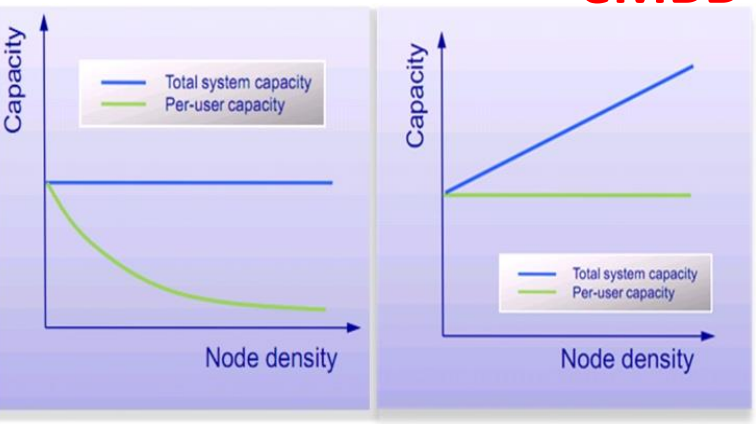
eMBB

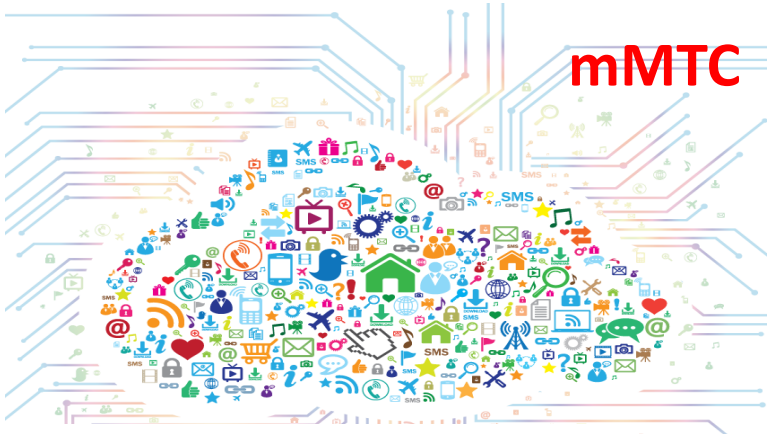


eMBB

- **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.*

- **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)

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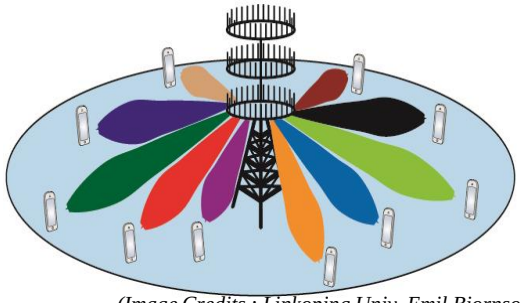
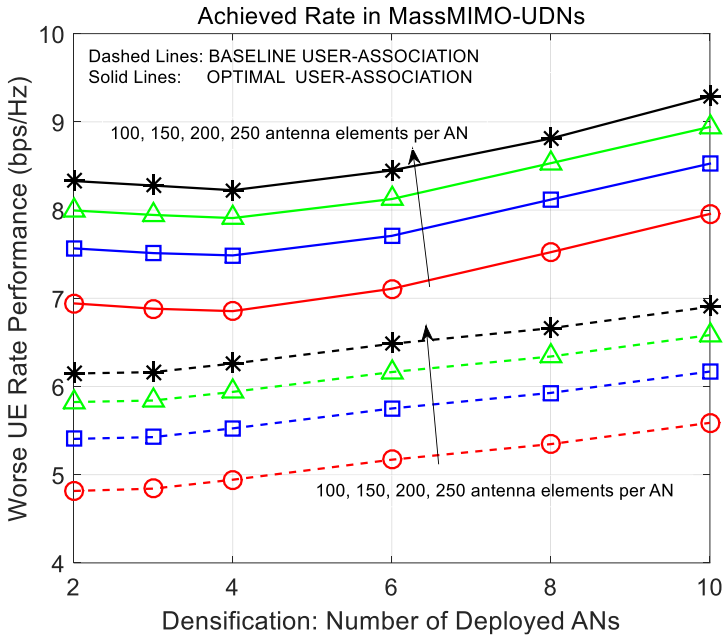
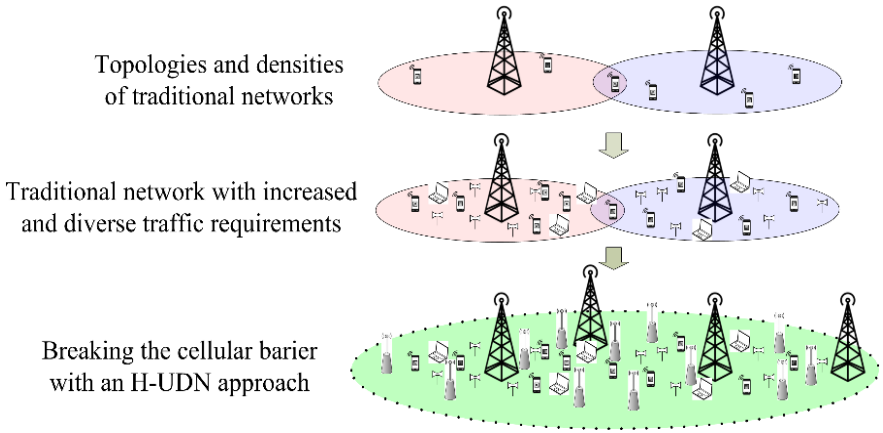
- **Large/Massive/Network-MIMO:**



(Image Credits : Linkoping Univ, Emil Bjornson)



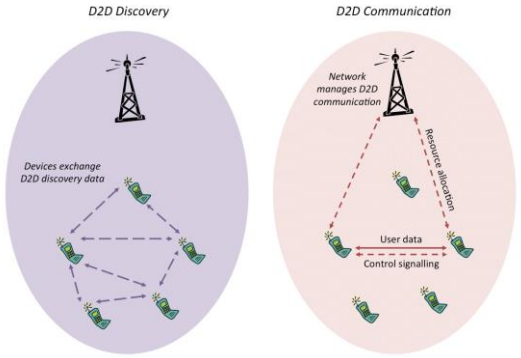
- **Ultra Dense Networks ('Cell-less' wireless)**

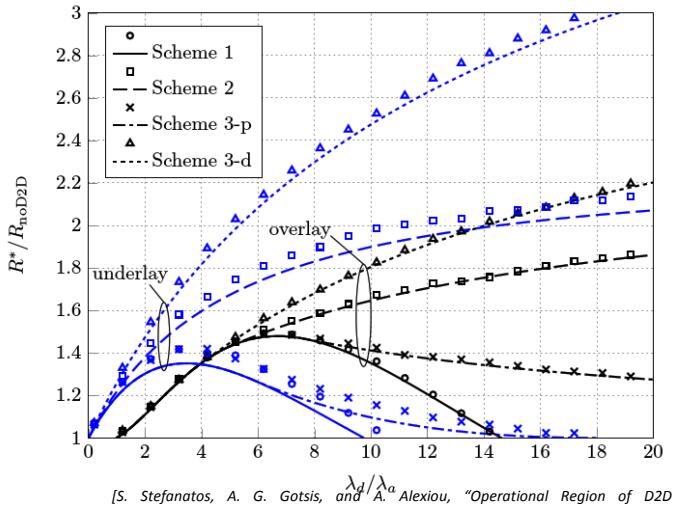


[A. G. Gotsis, S. Stefanatos, and A. Alexiou, "Optimal User Association for Massive MIMO Empowered Ultra-Dense Wireless Networks," IEEE ICC 2015 - Workshop on Advanced PHY and MAC Techniques for Super Dense Wireless Networks (ICC'15 - Workshops 13), Jun. 2015, London UK]

Enablers (2)

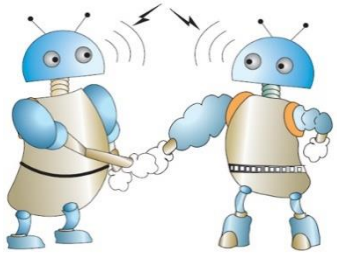
- **D2D**: exploiting intelligence at the edge of the network with Device-to-Device (D2D) connectivity and/or smart caching at the mobile side may offer an excellent network load balancing opportunity.

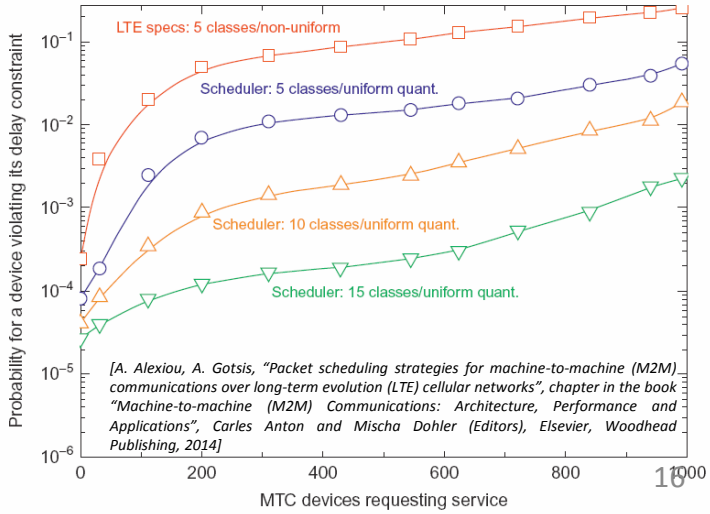




[S. Stefanatos, A. G. Gotsis, and A. Alexiou, "Operational Region of D2D Communications for Enhancing Cellular Network Performance," IEEE Transactions on Wireless Communications, 2015, to appear (available on arXiv)]

- **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.

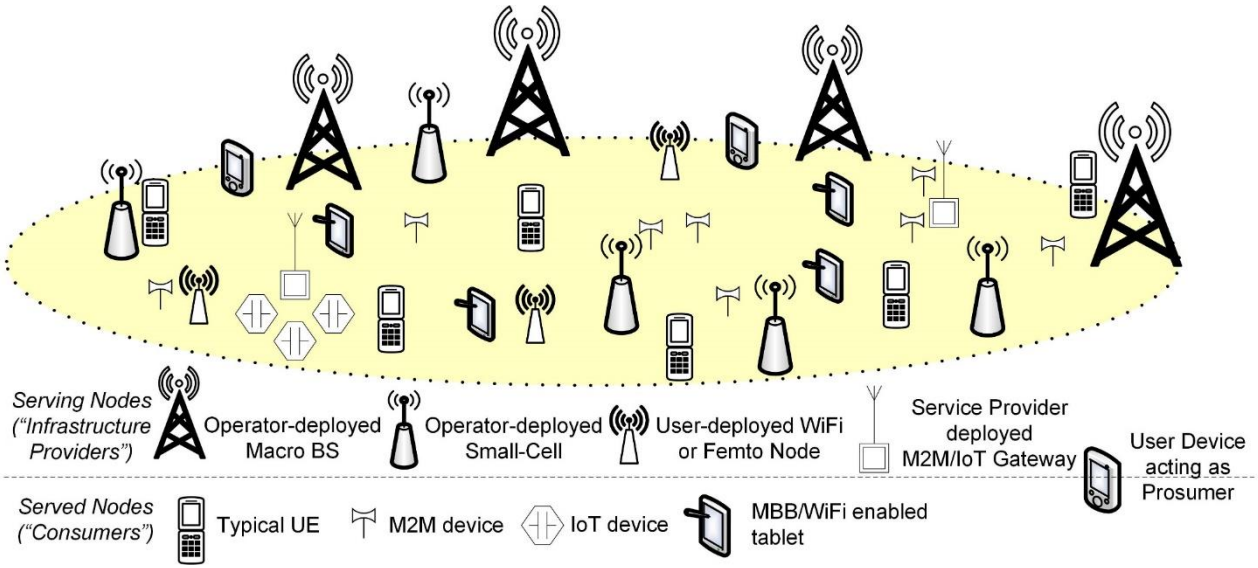




[A. Alexiou, A. Gotsis, "Packet scheduling strategies for machine-to-machine (M2M) communications over long-term evolution (LTE) cellular networks", chapter in the book "Machine-to-machine (M2M) Communications: Architecture, Performance and Applications", Carles Anton and Mischa Dohler (Editors), Elsevier,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

5G and Beyond Design and Architecture Principle

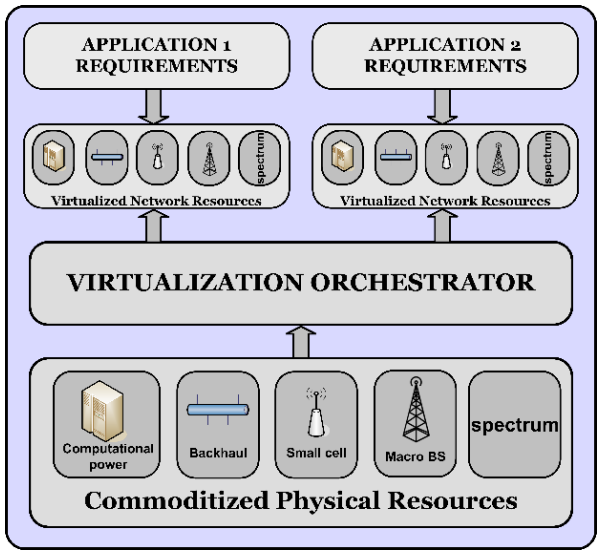
Extreme Network Densification



- 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

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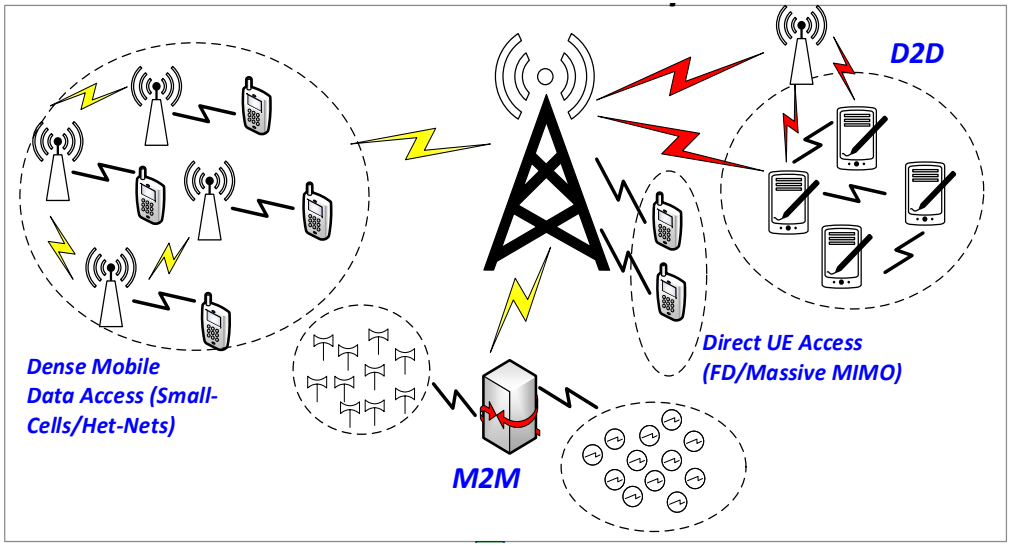

- Basic concept: exploit massive UE densification to access the network via a proximal link (M2M, D2D, SCN, WiFi, ..)
- Main challenge: '2-layer' multiple access, access/fronthaul/backhaul, overlay/underlay, cashing…

Beyond 5G: expectations

Tbps
CPS
AI
…?

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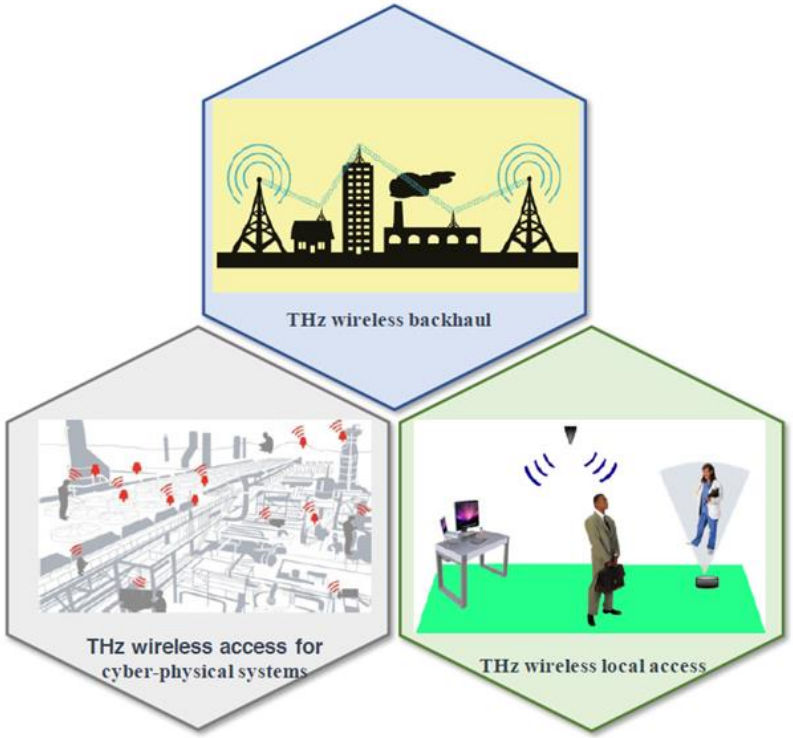

- Inherently support a large dynamic range of novel usage scenarios that combine extreme data rates with agility, reliability, zero response time and AI
- Cost-efficient and flexible provision of high-speed data connections guaranteed, zeroing the ‘digital divide’
- Extend the fibre optic systems QoE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

THz Opportunity and its unique Challenges

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- 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

Upcoming WWRF events

WIRELESS WORLD RESEARCH FORUM®

41st WWRF meeting, University of Aarhus, Denmark
30 October - 1 November 2018,

Theme: "Future Technologies for Business Ecosystem Innovation"

Contact

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