

FLAGSHIP UNIVERSITY OF OULU

Key drivers and research challenges for 6G

Kari Leppänen and Matti Latva-aho 6G Flagship

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6G World's First 6G Research Program

6G Enabled Wireless Smart Society & Ecosystem

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



6G Flagship was elected as Finland's high-tech Flagship, by Finnish Government through Academy of Finland





4.

Wireless Connectivity

Ultra-reliable low-latency communications vs. 1 Tbps

Enabling **Unmanned Processes**

Devices & Circuits

THz communications materials & circuits

Enabling Unlimited Connectivity

Distributed Computing

Mobile edge intelligence

Enabling Time Critical & Trusted Apps

Services & Applications

Multidisciplinary research accross verticals

Enabling **Disruptive Value Networks**



- To support companies in finalisation of the 5G standard by carrying out technology and system pilots.
- To develop/co-create the fundamental technology components to enable 6G systems.
- To speed up dependable, robust and secure digitalisation of society via 5G and 6G.





Vision for 2030

Our society is data-driven, enabled by near-instant, unlimited wireless connectivity.

6G will emerge around 2030 to satisfy the expectations not met with 5G, as well as, the new ones fusing AI inspired applications in every field of society with ubiquitous wireless connectivity.

Click here for our vision video

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5G¹

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WORLD'S FIRST 6G WHITE PAPER

http://jultika.oulu.fi/files/isbn9789526223544.pdf #6GFLAGSHIP 6GFLAGSHIP.COM

KEY DRIVERS AND RESEARCH CHALLENGES

FOR 6G

6G Research Visions 1 September 2019

66

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UBIQUITOUS WIRELESS

INTELLIGENCE



World's first 6G White Paper

The 6G research vision is based on three cornerstones:

2

6G technologies will bring to life the data-driven and hyper-connected future society. Major drivers for 6G include sustainability goals and societal challenges on top of productivity targets and technology enablers. Numerous business and societal players together create the new 6G infrastructure, products and services. KEY DRIVERS AND RESEARCH

RELESS

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http://jultika.oulu.fi/files/isbn9789526223544.pdf

6G Flagship aims to integrate intelligence with mobile communication technologies.

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- World's first 6G Wireless Summit gathered all major telecom players to throw ideas around 6G including speeches from Nokia, Ericsson, Orange, Telia, NTT DoCoMo, Samsung, MediaTek, and China Telecom, among others, in Levi, Finland in March 2019.
- The Summit launched 6G White Paper development with 70 experts from around the world representing different stakeholders.
- New version of 6G White Paper will be prepared annually.

https://www.6gsummit.com/ http://jultika.oulu.fi/files/isbn9789526223544.pdf



6Gଲି Key drivers for 6G research



Soft and hard values meet at 66



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Is it naïve to say: From 5G Engineering to 6G Humanity – or is it imperative?

TECHNOLOGY Enablers

Goals

SUSTAINABILITY

Quality Education + Clean Water and Sanitation + Gender Equality + Life Below Water + Life on Land + No Poverty + Good Health and Well-being + Climate Action + Sustainable Cities and Communities + Peace, Justice, and Strong Institutions + Clean Water and Sanitation + Zero Hunger + Industry, Innovation and Infrastructure + Affordable and Clean Energy + Reduced Inequalities + Partnerships for the Goals + Responsible Consumption and Production + Decent Work and Economic Growth

Education Innovations • Societal Services • Health and Wellbeing Services • Urbanisation vs. Remote • Infrastructure • Work Life Change • Data Security and Privacy • Automation • Personalisation

6G HUMANITY

RAN Agnostic / Automatically Orchestrated Transceivers + Non-device Centric Communications HBI + Extreme URLLC + Below CM Positioning + Consent and Privacy Preserving Data Sharing + Support for Ambient / Novel Sensing + Small Data Al (Distributed Learning) + Distributed Trust + Cyber-physical Security + Terahertz Technologies + 4D-Imaging and Image Projection and XR + Haptic Remote Telepresence + Full Spectrum Photonic Signal Processing + Proactive Decision Making/Informations Offering + Pervasive User Identification and Authentication + Net Neutrality + Zero-energy Communications + Al Inspired Air Interfaces + Grant Free Access (IoT)

Health • Manufacturing • Finance Technologies • Society 5.0 • Transport • Global Affordable Coverage • Education • Agriculture • Energy • FinTech

6 යි Initial 6 GKey Performance Indicators (KPIs)

Many of the KPIs used for 5G are valid also for 6G. However, the KPIs must be critically reviewed and new KPIs must be seriously considered.



SUSTAINABILITY AND

رقا المناقعة Initial 6G Key Performance Indicators (KPIs)

Generic 6G targets presented by academia and industry in different fora.



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Future 6G business ecosystem

Stakeholder roles in 6G will change compared to the current mobile business ecosystem and new roles will emerge.



Towards Local Operator Paradigm

Transition to higher frequencies and increasing role of indoor networks will boost network sharing in cities and indoor spaces, and drive the "local operator" paradigm.





Extended spectrum towards THz enables merging communications and new applications, such as 3D imaging and sensing.

New paradigms for transceiver architecture and computing will be needed to achieve 1 Tbps.

New opportunities for semiconductors, optics and new materials in THz applications.



6G Physical Layer and Wireless System

AI/ML will play a major role both in link and system level optimisation of 6G wireless networks.

New grant-free access methods are critical for truly massive machine-type communication.

Signal shaping is a way to achieve record-high spectral efficiency.

Analog modulation schemes in 6G?

The strongest security protection may be achieved at the physical layer.





6G needs a network with embedded trust.

6G will create data markets – privacy protection will be a key enabler.



6G needs an upgraded networking paradigm – from best effort to dependability.

Artificial intelligence and block chain may play a major role in 6G networks.

6G Merges Communications with New Applications

6G is not only about moving bits: it will become a framework of services, including communication service.

In 6G, all user specific computation and intelligence may move to edge cloud.

Integration of sensing, imaging and highly accurate positioning capabilities with mobility opens a myriad of new applications in 6G.

Trust and privacy are key prerequisites for successful 6G service platform.



6G

6G WIRELESS SUMMIT 17-20 MARCH 2020 LEVI, FINLAND

www.6Gsummit.com