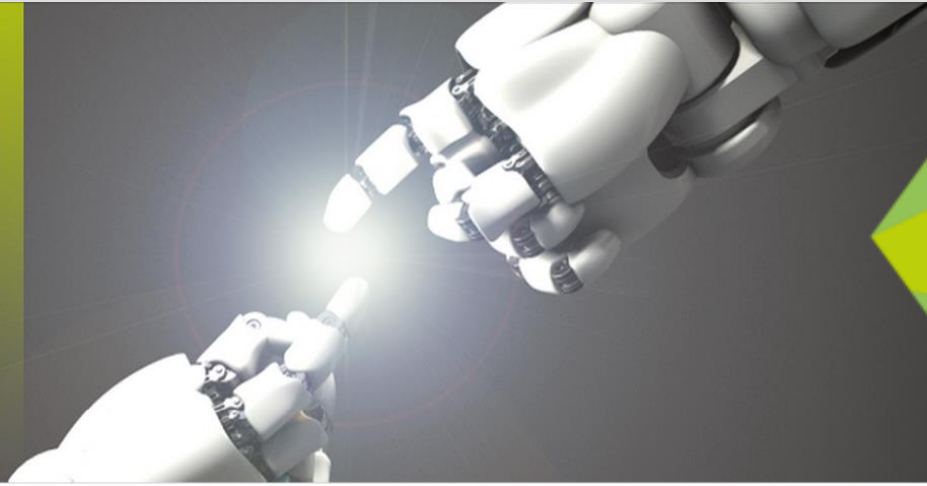




TECHNISCHE
UNIVERSITÄT
DRESDEN



5G LAB
GERMANY

On the Tactile Internet Standardization Activities – An Overview of IEEE, ETSI, and IETF Standards

Dr. Meryem Simsek

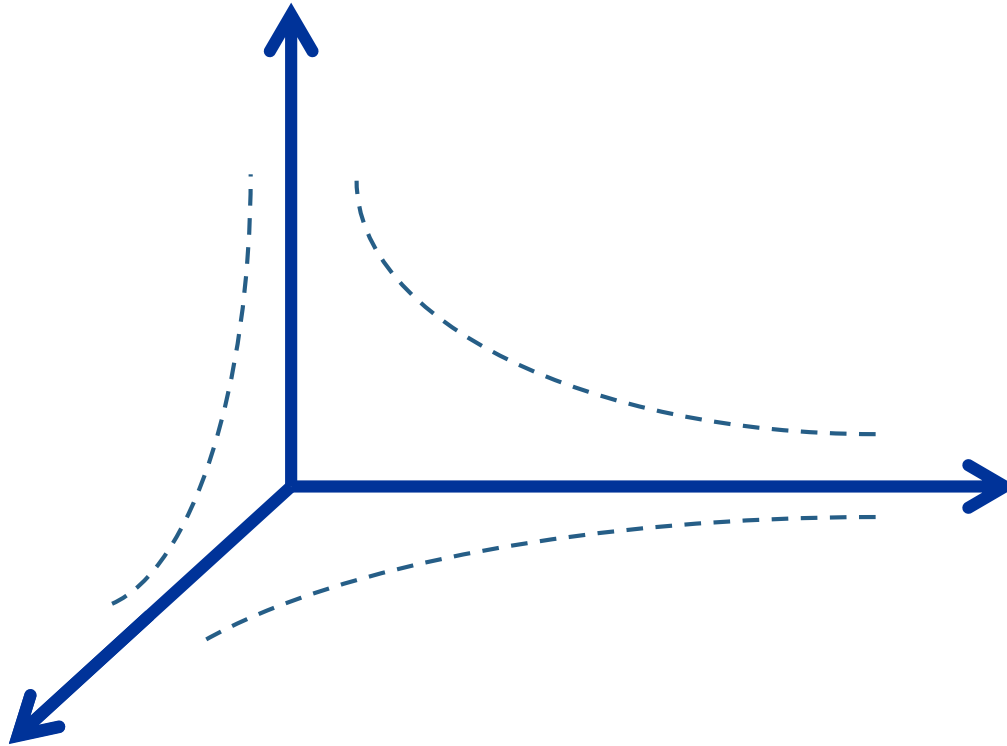
Group leader at Vodafone Chair, TU Dresden

Chair of IEEE ComSoc Tactile Internet Technical Sub-Committee

A 5G Hyperplane

Speed: $>10 \text{ Gb/s} \rightarrow \text{Tb/s}$

Massive Content



Massive Sensing

1b/s over 10 years
off an AAA battery

Massive Control

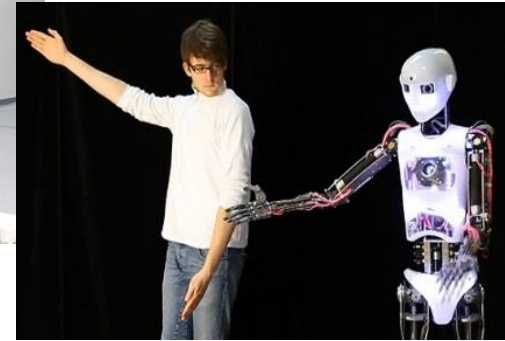
Response: 1 ms

The Tactile Internet

Moving from 50ms round-trip time → 1ms tomorrow



Revolution Ahead: The Tactile Internet



5G



Ubiquitous
Steering & Control
Communications

Health & Care
Traffic & Mobility
Sports & Gym
Edutainment
Manufacturing
Smart Grid,...

Tactile Internet: From Vision to Realization



VDE-POSITIONSPAPIER



TAKTILES INTERNET

Das IT-Netz der Zukunft


ITG VDE



The Tactile Internet

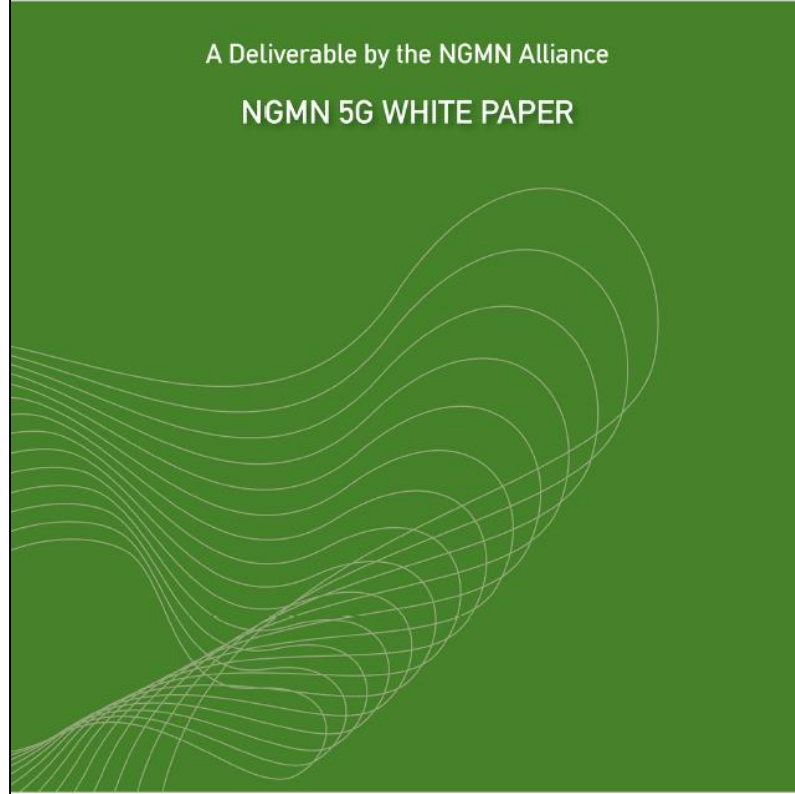
ITU-T Technology Watch Report
August 2014

Extremely low latency in combination with high availability, reliability and security will define the character of the *Tactile Internet*. It will have a marked impact on business and society, introducing numerous new opportunities for emerging technology markets and the delivery of essential public services. This Technology Watch report outlines the potential of the *Tactile Internet*, exploring its promise in application fields ranging from industry automation and transport systems to healthcare, education and gaming. It goes on to describe the *Tactile Internet's* demands on future digital infrastructure and its expected impact on society, concluding with a brief discussion of the role to be played by the ITU framework.



A Deliverable by the NGMN Alliance

NGMN 5G WHITE PAPER



next generation mobile networks

IEEE Tactile Internet Sub-Committee



The screenshot shows a web browser displaying the website <http://ti.committees.comsoc.org/>. The page features the IEEE ComSoc logo and the title "Tactile Internet Emerging Technical Subcommittee". A navigation menu includes links for Home, Officers, Meetings, Mailing List, Activities, and Standardisation. The "Officers" page is active, listing the following roles and contact information:

- Chair:** Meryem Simsek meryem.simsek@tu-dresden.de
- Co-chairs:** Mischa Dohler mischa.dohler@kcl.ac.uk and Latif Ladid latif@ladid.lu
- Secretary:** Falko Dressler dressler@ccs-labs.org

The main content area includes a "Welcome to Tactile Internet Emerging Technical Subcommittee" message, a small image of a hand touching a screen, and introductory text about the committee's focus on exploring and elucidating business and societal gaps and challenges. It also mentions Prof. Dr.-Ing. Dr. h.c Gerhard Fettweis and provides links to related documents.

IEEE Tactile Internet Sub-Committee



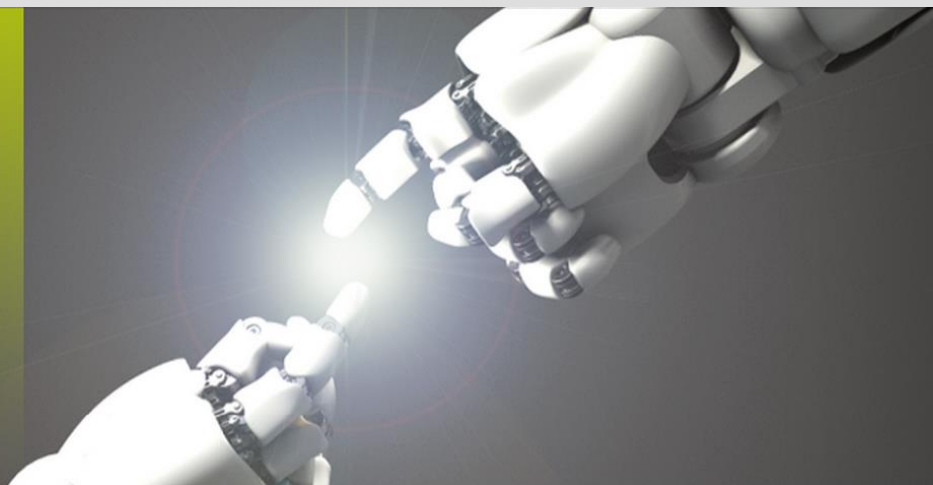
Globecom 2015: Workshop on Ultra-Low Latency and Ultra-High Reliability in Wireless Communications <http://www.ultra-wireless-workshop.com/>

WCNC 2016: Workshop on 5G & Beyond - Enabling Technologies and Application with focus on the Tactile Internet & Vertical Industry <http://www.ctr.kcl.ac.uk/5G2016/WCNC/>

Globecom 2016: Ultra-Reliable and Low-Latency Communications in Wireless Networks (URLLC) <http://www.urllc-wireless-workshop.com/>

Globecom 2016: Wireless Networking, Control and Positioning for Unmanned Autonomous Vehicles <http://www.wi-uav.org/>

WCNC 2017: Workshop on 5G & Beyond - Enabling Technologies and Application with focus on the Tactile Internet & Vertical Industry <http://www.ctr.kcl.ac.uk/5G2017/WCNC/> under preparation



World Class Standards

IPv6

- [IPv6 Participant Agreement](#)
- [IPv6 Member Agreement](#)
- [Signature Instructions](#)
- [Terms of Reference](#)
- [List of IPv6 Members](#)
- [GS Template](#)
- [IPv6 Activity Report](#)

IPv6 ▾ List of IPv6 Members

LIST OF IPv6 MEMBERS

Organisation Name	URL
Bell Mobility (CA)	www.bell.ca
China Telecommunications (CN)	www.chinatelecom.com.cn
Cisco Systems Belgium (BE)	www.cisco.com
Cosmote S.A (GR)	www.cosmote.gr
Hewlett-Packard (FR)	www.hp.com
Huawei Sweden (SE)	www.huawei.com
Huawei UK (UK)	www.huawei.com
University of Athens (GR)	www.uoa.gr
University of Luxembourg (LU)	www.snt.uni.lu

LIST of IPv6 PARTICIPANTS

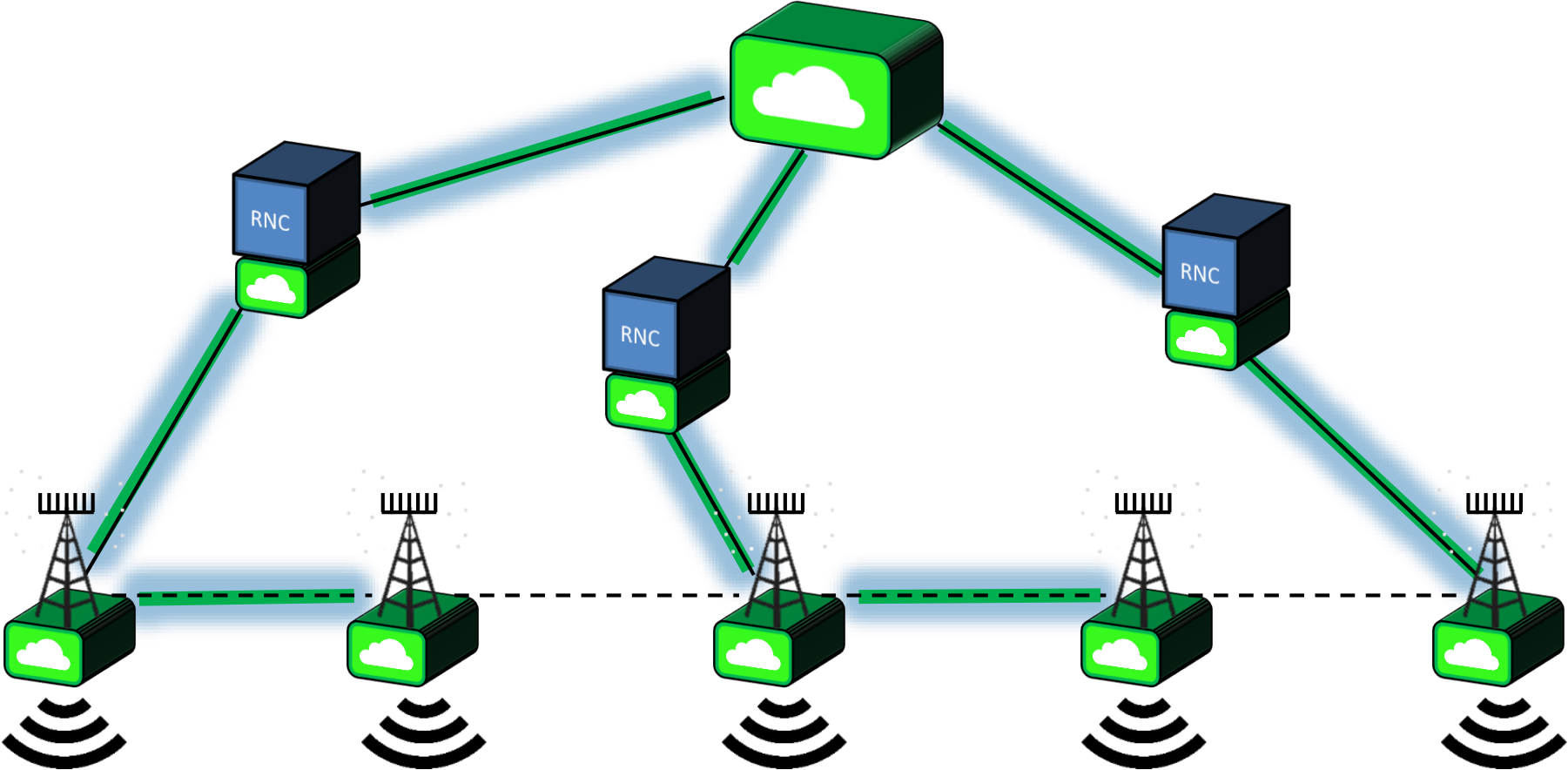
Beijing Internet Institute -BII - (CN)	www.biigroup.com
Celenium (US)	www.celenium.com
Citkomm KDVZ (DE)	www.citkomm.de
China Unicom (CN)	eng.chinaunicom.com
Device Gateway SA (CH)	www.devicegateway.com
HOP Ubiquitous S.L. (ES)	www.hopu.eu
Instituto Superior Tecnico IST (PT)	www.tecnico.ulisboa.pt
Mandat International (CH)	www.mandint.org
Microsoft (US)	www.microsoft.com
Nephos6 (US)	www.nephos6
Sixscape (SG)	www.sixscape.com
Technical University of Dresden (DE)	www.tu-dresden.de
University of Ljubljana (SI)	www.itre.org
University of Murcia (ES)	www.um.es
VN Telecom Consultancy (US)	www.von20.com

ETSI IPv6 ISG – DGS/IP6-0014



10	Doc. Nb. GS IP6 010 Ver. 0.0.2 Ref. DGS/IP6-0010 Technical Body: IP6 Details and Download	IPv6-based SDN and NFV Deployment of IPv6-based SDN and NFV	Drafting Stage Current Status: Early draft (2015-10-16) Next Status: Stable draft (2016-03-01)
11	Doc. Nb. GS IP6 011 Ver. 0.0.3 Ref. DGS/IP6-0011 Technical Body: IP6 Details and Download	IPv6-Based 5G Mobile Wireless Internet Deployment of IPv6-Based 5G Mobile Wireless Internet	Drafting Stage Current Status: Early draft (2016-01-28) Next Status: Stable draft (2016-03-01)
12	Doc. Nb. GS IP6 012 Ver. 0.0.1 Ref. DGS/IP6-0012 Technical Body: IP6 Details and Download	IPv6 Deployment and Security IPv6 Deployment and Security	Drafting Stage Current Status: Early draft (2015-10-06) Next Status: Stable draft
13	Doc. Nb. GS IP6 013 Ver. 0.0.1 Ref. DGS/IP6-0013 Technical Body: IP6 Details and Download	IPv6 Deployment in Privacy IPv6 Deployment in Privacy	Drafting Stage Current Status: Early draft (2015-10-06) Next Status: Stable draft
14	Doc. Nb. GS IP6 014 Ver. 0.0.1 Ref. DGS/IP6-0014 Technical Body: IP6 Details and Download	IPv6 based Tactile Internet IPv6 based Tactile Internet	Drafting Stage Current Status: Early draft (2015-07-09) Next Status: Stable draft (2016-03-28)
15	Doc. Nb. GS IP6 015 Ver. 0.0.1 Ref. DGS/IP6-0015 Technical Body: IP6 Details and Download	Impact of Mobile IPv6 Deployment of Mobile IPv6	Drafting Stage Current Status: Early draft (2015-07-08) Next Status: Stable draft (2016-03-30)
16	Doc. Nb. GS IP6 017 Ref. DGS/IP6-0017 Technical Body: IP6 Details and Download	6TiSCH Interoperability Test Specifications 6TiSCH Interoperability Test Specifications	Drafting Stage Current Status: TB adoption of WI (2015-07-09) Next Status: Start of work (2015-07-09)

Mobile Edge Cloud / Micro Cloud / Cloud



ETSI Contributions

- Proximity through anycast addressing
- Caching through neighbor discovery
- Low latency through fast forwarding and routing
- Agility: mobile edge clouds
- Impact of Tactile Internet

Draft ETSI GS IP6 0014 V0.0.2 (2016-02)



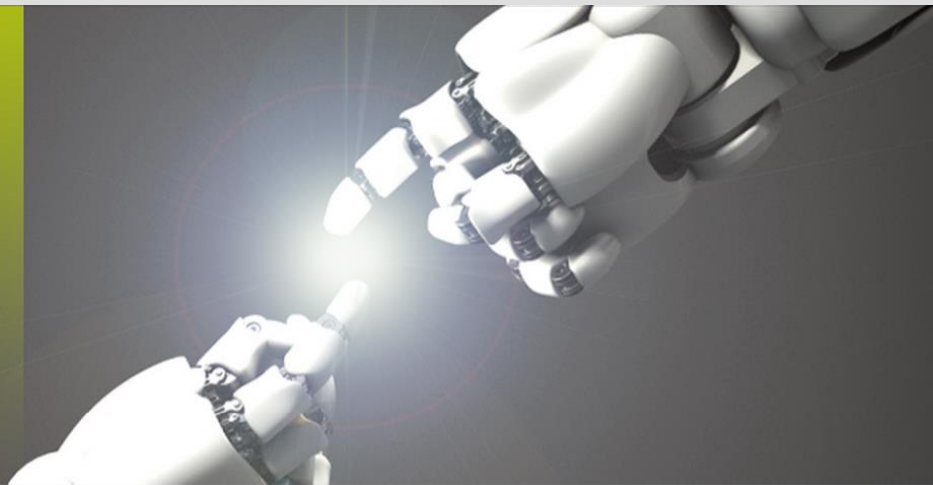
IPv6-Based Tactile Internet

Upcoming White Paper



Tactile Internet

- Mobile Edge Cloud
 - 5G
 - ...
- Contributions are welcome!



IEEE ComSocTM

IEEE Communications Society

IEEE – Tactile Internet Working Group



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STANDARDS DEVELOPMENT WORKING GROUP

TI - Tactile Internet

STATUS:

Active Working Group



Working Group Chair: Oliver Holland

Society: [IEEE Communications Society](#)

Sponsor: [Standards Development Board Committee \(COM/SDB\)](#)

IEEE-SA Liaison: [Contact the IEEE-SA liaison](#)

Active Projects Managed by this Working Group

PARTICIPATION IS EASY.

Anyone can participate for free. Members can lead groups and ballot on standards. Here's how to get involved in development:



FIND AN ACTIVE PROJECT

Pick from 100's of individual and corporate standards in development.



FIND A WORKING GROUP

Search by topic, or link to it from the Project Page.



CONTACT THE GROUP LIAISON

Voice your interest with a single click.

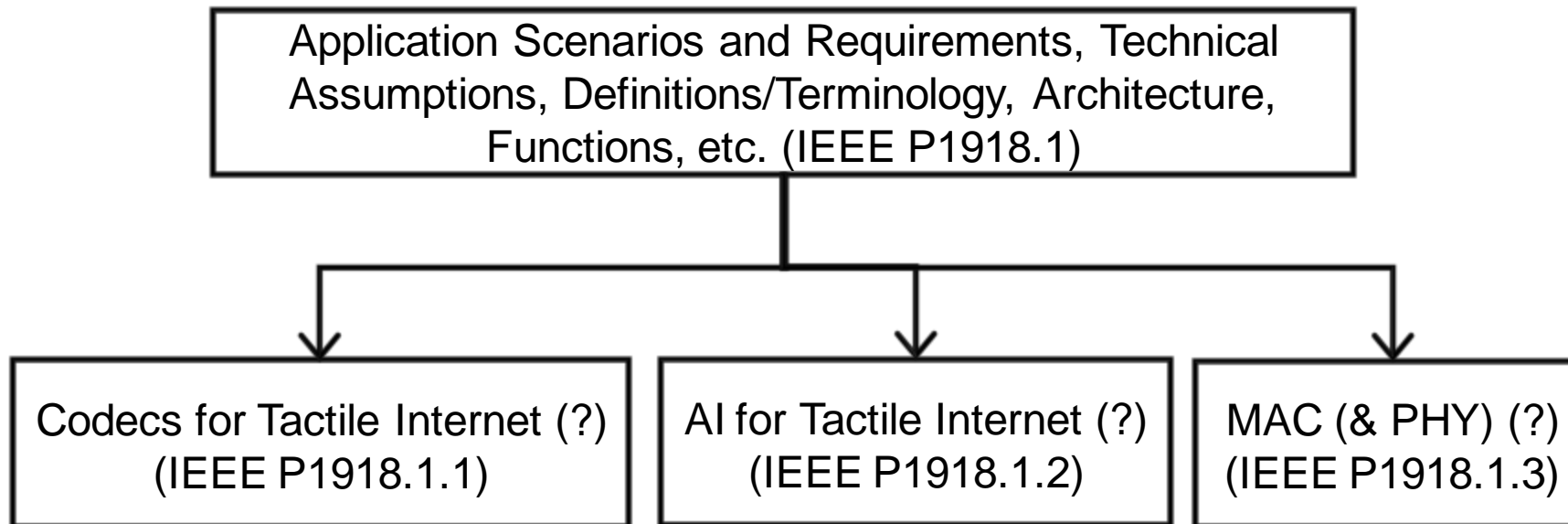
[Learn more about getting started](#)

JOIN IEEE-SA & SAVE!

IEEE – Tactile Internet Working Group



- There have been a number of proposals for further work under this scope. To be decided whether they are within the current standard (some might be), or should be amendments after the current standard is completed, or should be parallel standards under the scope of this working group.
- For the latter, an example of how this might look.



- The IEEE P1918.1 working group's mission is to describe an end-to-end framework for the Tactile Internet comprising the joint consideration of Communication, Computing, and Control (CCC)

Proposed Tactile Internet Definition



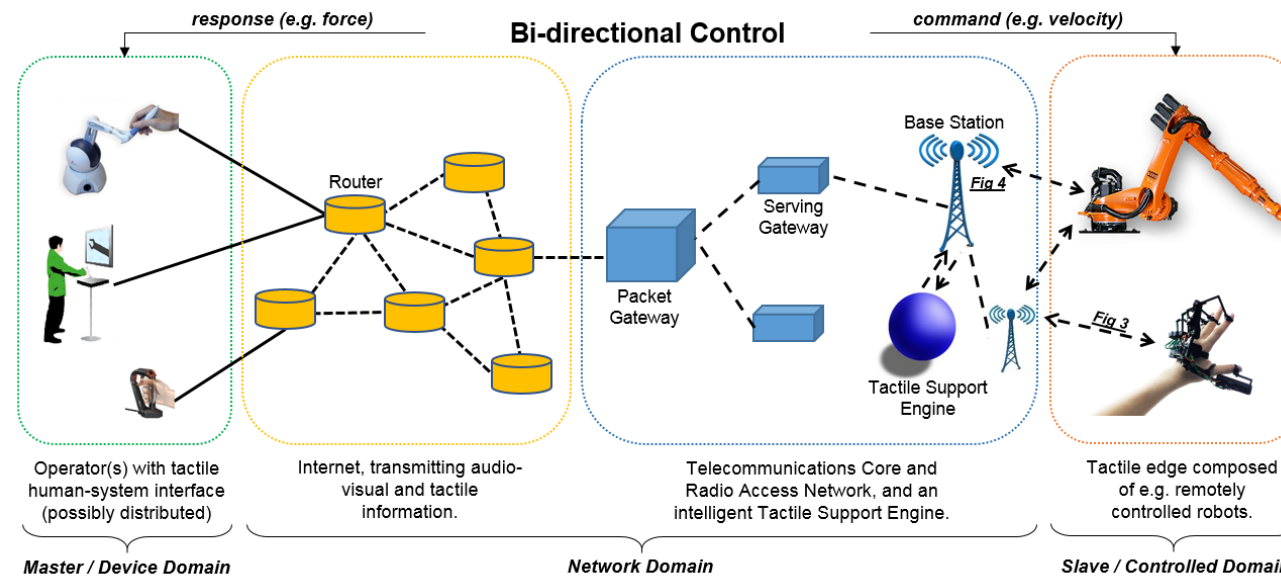
„A network or network of networks to remotely accessing or controlling virtual and/or real objects in perceived real-time“

Functional Architecture

The end-to-end functional architecture comprises three distinct domains.

- Master/Device Domain
- Network Domain
- Slave/Controlled Domain

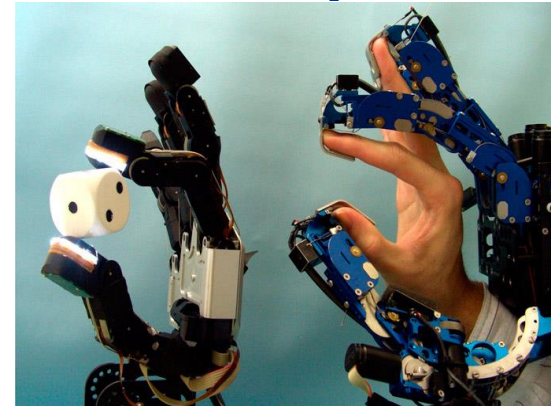
Information exchange is bi-directional and usually closes a global control loop



Codes

- Protocol for the Exchange of Device Capabilities (Handshaking)
 - Size of Workspace
 - Degrees of Freedom
 - Maximum Force/Torque
 - etc.
- Perceptual Coding for Closed-loop Kinesthetic Interaction
- Perceptual Coding for Open-loop Tactile Feedback

Kinesthetic Perception



Tactile Perception



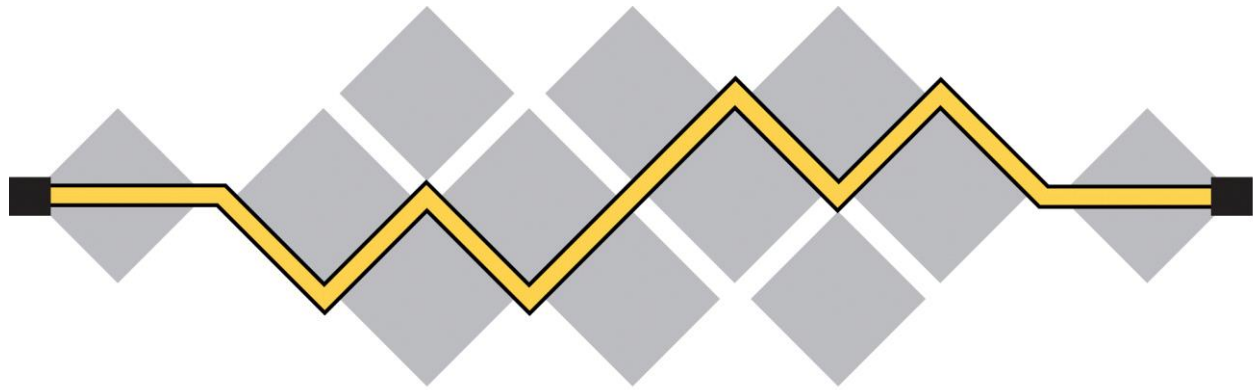
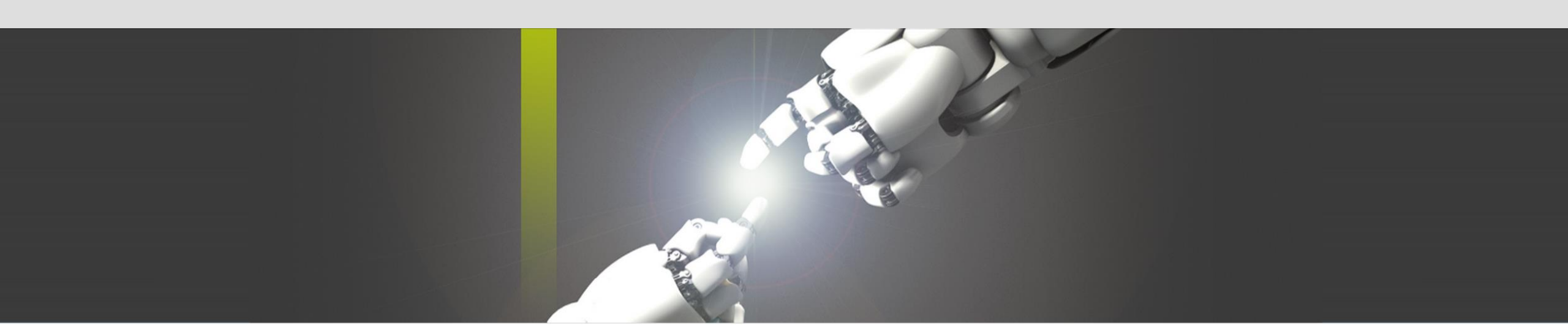
**Perception of
form, position, surface texture, stiffness, friction,
temperature, etc.**

Further Contributions



- Multi-connectivity architectures supporting Tactile Internet
- Use cases and requirements
- KPI studies
- Tactile Internet for extreme environments
- ...

- Next meeting: June 27, 2016



I E T F[®]

Contributions by Frank Fitzek



- IETF/IRTF
- No direct Tactile Internet standard, but related contributions

THANK YOU!

meryem.simsek@tu-dresden.de