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ComNets
Deutsche Telekom Chair of Communication Networks

Deutsche Telekom Chair of Communication Networks
Technical University Dresden

Professor Dr.-Ing. Dr. h.c. Frank H.P. Fitzek

Get in Touch with the Metaverse

Communication Networks – Why do we bother

Shit!
What can
we do?

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6G-life
CeTI

Interdependency of challenges

CeTI CeTI

Pandemic

Skills shortage

Aging society

Climate Change

TaHiL concept

Interdependency of challenges

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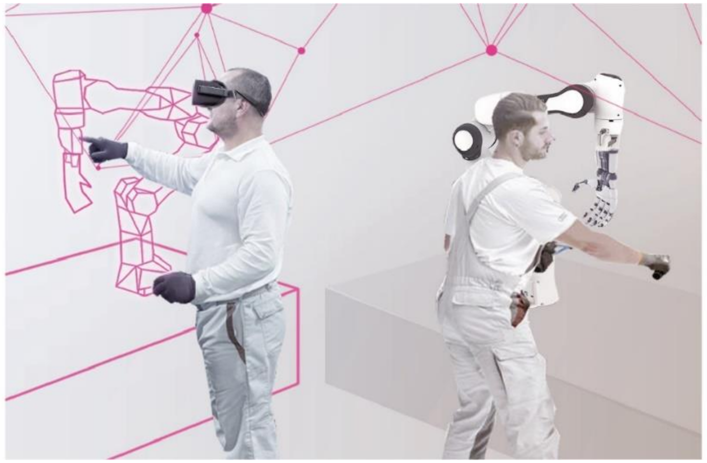
Pandemic

Skills shortage

Aging society

Climate Change



TaHiL concept

Interdependency of challenges

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Pandemic

Skills shortage

Aging society

Climate Change

TaHiL concept

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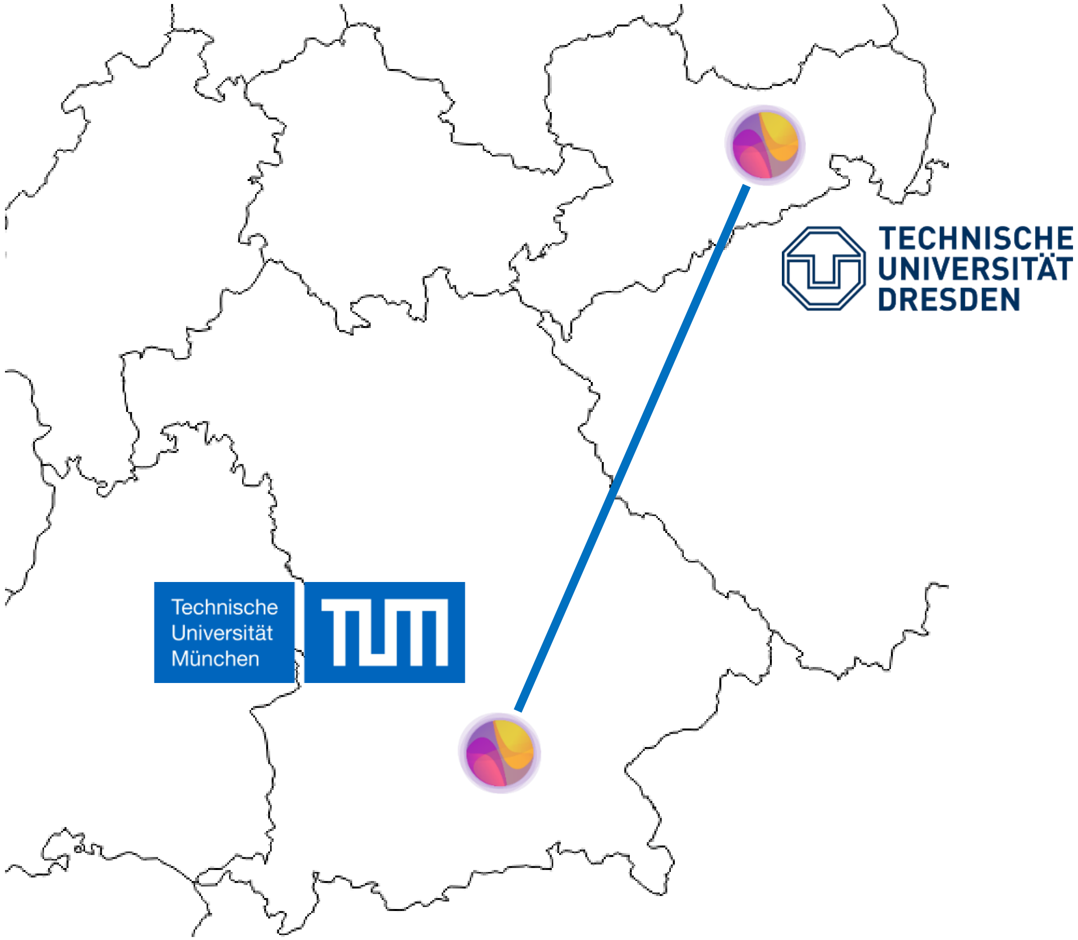
Future Communication Networks

6G-life

BMBF 6G Research Hub 6G-life

- Started August 15, 2021
- 70 Million € for 4 years
- > 60 Principal Investigators → 153 researchers

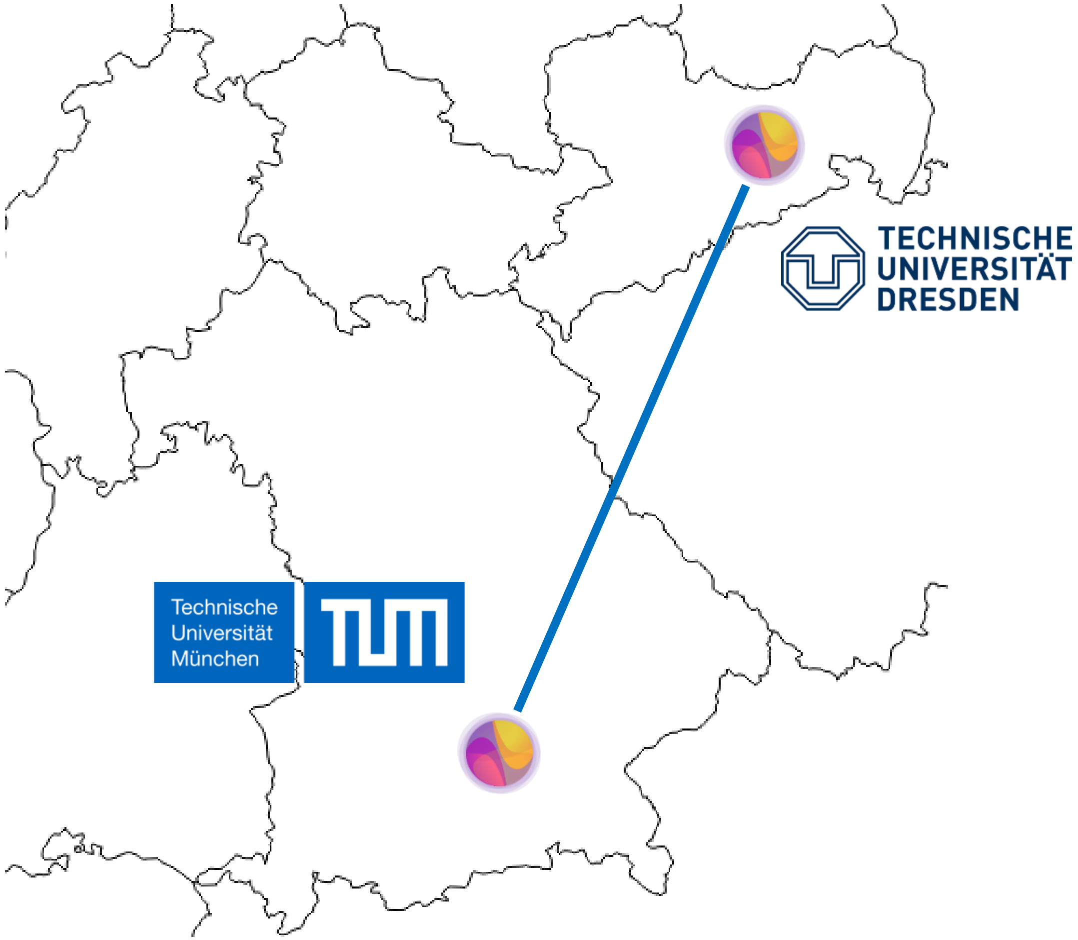


6G-life team

BMBF 6G Research Hub 6G-life

- Started August 15, 2021
- 70 Million € for 4 years
- > 60 Principal Investigators → 153 researchers

- 6G: focus is on humans and their communication and interaction with machines and the virtual world → holistic research on innovative concepts for scalable communication, novel methods, flexible software concepts and adaptive hardware
- Important fields of application: Industry 4.0 and healthcare (extending with industry projects)
- Four key performance indicators: Latency, Resilience, Security and Sustainability
- Digital Sovereignty and Digital Transfer
- 10 Million € for Start-ups



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Future Communication Networks

Novel Architectures for Softwarized Networks

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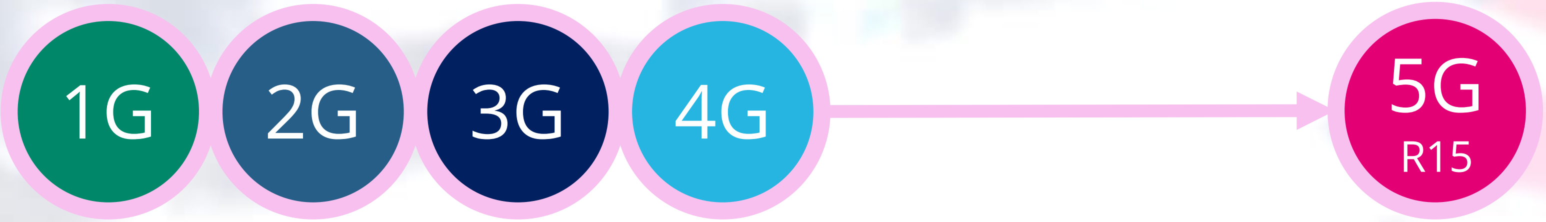
Evolution of Cellular Communication Systems



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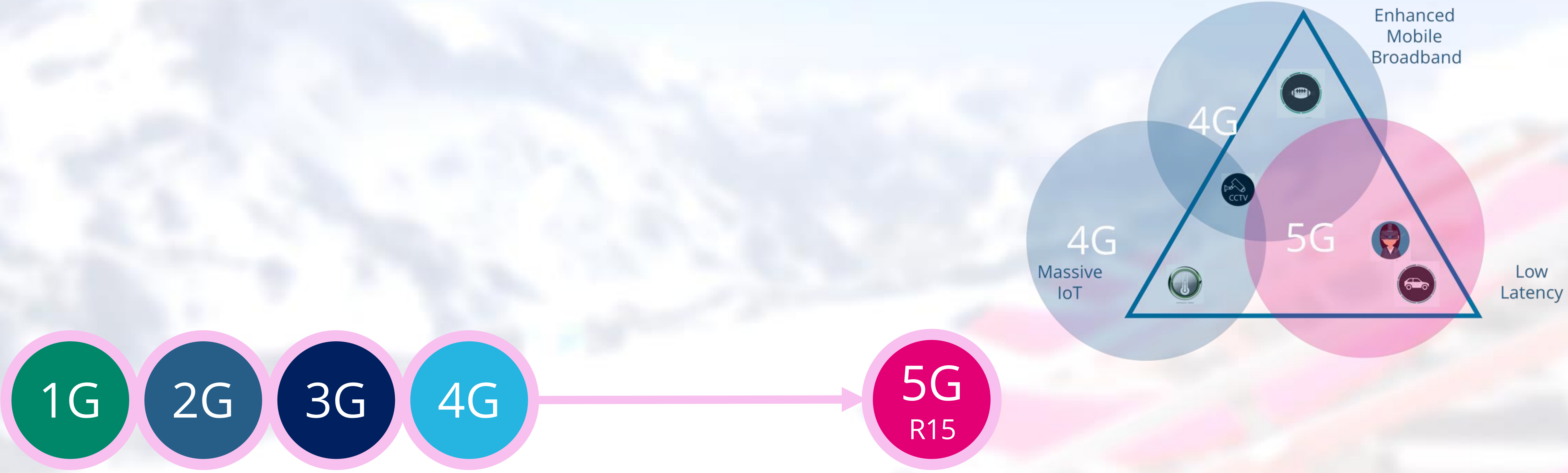
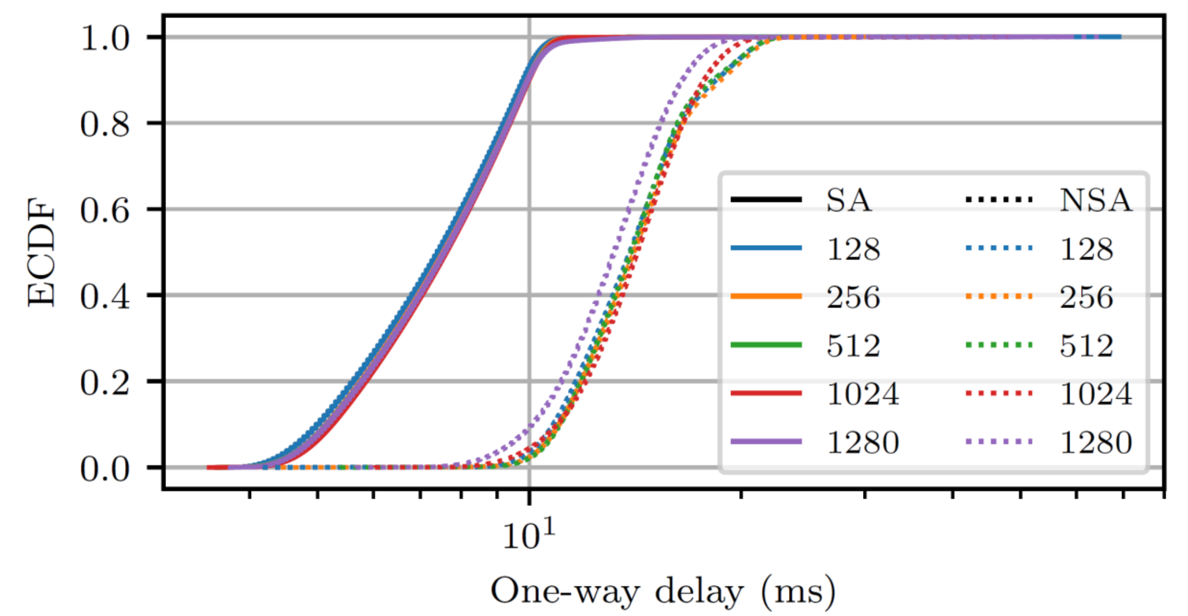
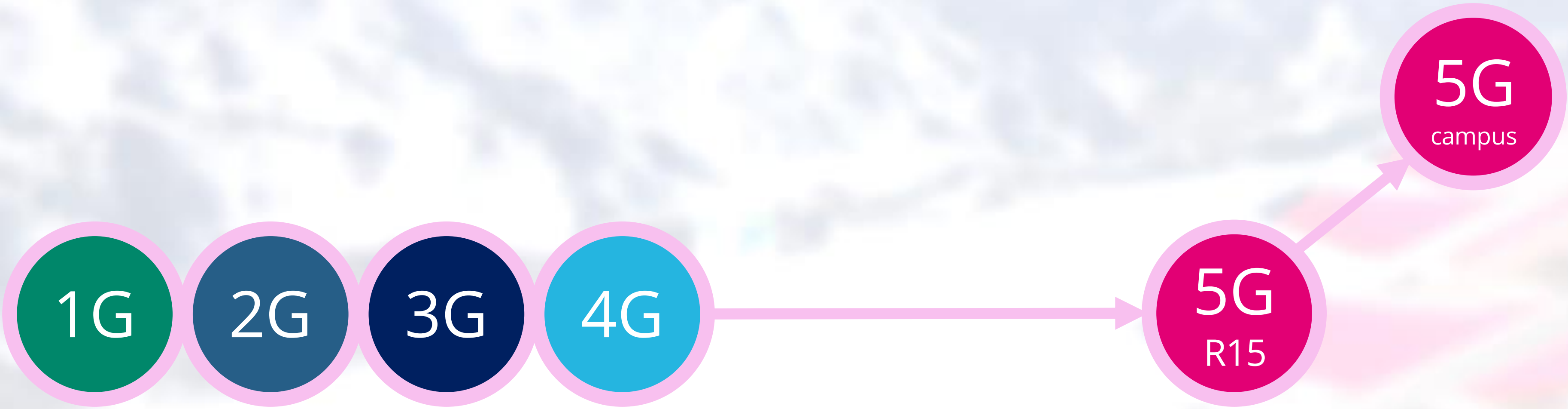
Evolution of Cellular Communication Systems



Evolution of Cellular Communication Systems



Evolution of Cellular Communication Systems



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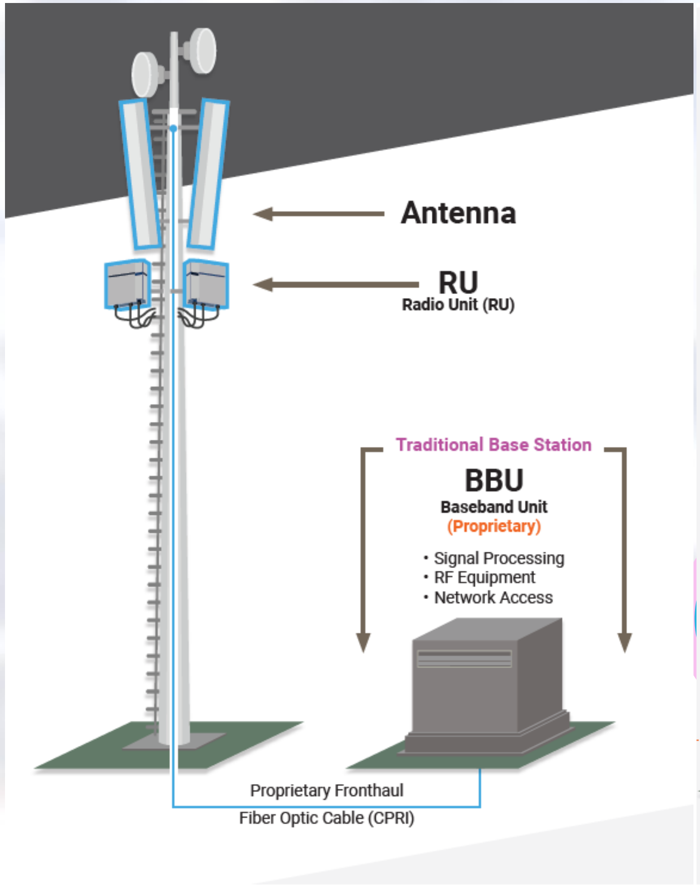
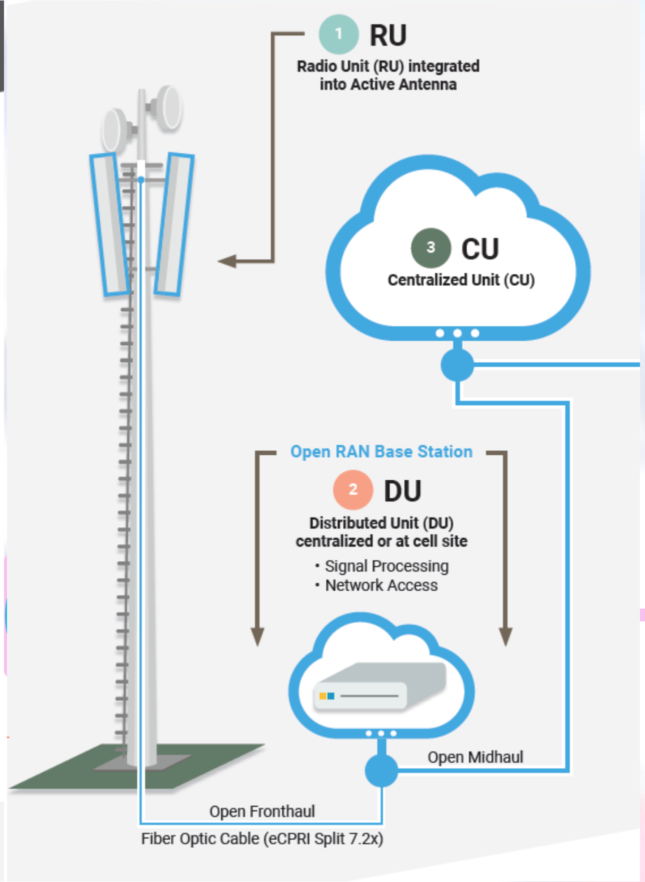
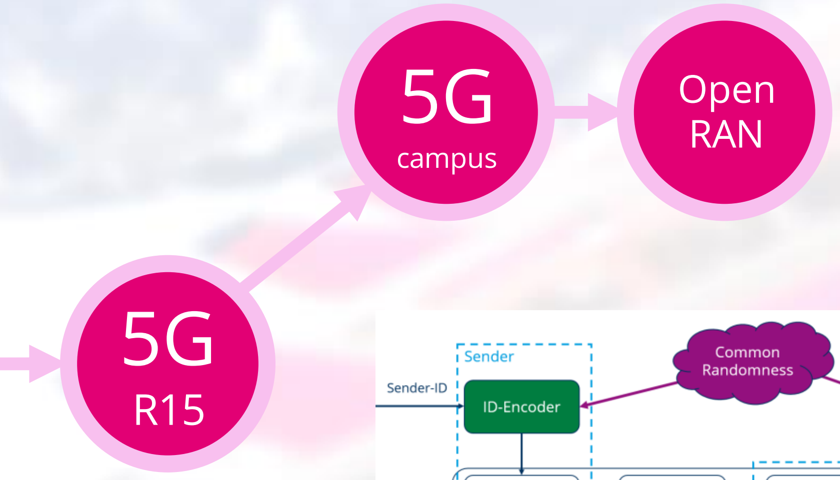
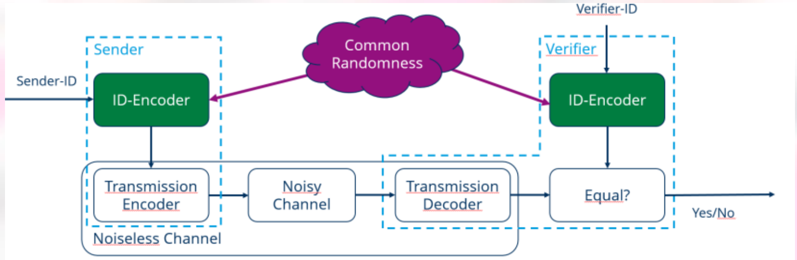
5G Campus (BMBF)

Evolution of Cellular Communication Systems









Evolution of Cellular Communication Systems

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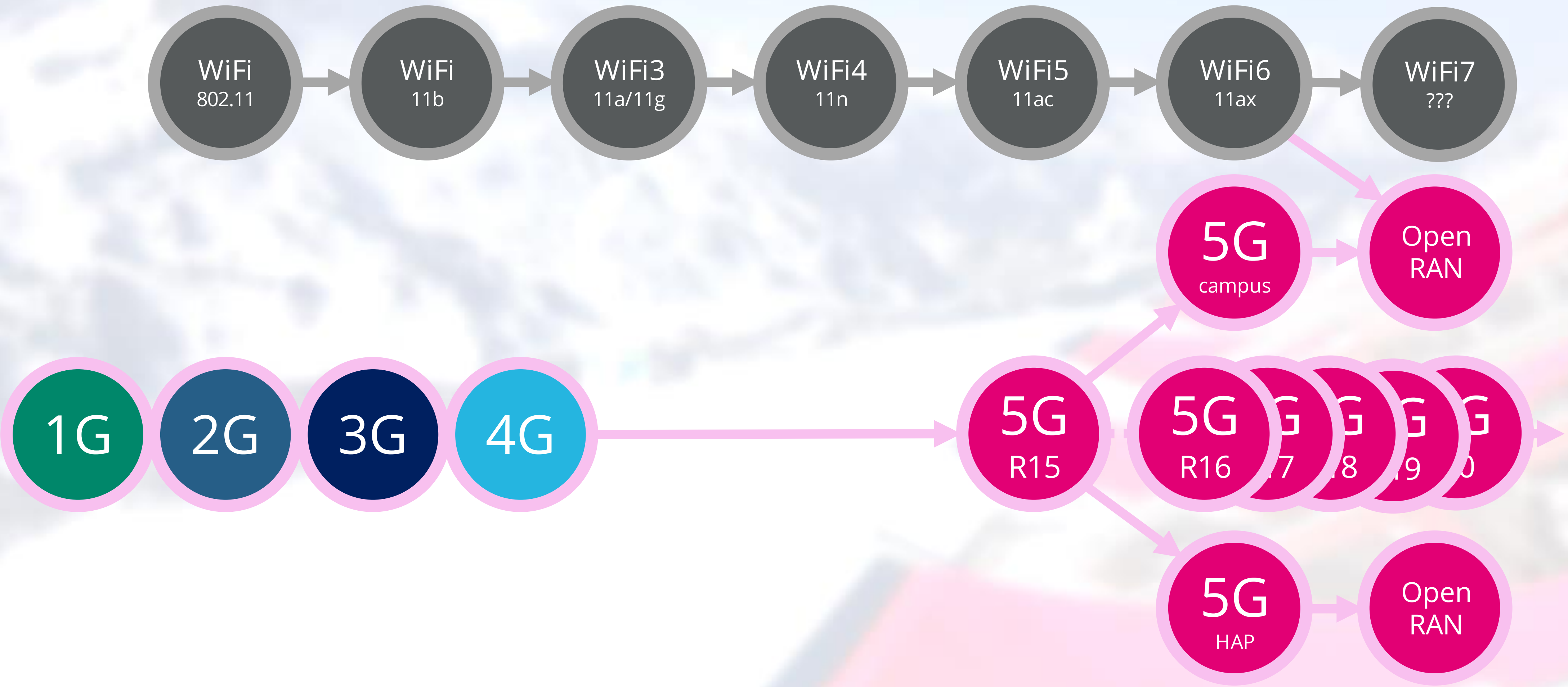
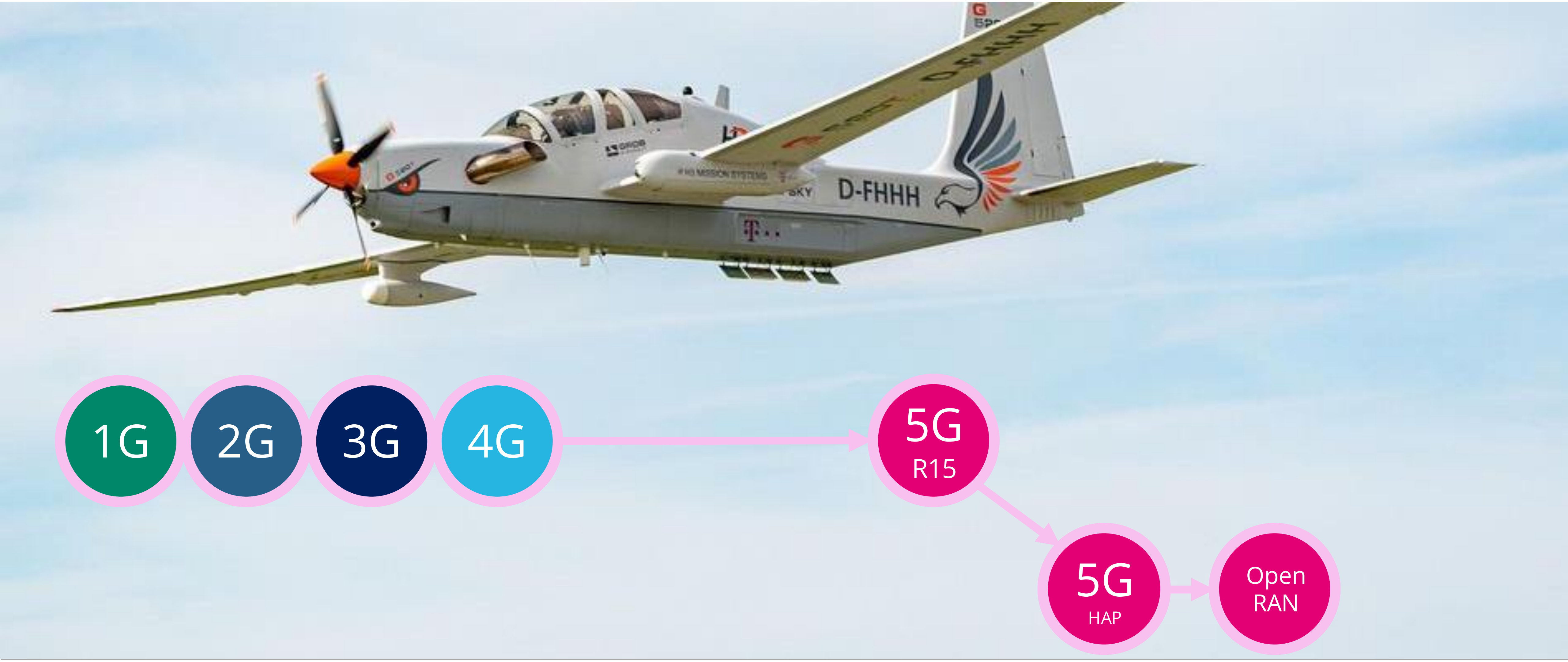
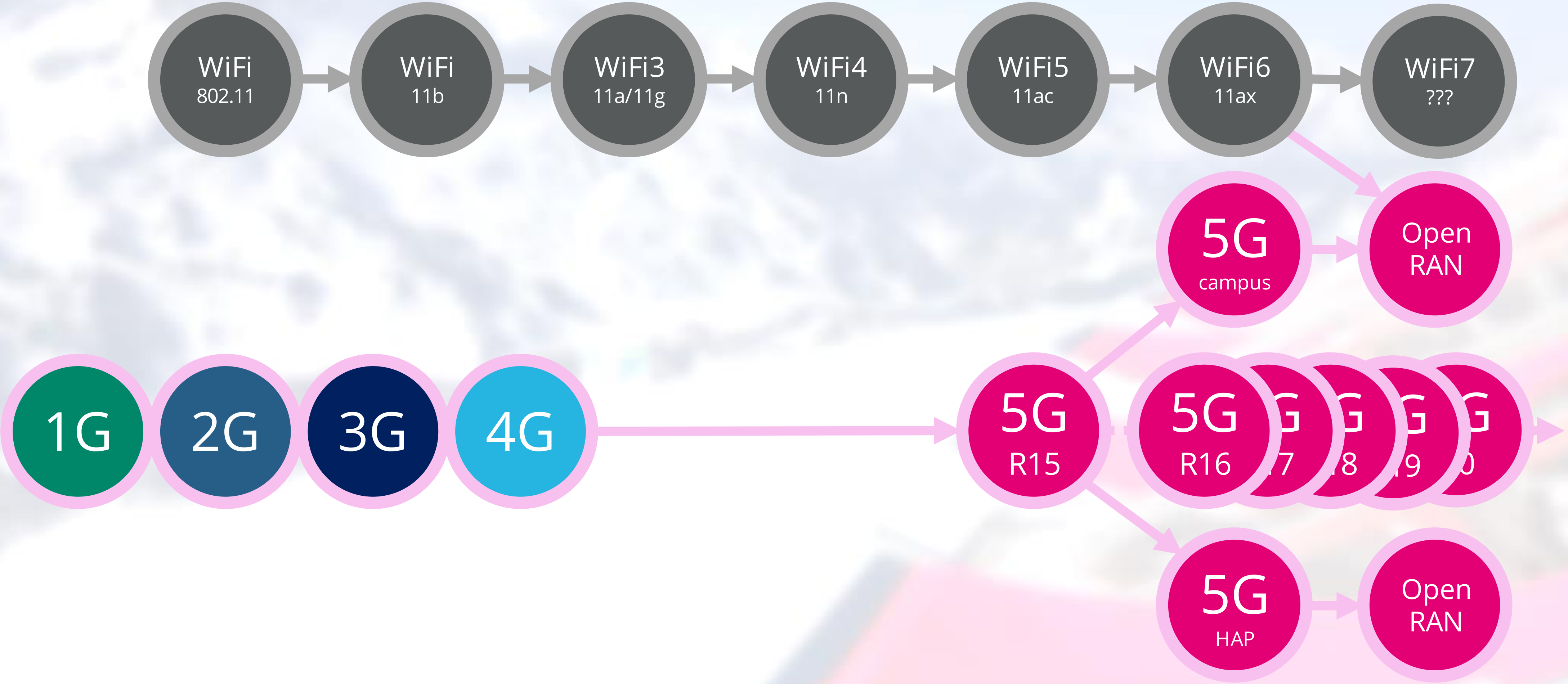


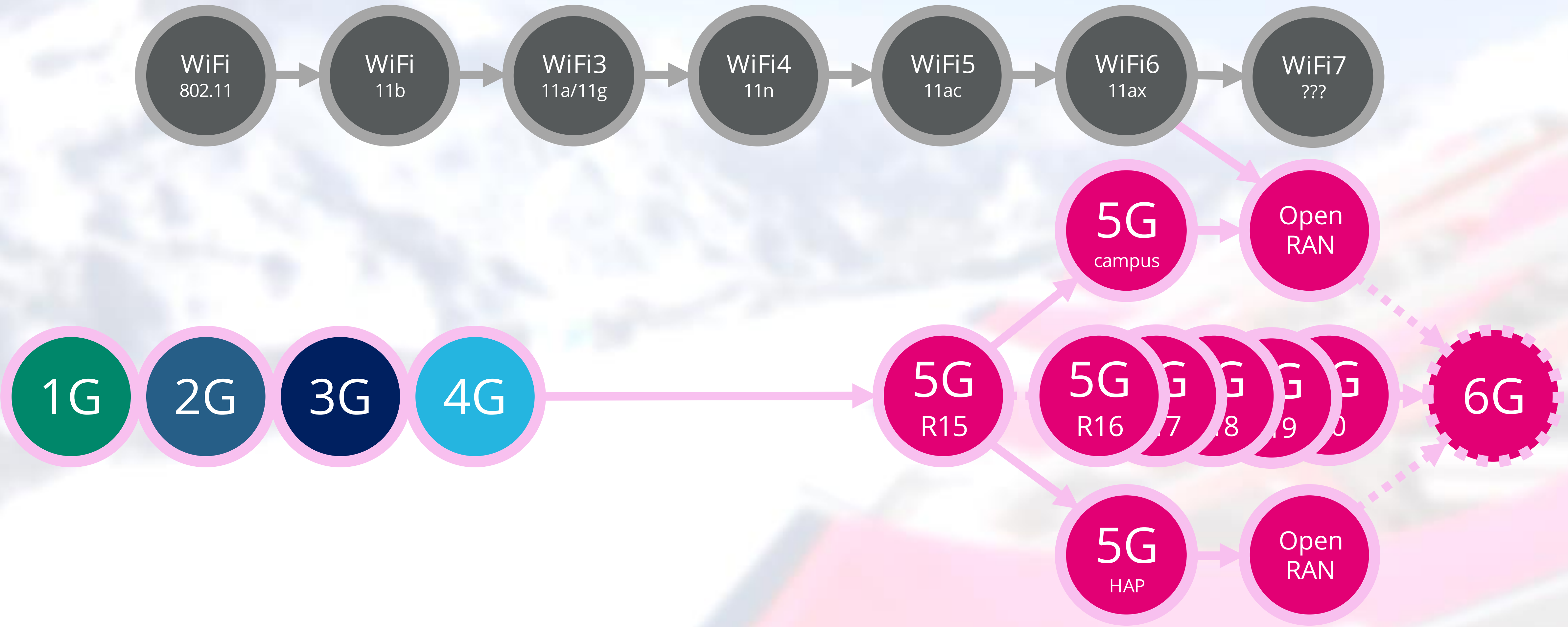
High Altitude Platforms



Evolution of Cellular Communication Systems



Evolution of Cellular Communication Systems



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Future Communication Networks

Novel Architectures for Softwarized Networks

Human Machine Co-habitation

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Democratise access to skills and expertise

Convey skills to other humans or machines in real and virtual worlds

Democratise access to skills and expertise

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Digital Transformation of the Human Body

Intuitive Human-Machine Interaction

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Post Shannon

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Post Shannon - Prelude

Shannon and Weaver wrote a book together in 1964 about conveying information between a sender and a receiver.

Shannon, C.E., Weaver, W. A Mathematical Theory of Communication. Champaign, IL, US: University of Illinois Press. 1964

Level A
The *technical problem*: How accurately can the symbol of communication be transmitted?

Level B
The *semantic problem*: How precisely do the transmitted symbols convey the desired meaning?

Level C
The *effectiveness problem*: How effectively does the received meaning affect conduct in the desired way?

Identification - a different problem of communication

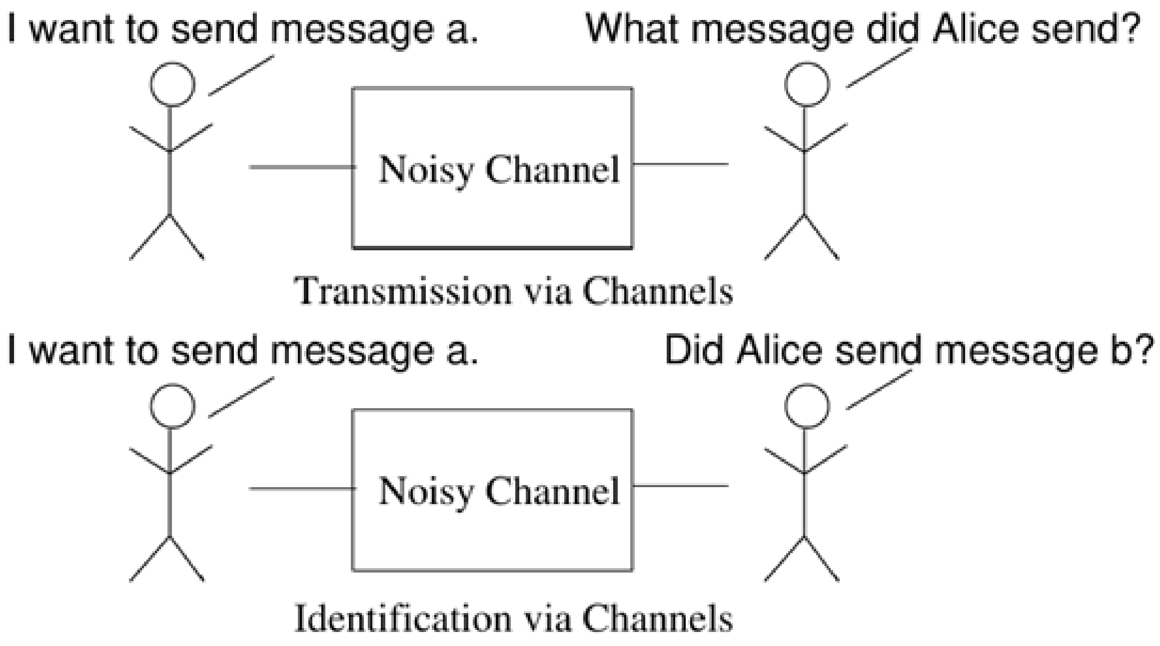
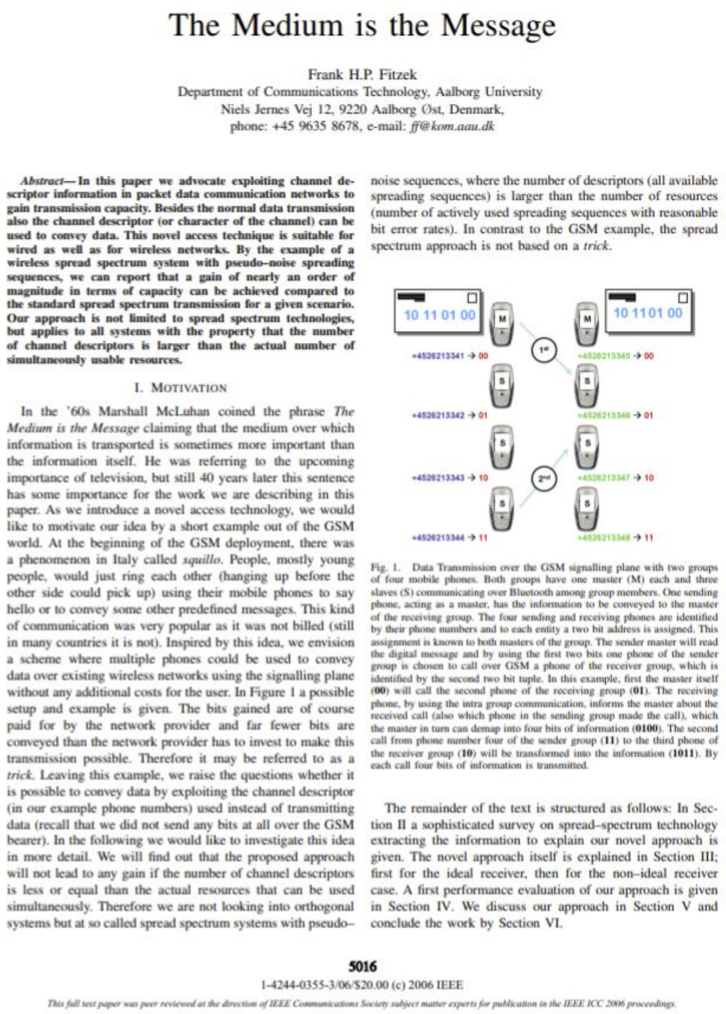


Figure 1: The difference between transmission and identification

Eswaran, K., 2005. Identification via channels and constant-weight codes.



The Medium is the Message

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***Abstract*— In this paper we advocate exploiting channel descriptor information in packet data communication networks to gain transmission capacity. Besides the normal data transmission also the channel descriptor (or character of the channel) can be used to convey data. This novel access technique is suitable for wired as well as for wireless networks. By the example of a wireless spread spectrum system with pseudo–noise spreading sequences, we can report that a gain of nearly an order of magnitude in terms of capacity can be achieved compared to the standard spread spectrum transmission for a given scenario. Our approach is not limited to spread spectrum technologies, but applies to all systems with the property that the number of channel descriptors is larger than the actual number of simultaneously usable resources.**

I. MOTIVATION

In the '60s Marshall McLuhan coined the phrase *The Medium is the Message* claiming that the medium over which information is transported is sometimes more important than the information itself. He was referring to the upcoming importance of television, but still 40 years later this sentence has some importance for the work we are describing in this paper. As we introduce a novel access technology, we would like to motivate our idea by a short example out of the GSM world. At the beginning of the GSM deployment, there was a phenomenon in Italy called *squillo*. People, mostly young people, would just ring each other (hanging up before the other side could pick up) using their mobile phones to say hello or to convey some other predefined messages. This kind of communication was very popular as it was not billed (still in many countries it is not). Inspired by this idea, we envision a scheme where multiple phones could be used to convey data over existing wireless networks using the signalling plane without any additional costs for the user. In Figure 1 a possible setup and example is given. The bits gained are of course paid for by the network provider and far fewer bits are conveyed than the network provider has to invest to make this transmission possible. Therefore it may be referred to as a *trick*. Leaving this example, we raise the questions whether it is possible to convey data by exploiting the channel descriptor (in our example phone numbers) used instead of transmitting data (recall that we did not send any bits at all over the GSM bearer). In the following we would like to investigate this idea in more detail. We will find out that the proposed approach will not lead to any gain if the number of channel descriptors is less or equal than the actual resources that can be used simultaneously. Therefore we are not looking into orthogonal systems but at so called spread spectrum systems with pseudo–noise sequences, where the number of descriptors (all available spreading sequences) is larger than the number of resources (number of actively used spreading sequences with reasonable bit error rates). In contrast to the GSM example, the spread spectrum approach is not based on a *trick*.

Fig. 1. Data Transmission over the GSM signalling plane with two groups of four mobile phones. Both groups have one master (M) each and three slaves (S) communicating over Bluetooth among group members. One sending phone, acting as a master, has the information to be conveyed to the master of the receiving group. The four sending and receiving phones are identified by their phone numbers and to each entity a two bit address is assigned. This assignment is known to both masters of the group. The sender master will read the digital message and by using the first two bits one phone of the sender group is chosen to call over GSM a phone of the receiver group, which is identified by the second two bit tuple. In this example, first the master itself (**00**) will call the second phone of the receiving group (**01**). The receiving phone, by using the intra group communication, informs the master about the received call (also which phone in the sending group made the call), which the master in turn can demap into four bits of information (**0100**). The second call from phone number four of the sender group (**11**) to the third phone of the receiver group (**10**) will be transformed into the information (**1011**). By each call four bits of information is transmitted.

The remainder of the text is structured as follows: In Section II a sophisticated survey on spread–spectrum technology extracting the information to explain our novel approach is given. The novel approach itself is explained in Section III; first for the ideal receiver, then for the non–ideal receiver case. A first performance evaluation of our approach is given in Section IV. We discuss our approach in Section V and conclude the work by Section VI.

1-4244-0355-3/06/$20.00 (c) 2006 IEEE
This full text paper was peer reviewed at the direction of IEEE Communications Society subject matter experts for publication in the IEEE ICC 2006 proceedings.

Frank H. P. Fitzek **The Medium Is The Message** IEEE International Conference on Communication (ICC), 2006.

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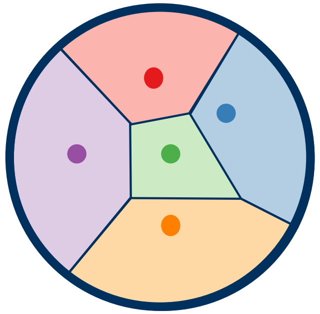
Identification capacity

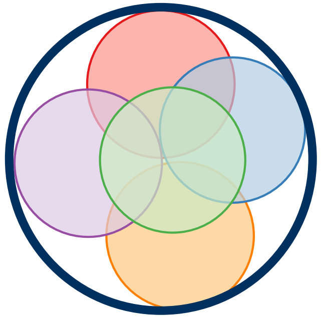
Transmission: $N = 2^{nR}$



Discrete Memoryless Channel (DMC):

- N number of entities
- n number of bits
- R rate (0.0-1.0)

ID: $N = 2^{2^{nR}}$



→ The number of identifiable entities **grows double exponentially** in block size, at the cost of a **new kind of error**

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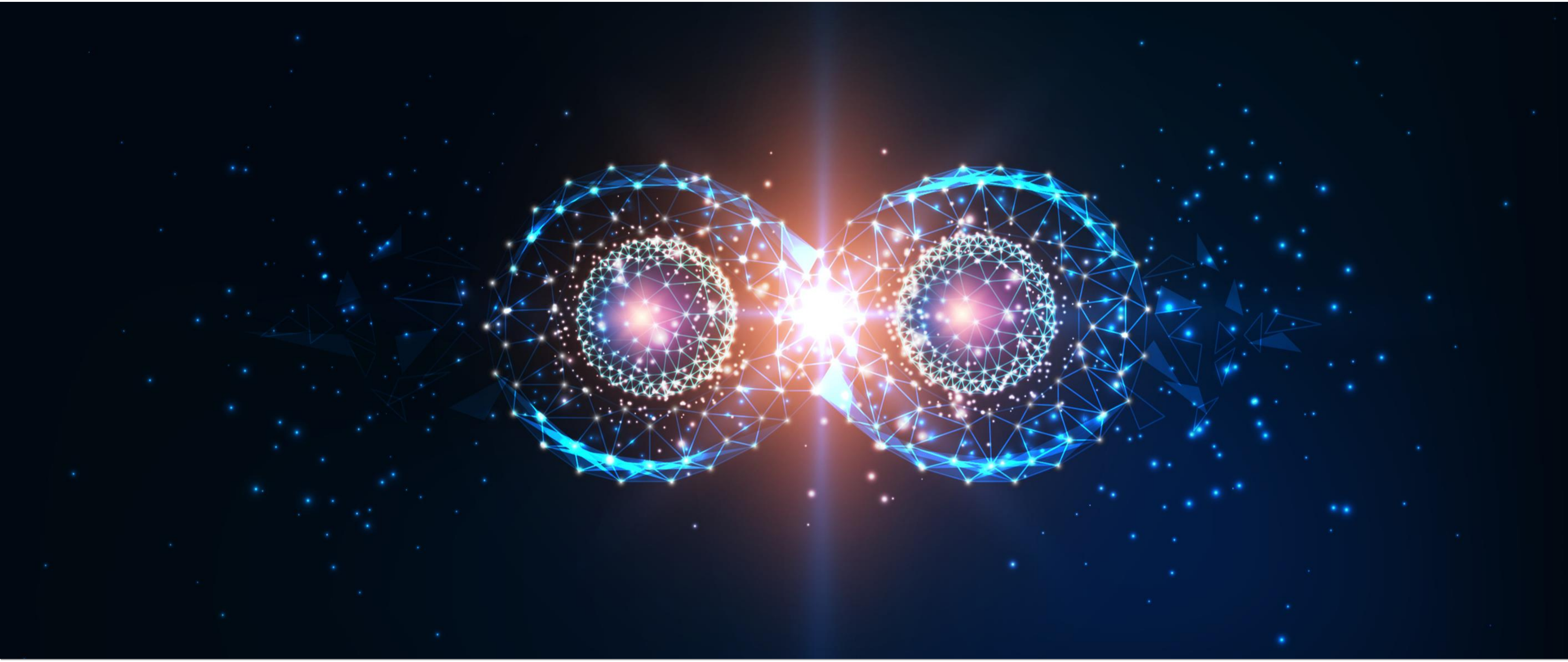
Quantum Communication Networks



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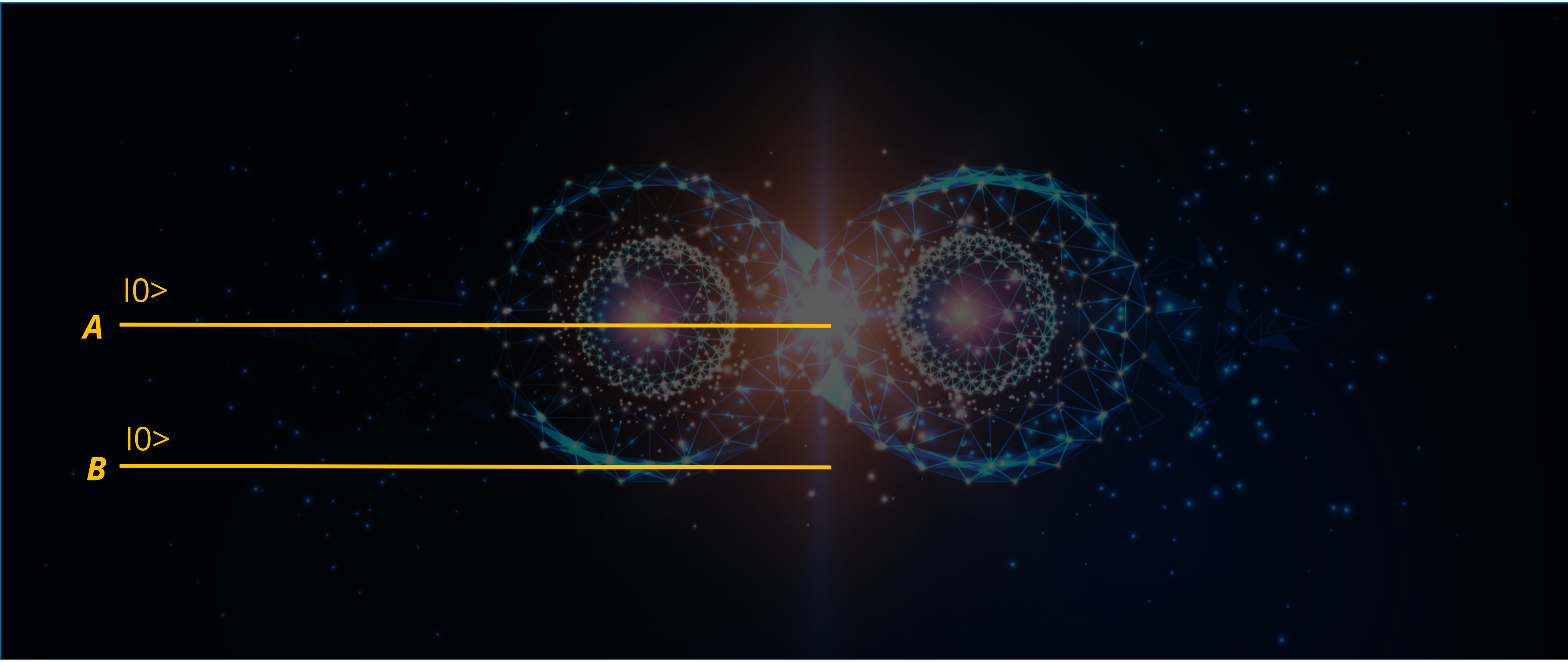
Quantum Communication Local Randomness



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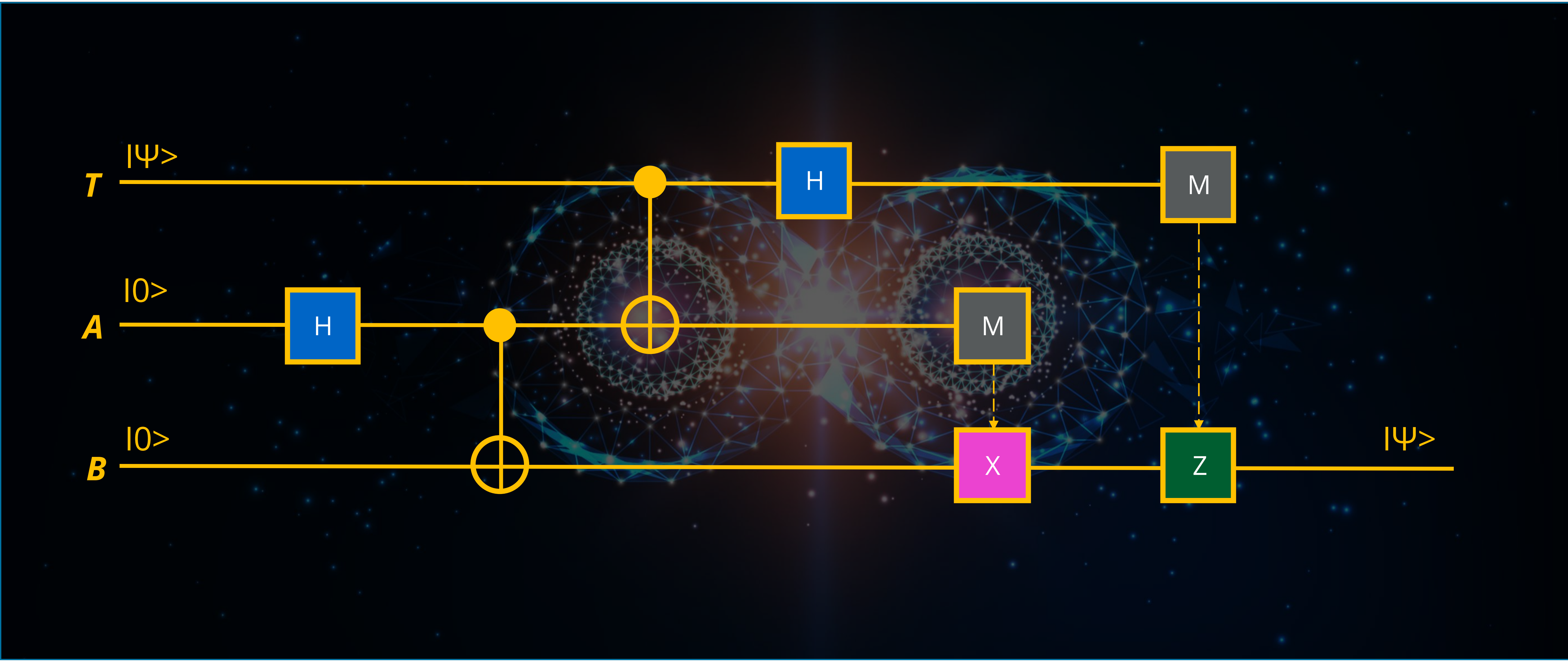
Quantum Communication Networks: Entanglement

Quantum Communication Networks: Teleportation



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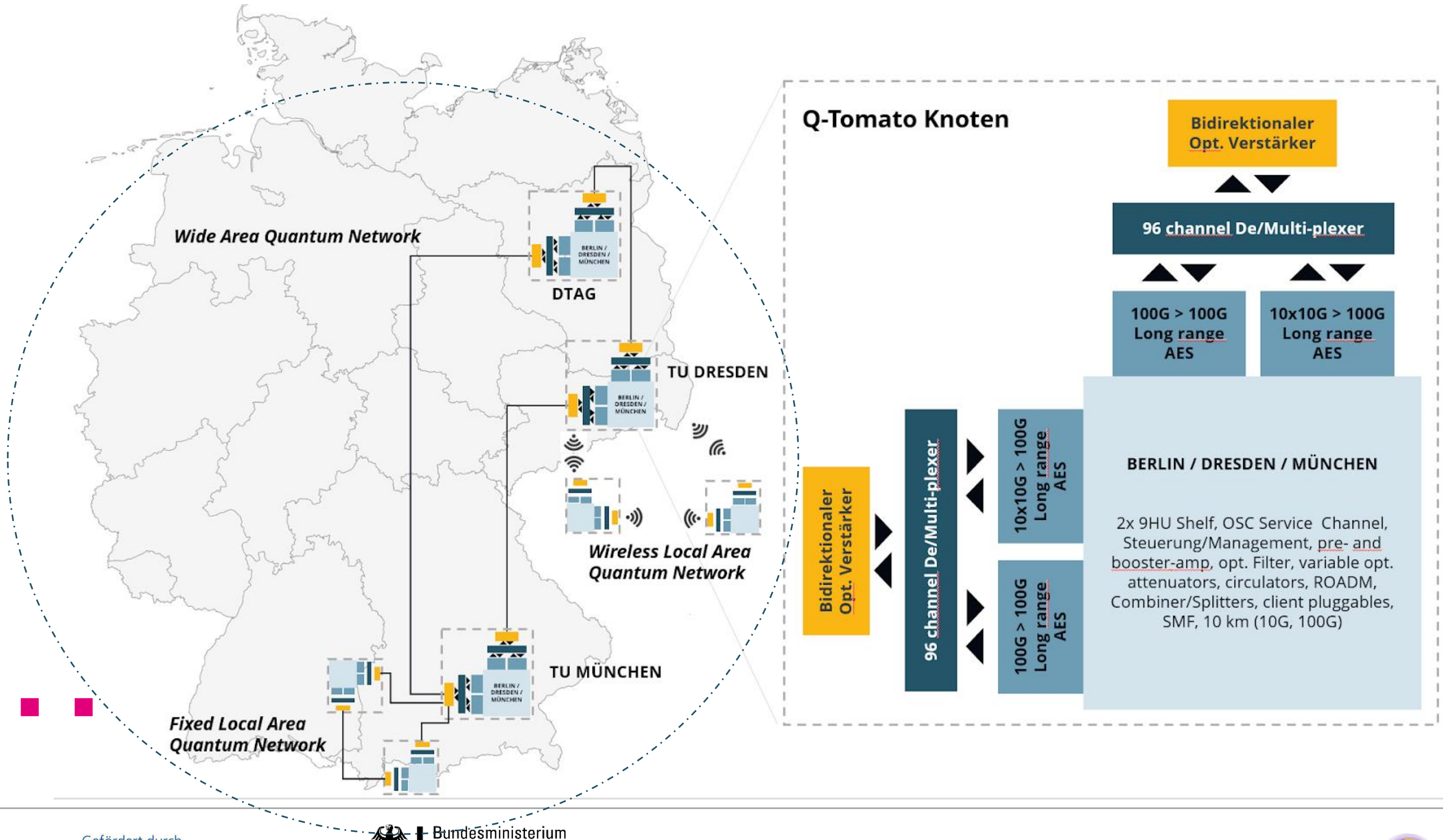
Quanten Testbed – Q-Tomato

2023



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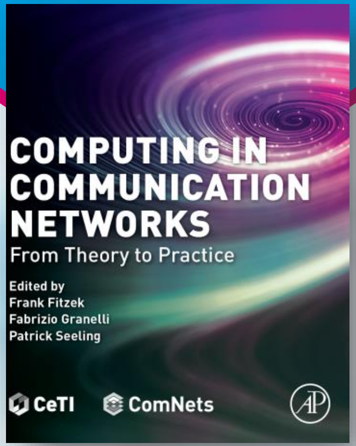
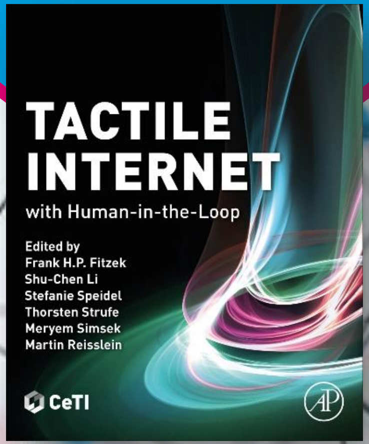


Human Machine Co-habitation



Post Shannon

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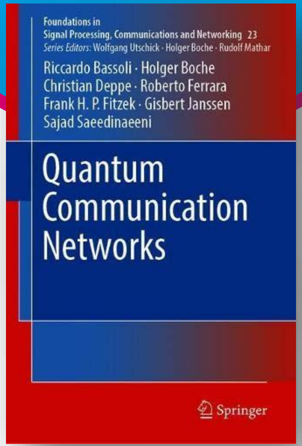

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