



6G-RIC // Research & Innovation Cluster

6G-RIC

Slawomir Stanczak

6G-RIC

Research and Innovation Cluster

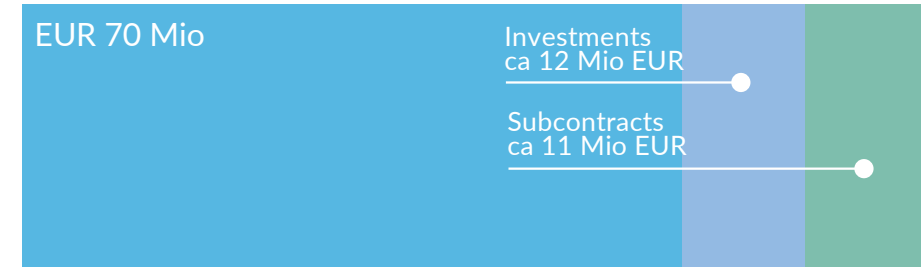


Open and secure 6G technologies as a global market opportunity for Germany

Coordination :
 Fraunhofer Heinrich Hertz Institute
 Prof. Slawomir Stanczak



Funded by BMBF
 EUR 70 Mio



1000x Throughput: Potential Energy Crunch

Bits per kWh!

1000x Throughput: Potential Energy Crunch

Bits per kWh!

$$1000 = 10 \times 10 \times 10$$

$\frac{\text{bits/s}}{\text{km}^2}$

Higher spectral efficiency

More advanced signal processing



Higher energy consumption

Higher density

More hardware



Higher energy consumption

Larger bandwidth

Sub-THz communication



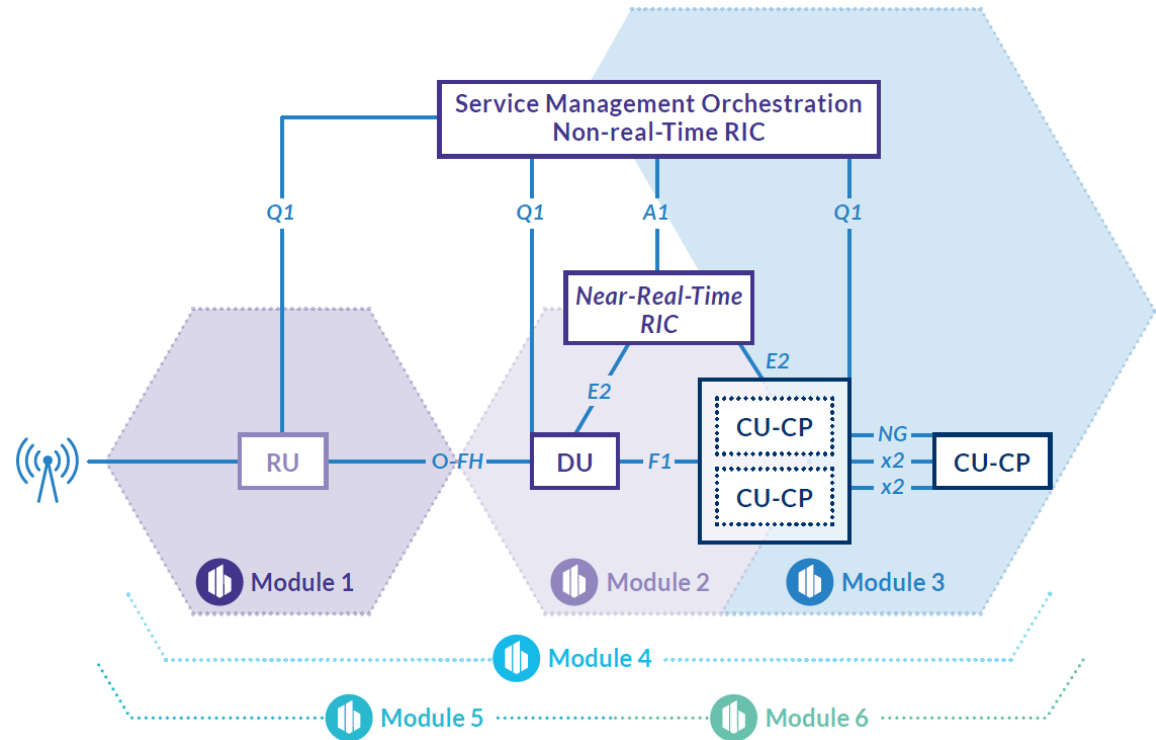
Higher energy consumption

Network Computing: Virtualization and Cloudification

Intelligence per kWh!

- **Central Unit (CU) can be easily virtualized**
 - 5-10% of the processing requirements in the BBU
- **Distributed Unit (DU)**
 - provides the real-time functions of the lower layers
 - 90-95% of the processing requirements in the BBU

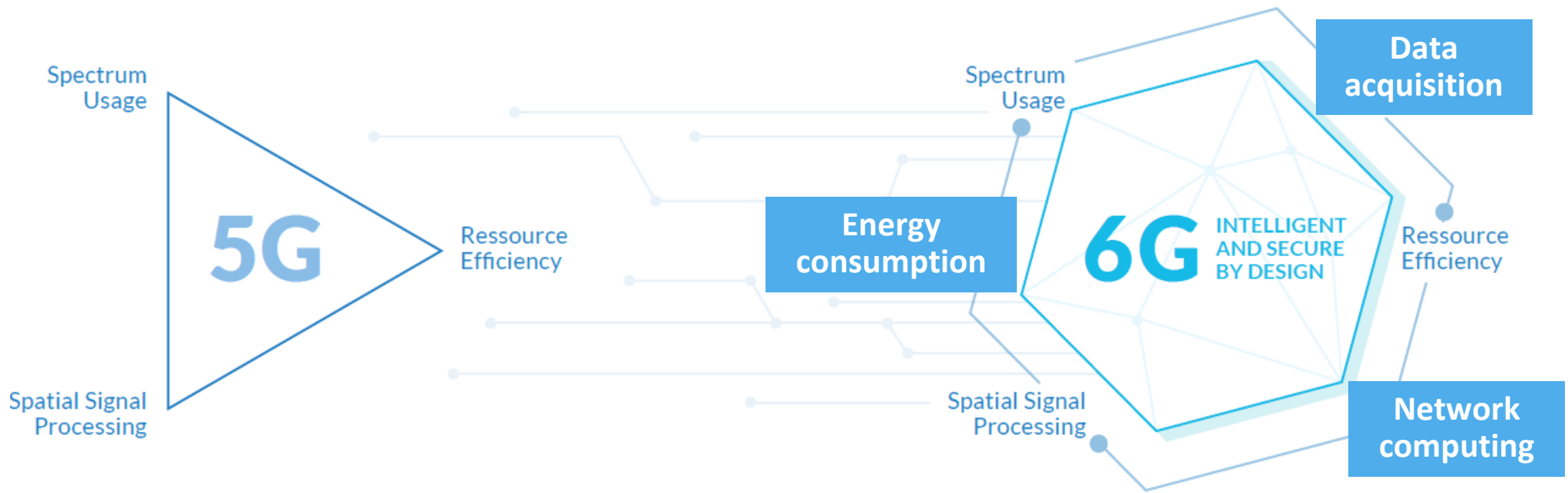
• **Virtualizing the DU is challenging!**



Energy efficient, real-time signal processing and network computing!

6G-RIC: Paradigm Shift in System Design

Transition towards 6G: Extended design dimensions



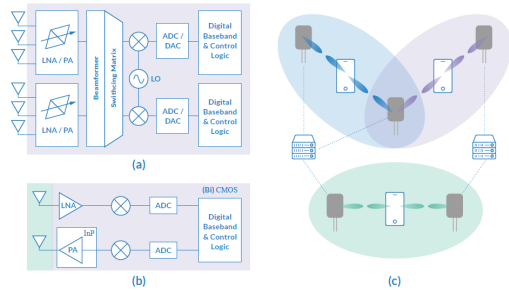
Energy efficiency as an integral part of the hardware and software design

6G-RIC Technical Innovation Areas (TIA)

Sub-THz Mobile Access

How to achieve the throughput increase in an energy-efficient way?

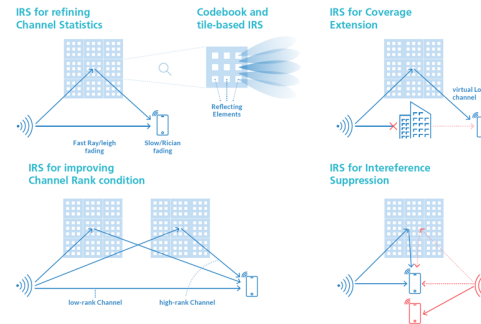
Energy-efficient transceiver architectures and radio access network design!



Steerable beamforming antennas: Key component of sub-THz and vital part of the 6G-RIC

Intelligent Reflecting Surfaces / Radio Environments

Key 6G technology or a hype?

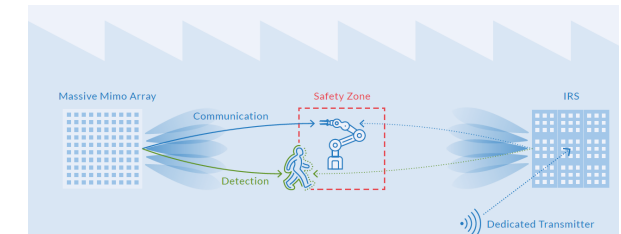


Advantages in selected scenarios, but low-complexity, real-time configuration is key!

Network as a Sensor

What level of integration of communication and sensing?

Beamspace processing for intrusion detection in industrial automation

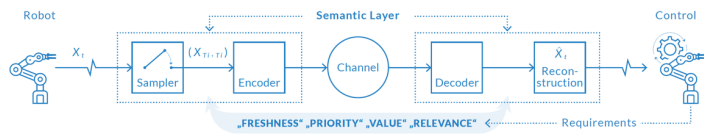


Tight integration of sensing and communication or coexistence?

Data Acquisition: Semantic Communication

Communication links are not bit pipes!

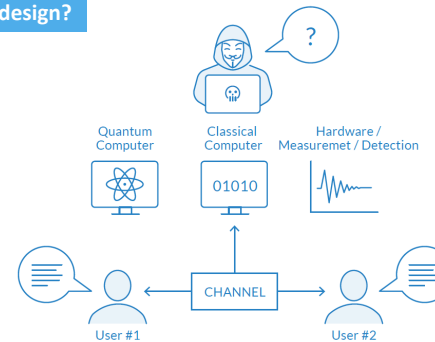
Semantic communication (6G-RIC viewpoint): "The provisioning of the right and significant piece of information to the right point of computation (or actuation) at the right point in time."



Goal-oriented unification of information generation, transmission and usage/control!

Embedded Security

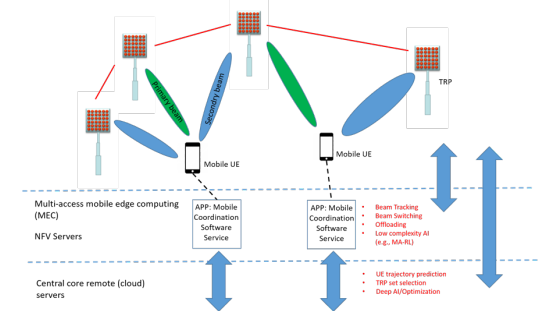
Security by design?



System security with open interfaces; Post-quantum security; PHYSEC

Autonomous Convergent Networks

Impact of 6G Technologies on Network Operation and Architecture



Enabling sub-THz Mobile Access via cell-free operation and distributed intelligence

Semantic Communication

The search for meaning

W. Weaver, 1949:

The technical problem:

- symbols conveying information should be reliably transmitted to the recipient;

The semantic problem:

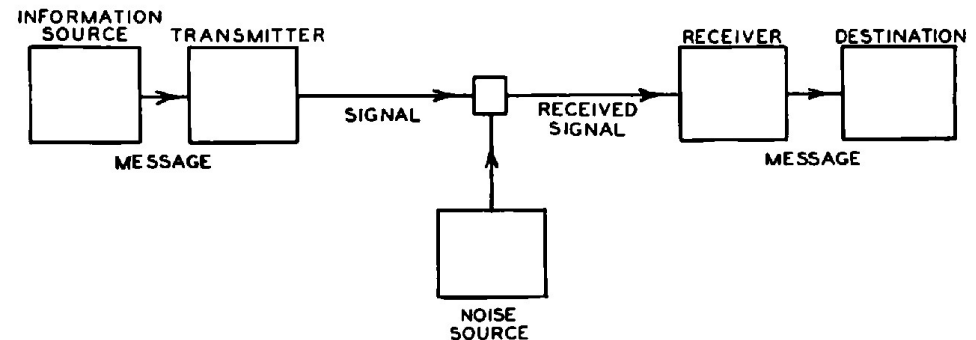
- the meaning conveyed by the transmitted symbols should accurately reflect the intentions of the sender;

The effectiveness problem:

- The conduct of the system in response to communications should be effective in accomplishing a desired task.

Historically, focus on the „technical problem“

Communication model as considered by C. Shannon, 1948



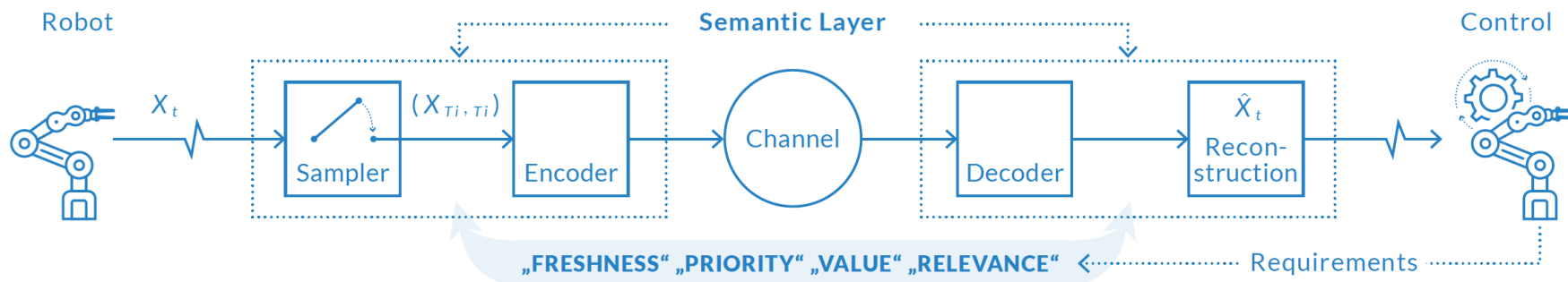
It fails to meet the needs of new networked intelligent systems

Beyond the technical problem of communication: escaping the „Shannon Trap“! [Popovski et al.]

Data Acquisition: Semantic Communication

Communication links are not bit pipes!

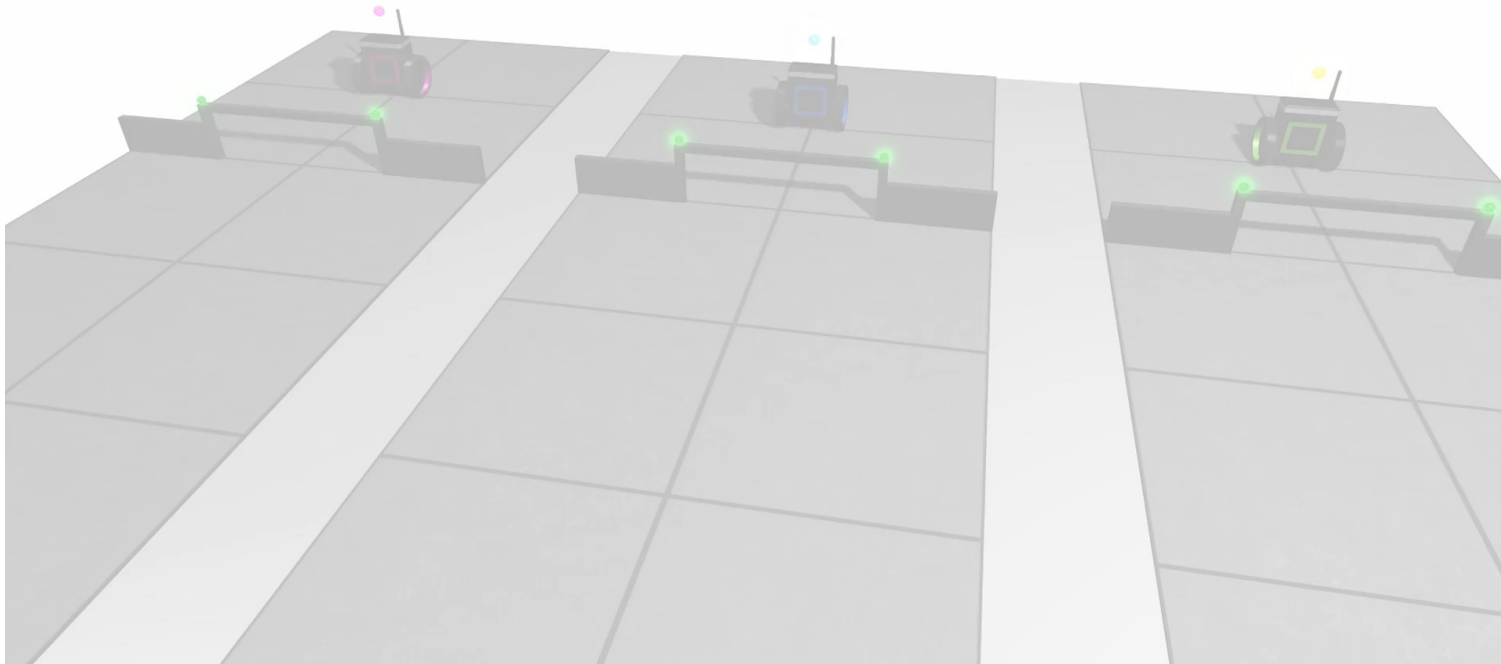
Semantic communication (6G-RIC viewpoint):
“The provisioning of the right and significant piece of information to the right point of computation (or actuation) at the right point in time.”



Goal-oriented unification of information generation, transmission and usage/control!

Example of Goal-Oriented Communication

Learning in Multi-Agent Systems for Reference Tracking Tasks



Fachgebiet Prof. Jörg Raisch

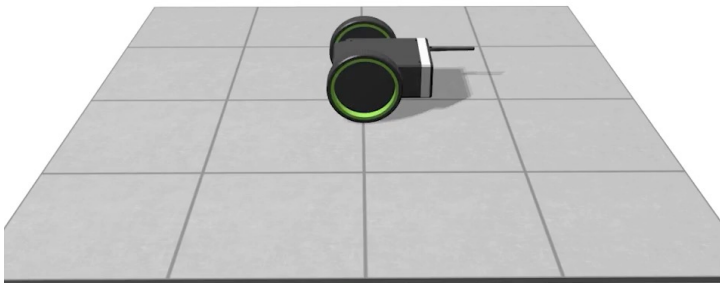


Example of Goal-Oriented Communication

Learning in Multi-Agent Systems for Reference Tracking Tasks

EXPERIMENTS

Fachgebiet Prof. Jörg Raisch



6G-RIC Position Paper

Published in Nov. 2022

- poses key research questions
- defines the research scope of the 6G-RIC
- basis for whitepapers and magazine papers

