

Edge Computing & 5G

Innovationsmotor für attraktive neue Produkte und Services

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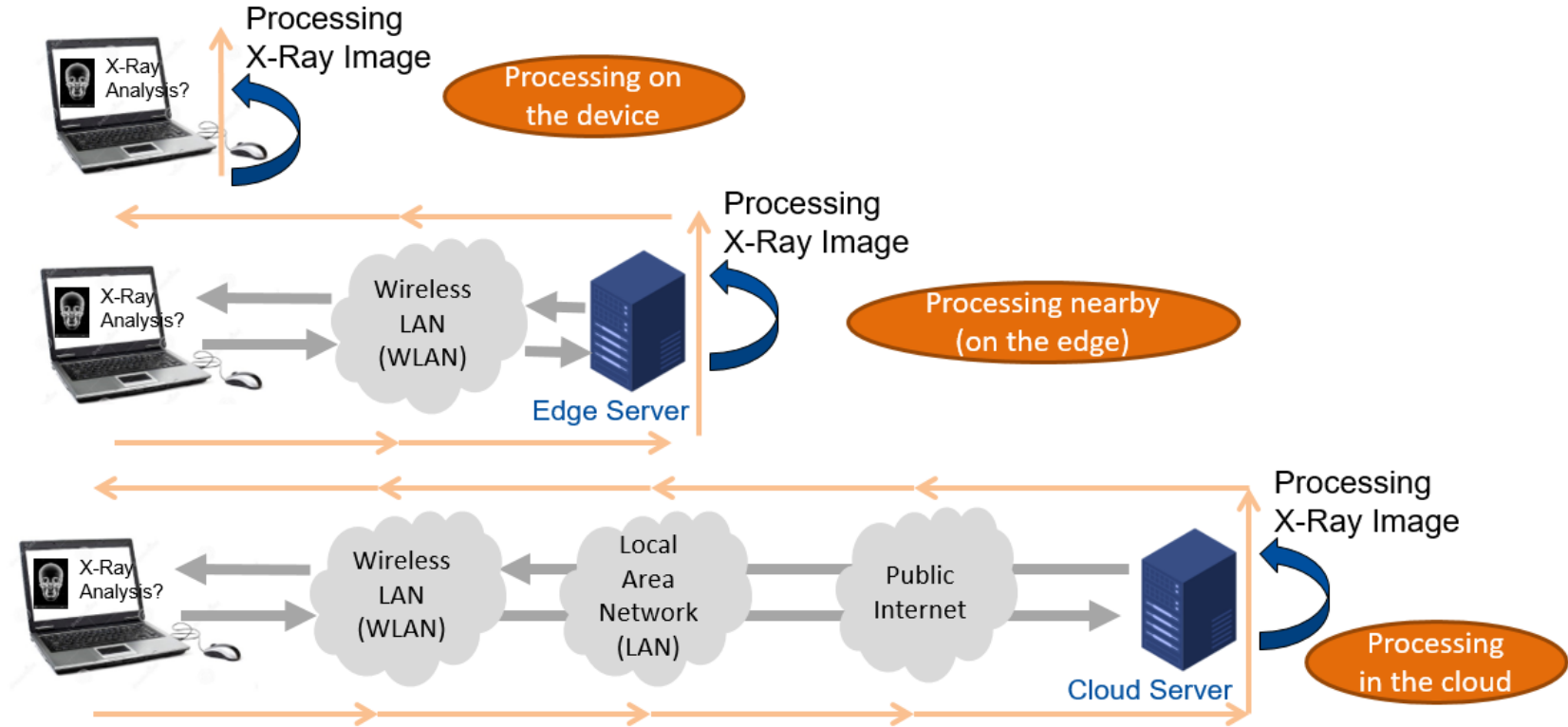
Edge Computing & 5G – Innovationsmotor für attraktive neue Produkte und Services

Überblick

- Edge Computing – Einführung und Definition
- Edge-Native Use Cases und Kundennutzen
- Überblick Edge Produkte und Services
- Technologische Herausforderungen von Edge & 5G
- Edge Computing im Giga for Health Projekt
- Zusammenfassung, Fragen und Diskussion

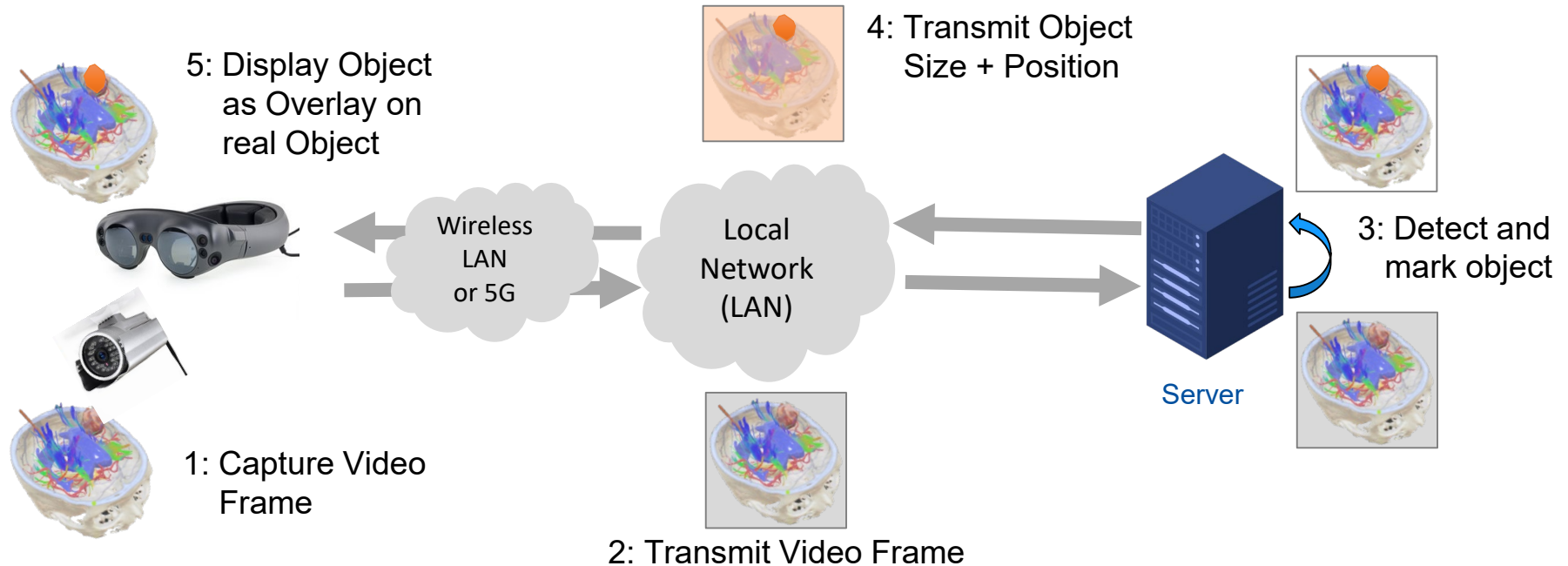


Key Question: Where to do the computing? On the device, near the device or in the cloud?



Example Use Case: Augmented Reality Application

Key Challenge: Very low end-to-end latency required!



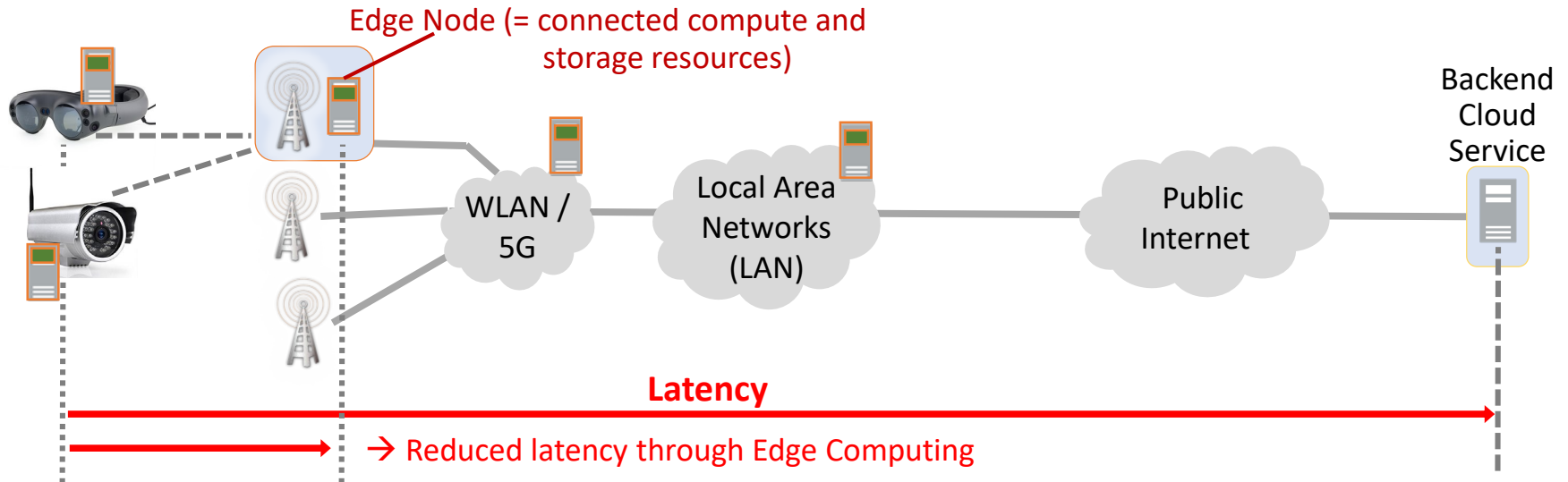
What is Edge Computing?



Edge Computing: small data centres at the network edge that offer connected compute and storage resources right next to the user

Example Use Cases:

- Augmented reality application connected with head mounted display
- Analyzing large volumes of data right at the edge (Edge Analytics)



Business Value enabled through Edge Computing

Business & Customer Value

- Disruptive improvement in customer experience (e.g. Tactile Services)
- Expansion of device capabilities
- Offload of heavy computation from device to edge
- Enabler for new types of services via distributed computing (e.g. edge analytics for IoT)
- Keep personal data local
- Masking disruption of centralised cloud services
- Lower upload data volume to the Cloud (e.g. Edge Analytics)

Prime factors

Latency & Jitter



CPU Power:
Storage:



Battery lifetime:



Server location:



Privacy:



Availability:



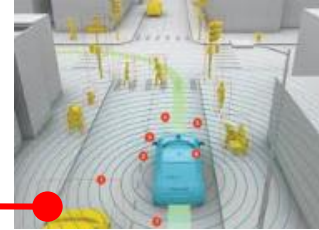
Backhaul traffic:



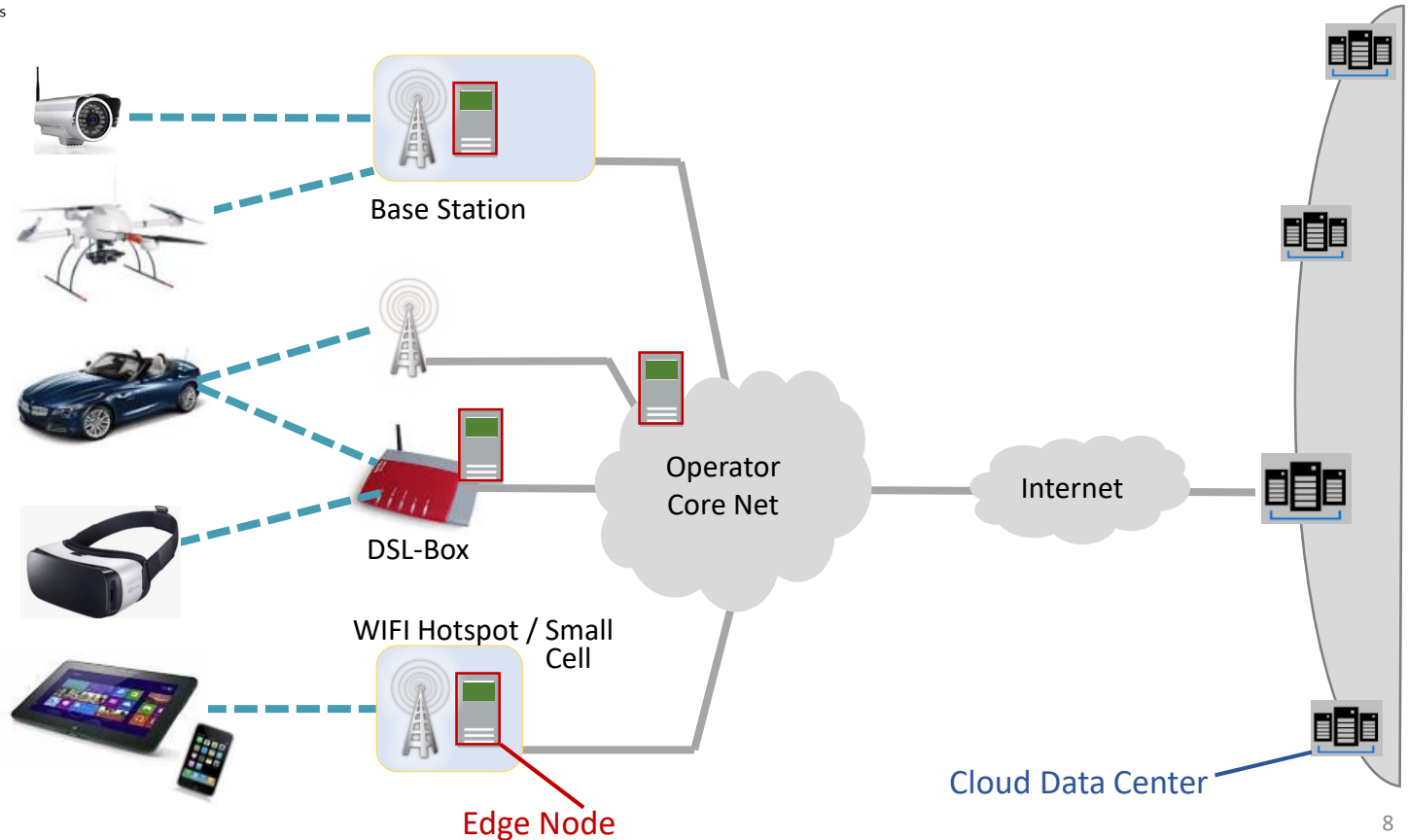
Overview Edge Application Areas

Application Areas

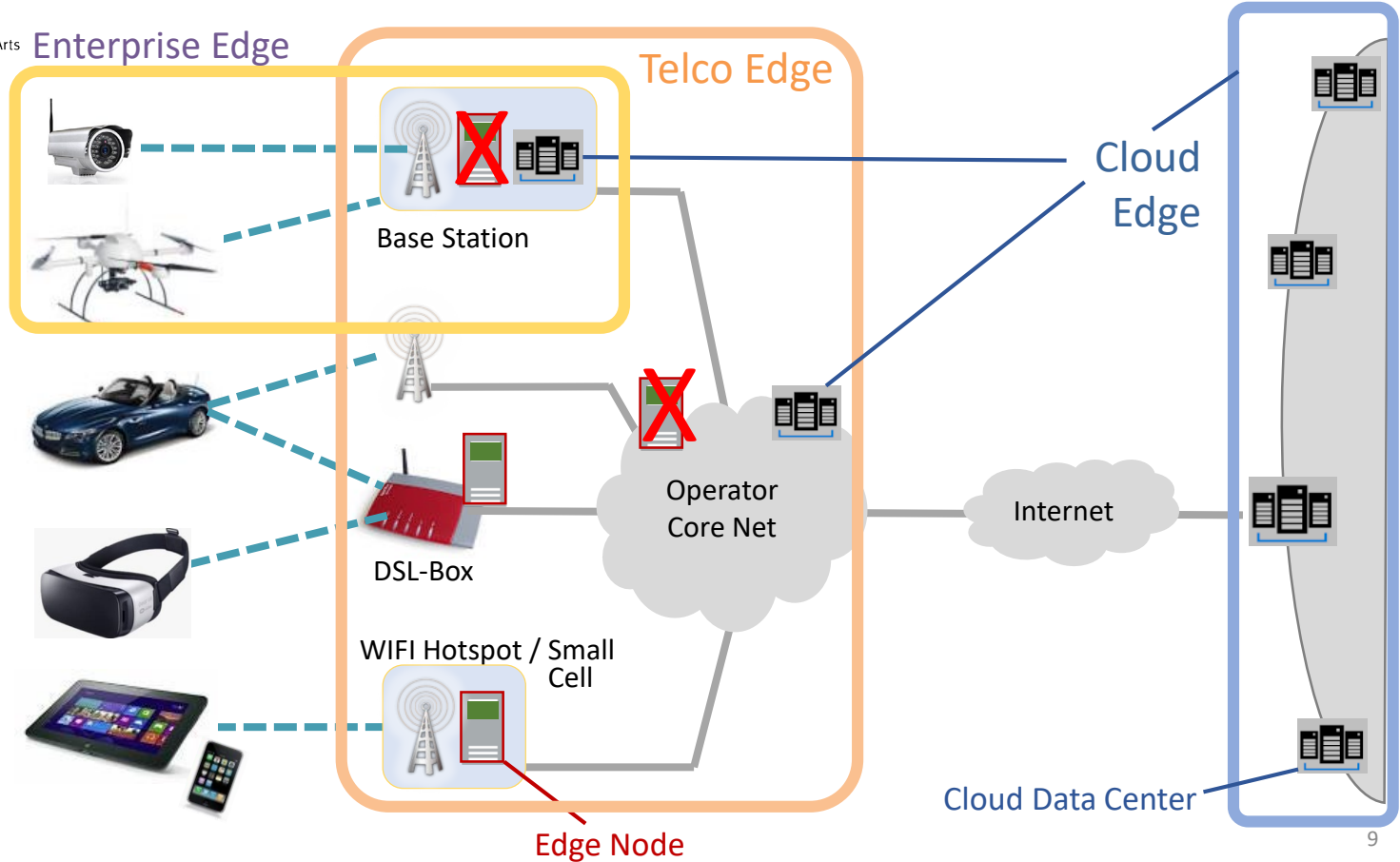
- Virtual Reality / Mixed Reality
- Cloud / Edge Gaming
- Edge Analytics / Data Thinning
- Self-driving Cars
- Robotics and Automation
- Drone Support Services
- Private LTE / 5G for Enterprises
- Voice Control
- Mobile App Enhancements
- Public Safety
- Caching Services / Content Delivery Networks



Current Edge Market Situation & Development

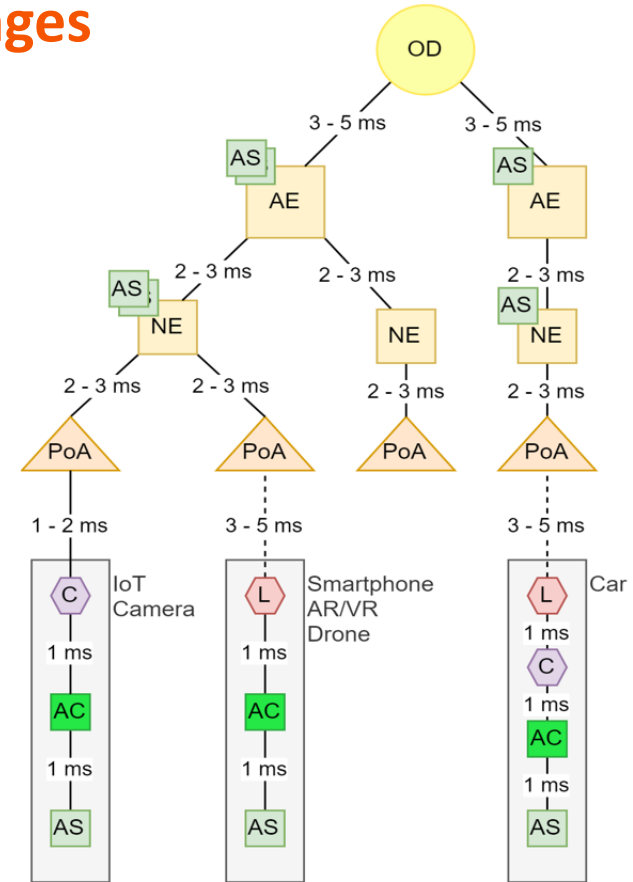


Current Edge Market Situation & Development



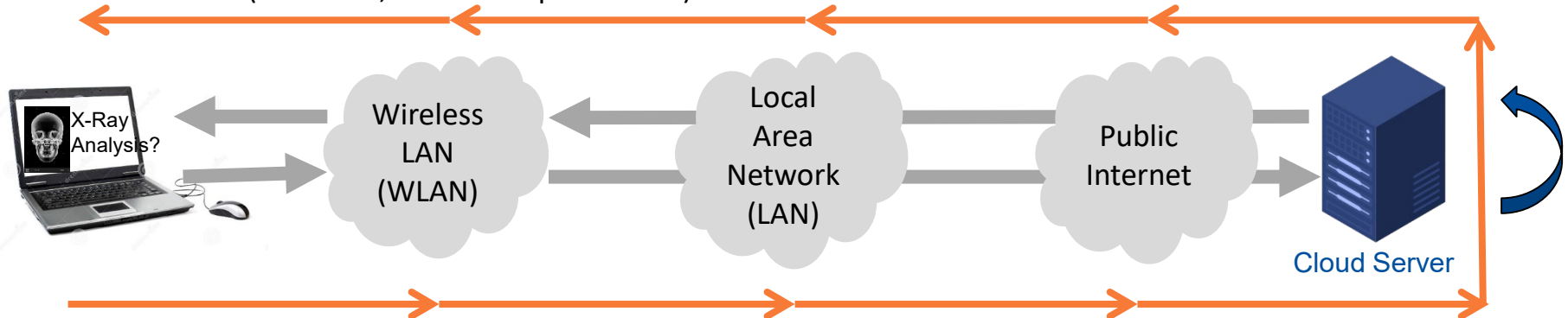
Key Edge Technology Challenges

- **Edge Discovery**
an edge application or sensor requests edge services
- **Edge Resource Allocation**
Allocating edge resources (e.g. edge nodes) to specific edge applications
- **Edge Handoff**
Shifting edge compute processes between edge nodes
- **Edge Federation**
Cooperation between edge operators regarding edge resources allocation and handoff
- **Low Latency Edge Operator Interconnect**
Provide low latency interconnect between edge operators
- **Globally Consistent API's**
To provide a globally uniform service



Typical Data Sizes and Latencies

- User expectations on latencies (end-to-end latency, round trip):
 - Web-page latency: < 1.000 – 3.000ms
 - Phone call latency: < 200ms
 - Live music playing: < 40ms
 - Augmented reality application: < 20ms
 - Video Frame Rate: < 16.6ms (HD Video, 60 Frames per second)
- Network transmission times for Dicom image of 800 Mbyte:
 - Wireless LAN (50 Mbit/s, e.g. Magic Leap): 2 Min. + 8 Sekunden
 - 5G (100 Mbit/s, download): 1 Min. + 4 Sekunden
 - Local Area Network (1.000 Mbit/s): 6.4 Sekunden



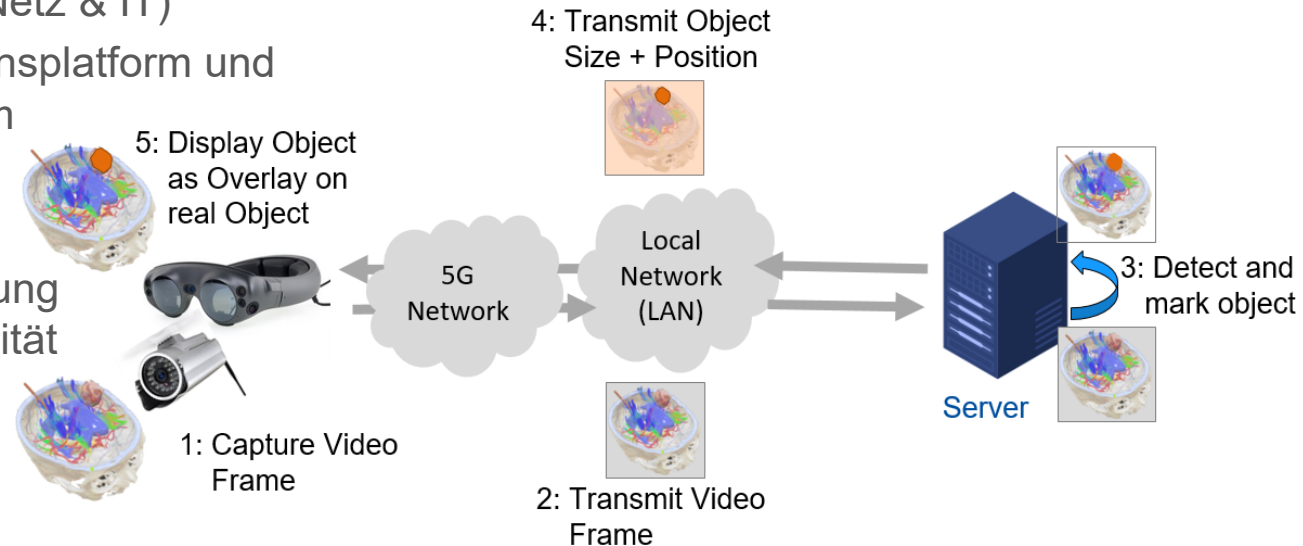
Giga for Health Projekt

Arbeitspaket: Mobile Edge Computing

Arbeitspaket Ziele (Smart Edge Lab)

- Unterstützung Edge Infrastruktur Planung und Aufbau (Netz & IT)
- Aufbau Edge Emulationsplattform und Edge Diagnoseplattform
- Emulation der Edge Infrastruktur
- Analyse und Modellierung der Edge Service-Qualität
- Optimierung der Edge Service-Qualität

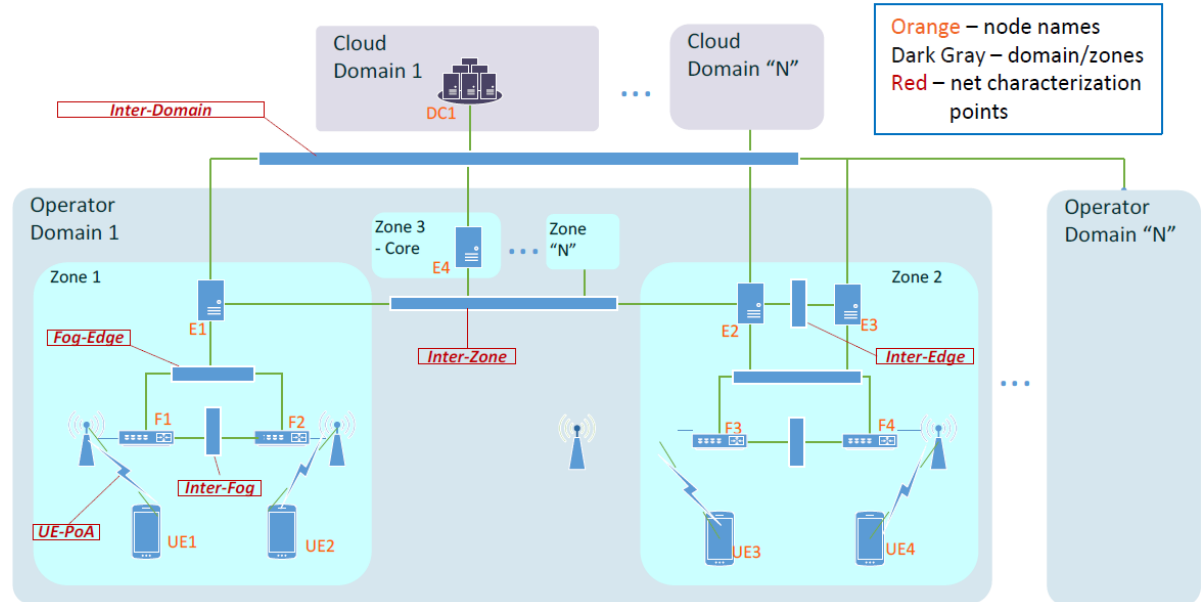
Ziel-Use Case (mit Digital Health Lab, AP 3.4): Herz-Transplantation mit AR Unterstützung



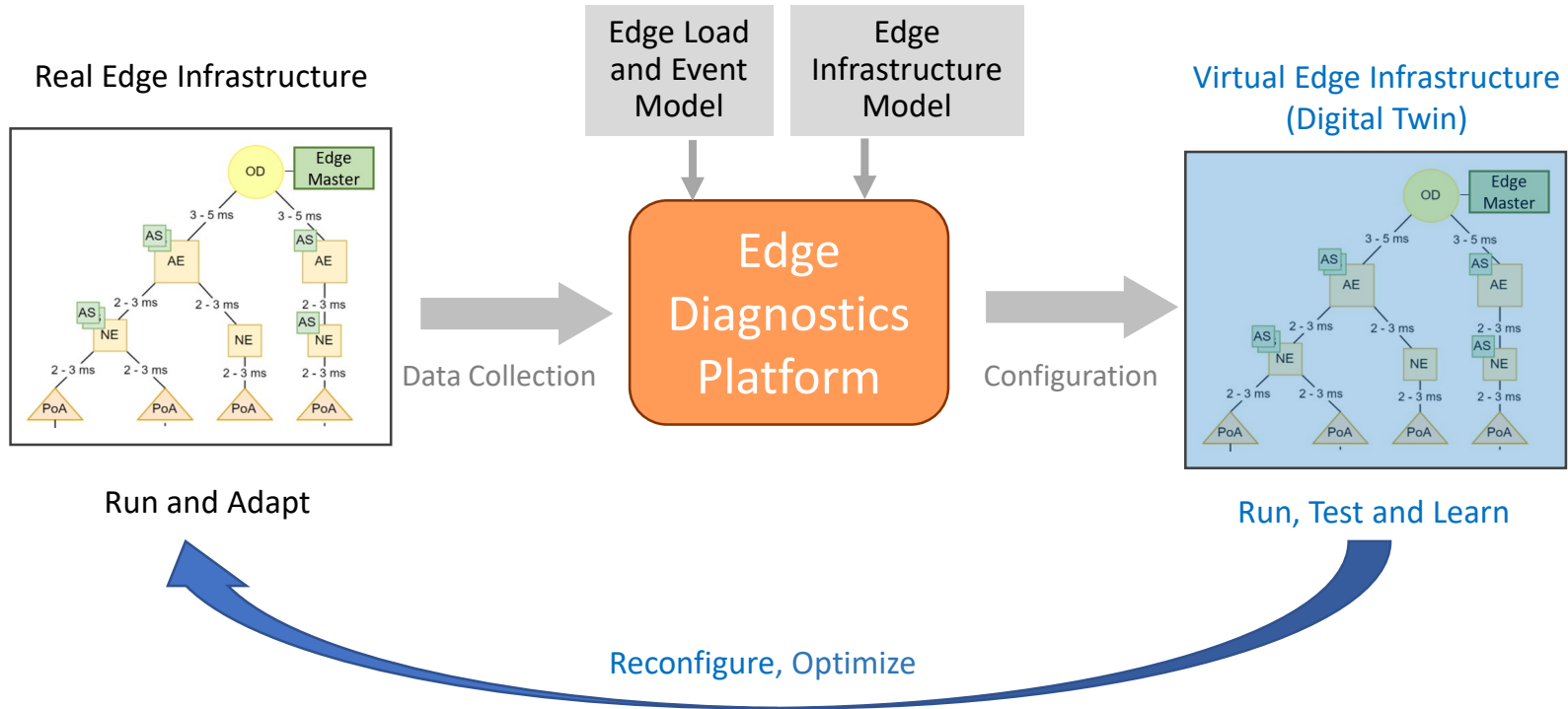
Edge Emulation – Overview Functions and Deliverables

- We can emulate
 - Edge infrastructure components (UE, networks and edge nodes)
 - Infrastructure loads and edge events (e.g. automotive scenarios)
- Emulation may be expanded with
 - UE- and server-HW in the loop
 - Real networks in the loop
 - Real edge management platform in the loop
- Emulation target deliverables
 - Performance assessment / measurement
 - Test & benchmarking algorithms
 - QoS prediction

We currently use the open-source emulation platform “AdvantEDGE “:
<https://github.com/InterDigitalInc/AdvantEDGE>



Edge Design & Optimization of Edge Infrastructures



Summary and Conclusions

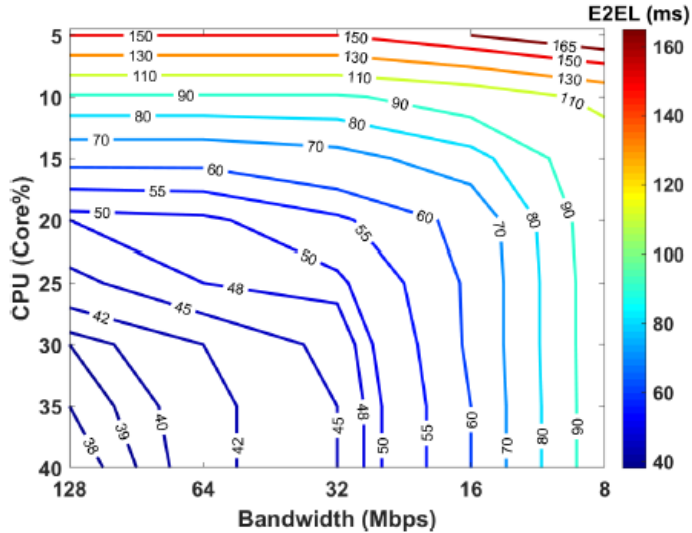
- Edge Computing enables a new category of services and customer experience
- By now there is a wide variety of edge service and technologies
 - Cloud Edge and Telco Edge
 - Edge node-, GPU-, QoS management technologies
- There are still a number of technology challenges for edge computing ... and we need more attractive edge native applications



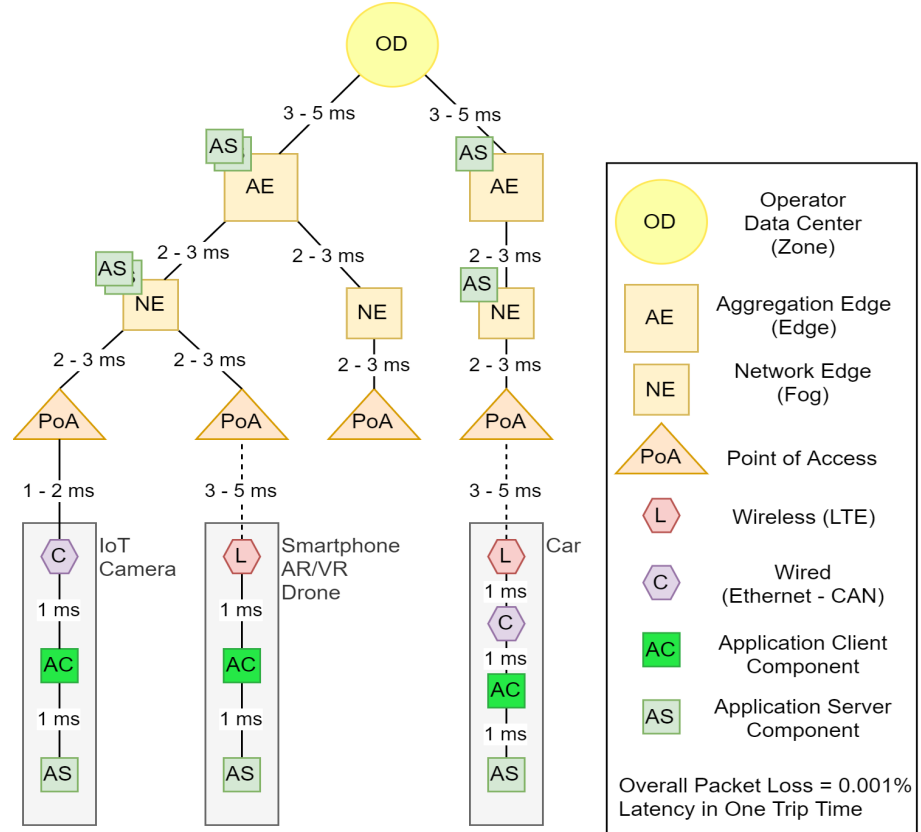
➔ Overall, Edge Computing is an innovation driver for new attractive products and services!

Appendix

Edge Diagnostics Platform – Resource Allocation



Latency variation with available compute (CPU) and network (bandwidth) resources



Bisherige Veröffentlichungen Giga for Health Projekt

- T. Bui, A. Sakr, J. Castrillon, and R. Schuster, "**Six-factors Score-based Match-making Based on Priority and Preemption for Resource Allocation in Edge Computing**", **IEEE EDGE 2021**, December 2021. (accepted)
- M. Abdulmaksoud, N. Dehadrai, J. Castrillon, A. Sakr, and R. Schuster, "**Edge Diagnostics Platform: Orchestration and Diagnosis Model for Edge Computing Infrastructure**", **IEEE EDGE 2021**, December 2021. (accepted)
- R. Gazda, M. Roy, J. Blakley, A. Sakr, and R. Schuster, "**Towards Open and Cross Domain Edge Emulation – The AdvantEDGE Platform**", The Sixth ACM/IEEE Symposium on Edge Computing: the 2nd Workshop on Edge Computing and Communications (**EdgeComm**), December 2021. (accepted)