



ETSI
NEW INTERNET FORUM

12 October 2018

WHEN IS THE BEST TIME TO START TALKING ABOUT “N+1” G – A VIEW ON THE DRIVING FORCES

Presented by Prof. Ning Wang, University of Surrey



Starting from 5G...



5G is... **CONNECTIVITY + INTELLIGENCE**

Automation



Data to information/knowledge transformation



Blurring boundaries between real and cyber worlds



Connected Devices of small and large sizes and capabilities
(robots, cars, sensors, actuators, smart phones driverless cars)



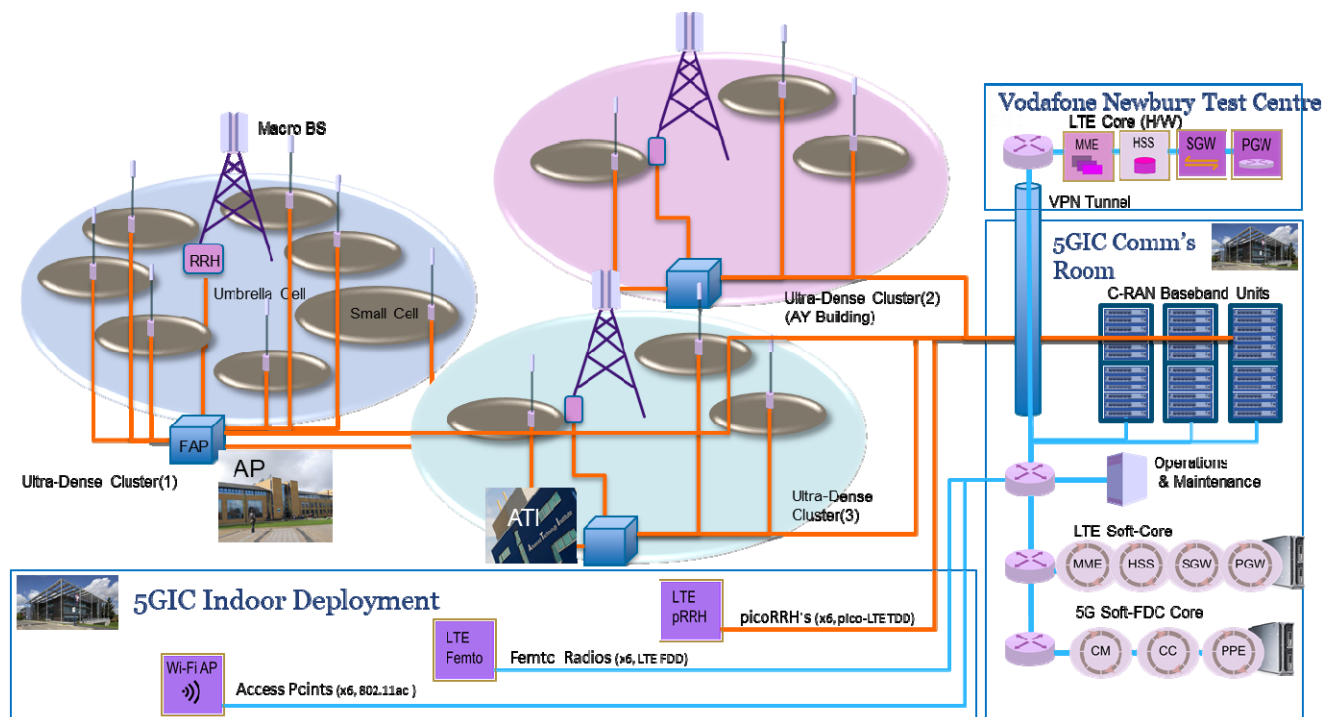
About 5G Innovation Centre (5GIC)



Development of 5G Core Network Architecture at 5GIC

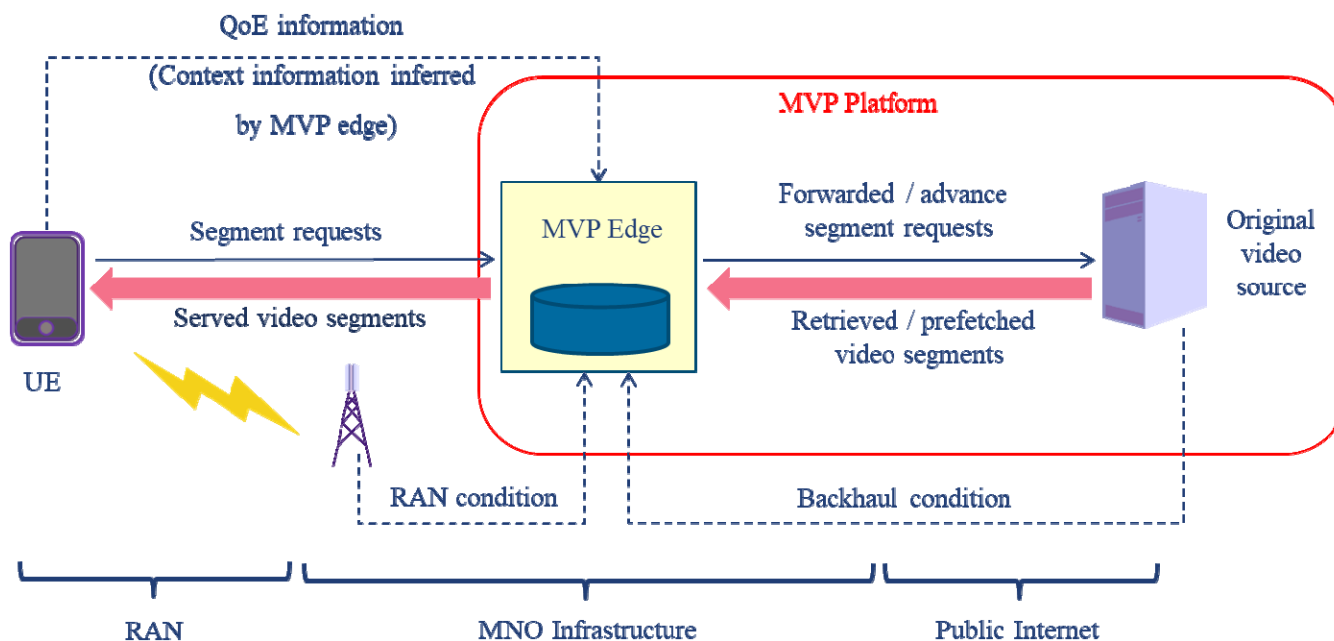


- Independently designed and developed 5G core network architecture – The **Flat Distributed Cloud (FDC)** and its supporting mechanisms
 - Fully compatible with **3GPP specification** (Release 15)
 - Context-awareness: the **Meta Data Protocol (MDP)**
 - Supporting dynamic **network slicing**, with creation time of new slice **within 2 minutes**
 - Supporting **over 1 million** (emulated) users by July 2018





Development of 5G Edge Intelligence at 5GIC



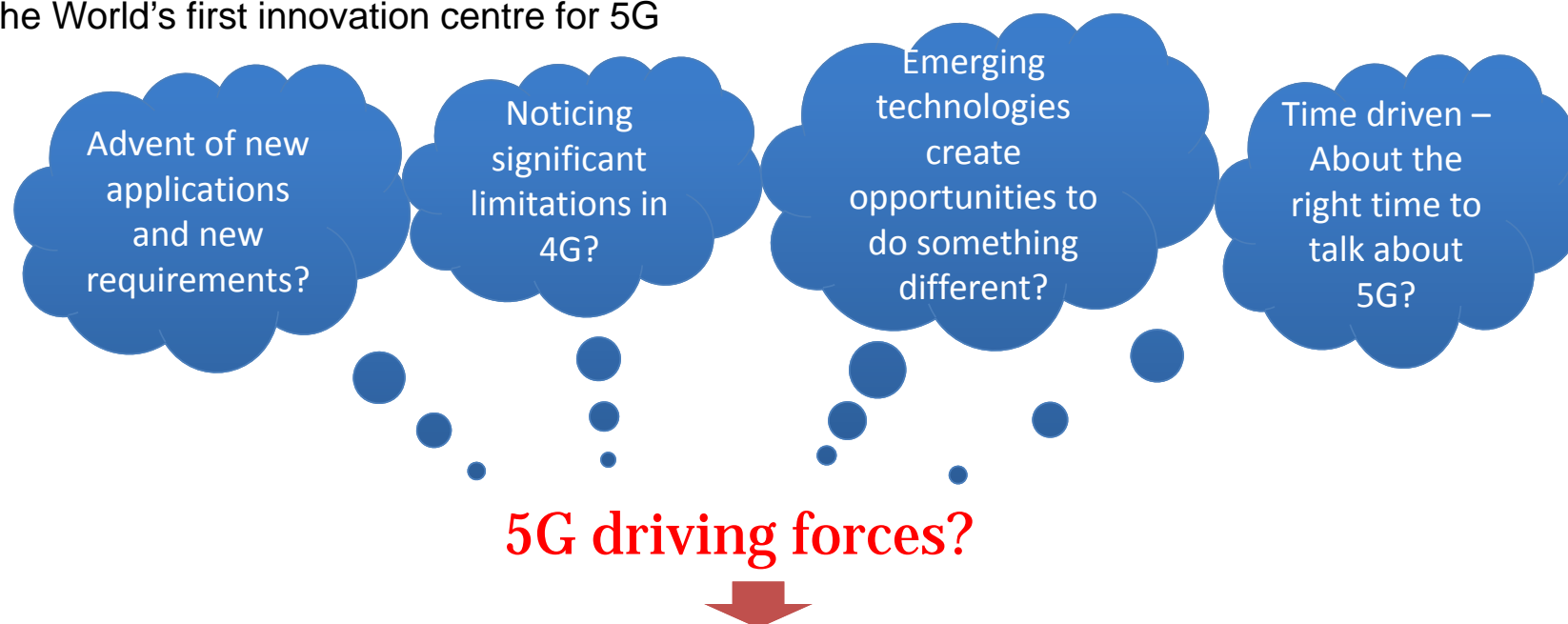
- MVP: Mobile edge Virtualisation with adaptive Prefetching
- ETHLE: Edge-based Transient Holding of Live Segment
- **First platform that enables QoE-assured 4K mobile video delivery at Internet scale**

- ★ Featured at IEEE Communication Society Technology News, September 2017
- ★ Demonstrated at Mobile World Congress (MWC) in 2018



Possible Driving Forces of 5G Innovation

- Our 5G vision started back in 2012, which led to the establishment of 5GIC jointly funded by the UK Government and the Industry
- The World's first innovation centre for 5G

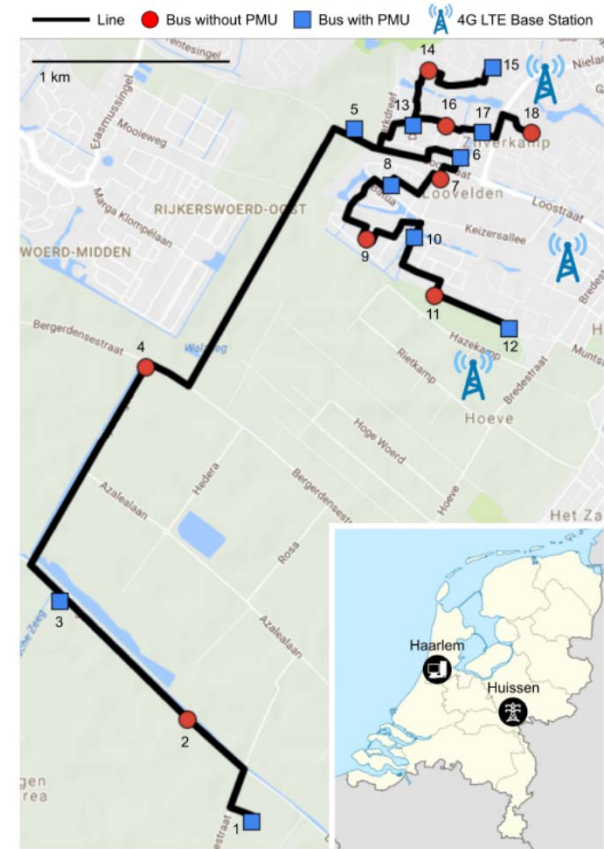
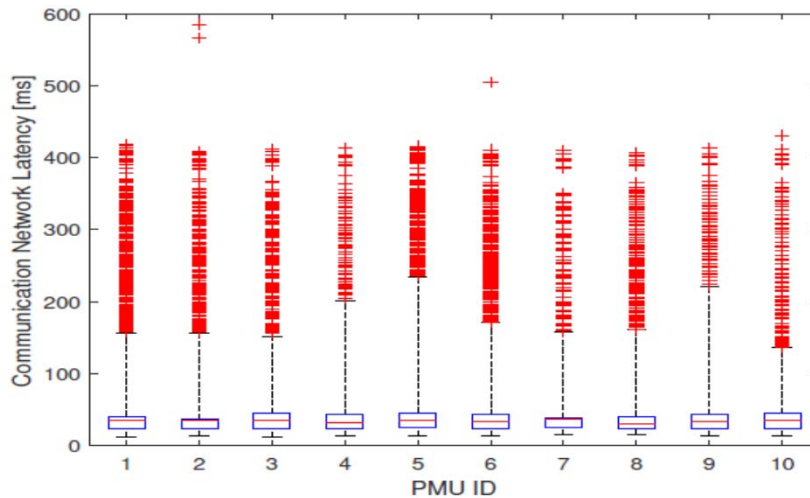


Some previous examples that made us desire 5G

Access Technology Limitation (Example)



- **Real-Time State Estimation (RTSE)** in smart power grids (2012-2013)
 - Streaming of measurement data created from PMU (Phasor Measurement Units) at individual substations in the field to remote PMU Data Centre (PDC) with 5 nines assurance
 - E2E network latency <20ms → Allows active power control
 - E2E network latency <10ms → Allows feasible power failure detection
 - **4G radio NOT an option for assuring latency**

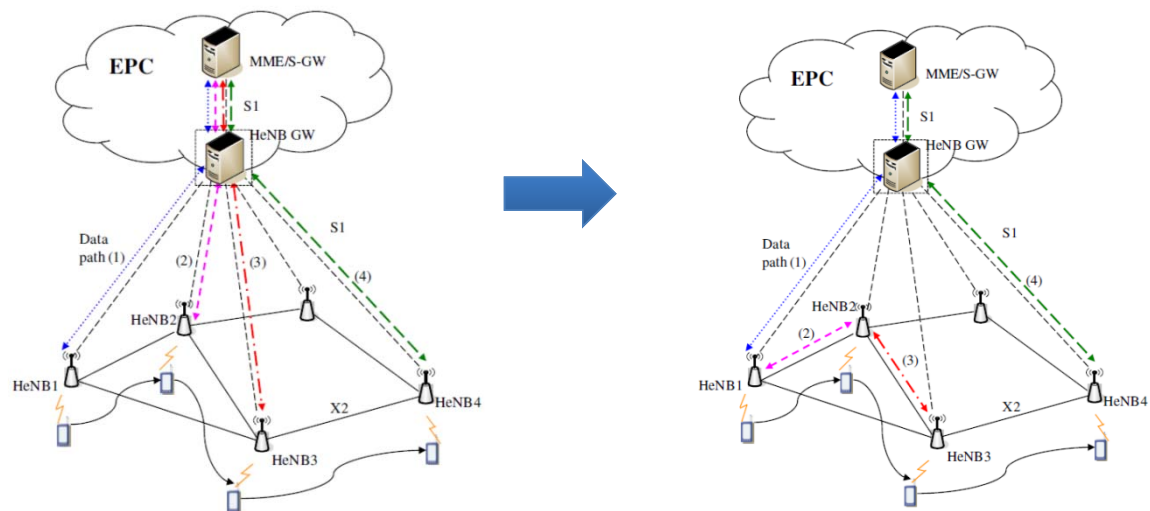


Core Network Inefficiency (Example)



- Inefficiency in mobility management in the hierarchical LTE / LTE-A architecture
- Handover triggers massive signalling messages to the central MME in the core
- Our approach at that time
 - Making mobility management more local – selective X2 handover vs. S1 handover
 - In 5G: **Collapsed network architecture** that allows control functions to be closer to users
 - In 5G: **Traffic redirection function** fulfilled by session management function (SMF) in control plane and user plane function (UPF) in the data plane

T. Guo, A. Quddas, N. Wang and R. Tafazolli, “*Local Mobility Management for Networked Femtocells Based on X2 Traffic Forwarding*”, IEEE Transactions on Vehicular Technology, Vol. 62, Issue 1, 2013, pp. 326-340



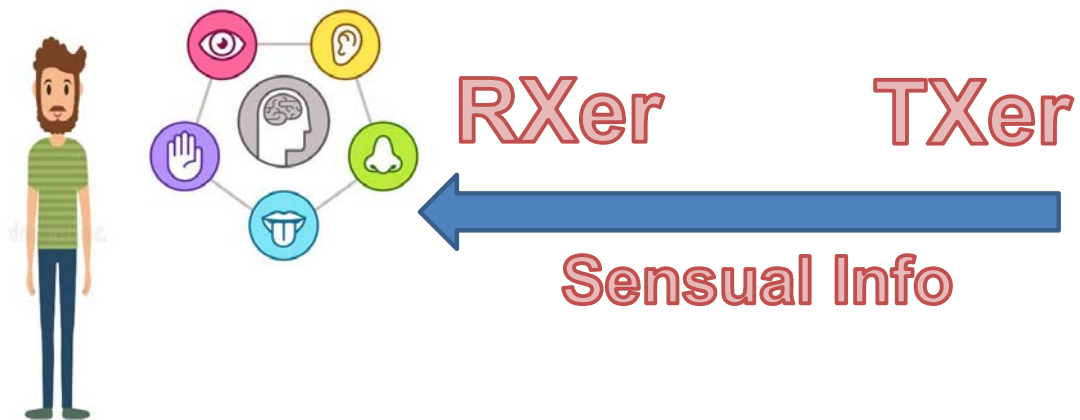
Back in 2018...



- **So where are we now?**
- **What are possible and what are impossible for 5G?**
 - Applications & services that cannot be supported? (Talk focus)
 - New technologies too early to get deployed in 5G?
 - Network limitations – not too late to evolve 5G network architecture



Simplest Form of Multi-sensory Teleportation



Sensitivity of senses

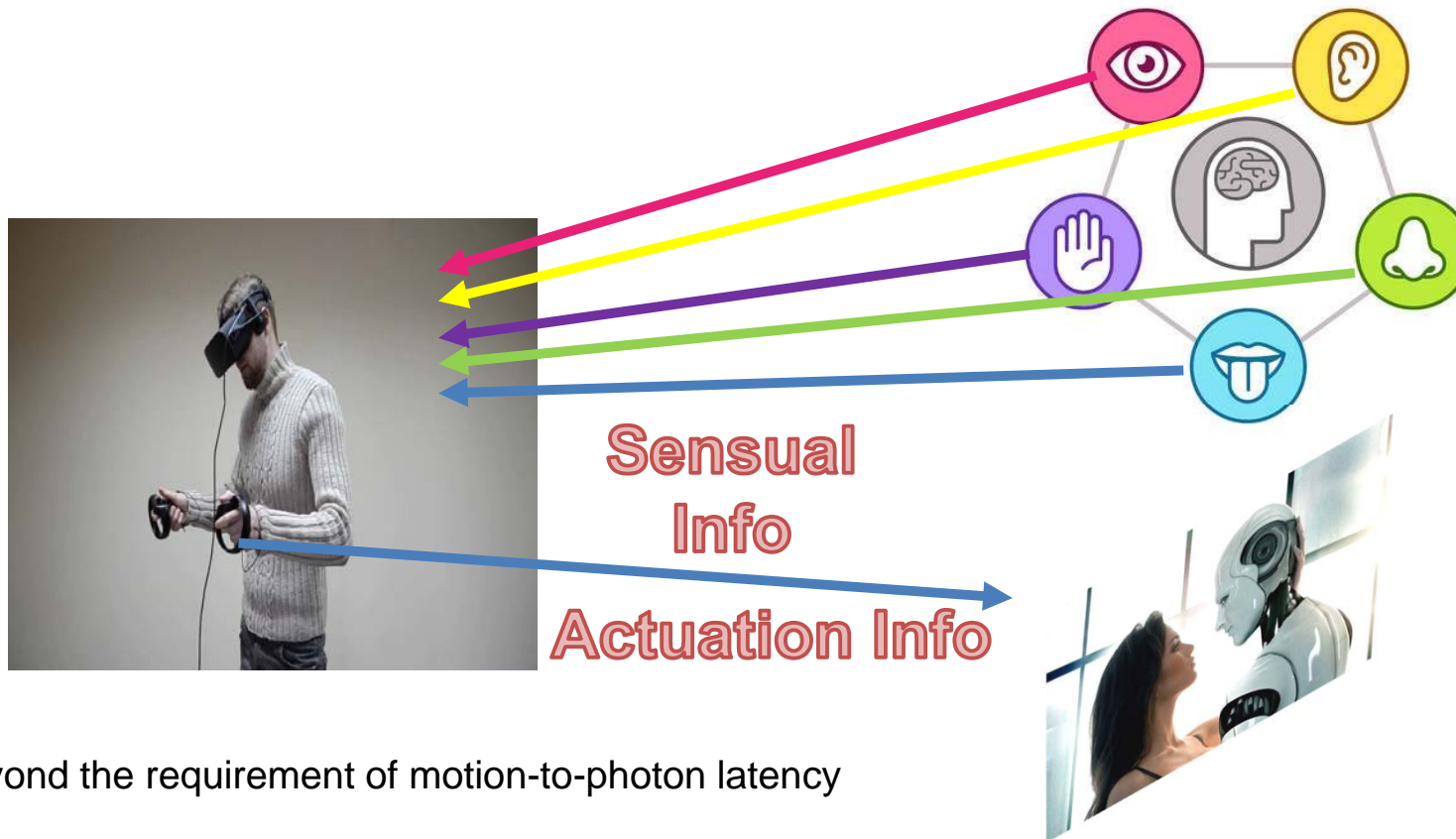
👁️ 👂 > 🖱️ > 🗑️ > 🤏

Realisation difficulty

👁️ 👂 < 🖱️ < 🤏 > 🗑️



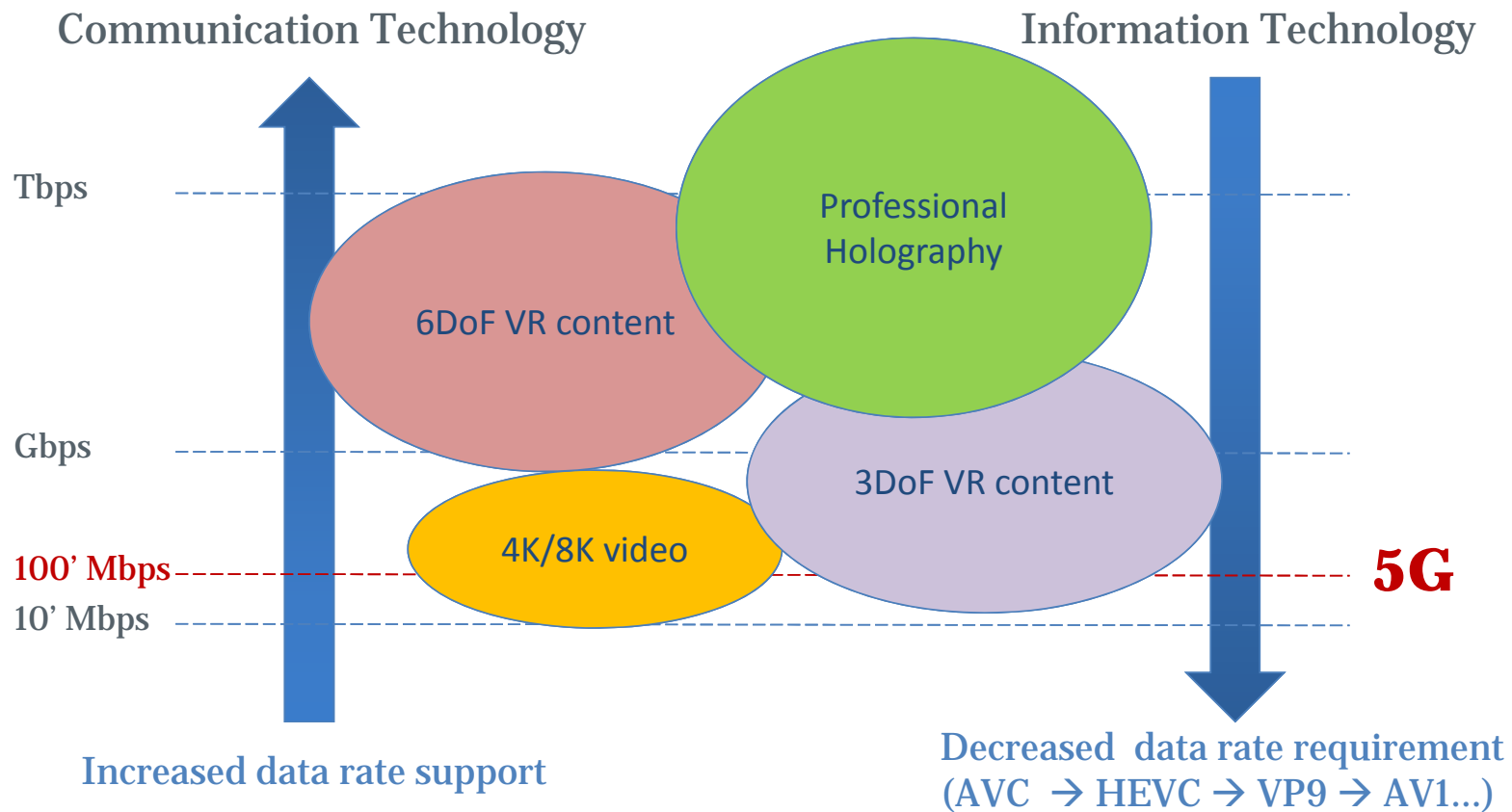
Real-time Multi-Sensory Tele-Interactions



..Beyond the requirement of motion-to-photon latency



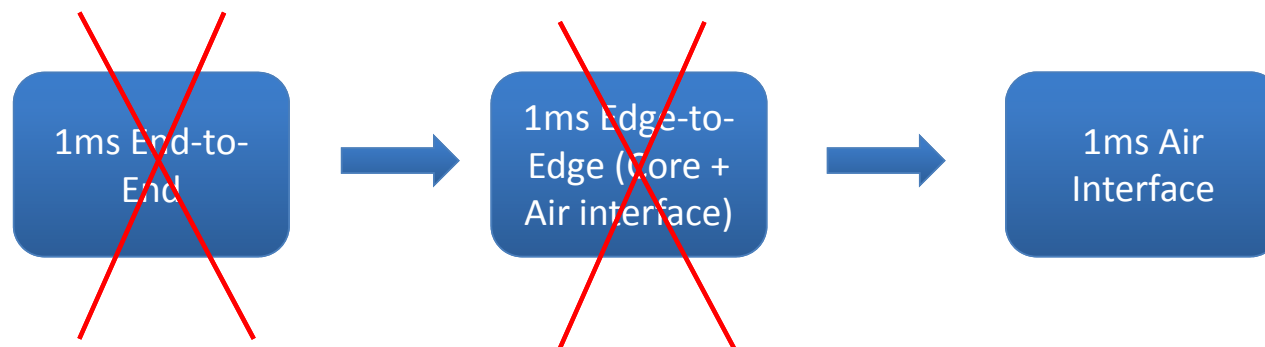
N+1 G for Data Rate Evolution?





A Game of Latency within Network

- Still remember the evolution of 1-millisecond view on 5G latency?



- How to satisfy latency requirements in real applications and across the global Internet?



- Sometimes latency bottleneck **does not** come from the network side!
 - Encoding/decoding, security/encryption etc.

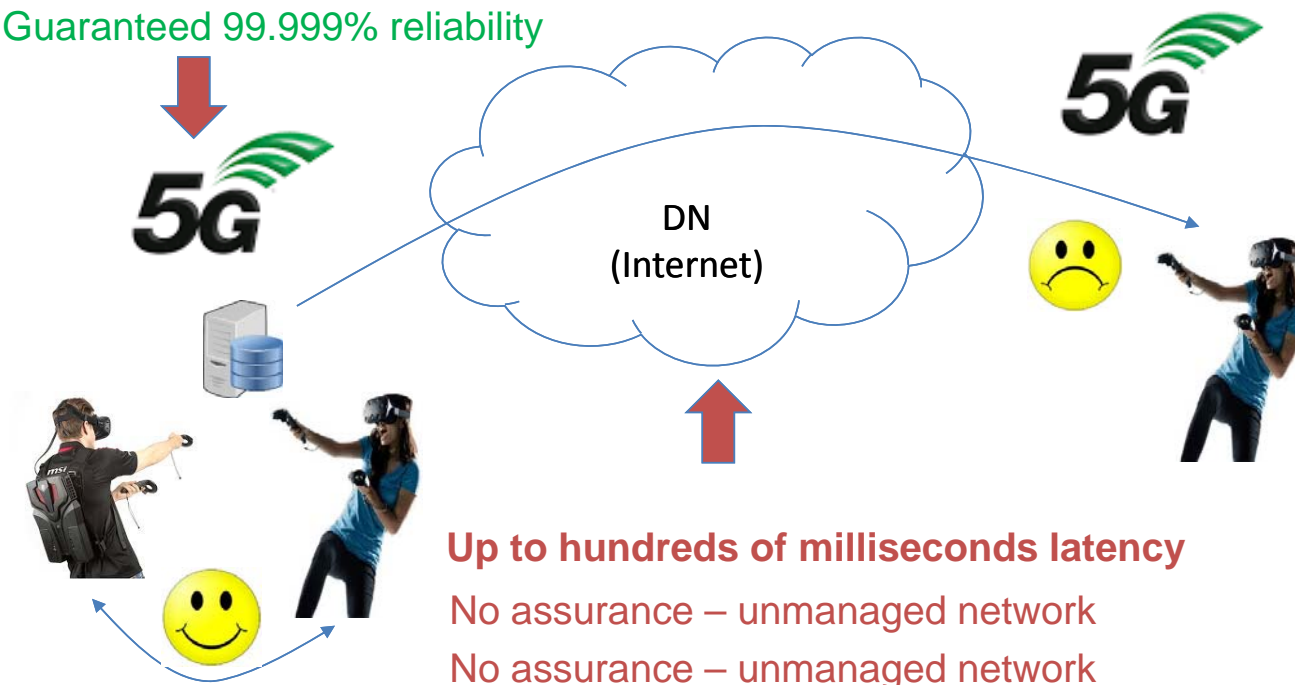
Unified Design of Future “G”s and Internet



Guaranteed 100's Mbps user perceived data rate

Up to 10 millisecond latency

Guaranteed 99.999% reliability

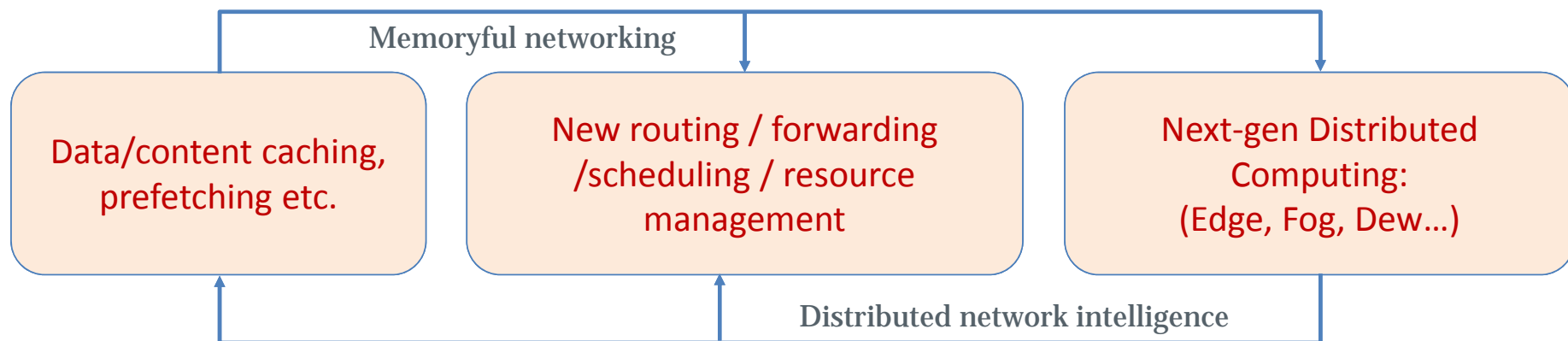
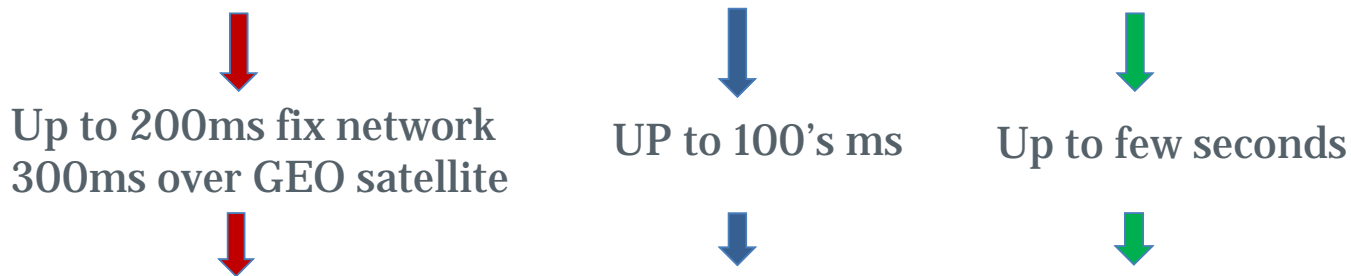


Meaningless to only talk about latency reduction in X “G” but forget about the constraints from Internet

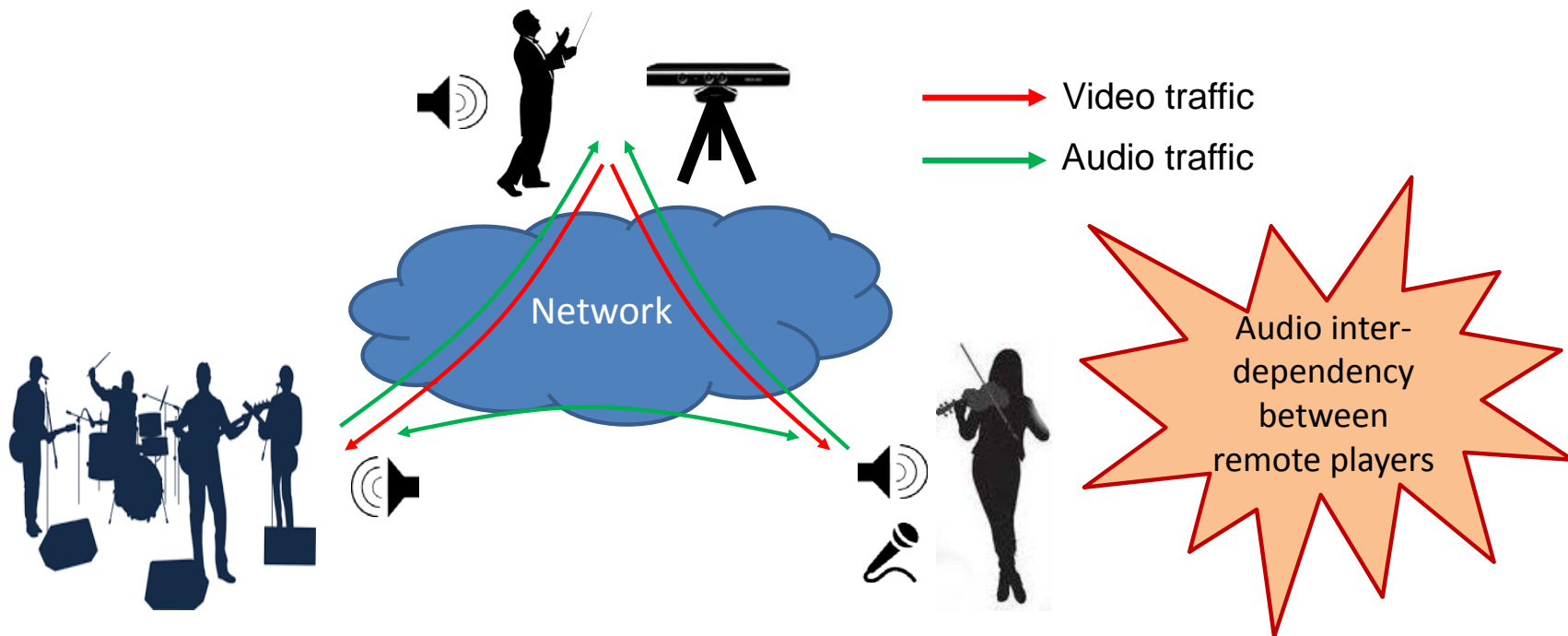


N+1 G for Latency?

Total accumulated Latency



Latency Synchronisation



Latency synchronisation for only two senses (video/audio) in such a distributed concert application is sufficiently difficult!

Conclusions



- **Largely driven by future application requirements**
 - Immersive x-Reality applications
 - Automation applications
- **Integrated future network design**
 - Networking + Distributed computing
- **No more “parallel” design of “xG” and future Internet?**
 - Building real end-to-end capabilities



Thank You



ETSI New Internet Forum

