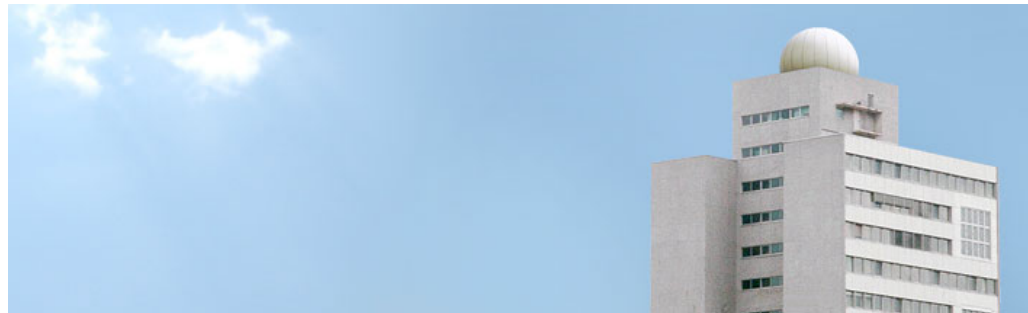


Ultra-Low Delay Video: Towards Tactile Internet

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Overview

- 1. Introduction**
- 2. Standardization Efforts**
- 3. Video Delivery Latency**
- 4. Current Techniques**
- 5. Future Work**

Introduction

Tactile Internet

- ...extremely low latency => 1 ms End-to-End.
- ...humans will wirelessly control real and virtual objects.

Emerging applications...

- ... industry automation and transport systems, healthcare, education and gaming.

Examples...

- ... Shared Haptic Virtual Environments: tasks that require fine-motor skills (tele-surgery, micro-assembly).
- ... Connected vehicles: collision-avoidance by cooperative-driving manoeuvres.

[1] ITU-T Technology Watch Report (August 2014) - The Tactile Internet

Standardization Efforts

3GPP SA1...

- ...Study Item SMARTER: New Services and Markets Technology Enablers (5G):
 - 20 Use Cases (20% done, [2])
 - Ultra-Low Delay use cases include:
 - Interactive services for high speed zones in office environments
 - Industrial control
 - Tactile Internet
 - Remote control (connectivity for drones)

[2] Draft Minutes of 3GPP TSG SA WG1 Meeting #70 (SMARTER)

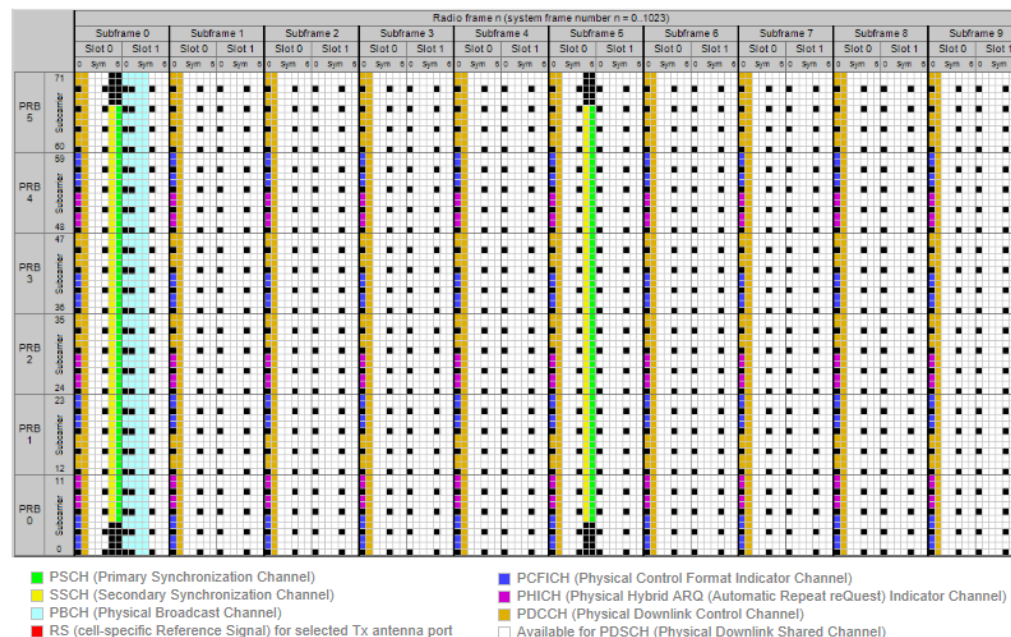
[3] NGMN White Paper on 5G

[4] 4G Americas' Recommendations on 5G Requirements and Solutions

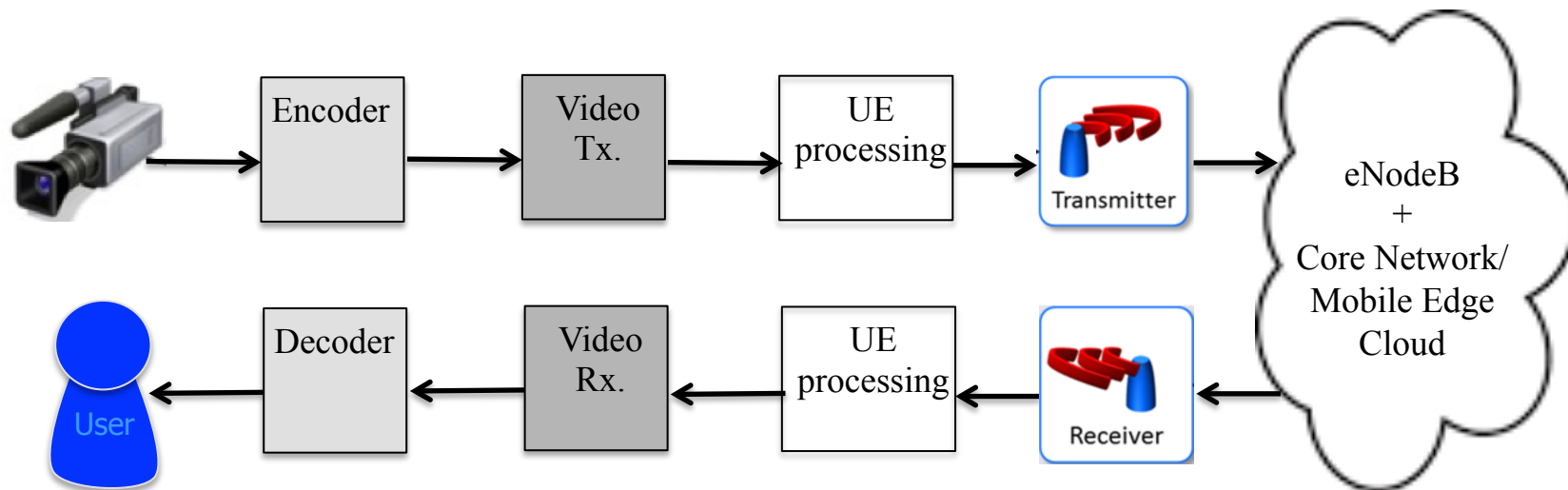
Standardization Efforts (Cont.)

3GPP RAN2...

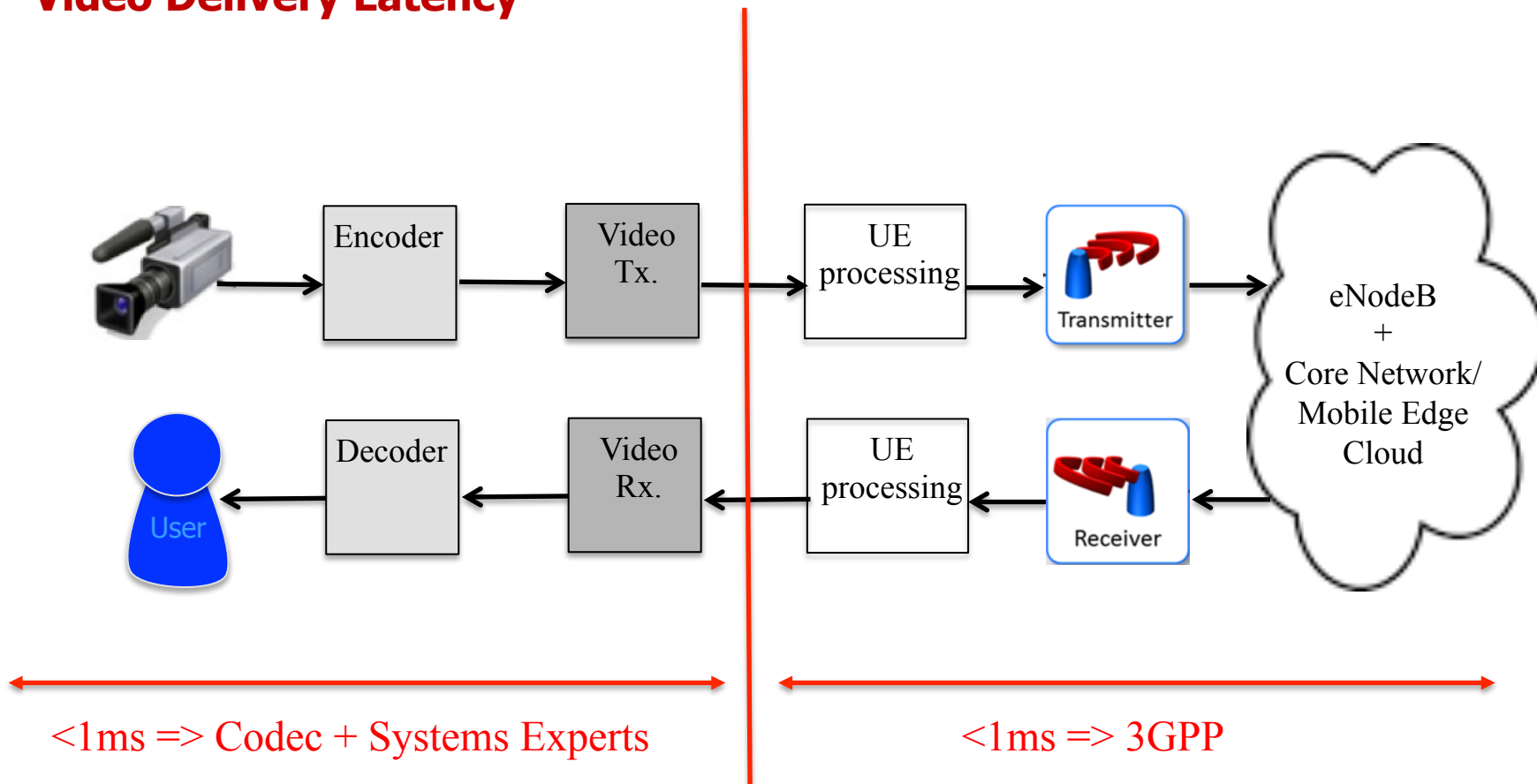
- ...Study Item LTE_LATRED: Latency reduction techniques for LTE (Rel-13) [5]:
 - Level of completion (0% according to SR, finishes June 2016)
 - TTI shortening
 - Fast uplink access solutions
 - Reducing processing time
 - Improves TCP performance



Video Delivery Latency

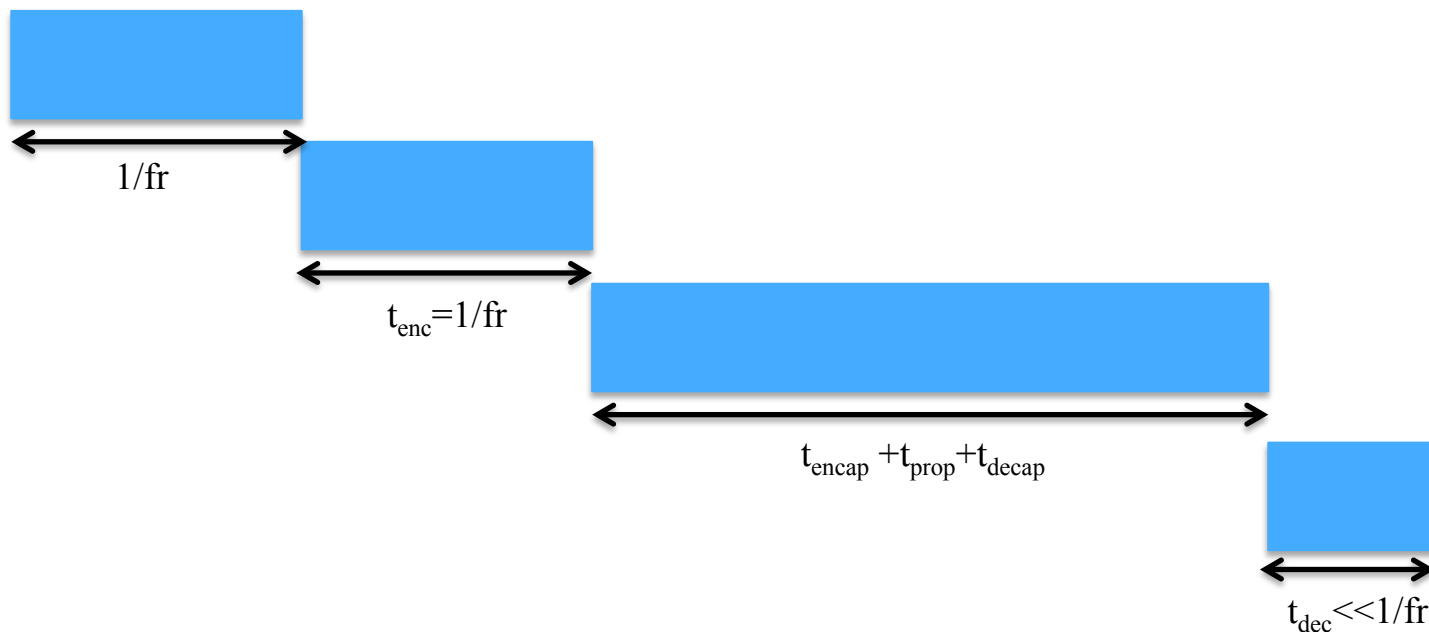
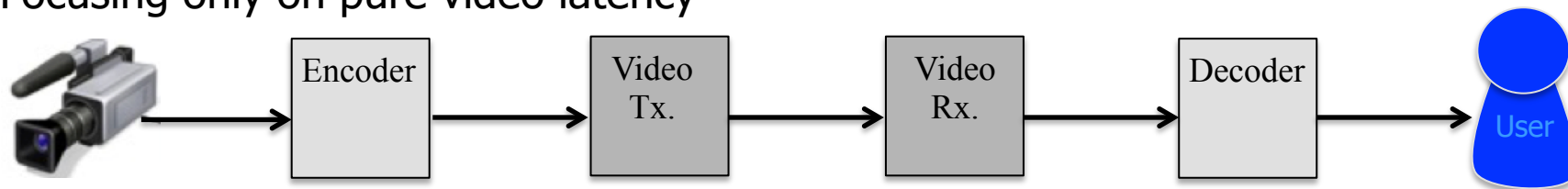


Video Delivery Latency



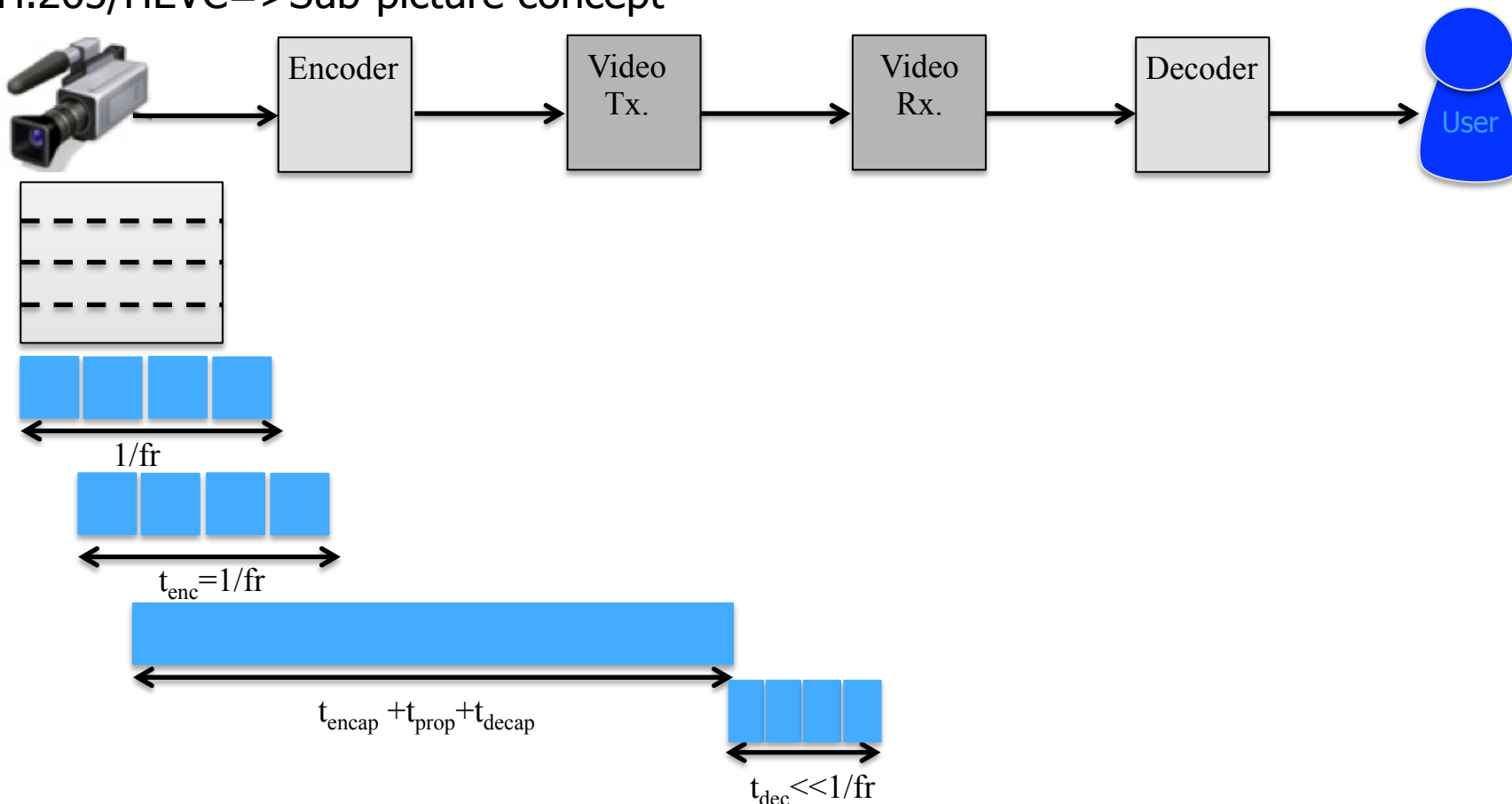
Video Delivery Latency (Cont.)

Focusing only on pure video latency



Current Techniques

H.265/HEVC => Sub-picture concept



Current Techniques (Cont.)

H.265/HEVC=>Sub-picture concept

- dependent Slices: higher compression efficiency than regular (independent) slices
 - Reduced slice header
 - Entropy encoding across slices
- sub-picture timing: decoding not at picture level but finer granularity (slices)
 - AVC did not have sub-picture timing
 - HEVC allows for Ultra-Low Delay

Current Techniques (Cont.)

t_{encap} and t_{decap}

- RTP considered. Each slice in a different RTP packet as soon as available
- HEVC RTP Payload Format
 - Waiting for WriteUp Status. Very soon published as RFC

Future Work

- **Similar approaches for sub-picture processing in future video codecs**

Can we do it even more efficient?

- **System Perspective**

- High reliability
- We need more interaction between physical layer and application layer
 - QoS guarantee