Cost-effective, Accurate and Scalable Mobile Network Synchronization and Monitoring

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Presentation overview

5G deployment drivers

Network densification

Dense network synchronization

Dense network monitoring

Summary

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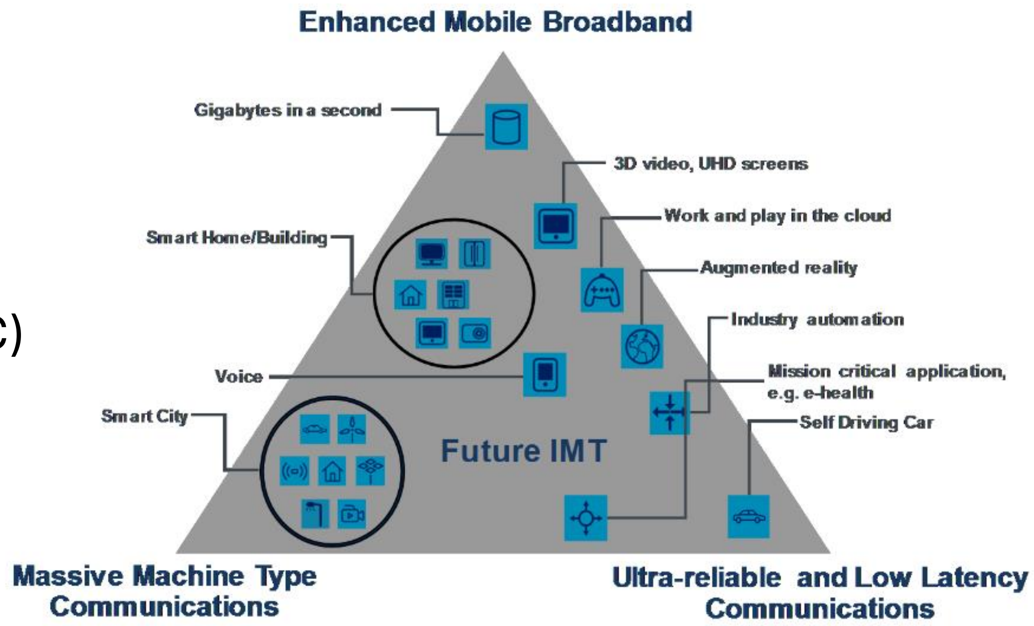
5G capabilities and drivers

- 5G capabilities as per ITU-R
  - Enhanced mobile broadband (eMBB)
  - Ultra Reliable Low Latency Communications (URLLC)
  - Massive Machine Type Communications (mMTC)



- 5G drivers
  - Network slicing to optimize infrastructure use and revenue streams for network operators
  - Users are data bandwidth hungry – social media (video sharing), lately also video conferencing and in future virtual offices:
    - How do we get the higher data transfers?

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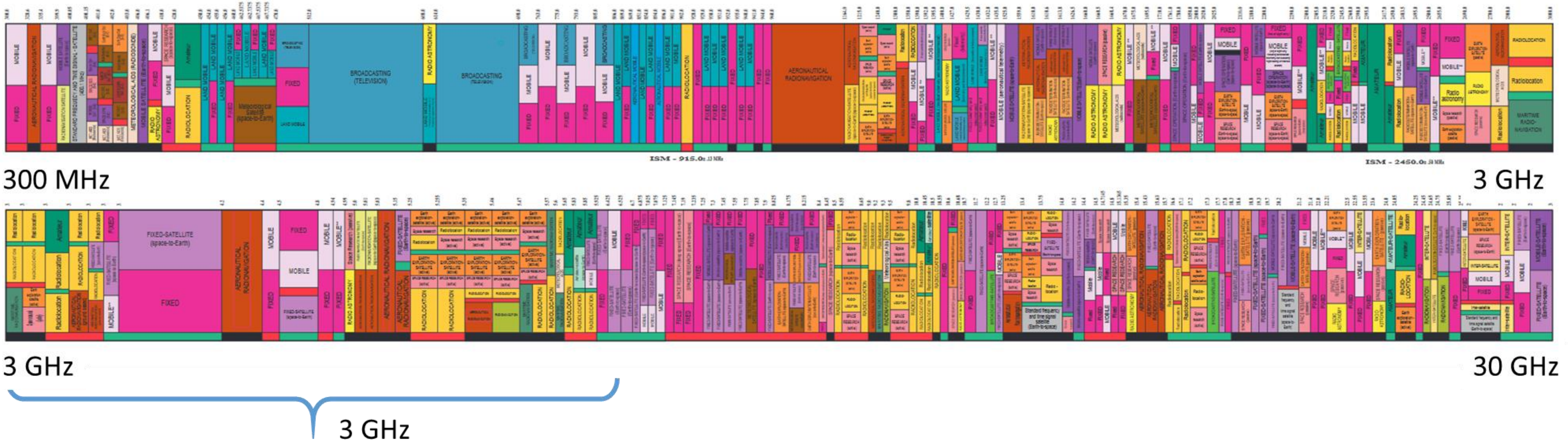
eMBB and network densification

- Spectrum in below 6GHz is expensive and overpopulated (US allocation table)



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eMBB and network densification

- Spectrum in below 6GHz is expensive and overpopulated
- Solution: spectrum sharing and moving to higher frequencies (mmWave)
- Specifically mmWave is attractive due to bandwidth availability, yet significant propagation losses in that spectrum range shorten inter-cell distance.
- eMBB requires more data transfer capacity for backhaul network
- Likely solution -> mobile network densification

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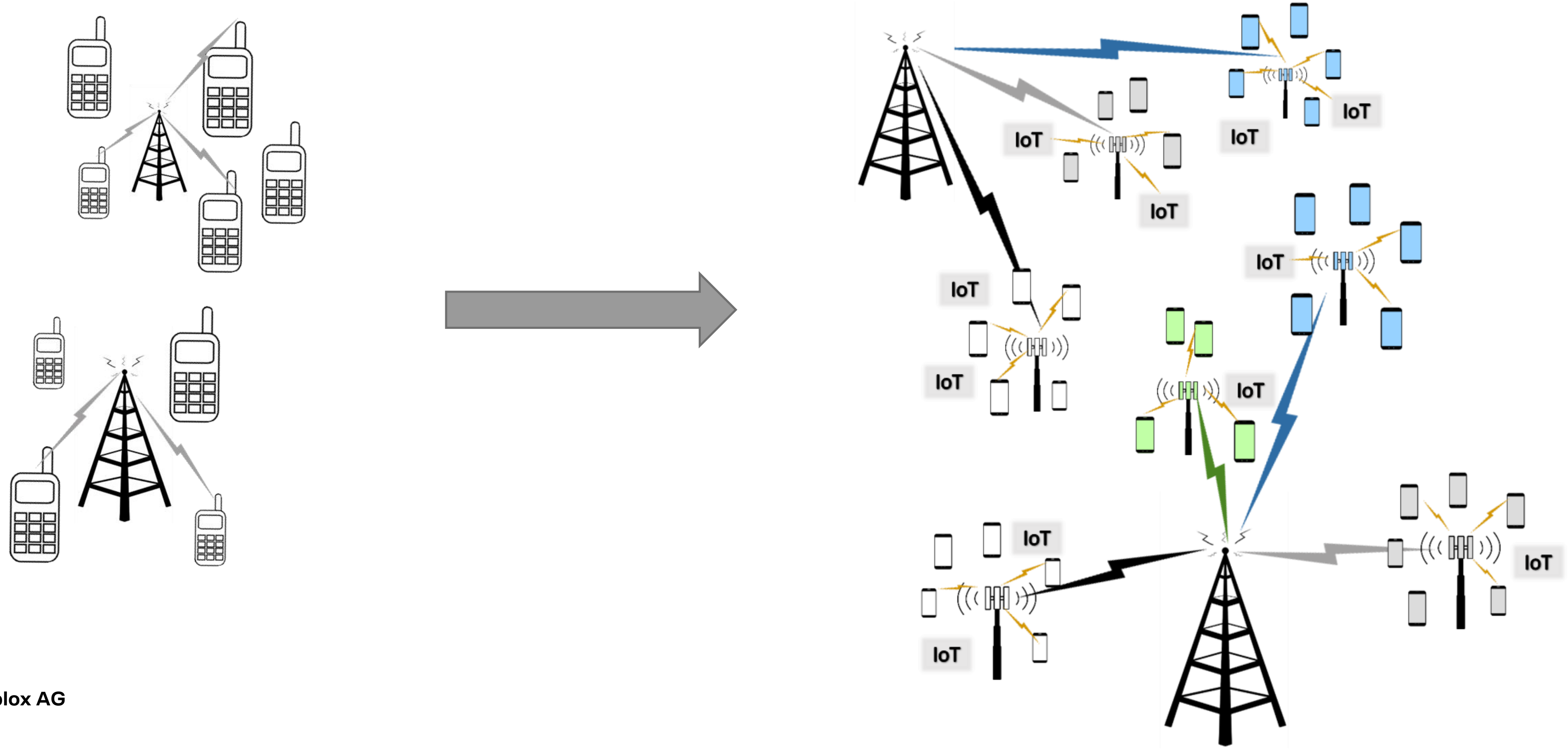
Mobile network densification

- Significant increase in the number of base stations (and connected devices)



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Dense network synchronization

- Densification – an awful lot of things to synchronize to a common timing standard and monitor
- As usual there is no silver bullet, or one size fits all: different approaches are taken by different mobile network operators
- PTP distribution over fiber with improved boundary clock classes
- GNSS based Primary Reference Timing Clocks (PRTCs) closer to the network edge
- Or even better: a combination of the above two to increase resiliency of the timing synchronization
- 3GPP based synchronization requirements mostly focus on **relative time sync**
- Current requirements to meet PRTC-B at the edge and ePRTC at the core network

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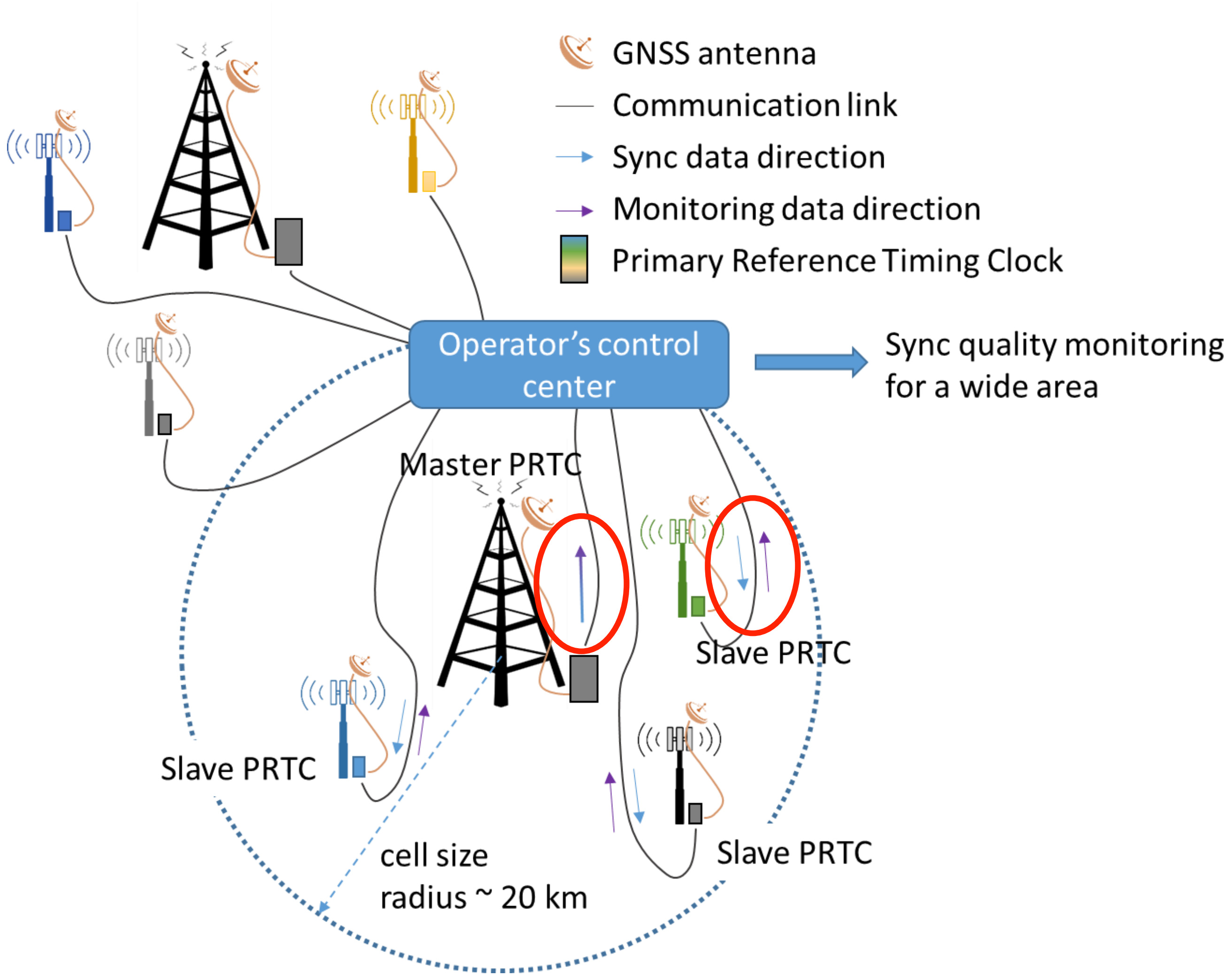
Dense network synchronization

- CVTT – receivers within close proximity are experiencing the same deteriorating conditions (sun activity – ionosphere delay, troposphere delay, but not multipath)
- Differential Time Transfer introduced by u-blox – uses principles of Common View Time Transfer (CVTT) to deliver highly accurate sync: Master/Slave at least PRTC-B to UTC, ePRTC in between Master and Slave PRTCs
- RTCM correction stream used as sync data



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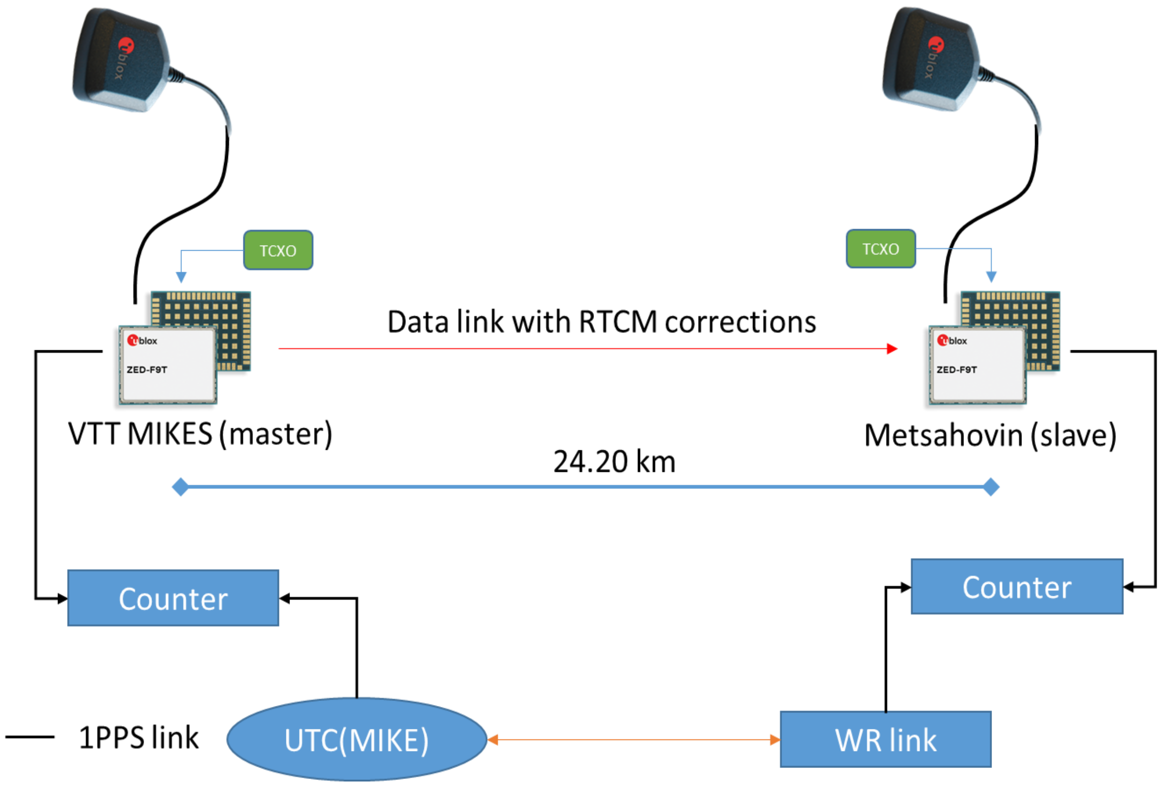
Dense network synchronization – DTT experimental results with patch antennas

- DTT results measured by Finland's timing metrology lab (MIKES) over 24 km baseline



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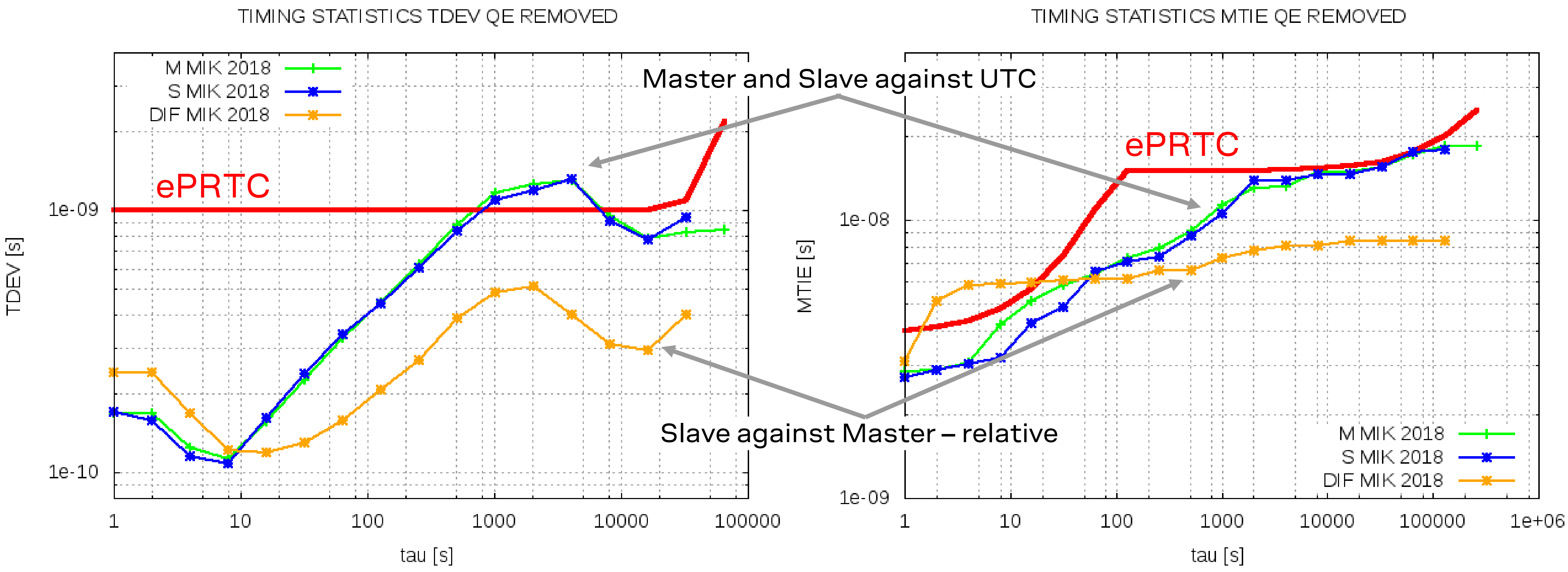
Dense network synchronization – DTT experimental results with patch antennas

- DTT results measured by Finland's timing metrology lab (MIKES) over 24 km baseline (ePRTC mask)



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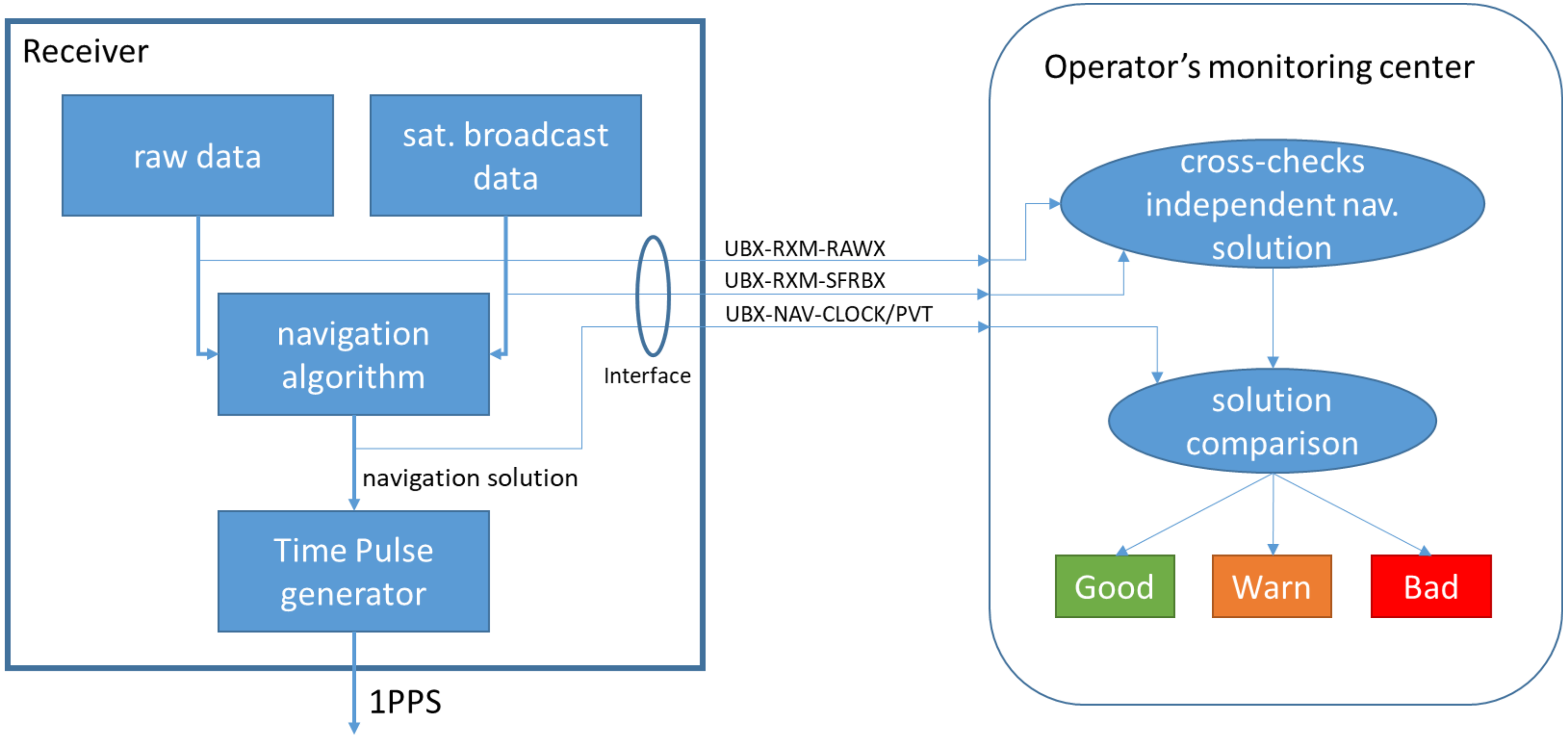
Dense network monitoring – part 1 – navigation cross-check

- How to monitor such a wide network without adding new devices?
- Use GNSS data stream from the receiver (e.g., RTCM, or UBX-RXM-RAWX) to verify receiver's measurements and navigation (timing) solution in the monitoring center by computing clock bias independently of the receiver and comparing with the receiver's published solution (UBX-NAV-CLOCK/PVT)



- If you need monitoring, the same data as for DTT sync is needed

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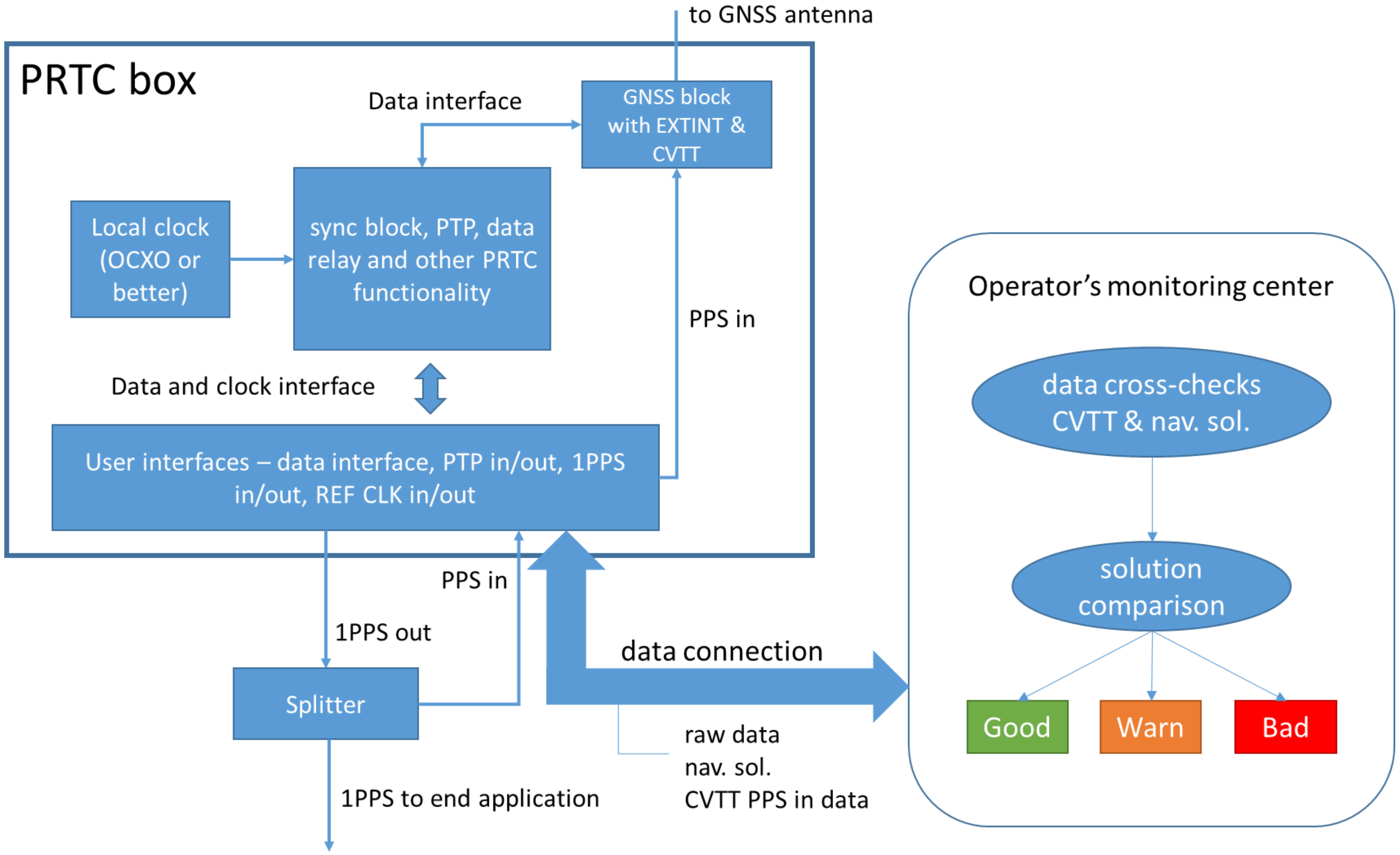
Dense network monitoring – part 2 – physical signal check

- Feedback PRTC's 1PPS output back into receiver as an external input and timestamp it in the receiver;
- Use raw data with CVTT algorithm in the data center to compare this physical PRTC output with any other (secure) clock in your system
- Using raw data is a powerful tool, but also a responsibility: computing orbit/clock corrections, computing navigation solution, cross-checks, outlier detection, etc.



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Summary

- Differential Time Transfer improves synchronization accuracy significantly for local areas ~ 20 km radius by using advantages of Common View Time Transfer (CVTT) approach even with patch antennas
- Raw data and CVTT principles allow operators to do all sorts of monitoring: consistency checks, physical pulse check against any other clock, etc., **but**
- Using raw data for monitoring purposes assumes one knows how to compute clock & orbit corrections, navigation solution, CVTT, etc. Seems straightforward looking at Wikipedia or ITU-T (TP-GSTR-GNSS - Considerations on the use of GNSS as a primary time reference in telecommunications), but the devil is in the detail…

Thank you for your attention