Drivers for High Accuracy and Deterministic Time

Calnex

Tim Frost,
WSTS, April 2017

www.calnexsol.com

Agenda

Calnex

- 5G: Uses and Implications
- Fronthaul Networks
- Indoor Positioning
- Industrial Automation
- Internet of Everything

5G Requirements

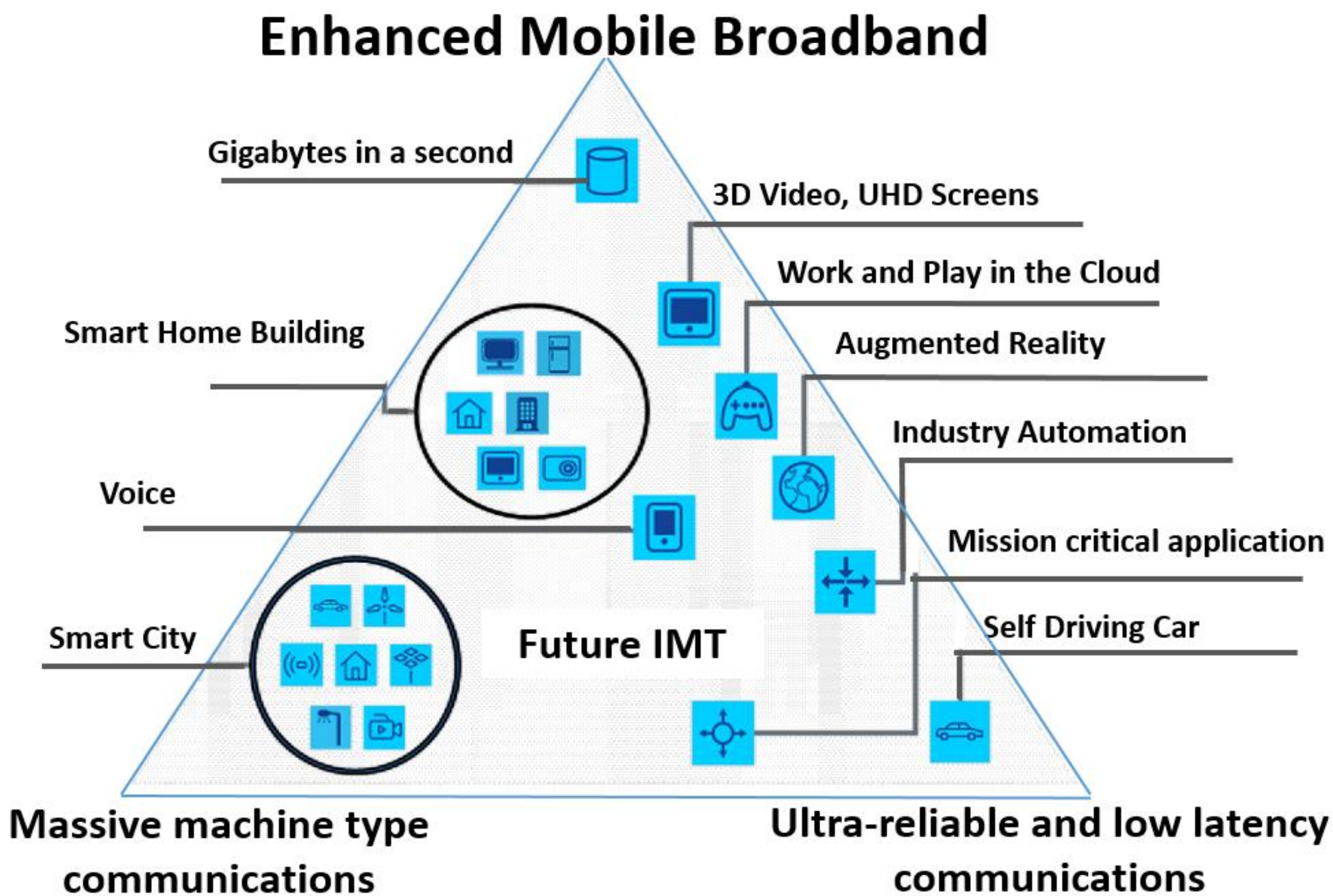
What is 5G?

Mobile Operators vision:

- Anything that's better than the current offering that can be branded as "5G"
- Current LTE-Advanced offering is just carrier aggregation, already being branded 4.5G in some markets
- Quite likely that anything beyond Carrier Aggregation (CA) will be marketed as 5G!
    - E.g. eICIC, CoMP, MBMS

What are the uses?

Calnex

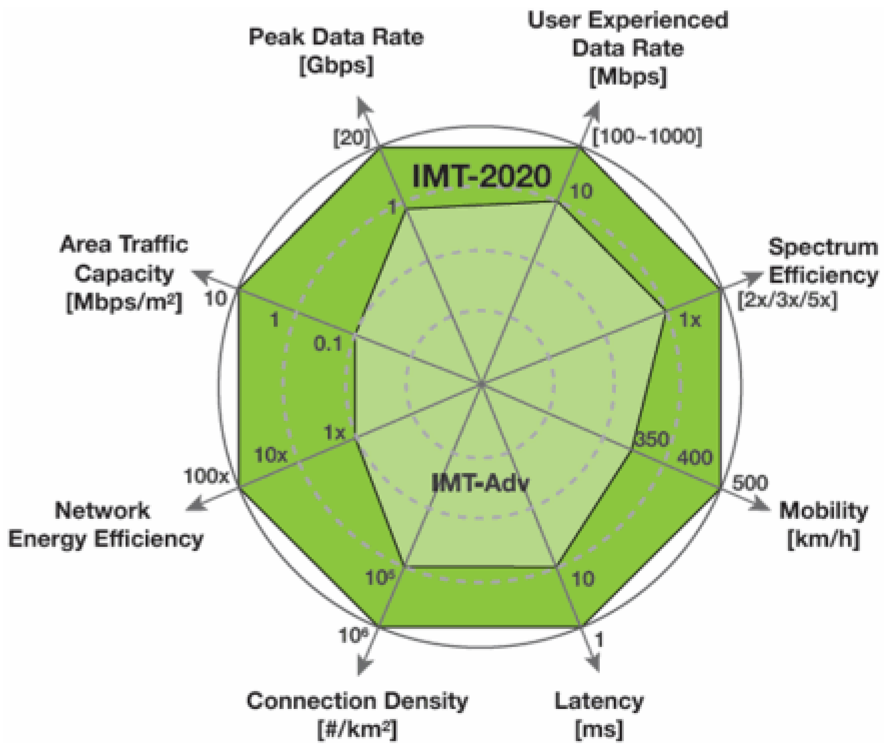


From ITU-R M2083.0, "IMT Vision"

What is the performance?

Calnex

IMT-2020 – the ITU's vision of "5G", to roll out in 2020



- IMT-Advanced (LTE, 4G)
- IMT-2020 (5G), relative to IMT-Advanced

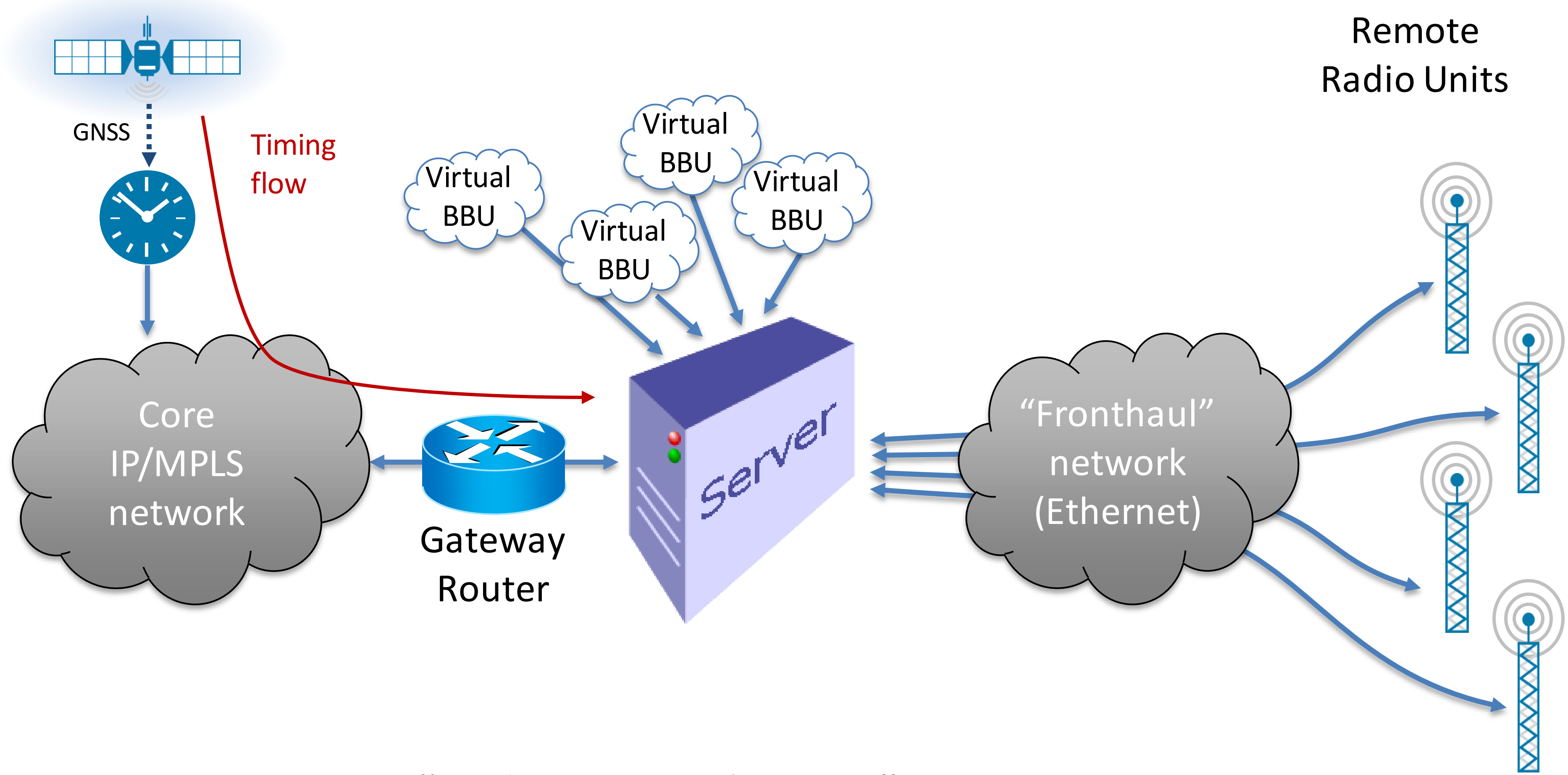
What are the implications?

Calnex

- Peak data rate of 20Gbit/s
  - High speed backhaul of 25Gbit/s or more
- User experienced data rate of 100-1000Mbit/s
  - Co-operative processing and interference management
- Connection density of 1M connections/km^2
  - Requires dense small cell deployment
- Latency < 1ms
  - Distributed architecture, data processing and switching at the edge
  - Fronthaul, distributed radio units with co-located baseband and switching

Fronthaul Networks

Fronthaul Architecture



- IEEE1904.3 – "Radio over Ethernet"
- IEEE802.1CM – "Time Sensitive Networking for Fronthaul"

Fronthaul sync requirements

Calnex

Inter-site Carrier Aggregation (CA)

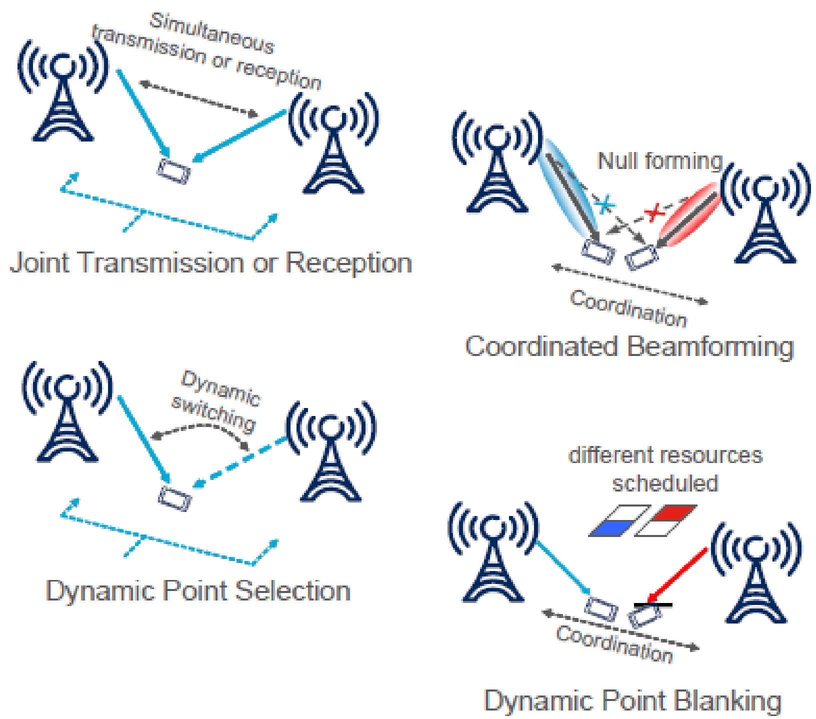
- CA bonds two carriers together into a single channel
  - For two non-adjacent carriers in the same band, or two carriers in different bands, frame alignment must be better than 260ns
- But it's always been that, even in 4G. So what's new?
  - In 4G, aggregated carriers were transmitted from the same antenna, generated by the same eNodeB
  - In 5G fronthaul architecture, carriers may be transmitted from separate radio units, connected over an Ethernet fronthaul
- 260ns frame alignment translates to ±130ns from central clock

Fronthaul sync requirements

Calnex

Co-ordinated Multi-Point (CoMP)

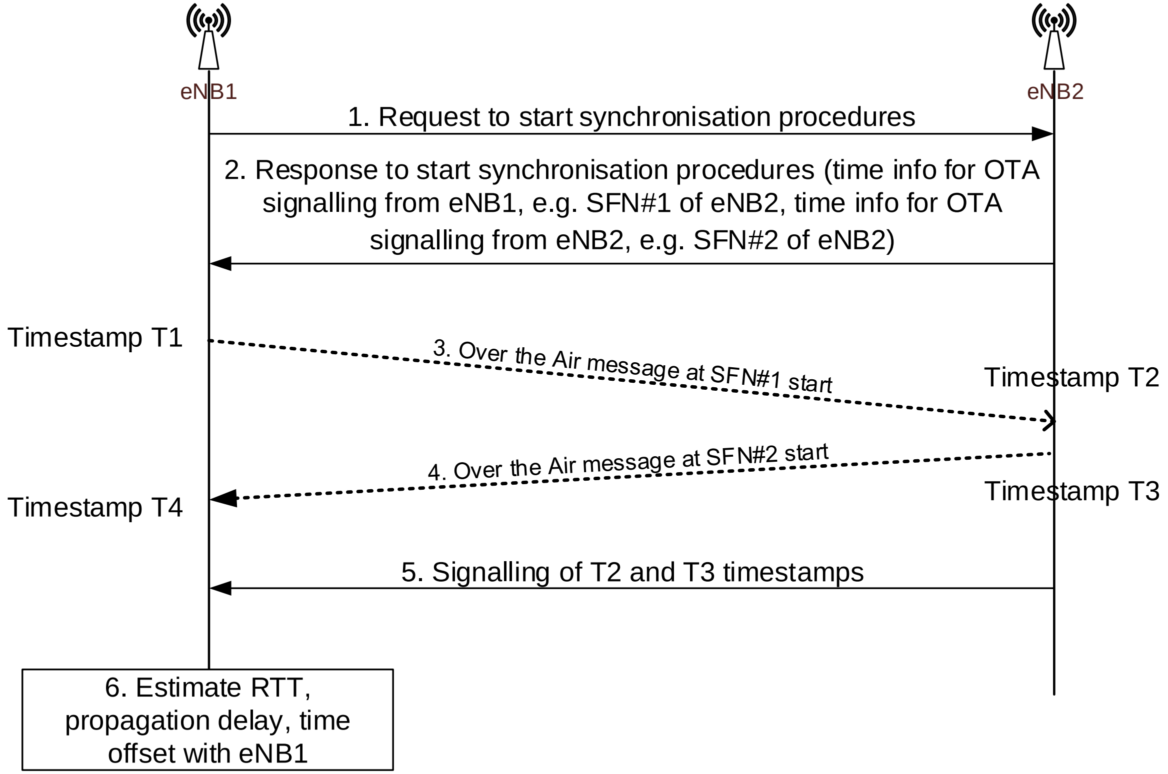
- CoMP is a family of technologies
  - Joint Transmission or Reception
  - Co-ordinated Beamforming
  - Dynamic Point Selection
  - Dynamic Point Blanking
- Joint transmission requires frame alignment of ~0.5us at the UE *(i.e. phone or user device)*
  - Translates to around 250ns at the radio unit



Over-the-air synchronisation

Calnex

- Radio Interface Based Synchronisation *(RIBS, 3GPP 36.898)*
  - "Listen" to the signal from a neighbouring cell, and align transmission
  - Signal propagation delay estimation – looks a lot like PTP over the air!
  - Methods still under study, not finalised yet



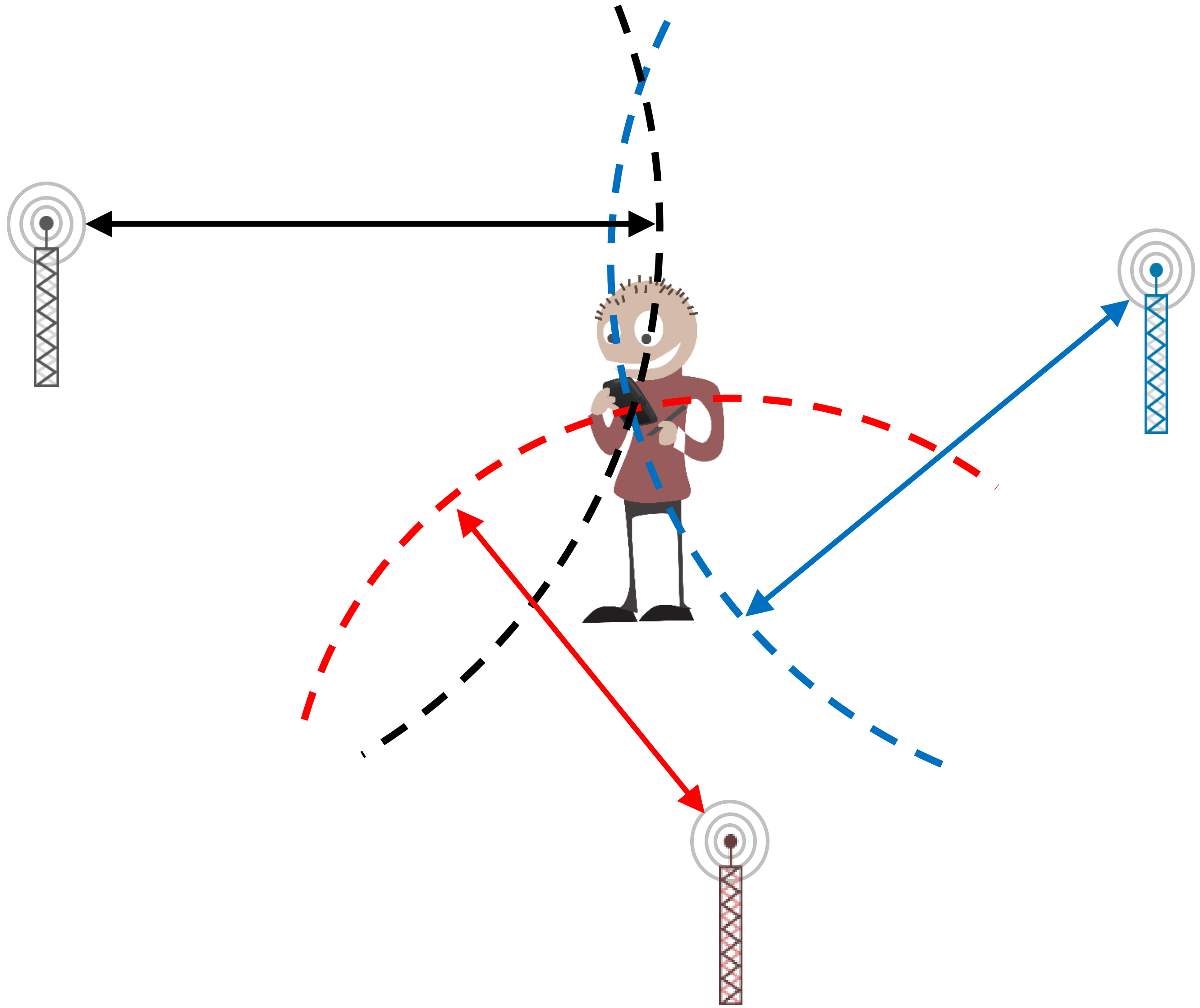
Indoor Positioning

Indoor Positioning

Calnex

- For outdoor positioning there is GPS
  - Precision GPS vendors claim centimetre level accuracy
  - Applications include:
    - Precision Agriculture – GPS controlled ploughs, harvesters etc.
    - Stock control – container location in a shipyard
    - Autonomous vehicles
- But what about indoors?
  - Warehousing – where is my stock?
  - Autonomous vehicles in underground parking lots
  - Sensor networks – where is the sensor?
  - Emergency location – in a large building, it may take a long time to find someone needing emergency assistance
- Competing technological solutions
  - WiFi, Bluetooth, 5G all looking at satisfying indoor positioning needs

Observed Time Difference of Arrival



Positioning Requirements

Calnex

- E911: within 50m horizontal accuracy for 80% of emergency calls
  - Requires time synchronization to better than 150ns
- Targets for 5G “Higher Accuracy Positioning”: *
  - Accuracy level of <1m in 95% of the service area
  - Network-based positioning in 3D space to between 10m and <1m in 80% of situations
  - If implemented using OTDOA, requires time synchronization to better than 3ns
- OTDOA not the only technique for positioning, but any positioning solution requires time to some degree

* 3GPP TR 22.862: Feasibility Study – Enablers for Critical Communications

Industrial Automation

Cyber-physical systems

- Main requirement: deterministic latency
  - Low latency is nice, but deterministic latency is key
- Internet was created to be “as dumb as possible”
  - Intelligent end-points, dumb network
  - Little or no state to be held in network, just route as fast as possible
  - Network performance is variable, “best effort”
- Time-aware systems
  - Intelligent networks, accurate time everywhere
  - Use time for scheduling and routing decisions
  - Accurate time is integral to the performance of the intelligent network
  - Network performance is deterministic

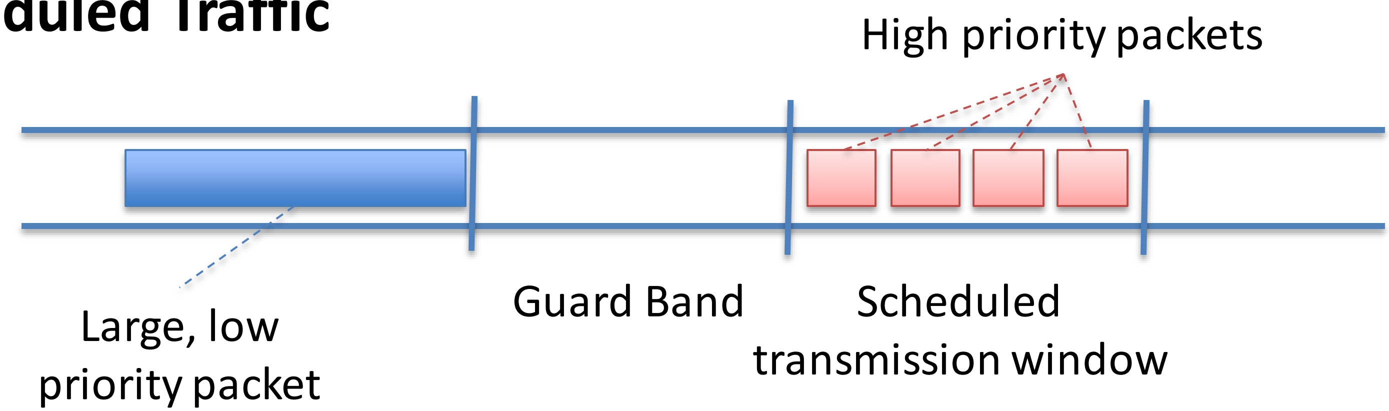
Deterministic networking

Calnex

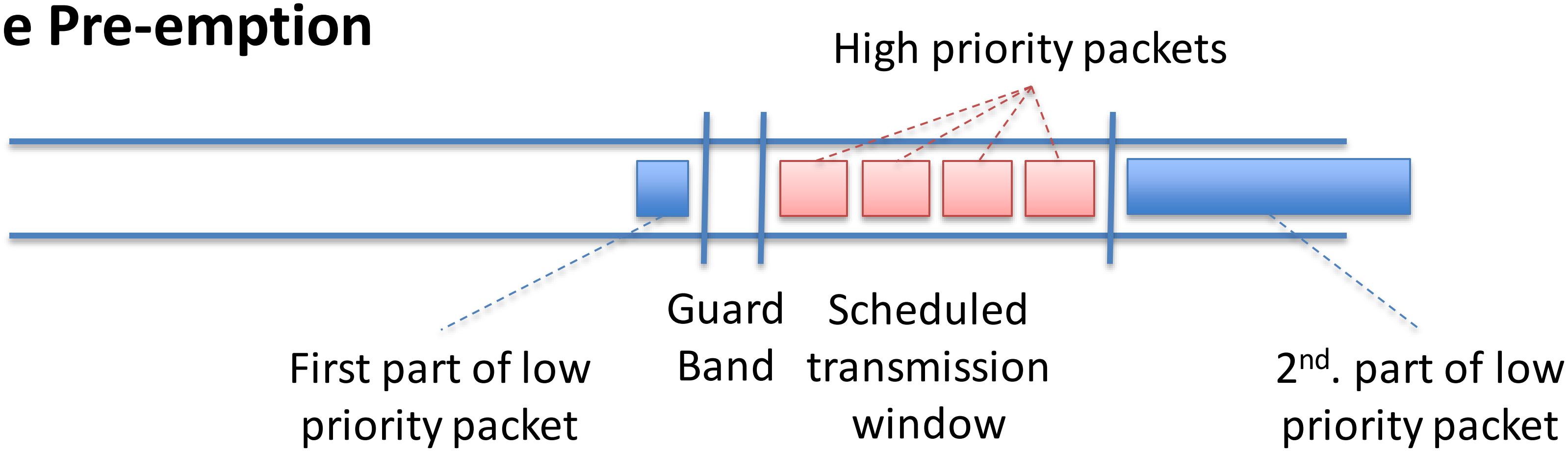
- Scheduled low-latency windows
  - “Railway signalling model”: clear the tracks for the high-speed train
- Frame pre-emption
  - Allow large, lower-priority packets to be divided in two
  - Reduces the guard-band required to ensure the low-latency window isn’t impeded
- Cut-through switching
  - Start switching and forwarding packets before they have been completely received
  - Reduces latency associated with “store-and-forward” of large frames

Frame Pre-Emption with Scheduled Traffic

Scheduled Traffic



Frame Pre-emption



Internet of Everything

Information overload

Calnex

- Information is important, timely information is key
  - Much information loses its importance with time
  - Sensors, warnings, alarms – timing of data is imperative, to allow intelligent decision making
  - Every piece of information must be timestamped to some level of accuracy
- Example: autonomous vehicles
  - Knowing another vehicle was on a head-on collision course a few seconds ago (or a few milliseconds ago) is too late
  - Knowing it is on a head-on collision course NOW is important
  - Of course, in a computer system, NOW is never “now”, it is only “recently”
  - Each application will have it’s own tolerance for how recently “NOW” can be

Conclusion

Calnex

- Time is the enabling item behind a large number of different applications
- Solomon put it this way:
    - “There is a time for everything, and a season for every activity under the heavens. A time to be born, a time to die…”
- It’s not yet time for the sync community to die

Calnex

INTEGRITY

PTP TIME MEASUREMENTS REQUIRE TRUE PRECISION

Tim Frost,
Strategic Technology Manager
tim.frost@calnexsol.com

www.calnexsol.com
+44 (0) 1506-671-416