Power Matters

The Next Generation HetNet & The Transfer of Time

WSTS 2015

Consensus “Vision” For 5G

Features/Buzz words	Requirements

Features/Buzz words

- Reliable
- High speed
- Ubiquitous
- Ultra-dense
- IoT
- M2M
- Vehicle to anything
- Security
- Safety critical

Requirements

- Auto-integration,
- Self-management,
- Easy install
- Stringent latency
- Low delay
- Reduced overhead,
- Reduced energy
- Tight synchronization
- Control of time/phase

- Everything in the world you can possibly imagine

5G : Some Problems & Solutions

- Problems:
  - Multi-faceted wireless access with many different spectrum both licensed and unlicensed (LTE-A /LTE-U/LTE-AA, 802.ax, mmW, etc)
  - Massive Small Cell Densification & massive MIMO
  - Many UE, different SIR, dynamically changing power =
    - unpredictable noise between adjacent cells
    - non-homogeneous interference on different frequency sub bands.
- Solutions:
  - Different levels of inter-cell coordination/cooperation to
    - enhance capacity,
    - keep interference low,
    - manage mobility/spectrum & eNB/AP response to non-uniform traffic distribution
- Mechanisms will be needed to
  - efficiently allocate resources,
  - collect contextual information / metrics
  - manage clustering techniques for the plethora of diverse small cells.
- Synchronisation will be needed for
  - Reduce interference
  - higher spectral efficiency
  - coordinated multipoint
  - minimise delays
    - distribution

Definition of Holdover
(Synchronization in Telecommunications)

- *An operating condition of a clock which has lost its controlling input and is using stored data, acquired while in locked operation, to control its output. The stored data are used to control phase and frequency variations allowing the locked condition to be reproduced within specifications.*

- *Holdover begins when the clock output no longer reflects the influence of a connected external reference, or transition from it. Holdover terminates when the output of the clock reverts to locked mode condition.* (ETSI)

- Holdover can be considered as a measure of ongoing accuracy, or a statement of the error acquired by a clock when there is no controlling external reference to correct for any errors.

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Holdover

- Clocks that are not locked to each other will drift apart.
- To show the same time, clocks have to be synchronized
- “Synchronization” has to be performed regularly to bring clocks back in line with each other
- “Holdover” is the period between synchronization events
- Clock accuracy under holdover, and the period of effective holdover, rely on factors such as:
  - Specific Timing requirements of the application (clock accuracy)
  - Quality and Performance of the holdover oscillator
    - higher quality oscillators provide longer holdover
  - Degree and speed of Temperature changes affecting the oscillator
  - The algorithms used to manage the oscillator
  - PLL design

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Phase Alignment and Holdover

- Inter cell phase alignment requirement
  - Cells do not have a hard step function edge, there is fuzzy intersect with zones of overlap that move dynamically according to cell output, interference, walls, reflection, UE movement, etc
  - The requirement is that the eNB should have an inter cell alignment within a 3usec window around a non-absolute mean
  - If a PRTC for example loses lock to GPS and immediately signals it is past 100nsec and allows the attached eNB to unlock, they will rapidly scatter randomly in time/phase – the differential drift between any adjacent eNB is unpredictable in direction and speed
  - If the PRTC maintains a “GM” viable flag to the eNB – even if this is not within the PRTC spec, then the cluster of cells will move together - they will stay in sync and provide service
  - The GM will slew back into line with the PRTC when the GPS returns and similarly slew the eNB back to the new mean.

Typical Sequence & Resolution

Scenario 1

- Loss of GNSS
- GM Signals eNB that clock class is no longer PRTC
- slave clock enters holdover
- Typically Small Cell / AP will not be able to holdover for more a few hours - at edge of maintenance window for many locations
- Each eNB will begin to drift away from mean values at different rates and in different directions either side of mean

Scenario 2

- Loss of GNSS
- GM continues to signal PRTC value
- Slaves follow GM as if PRTC is available
- GM will drift but entire cluster of SC will dfit in same direction at same speed
- If GNSS does not return within TBD time then scenario 1 holds

Time transfer and holding time

- Smart GNSS developments that enable better, more coherent, and deeper penetration of signals into buildings
- Legacy PTP and ng PTP
- Mini high performance OX (eclectic mix driven by different requirements for temperature, duration, telecom level holdover etc)
- New analog and digital mixed signal techniques for spatial reuse and interference management
- Lidar application to telecom signaling based on sensors and 4d resolution
- Other things we don't know yet
- Synthetic RF spectrum pairing and use of NLOS with mmw and massive MiMO and beam-forming to stay within current time transfer boundaries

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Conclusion

- In a massively dense eNB environment TDD is going to be used to increase efficiency and improve interference control and spectrum management
- For phase/time sync Holdover should be an elastic concept and not an absolute. The potential for operation within the maximum values of the Time Error budget and the fuzziness of the +/-1.5usec boundary in real world operation can be combined to deliver a holdover value that is also elastic
- This will be combined with massive spatial reuse and smart RF and laser technologies to allow time transfer granularity at tens of nanoseconds