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Network Time Distribution for Small Cells

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WSTS, April 16, 2013

Agenda

- Small Cell Synchronization Requirements
- Small Cell Deployments
- Time and Frequency Distribution
- Moving Time to the Edge
- Conclusions

Do not squander time!

Small Cell Synchronization Requirements

Small Cell Synchronization Requirements

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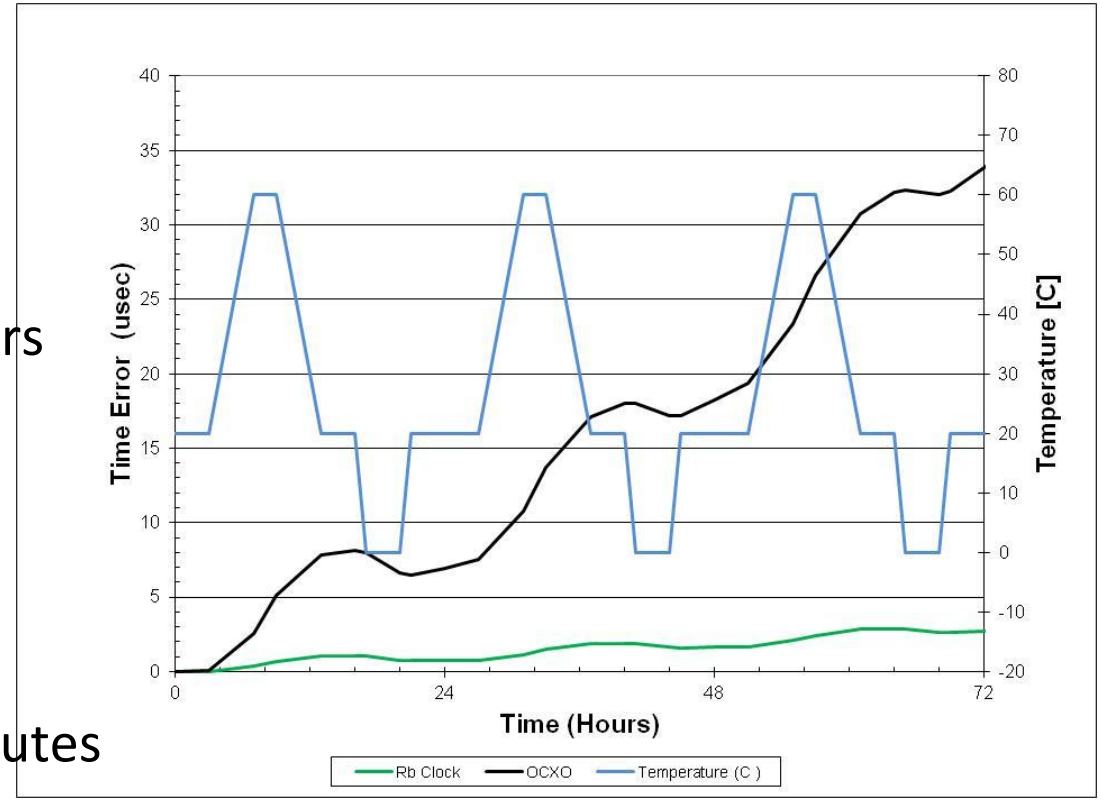
Application	Frequency: Network / Air Interface	Time / Phase
FDD Local Area Cell	100ppb	Not required
FDD Home Cell	250ppb	Not required
TDD Local Area Cell	100ppb	± 3 µs phase alignment
TDD Home Cell (< 500m)	250ppb	± 3 µs phase alignment
LTE – CSFB to CDMA2000		± 10 µs time alignment
LTE-A MBSFN		
LTE-A Hetnet Coordination (eICIC)		± 1 – 5 µs phase alignment*
LTE-A CoMP (Network MIMO)		

** Vendor specific figures, no 3GPP specification*

How long can you hold a microsecond?

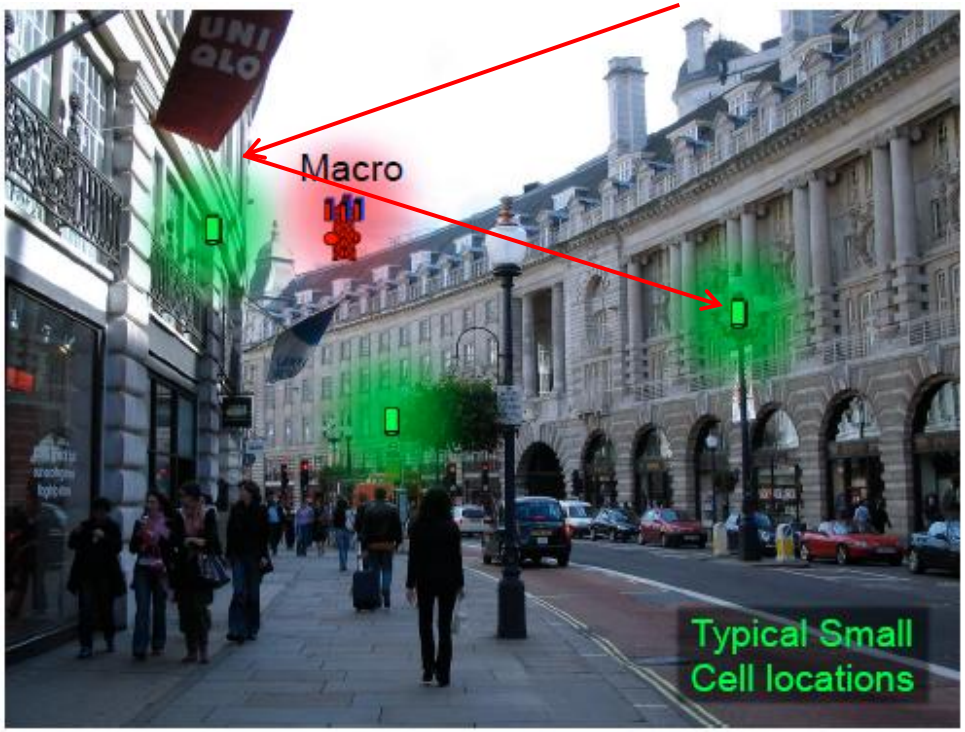
- PRS (Primary Reference Source):
  - Frequency error ≤ 1 x 10^{-11} (G.811 specification)
  - Phase drift up to 1µs in 100,000s (~28 hours)
- Rubidium clock
  - Phase drift under temperature cycling: ~1.5µs in 24 hours
  - Holds 1µs for a few hours
- Good quality OCXO
  - Phase drift under temperature cycling: ~8µs in 24 hours
  - Holds 1µs for a few minutes



Small Cell Deployments

Street deployment

- Urban canyons
  - Poor GNSS environment, multipath reflections and restricted sky view
- Difficult backhaul
  - Typically NLOS or LOS microwave, not ideal for packet timing



Pictures from Telefonica wi-fi small cell trial, London, summer 2012

Indoor deployment

Rail stations

Stadiums

Shopping malls

Airports

Time and Frequency Distribution

Satellite Time Distribution (GPS)

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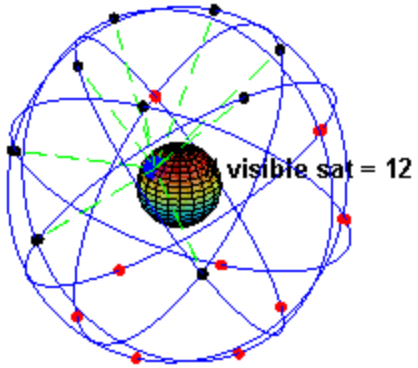
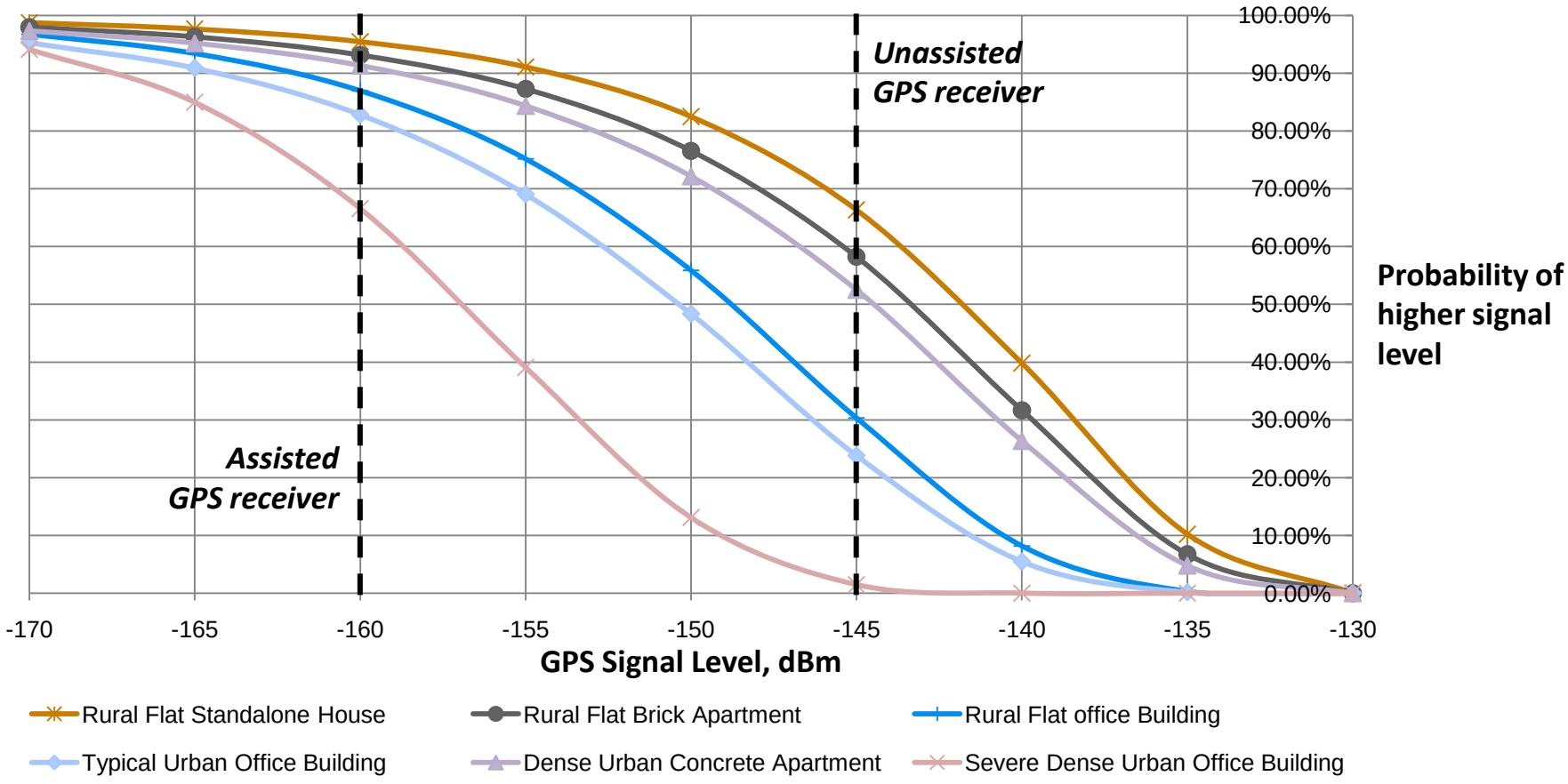
- Time distributed by radio from satellite
- Typical accuracy: < 100ns
- Advantages:
  - Global availability
    (provided there is a clear view of the sky)
  - Accuracy
  - System reliability
- Disadvantages:
  - Clear view of sky may not be available
  - Vulnerability to interference from ground based transmissions
  - Antenna issues – wind, rain, snow, ice, corrosion, bullets!
  - Political issues



In-Building Reception

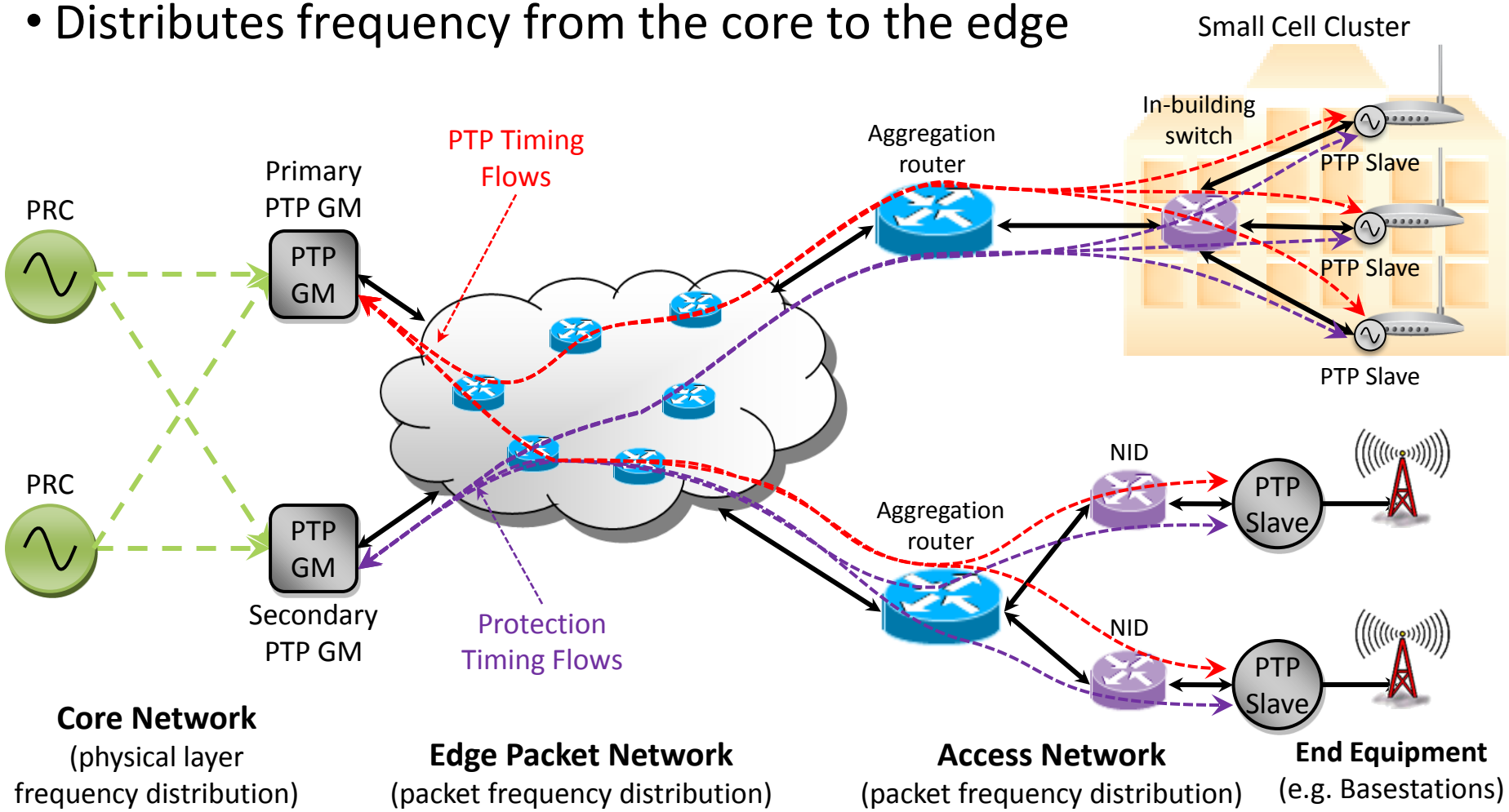
- Signal strength at earth surface around -130dBm
- Buildings may attenuate this by over 40dB



Graph adapted from Small Cell Forum white paper "Femtocell Synchronization and Location", May 2012

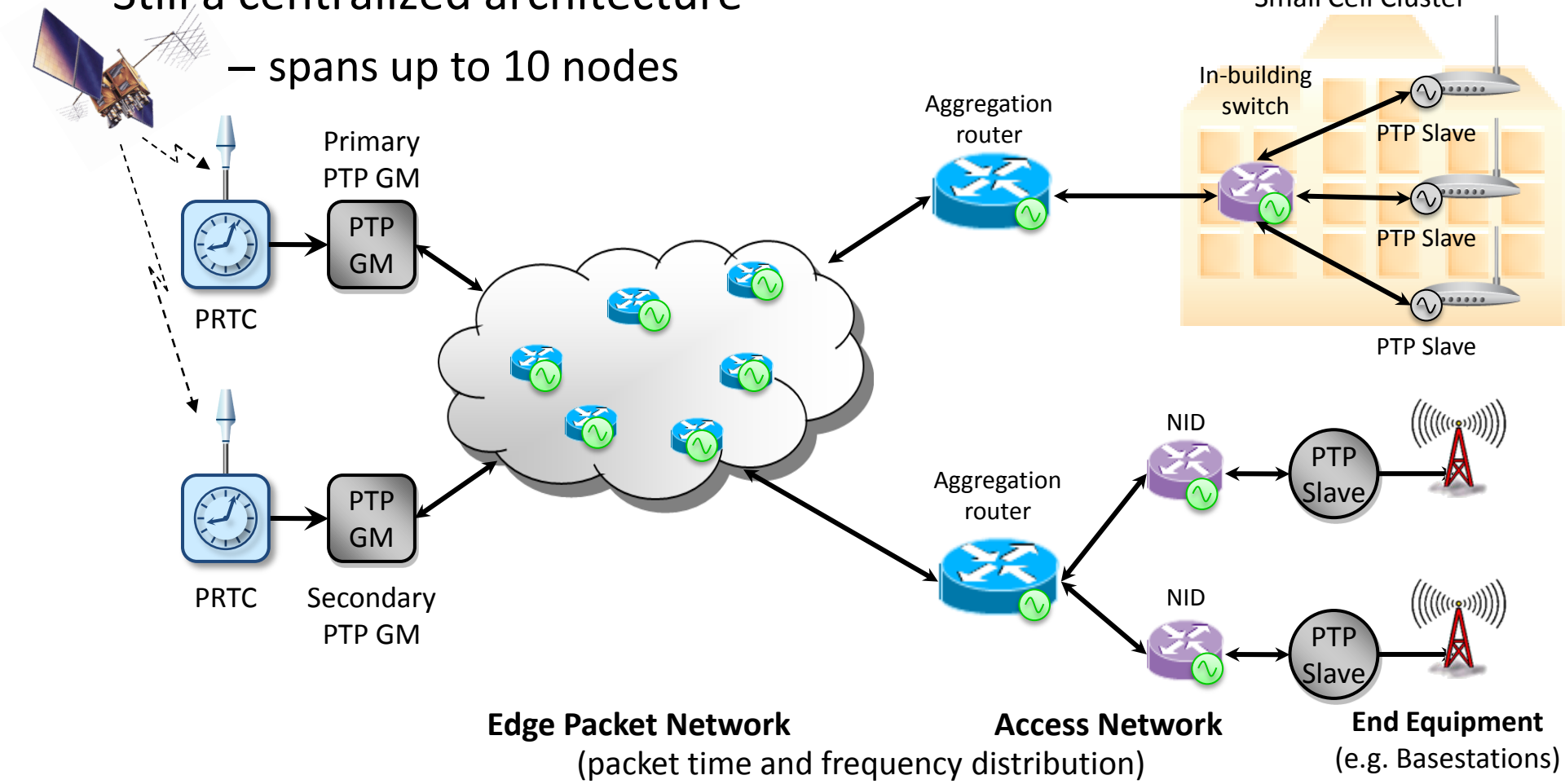
Network Frequency Distribution: G.8265.1

- Centralized architecture
- Distributes frequency from the core to the edge



Network Time Distribution: G.8275.1

- Boundary clock at each node
- Still a centralized architecture
  - spans up to 10 nodes



Main Issue: Path Delay Asymmetry

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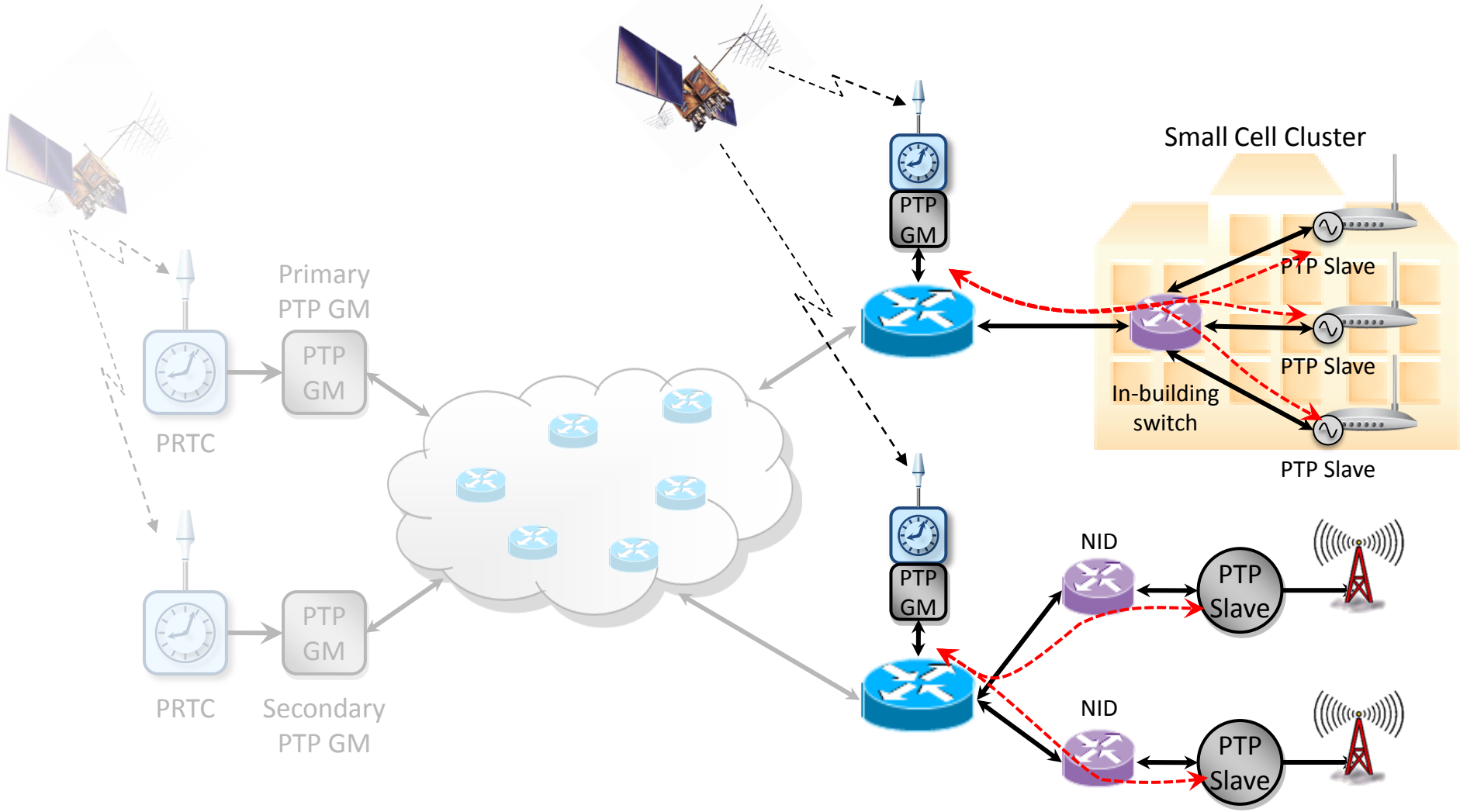
- Delay asymmetry is the difference between forward path delay and reverse path delay
  - Causes a time offset of half the delay difference
- Budget for time offset:
  - 50ns for each boundary clock (550ns total, including final slave)
  - 250ns for link asymmetry (total of all links)
  - PTP can't estimate this: must be measured
- Measurements on real fibers:
  - Delay difference between fibers in same core varied by up to 200ns per link
  - Caused by length differences in fibers, plus cuts/resplices
- Conclusions
  - Each individual link must be measured and compensated
  - 250ns link asymmetry budget for network is for error in compensation, not the budget for the asymmetry itself

Moving Time to the Edge

Distribute PRTC to the edge



Edge Packet Network
(packet time and frequency distribution)

Access Network

End Equipment
(e.g. Basestations)

Distribute PRTC to the edge

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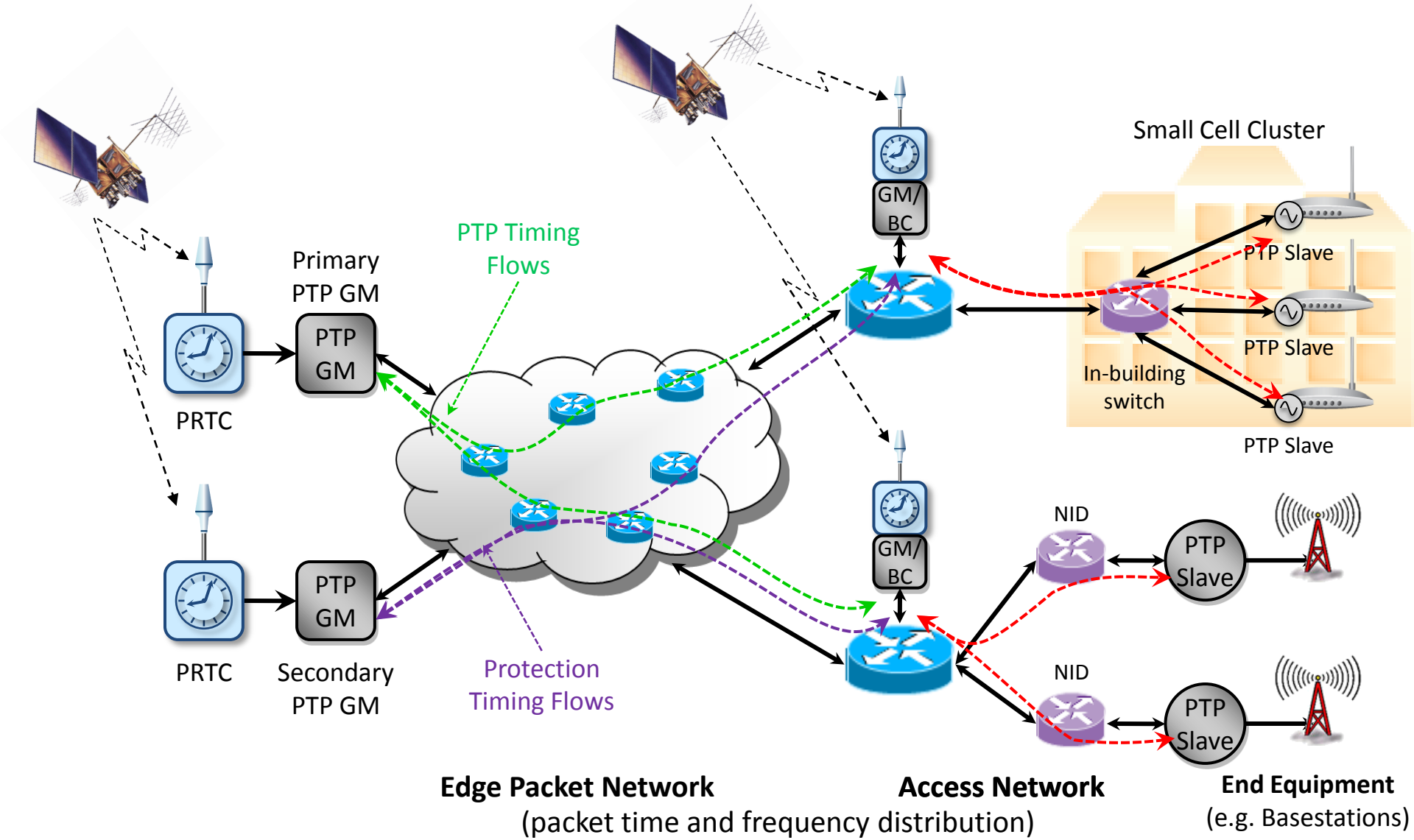
- Close enough that link asymmetry is not an issue
  - Within a few miles, not hundreds of miles
  - Closest aggregation point that is physically accessible for GPS
  - Set budget to accommodate this smaller value
- In indoor deployments:
  - Use a single antenna on the roof, and distribute time over LAN
  - Alternatively, deploy at aggregation point for multiple small cell clusters
- In outdoor deployments:
  - Place a PRTC at strategic aggregation point for microwave
- Moving PRTC close helps to reduce dynamic time error (noise), as well as constant time error (offset)

Distributed PRTCs with PTP backup



Hybrid PTP/GPS Solution

- Advantages
  - Initial PTP time fix allows faster acquisition of GPS signal
  - Accurate GPS time allows calibration of overall PTP asymmetry
  - PTP provides backup in event of GNSS failure

- Disadvantages
  - Requires installation of multiple infrastructures

Conclusions

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- Asymmetry of network elements and links is the biggest contributor to time error
- Not solved by putting boundary clocks at each node
- Either:
  - Manually measure each link and compensate for it
  - Minimise, by placing PRTC as close to the application as physically possible
  - Automatically calibrate the path, using GPS reference
- Hybrid techniques address the deficiencies of both PTP and GPS
  - Creates an accurate, robust solution for precise time distribution

Thank You

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