Synchronizing Small Cells

Calnex

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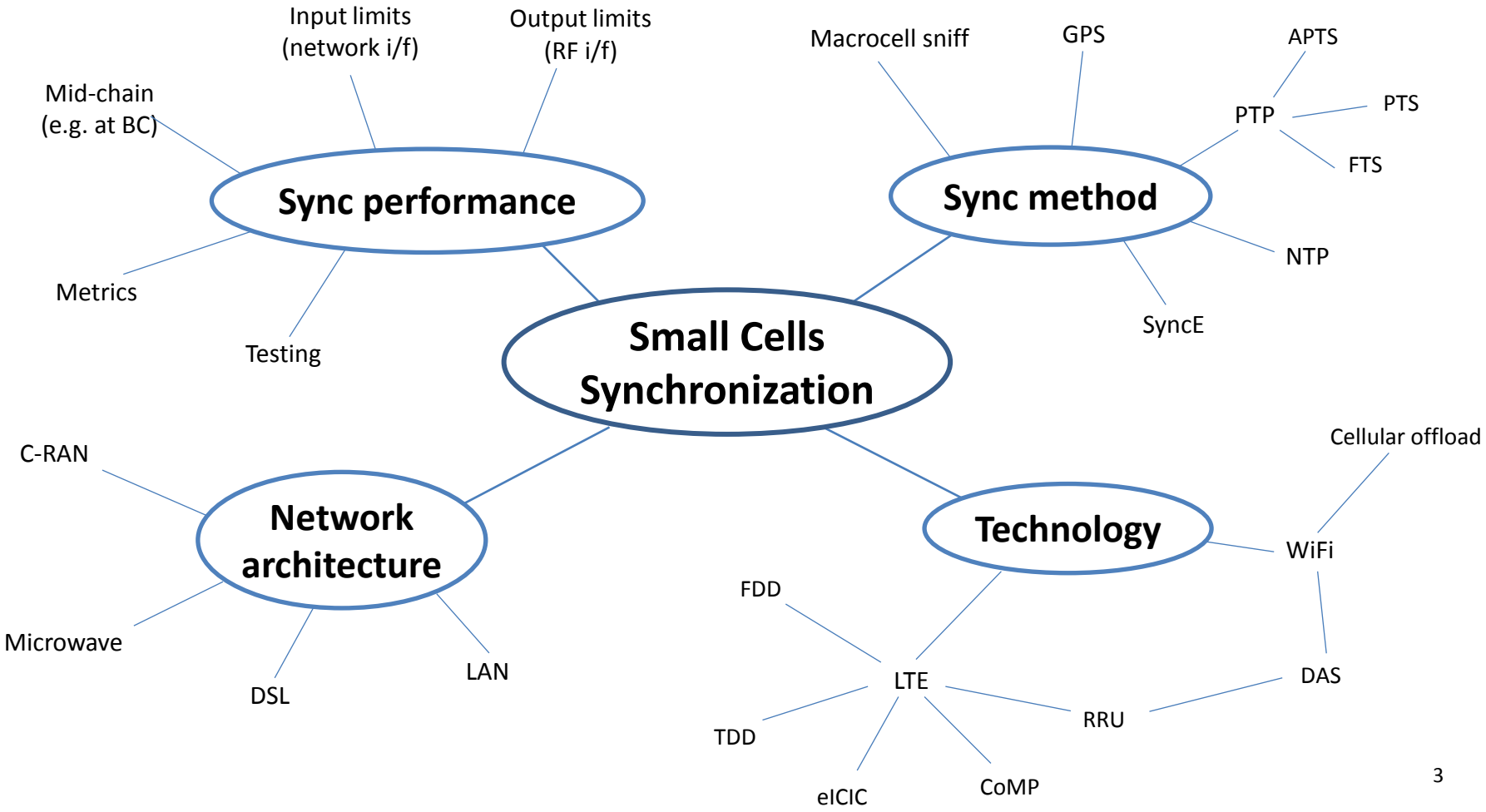
Presentation overview

- Small Cell Sync Requirements
- Deployment Types
- Measuring Small Cell Synchronization

Where do you start?

Diverse landscape, multiple architectures, multiple technologies



Small Cell Sync Requirements

“Air Interface” Sync Requirements

Frequency requirements:

- Carrier small cell: 100ppb
- Residential small cell: 250ppb

Time requirements:

- LTE FDD with no co-ordination: no requirement
- LTE TDD with no overlapping coverage: no requirement
- LTE TDD with overlapping coverage: ± 1.5µs
- LTE FDD or TDD with eICIC or CoMP: ± 0.5 – 5µs *
- E911 OTDOA (Observed Time Difference of Arrival): ± 0.1µs

* Depends on technology and throughput requirements
3GPP have stated it will never ***require*** better than ± 1.5µs

Frequency Sync Delivery Requirement

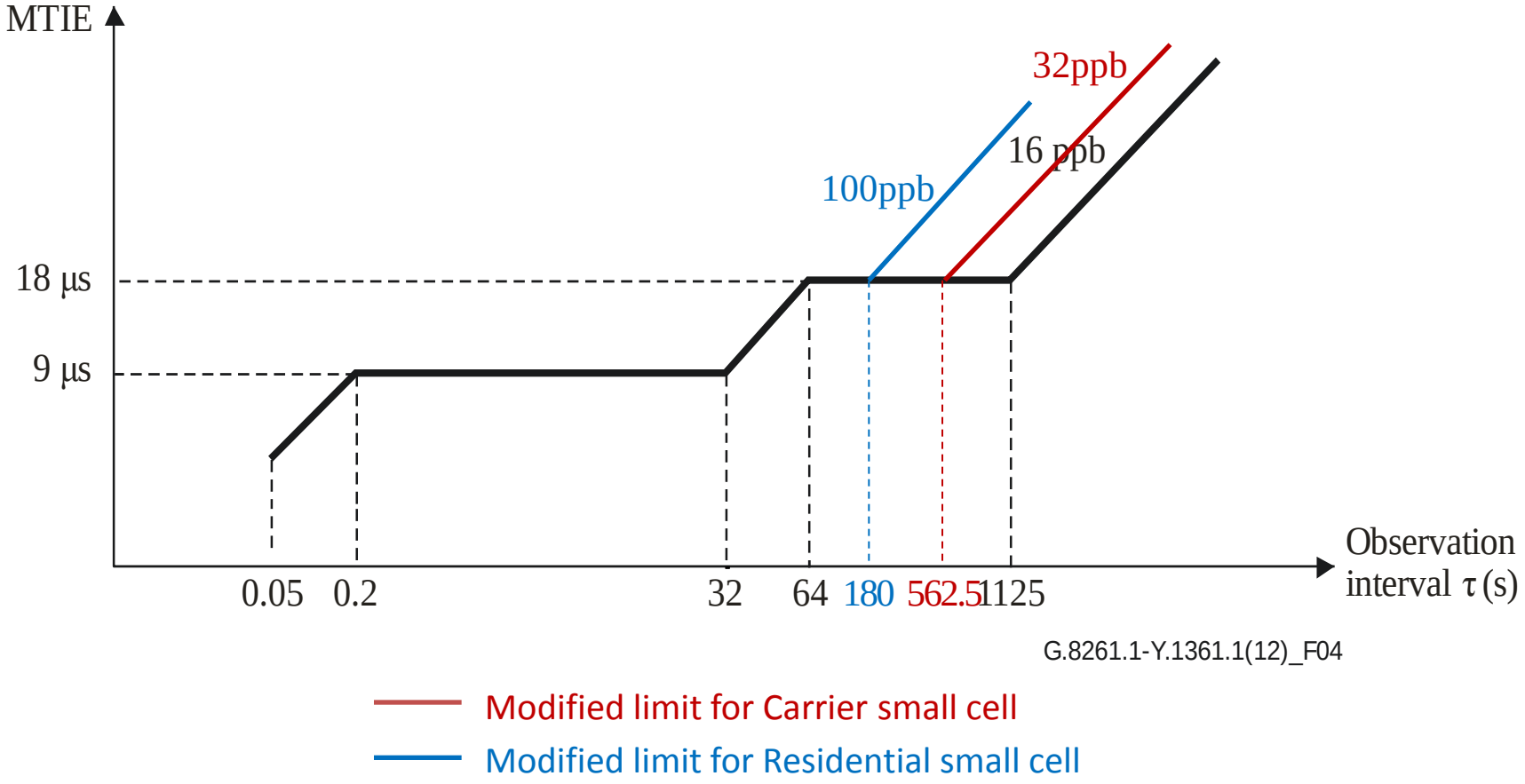


Figure 4/G.8261.1 – Output wander network limit for case 3 based on [ITU-T G.823]

Time Sync Delivery Requirement

Air interface requirements, less:

- 150ns for basestation internal tolerances
- 250ns for short term holdover (e.g. to allow reference switch)

Example for LTE TDD:

- ±1.5μs at the air interface
- ±1.1μs at the network interface

Example for LTE CoMP (tightest tolerance):

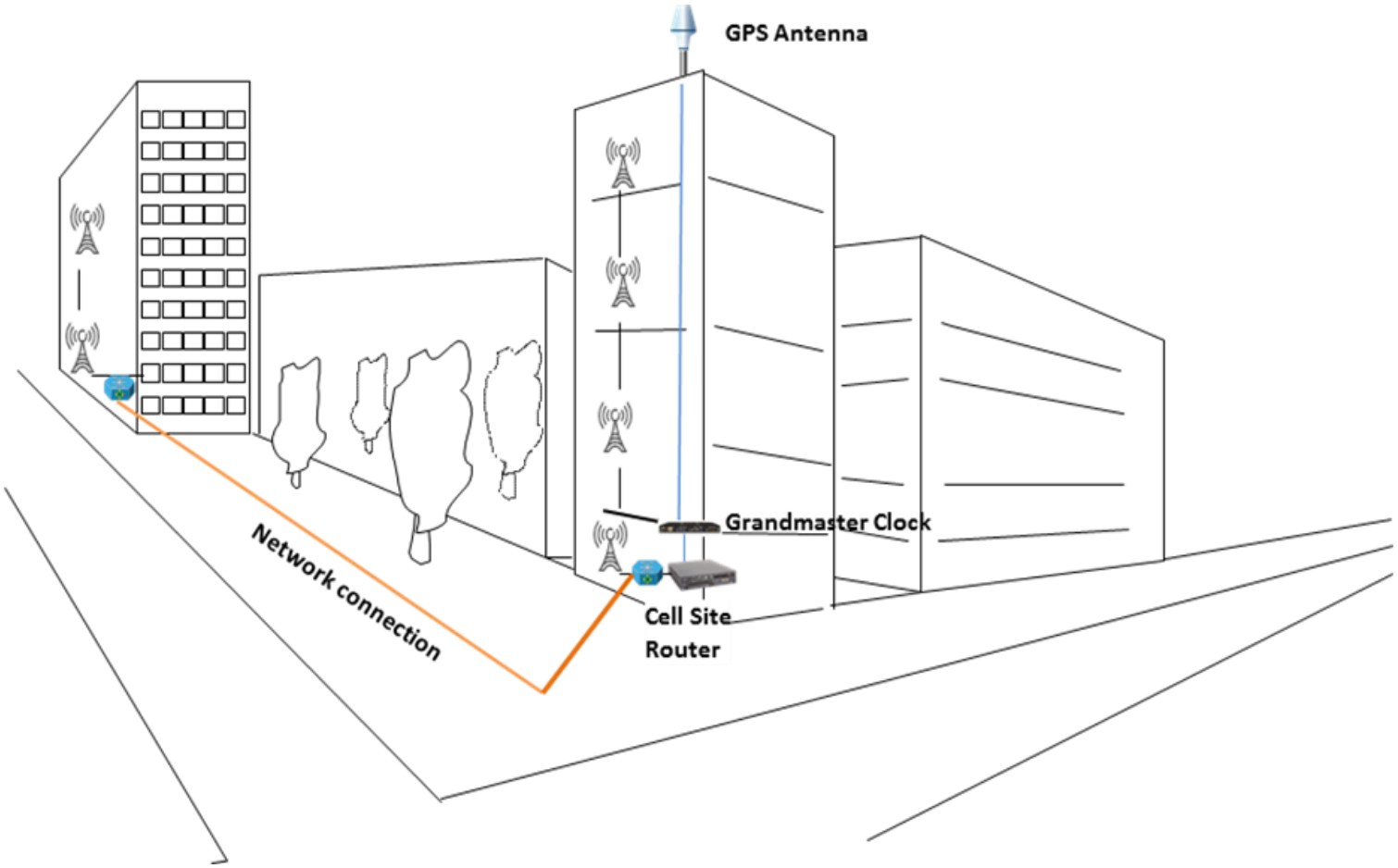
- ±500ns at the air interface
- ±350ns at the network interface (no reference switching)

Coming Soon…

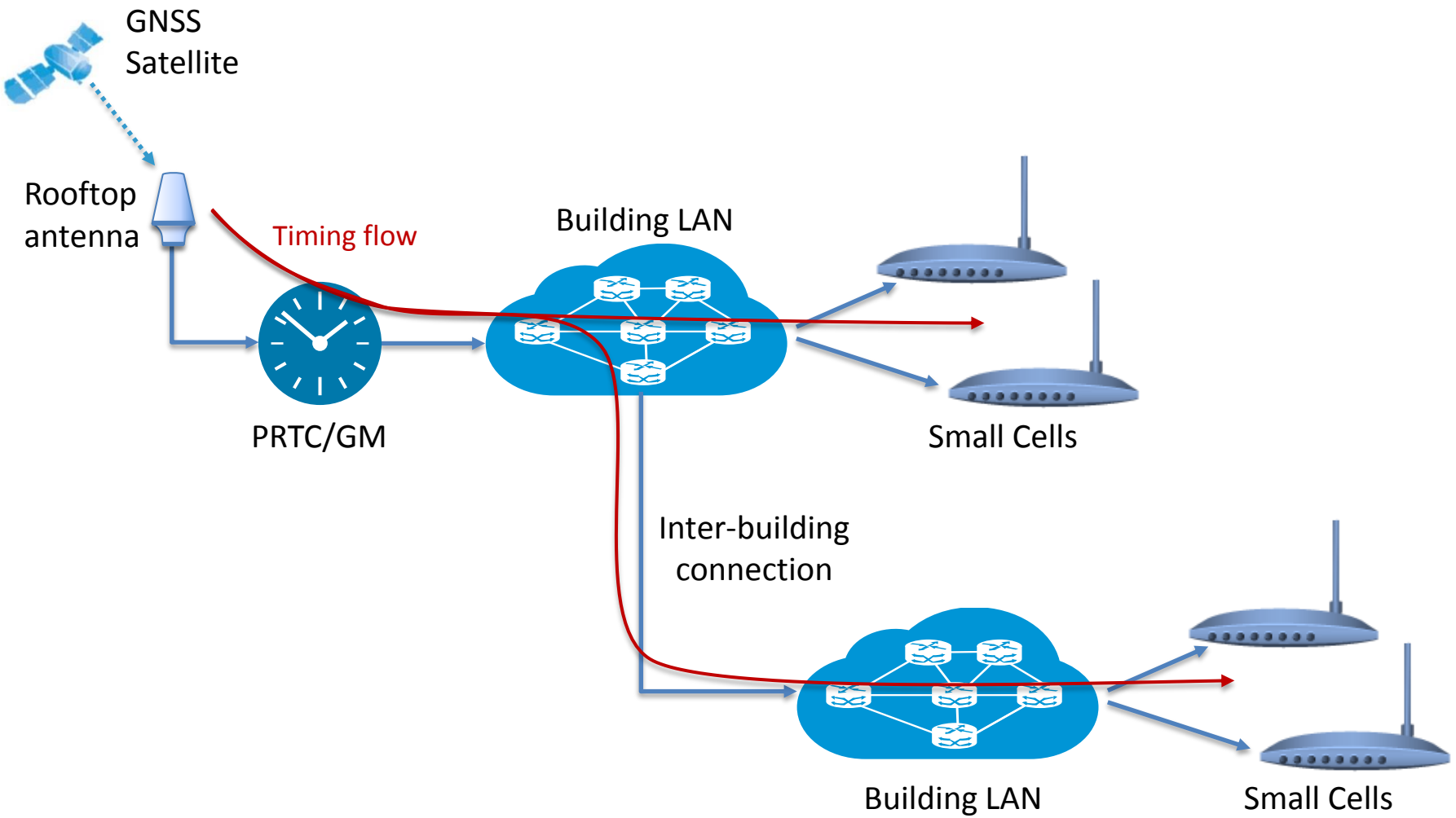
- CRAN Architecture
  - Baseband units co-located, fronthaul network used to distribute baseband signals to remote radio units
  - Common interface standards: CPRI, OBSAI
- NGFI: Next Generation Fronthaul Interface
  - Evolution of fronthaul to use Ethernet with PTP/SyncE time synchronization
  - Required for future “5G” radio requirements
- Frame Time Alignment Requirements between RRUs:
  - Inter-band carrier aggregation: 1325ns frame time alignment
  - Intra-band carrier aggregation: 155ns frame time alignment
  - MIMO and TX Diversity: 65ns frame time alignment

Deployment Types

AT&T In-Building Proposal



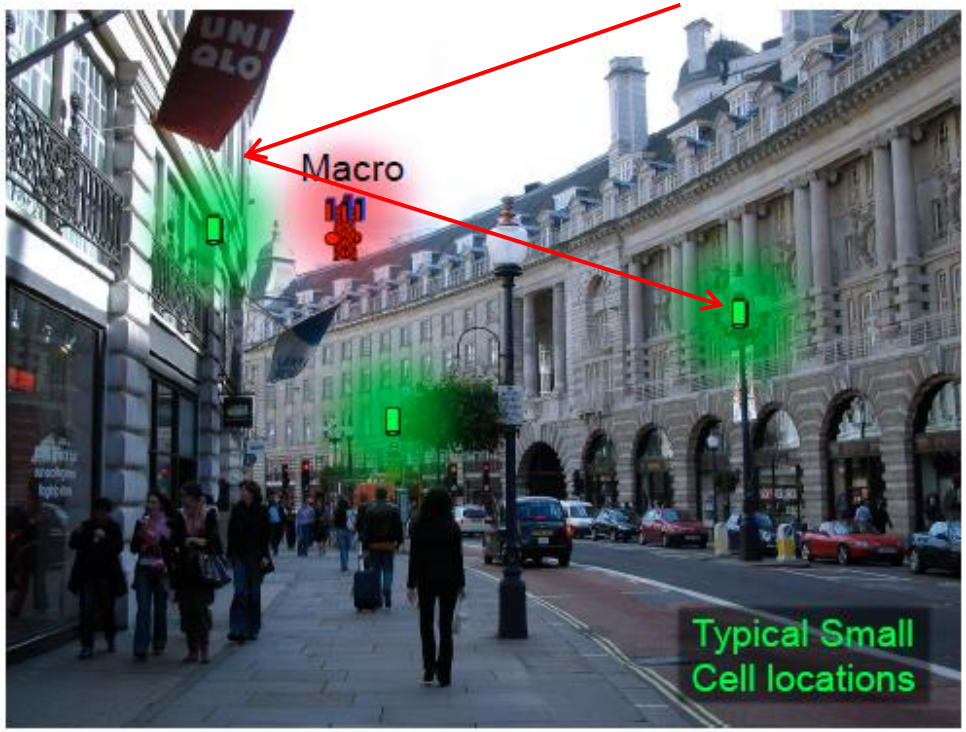
In-Building Network Diagram



Street deployment

Urban canyons, microwave backhaul

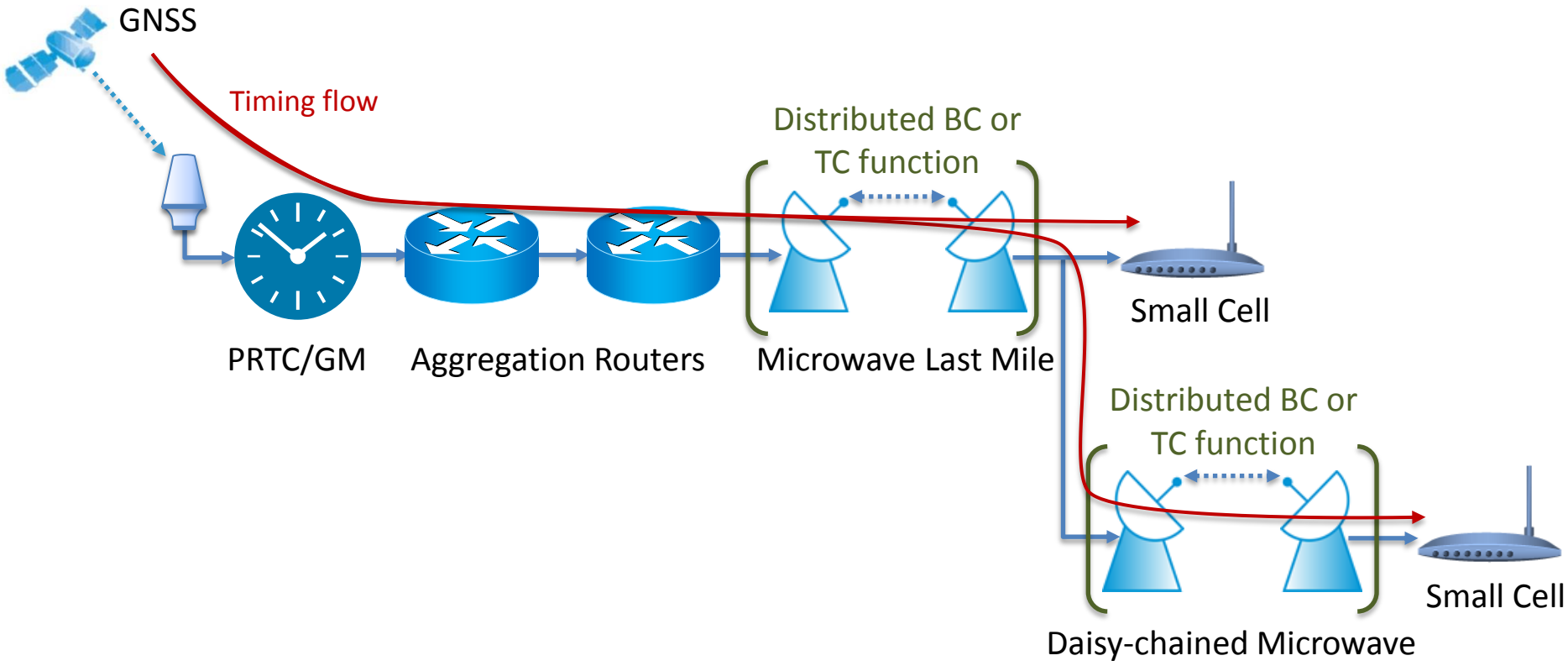
- Poor GNSS environment, multipath reflections and restricted sky view
- Backhaul typically NLOS or LOS microwave



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

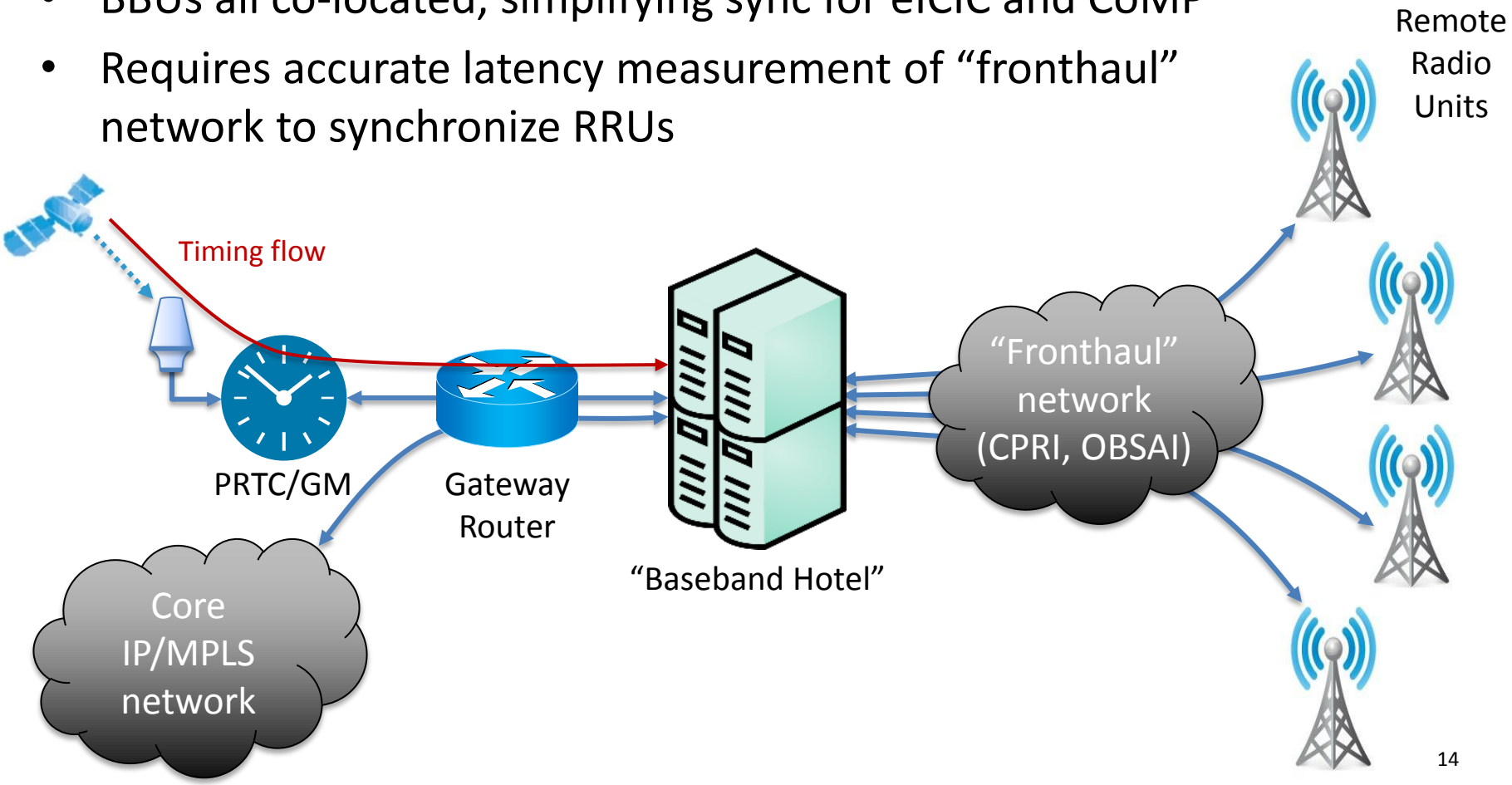
Small Cell Microwave Backhaul

- Microwave equipment often includes PTP support, e.g. BC or TC
- What performance standards must the BC or TC function meet?



C-RAN Architecture

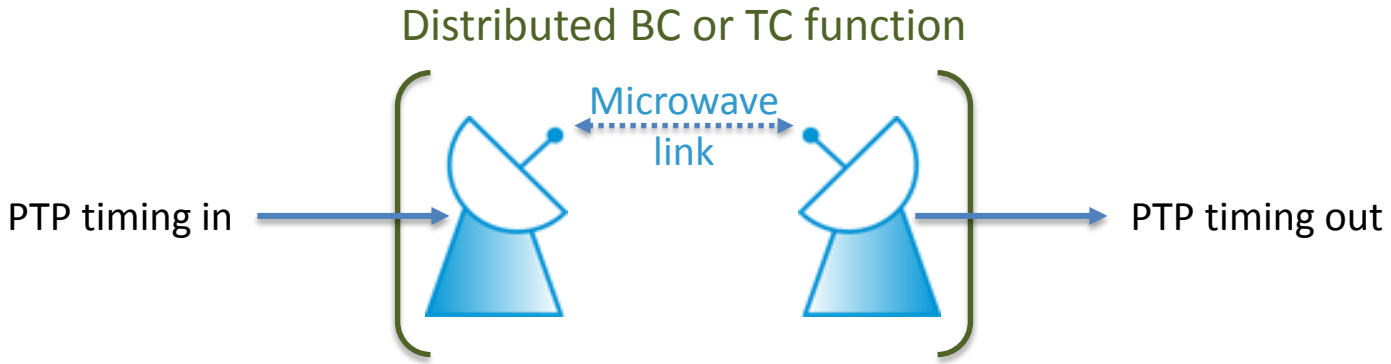
- Centralizes Baseband Units (BBUs) in a “baseband hotel”
- BBUs all co-located, simplifying sync for eICIC and CoMP
- Requires accurate latency measurement of “fronthaul” network to synchronize RRUs



Measuring Small Cell Synchronization

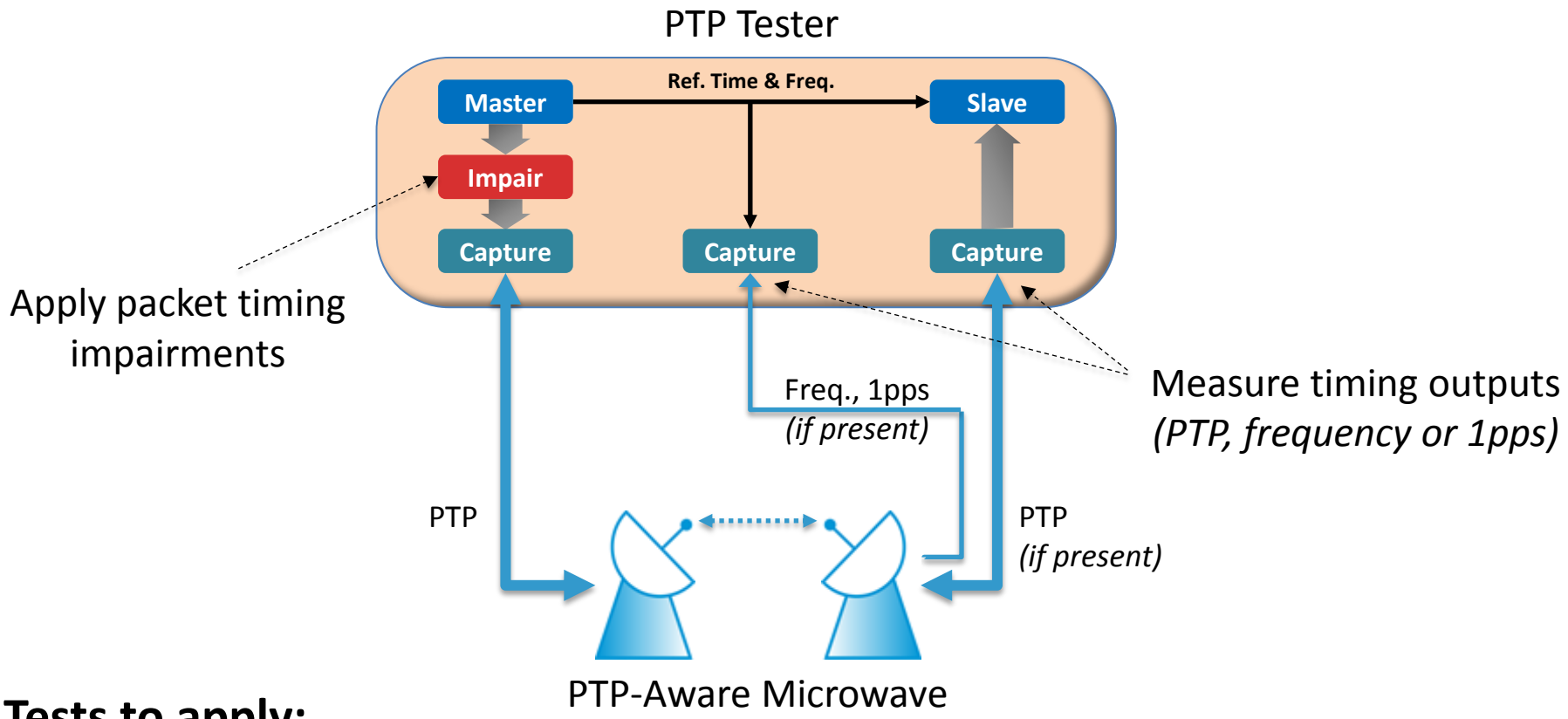
Distributed BC and TC

- What should the performance spec be for a distributed BC/TC function (e.g. microwave unit)?



- Current BC spec (G.8273.2) is for a single network element
- Proposal for a “distributed BC/TC”:
  - Based on sum of two G.8273.2 BCs
  - G.8171.1 HRM can remain unchanged; distributed BC uses two nodes

Microwave Test Configuration



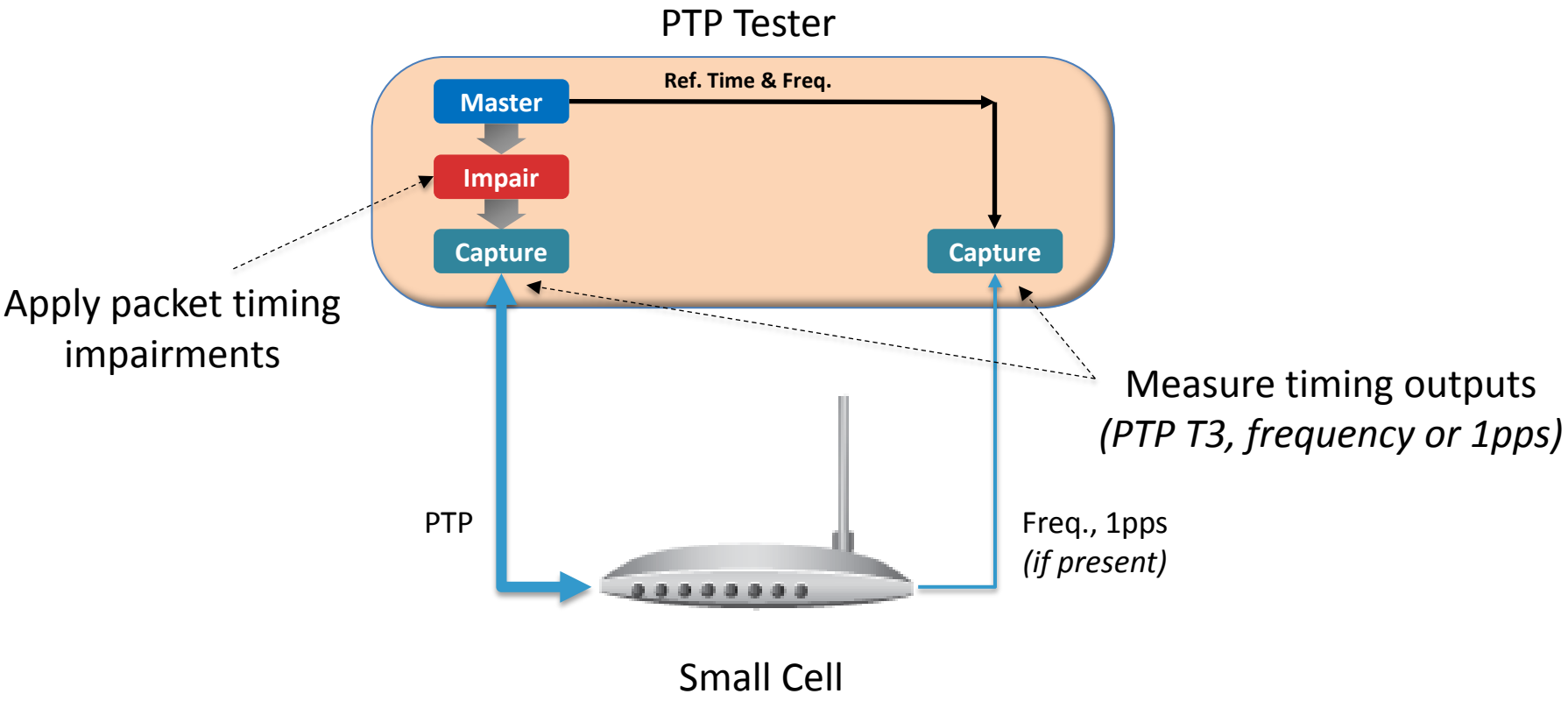
Tests to apply:

- Noise generation (±100ns cTE, 50ns p-p dTE proposed)
- Noise tolerance (from network limit, possibly 1.1µs max|TE|, 500ns p-p dTE)
- Noise transfer (tests filtering capability)

How to measure small cell sync

1. **At the sync interface output**
   - ***BUT*** most small cells don't have extra outputs such as sync interfaces
   - Possibly a test point is accessible in the lab, but not in a field environment
2. **At the network interface**
   - Probe PTP flow at network interface, then the originTimestamp in the Delay_Req message (T3) gives a direct readout of internal clock state
   - ***BUT*** PTP devices are not required to insert an accurate T3 value
     - IEEE1588-2008, Clause 11.3.2: ***"The originTimestamp shall be set to 0 or an estimate no worse than ±1 s of the egress time of the Delay_Req message."***
     - Requires on-the-fly hardware timestamp insertion, which is only mandated for one-step PTP master
3. **At the air interface**
   - Monitor the RF output signal, decode frames for frequency and alignment

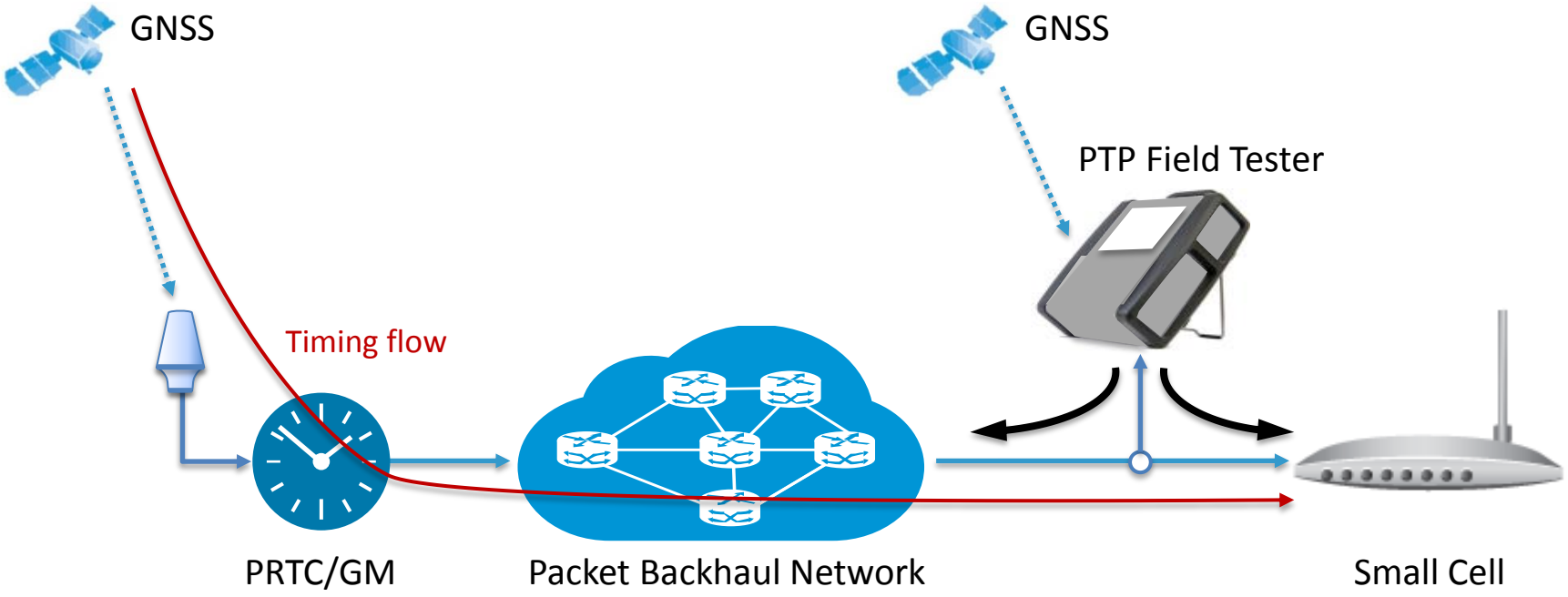
Lab Test Configuration



Tests to apply:

- Noise generation and tolerance for frequency (from G.8263)
- Noise generation and tolerance for time (to be determined)
- Noise transfer (tests filtering capability)

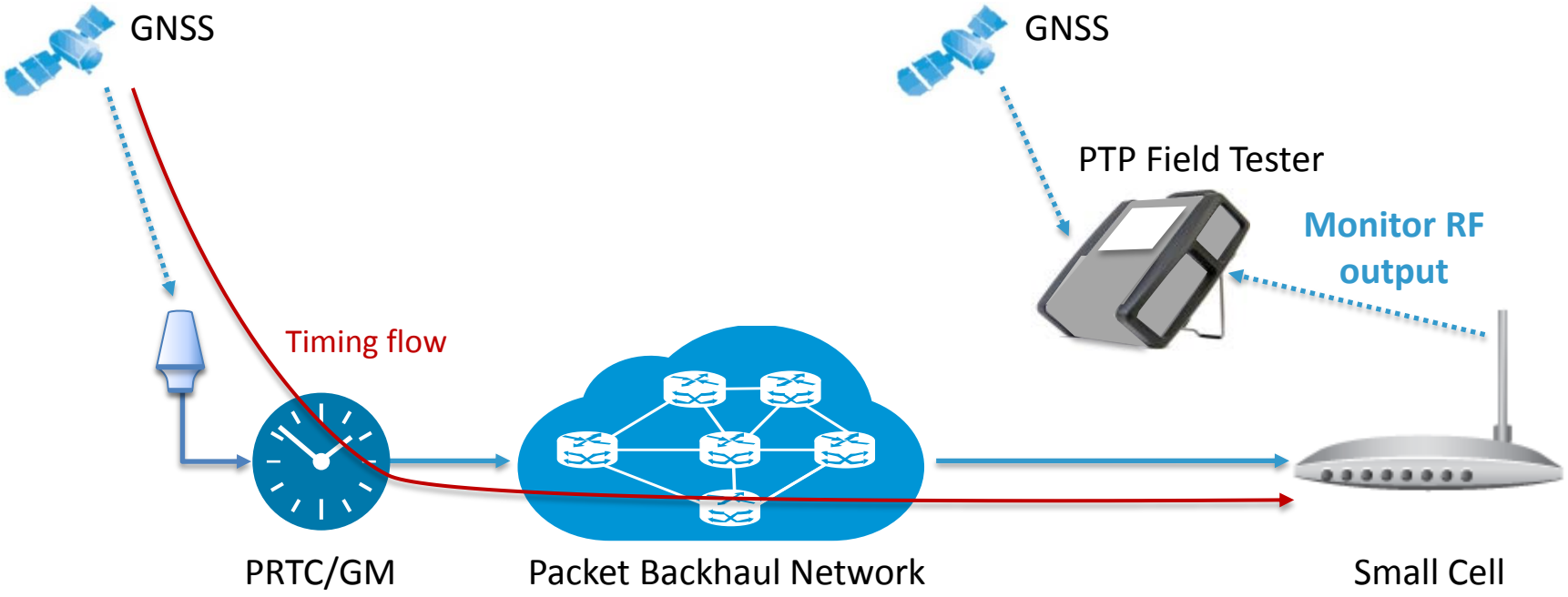
Field Test Configuration



PTP Field Tester monitors:

- Quality of sync coming from PRTC/GM
- Accuracy of small cell sync (if accurate T3 available)

Over-the-air Sync Test Configuration



PTP Field Tester monitors:

- Frequency and time sync of RF output
- Non-invasive method; no disconnection required to insert tap

INTEGRITY

TIME ERROR MEASUREMENTS REQUIRE TRUE PRECISION

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