Synchronization over the air

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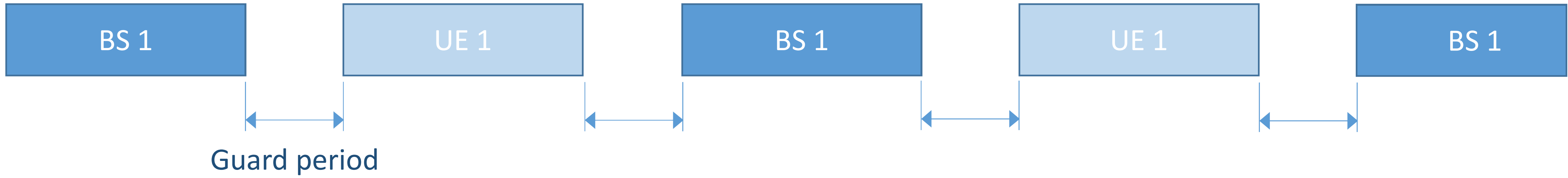
Agenda

- TDD Synchronization Requirement
- Overlapping Coverage Areas
- Synchronization Over The Air
- Measurement Over The Air
- Conclusions

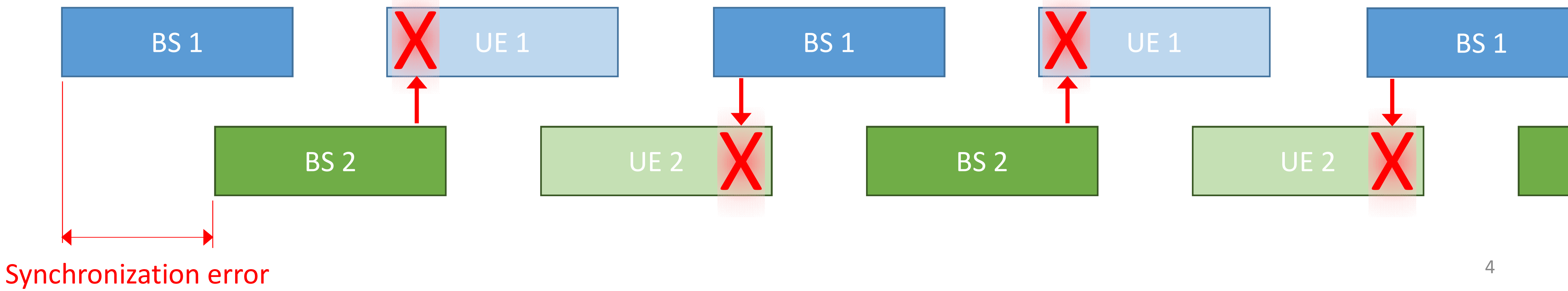
TDD Synchronization and Overlapping Coverage Areas

Why do we need synchronization?

- TDD networks alternate between upstream and downstream transmissions:



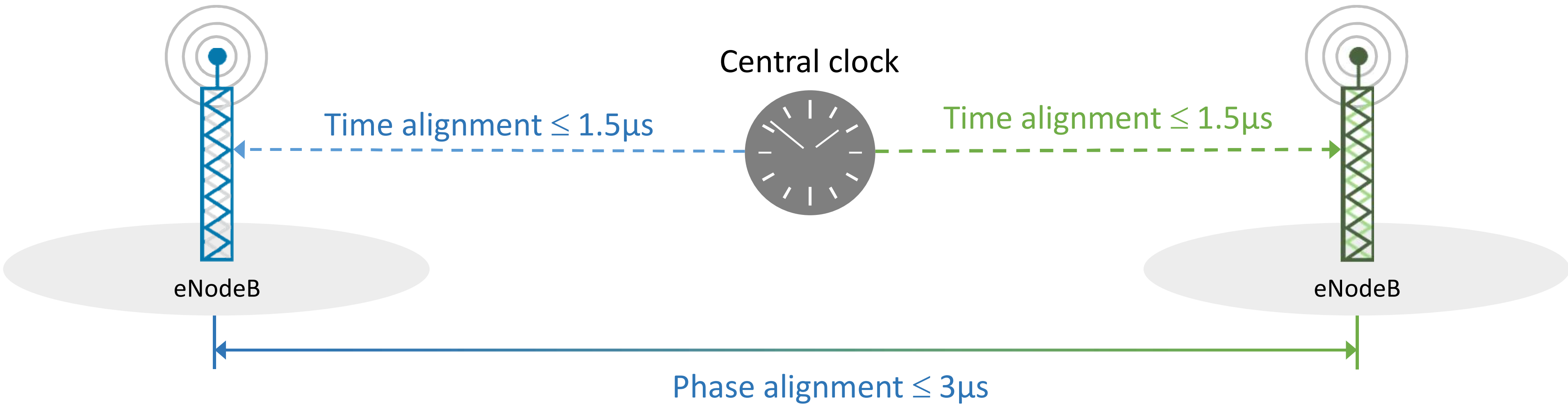
- If synchronization is poor between cells, a neighbouring cell transmission can interfere with UE transmissions:



Synchronization Requirement

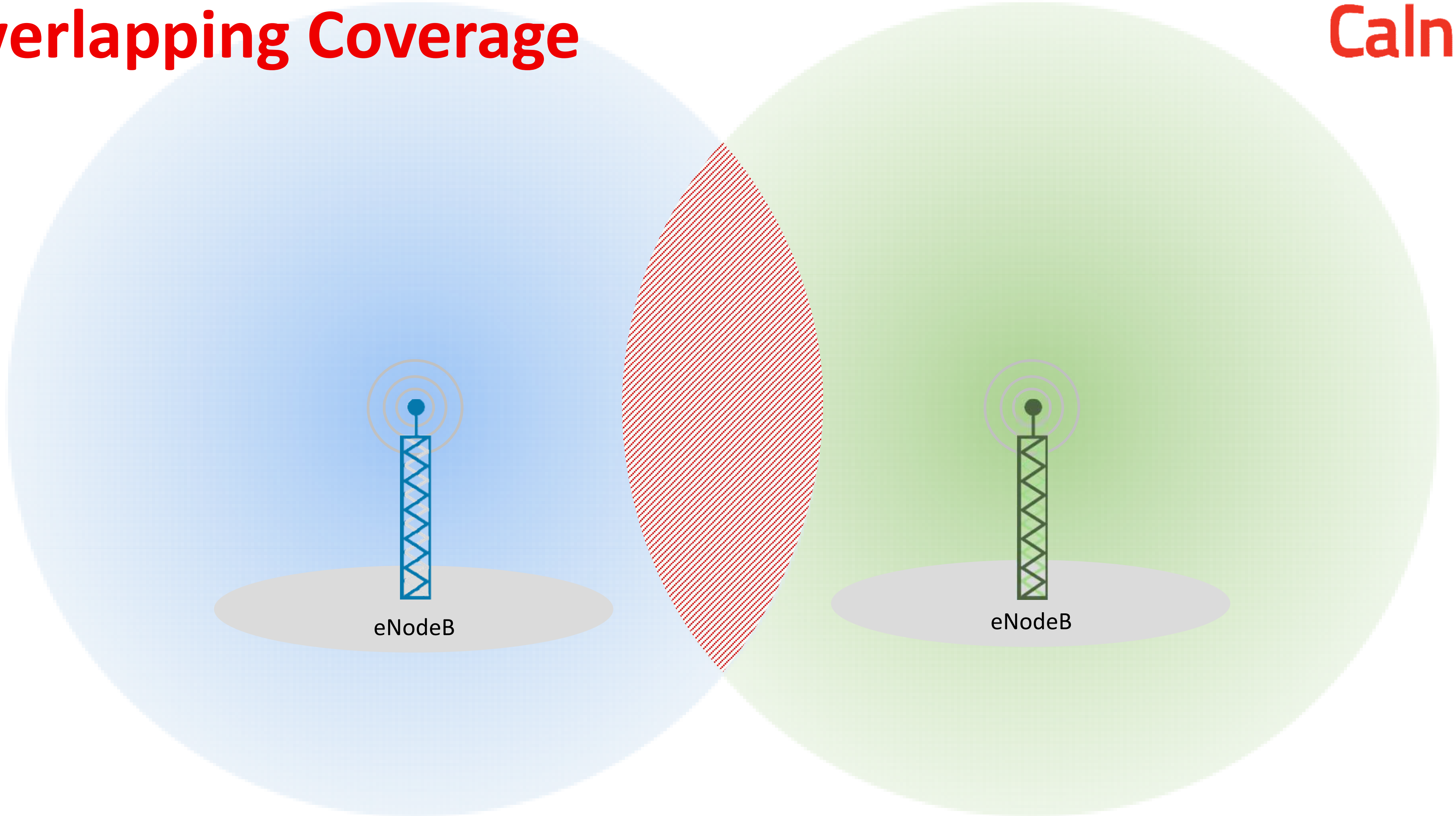
Calnex

- "The maximum absolute deviation in frame start timing between any pair of cells on the same frequency that have overlapping coverage areas shall be ≤ 3μs" *
- This is a ***phase requirement*** (i.e. it is relative to the other cell), not a ***time requirement***
- It is normally implemented as a ***time requirement*** to a ***central clock***

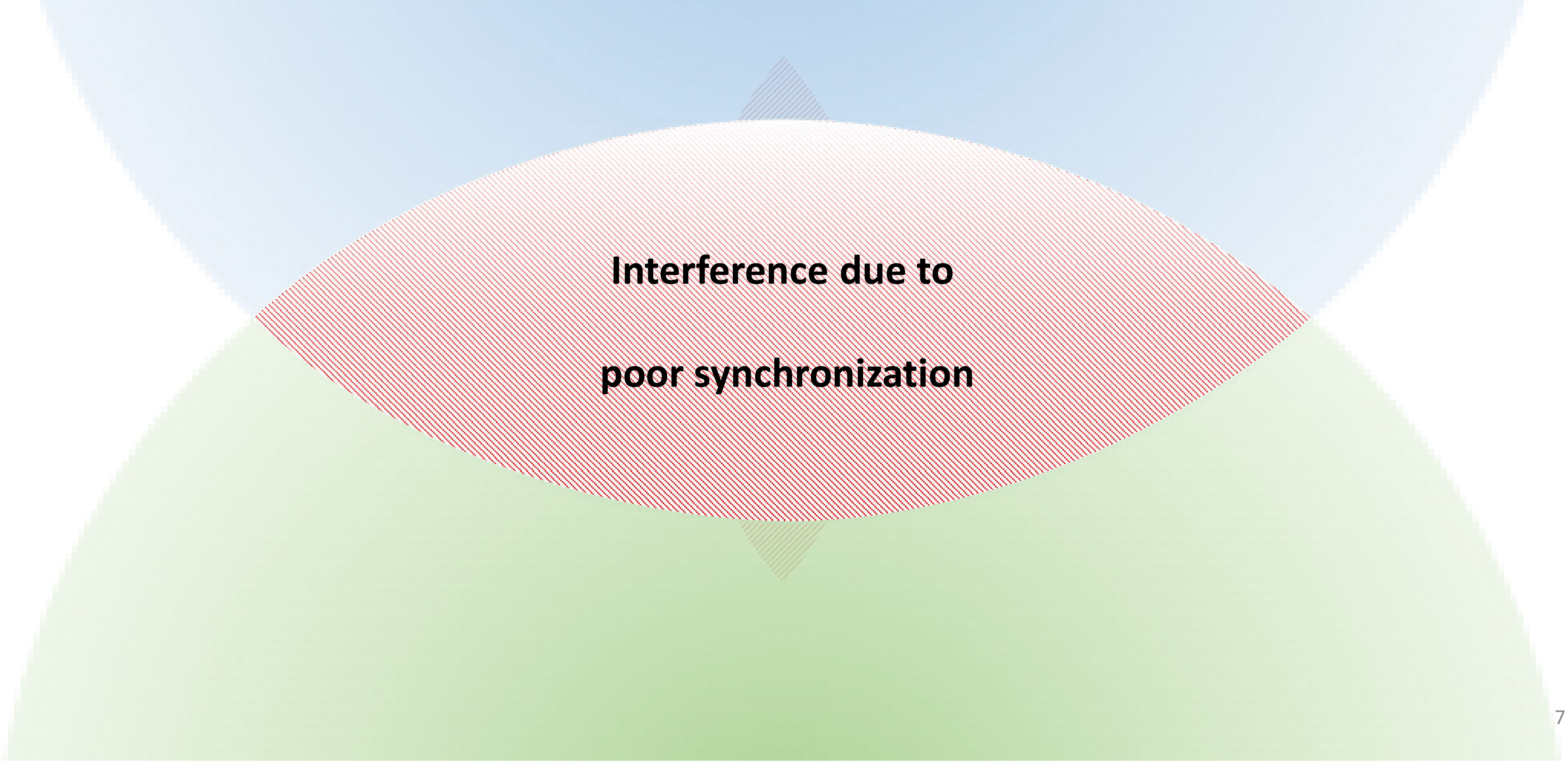


* 3GPP TS 36.133, section 7.4

Overlapping Coverage

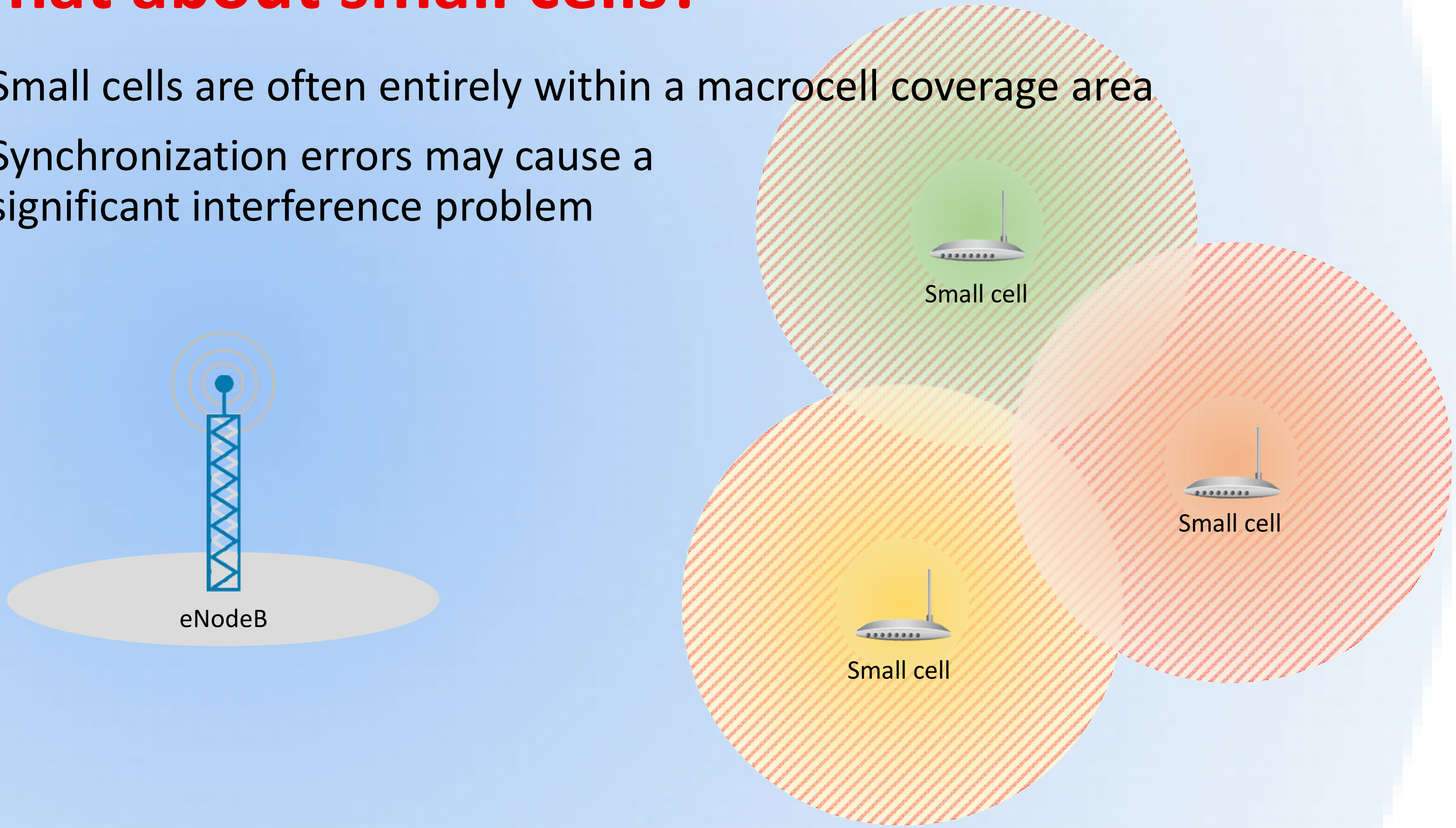


Interference Area



What about small cells?

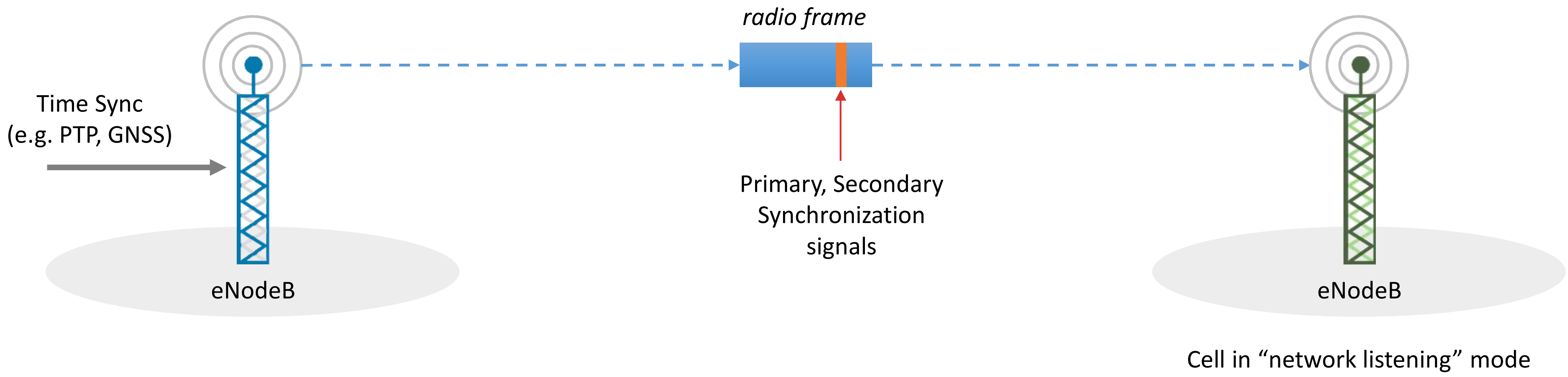
- Small cells are often entirely within a macrocell coverage area
- Synchronization errors may cause a significant interference problem



Synchronization Over The Air

Synchronization over the air

- What if you could synchronize one cell from another?

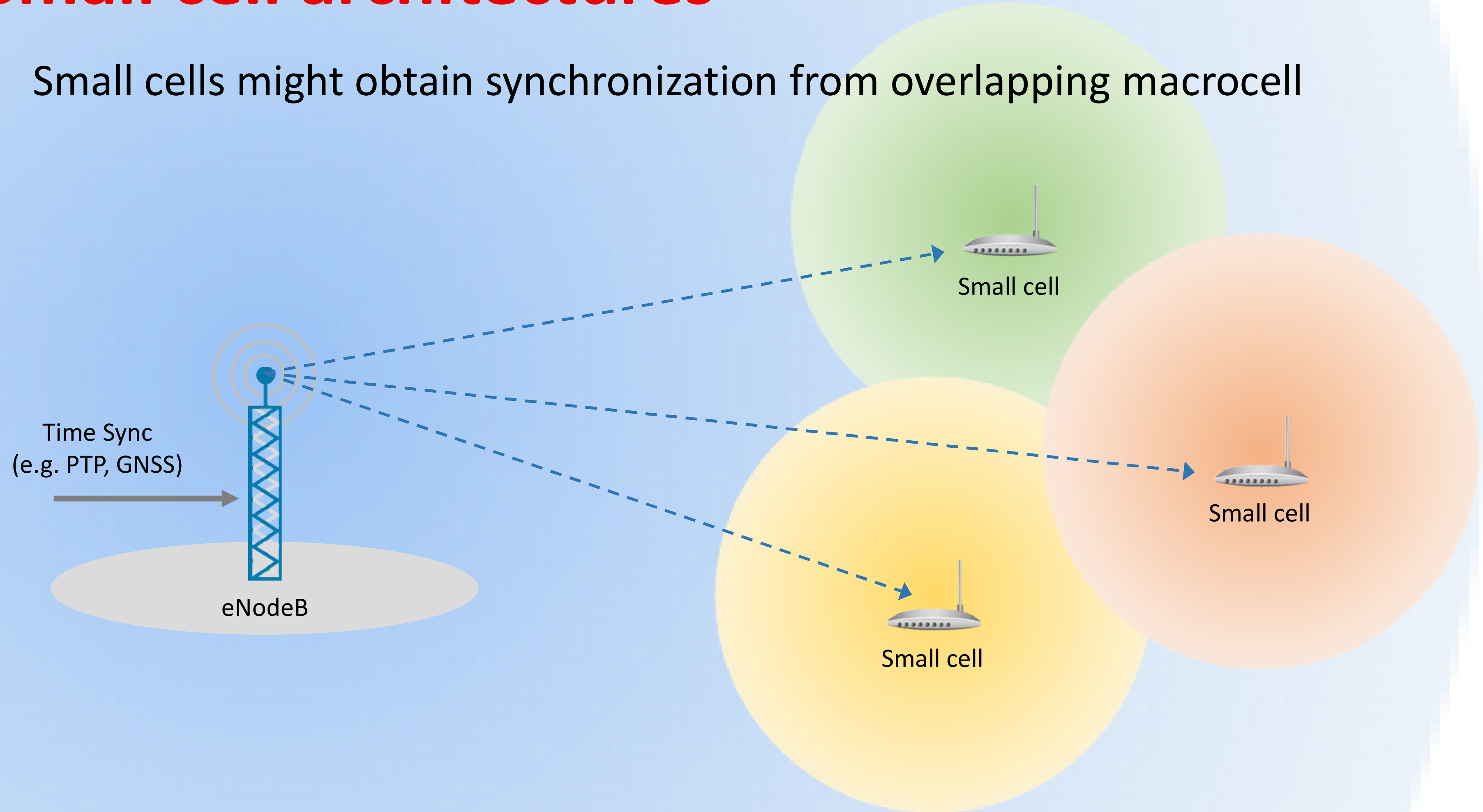


- “Network Listening” cell synchronizes itself to the radio frames coming from a nearby cell that is already synchronized*
- Also known as “radio interface based synchronization” or RIBS

* 3GPP TR 36.922, section 6.4.2.1,
3GPP TR 36.872, section 6.3

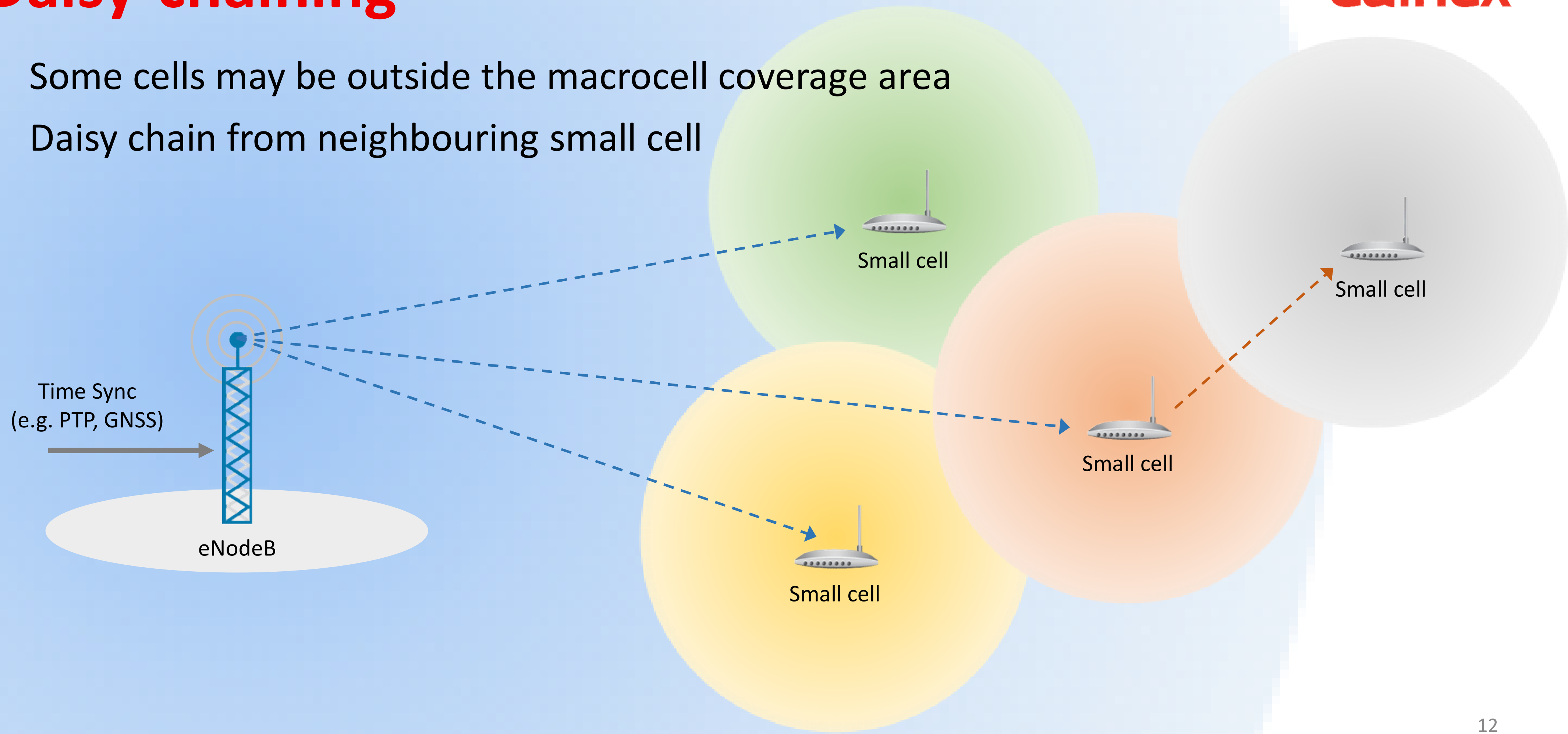
Small cell architectures

- Small cells might obtain synchronization from overlapping macrocell



Daisy-chaining

- Some cells may be outside the macrocell coverage area
- Daisy chain from neighbouring small cell



Self-backhaul

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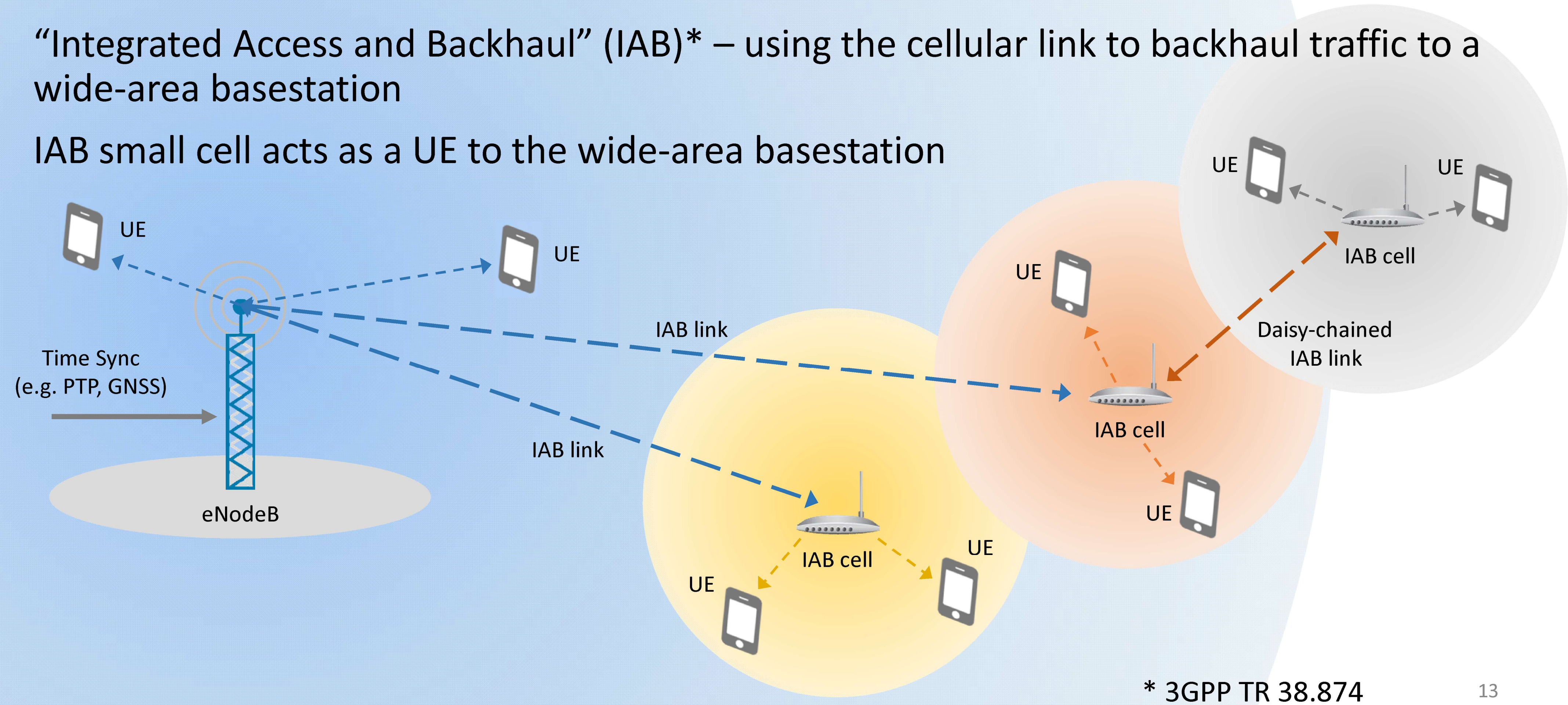
- "Integrated Access and Backhaul" (IAB)* – using the cellular link to backhaul traffic to a wide-area basestation
- IAB small cell acts as a UE to the wide-area basestation



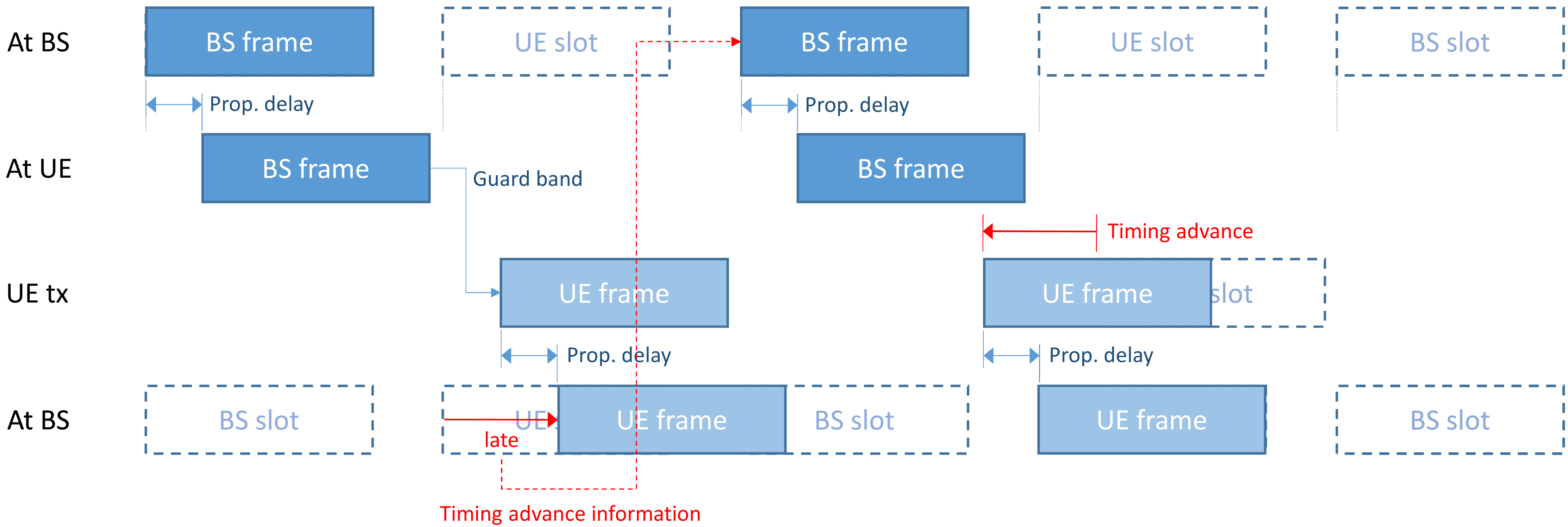
* 3GPP TR 38.874

Delay Compensation

Timing Advance

Calnex

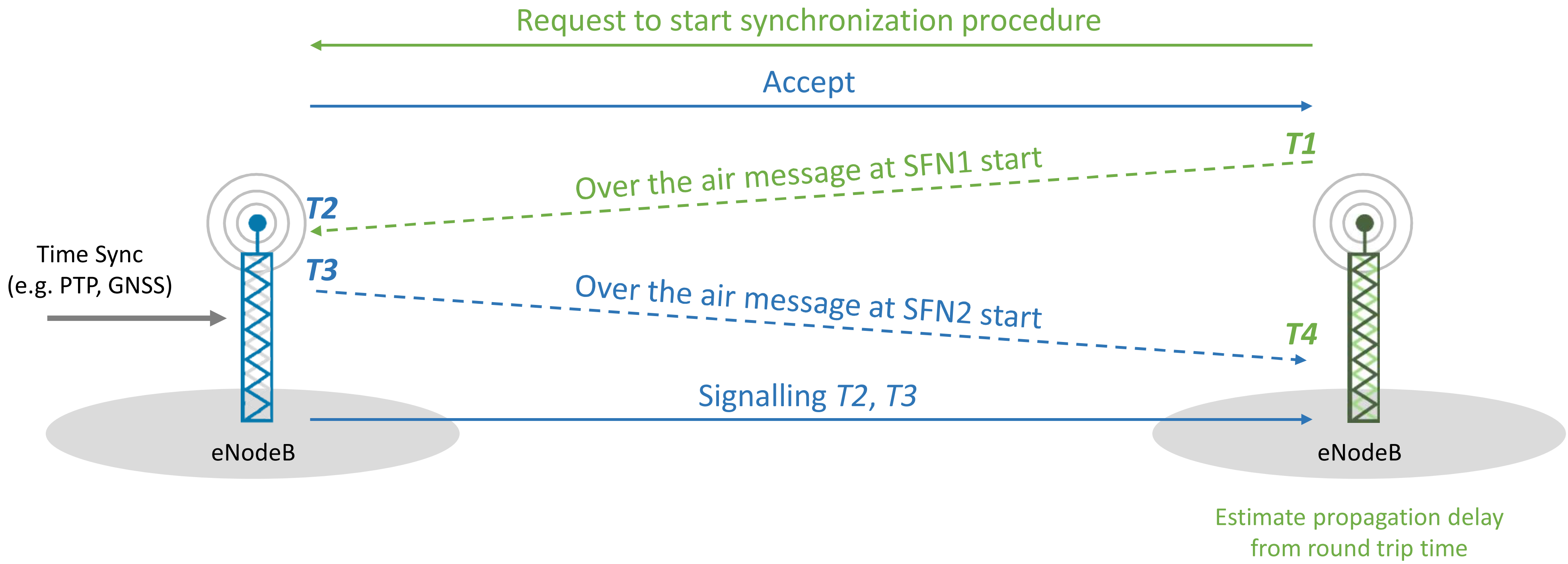
- Timing advance alters the UE transmission timing to ensure frames line up at the BS



- Timing advance is a measure of round trip delay, and can be used to compensate BS sync

Active delay measurement

- Another method uses active delay measurement using two-way signals:



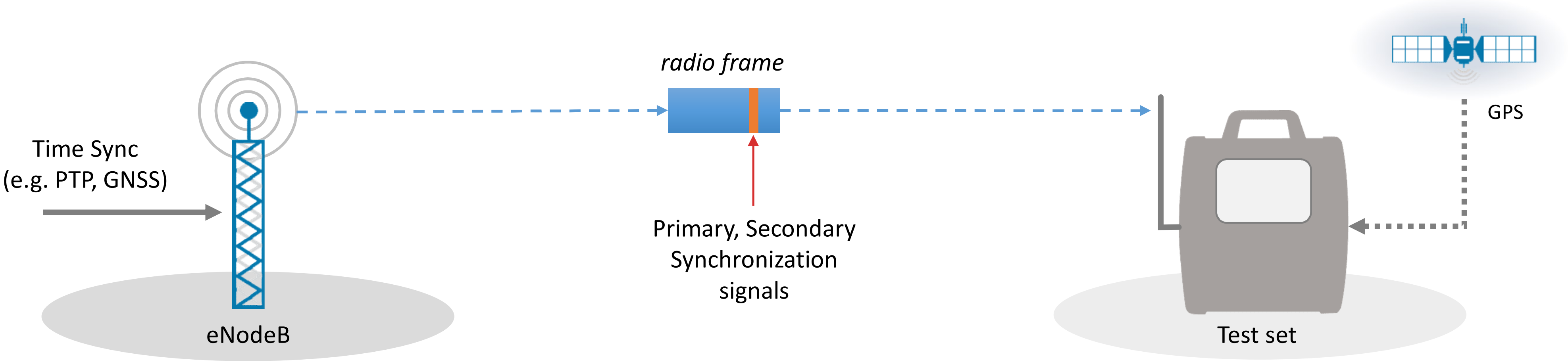
Location-based methods

- Timing advance only works if the receiving cell also functions as a UE
  - Adds complexity to small cells not using IAB
- Active measurement also requires small cell to include an extra transceiver
- Passive compensation requires configuration of basestation location (latitude, longitude, elevation)
  - This information is already required for the UE positioning function
  - Can be used to calculate distance to serving cell, and compensate for the delay
  - 3μs is approximately 900m at the speed of light, so tolerance is quite large for TDD

Measurement Over The Air

Measuring synchronization over the air

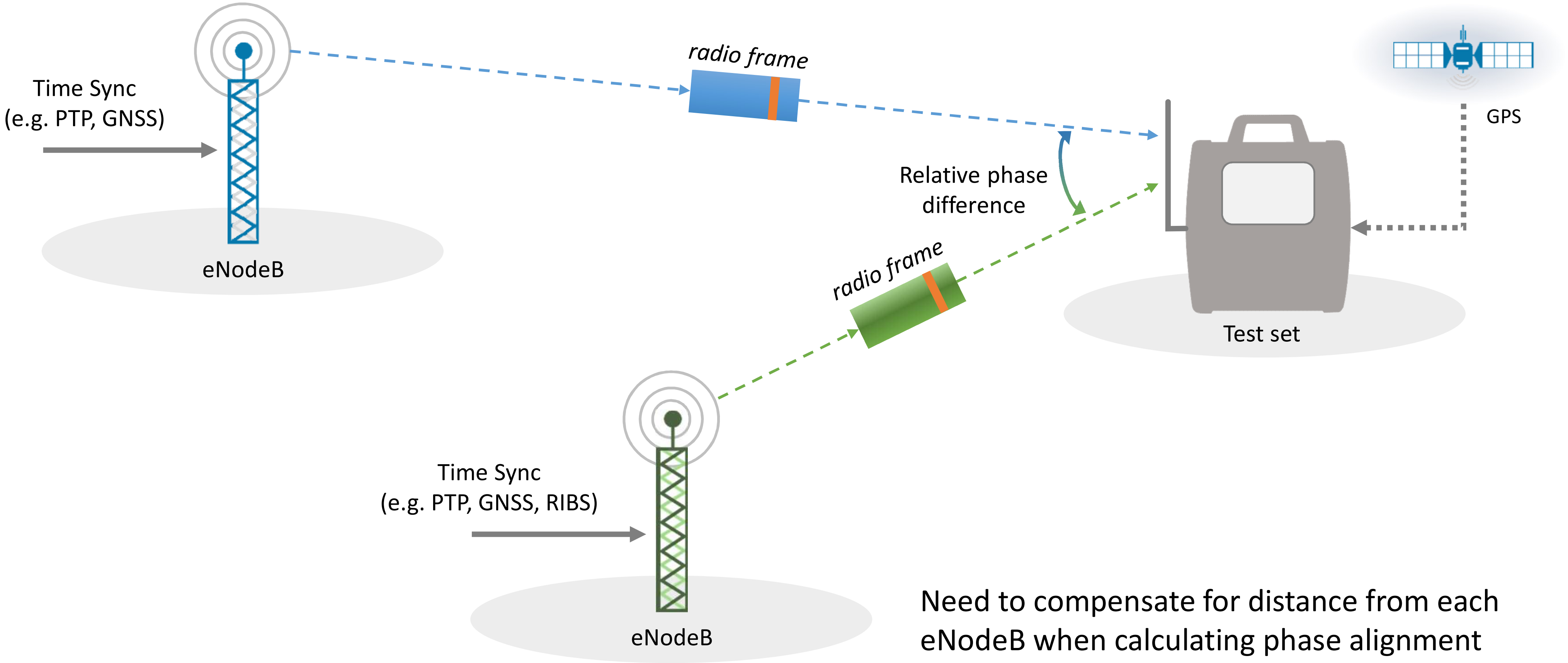
- If radio signals are being used for synchronization, you'll want to measure them, right?



- Need to compensate for distance from eNodeB when calculating time error
  - Use passive, distance-based compensation

Relative phase measurements

- Since phase alignment is the fundamental requirement, measure that too



Need to compensate for distance from each eNodeB when calculating phase alignment

Conclusions

Conclusions

- Synchronization over the air is a viable technique for small cells
  - The cellular signal itself becomes part of the sync chain
- Measurement over the air verifies the entire synchronization chain
  - Non-invasive, easy to make measurement
  - Doesn’t require physical access to eNodeB site or equipment
  - Doesn’t disrupt service while making (or setting up to make) the measurement
- Uses include:
  - Network design verification
  - Installation test
  - Troubleshooting

Insight and Innovation

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