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PTP – is it Hobson’s Choice?

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The Question…

With pressures on cost, power & size, particularly for small cells, do we need something more?

We were asked: "Is it possible to re-use wireless technology to lower cost, size & power?"

Different backhaul technologies are coming fast and furious, is synchronization keeping up?

Are the available synchronization technologies capable of covering upcoming sync requirements?

What we did…

1. We took an existing wireless technology and
   'put it through its paces' to see what was possible

2. We built a small technology demonstrator

3. We ran some experiments and collected results

4. We concluded that it shows a lot of promise and appears feasible.

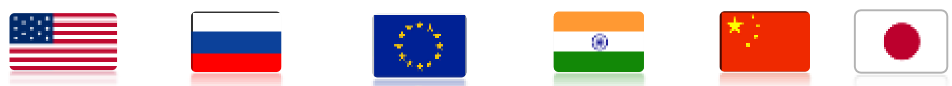
5. We defined some next steps…. & welcome feedback

Are the available synchronization technologies capable of covering upcoming sync requirements?

Let’s start with what we (all?) agree on…

- **Time or Phase alignment is required in network equipment**
  - Some more than others
  - Some sooner than others

- **Time or Phase provision choices include…**



  - GNSS (GPS, GLONASS, Galileo, IRNASS, BeiDou, QZSS)
  - PTP (IEEE1588, Precision Time Protocol)
  - NTP (Network Time Protocol)
  - OTA (Over the Air techniques)
  - eLORAN (Long Range Navigation)
  - Cs (Caesium or other highly stable clock)

Which options satisfy availability, accuracy & cost criteria?

Existing (?) Time & Phase Delivery Options

Time delivery option	Use today	Robust Availability	Robust Accuracy	Cost	Notes
GNSS	Extremely widespread			 *antenna	Easily blocked High OPEX
PTP	Growing rapidly				Network engineering can fix accuracy
NTP	Widespread non telecom				V4 req’d for accuracy Only V3 widespread
OTA	Not widespread				Needs standard Requires air i/f
Cs or other	The ‘root’ of all clocks today				Expensive Needs to be aligned

High Quality phase delivery costs

Time  &  Money

Telecom is widely settling on the following selection

GNSS & PTP assisted by SyncE

GNSS for accuracy

Primary: Where & when available, use GNSS

Backup: SyncE &/or PTP

PTP for availability

Primary: PTP is available everywhere even when no access to GNSS

Backup: SyncE

So what's Hobsons Choice?…

"Thomas Hobson (ca. 1544–1631) sometimes called "The Cambridge Carrier", is best known as the name behind the expression Hobson's choice.

He arranged the delivery of mail between London and Cambridge up and down the Old North Road, operating a lucrative livery stable outside the gates of St Catharine's College, Cambridge as an innkeeper. When his horses were not needed to deliver mail, he rented them to students and academic staff of the University of Cambridge.

Hobson soon discovered that his fastest horses were the most popular, and thus overworked. So as not to exhaust them, he established a strict rotation system, allowing customers to rent only the next horse in line.

This policy, "this one or none" ("take it or leave it"), has come to be known as "Hobson's choice". It is not an absence of choice, rather choosing one thing or nothing."

When GNSS is not available is PTP, therefore, "Hobson's Choice"?

Is PTP ‘Hobson’s Choice’ or…
Should we look for an alternative?

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We have chosen PTP assisted with SyncE when GNSS is not feasible

- However, we know that SyncE support is not always possible
- How about when the network is hostile to PTP & network engineering is not an option

The Needs:

Accuracy of GPS with ‘deploy-ability’ of PTP

Would like:

Lowest cost, lowest power, smallest size

If we experiment with an existing wireless technology could it help?

IoT national networks using “LoRa”
LoRa = Long Range

- **Operators are deploying Long Range national networks for IoT**
  - Applications such as asset tracking, smart grid and many others driving IoT
  - Coverage in-buildings is possible with links more robust than GSM
  - Based on Semtech’s LoRa silicon devices

- **Extremely low power**
  - 10 year battery life

- **Co-exist with LTE, WCDMA & GSM etc.**
  - Gateways are sharing cell towers

This technology includes ranging and location of end-points

As with GNSS, when you have position, you have time.

LoRa IoT Radio specifications

❑ Frequency bands:

- 868MHz, 915MHz, 2.4GHz (significantly lower range)

❑ Tx Power levels:

- up to 14dBm (slight differences in regions)

❑ Power consumption:

- Endpoint Transceiver:
  <100mW when active at 14dBm TX power
  <1uW when standby

❑ Link Budget:

- 168dB- Exceeds GSM cell link budget by 10-20dB

❑ Modulation:

- Spread-spectrum

Let’s start by checking 3 parameters:

Before we look at the delivery of Phase synchronization, lets look at 3 important parameters of the base wireless technology…

1. **Can we get good urban coverage and in-building penetration?**
2. **Is it robust to interference and aggressive blocking?**
3. **Is coverage predictable?**

Then let’s ask…

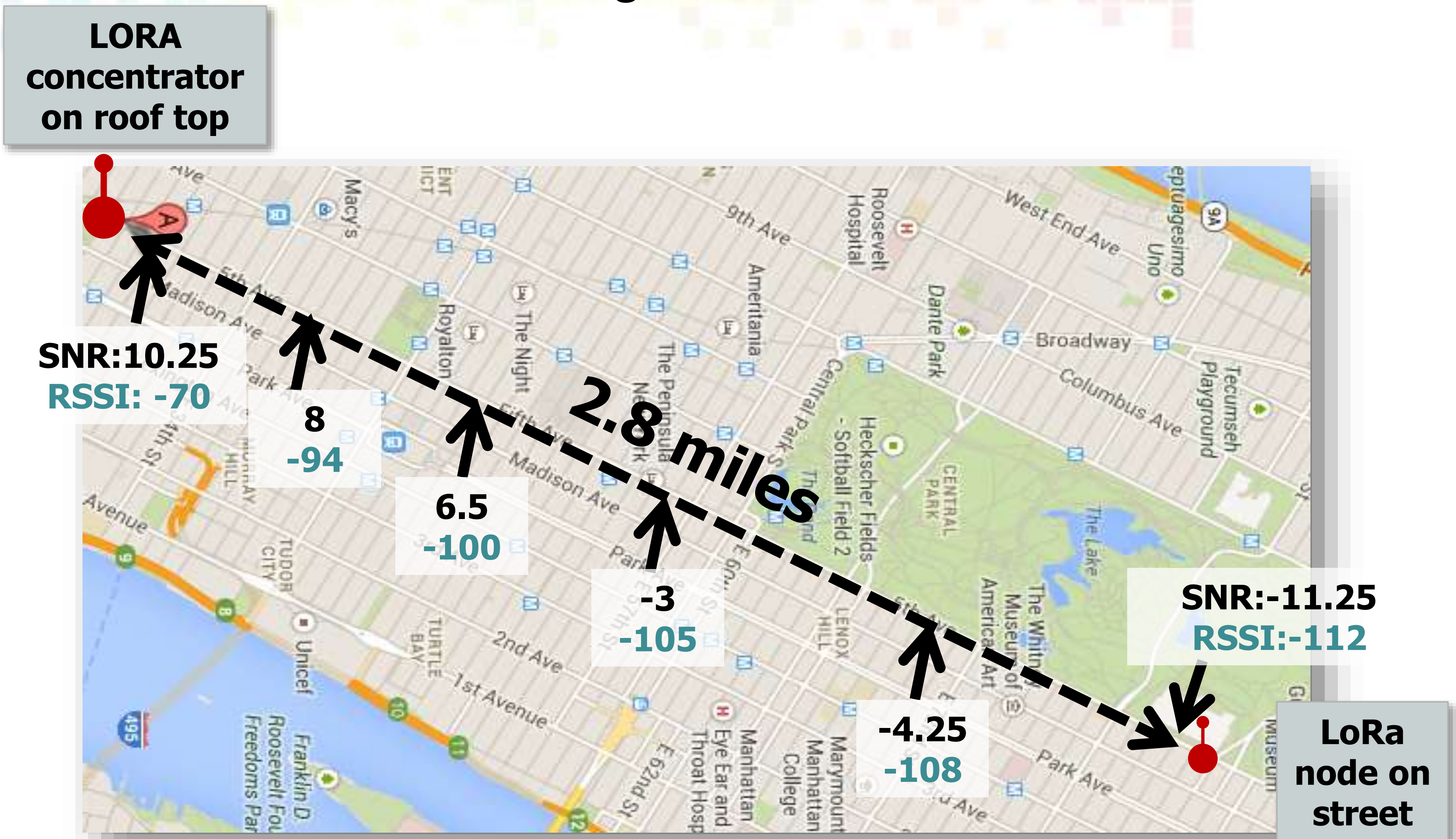
Is the IoT technology good enough to distribute phase synchronization?

1: Does it have good urban coverage? NYC Field Test: 868MHz

Predictions are that 7 concentrators will cover all of lower Manhattan

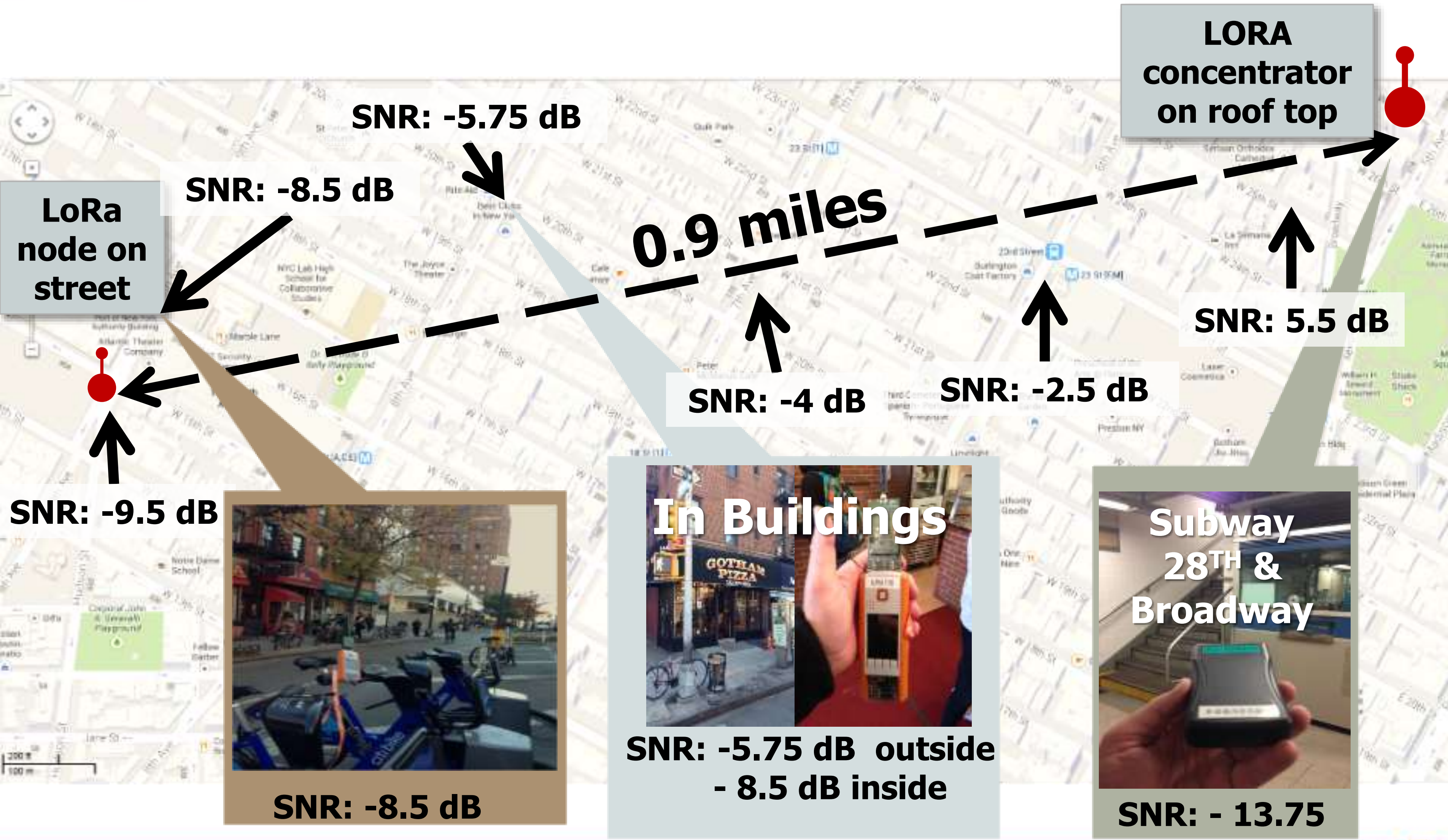
A conservative 1 mile radius allows for some in-building penetration even at the edges.

1: Does it have good urban coverage?
Outside test: Walk Straight North to the Met



SNR and RSSI were measured on valid packets received by roof-top concentrator
With max spreading factor LoRa operates down to SNR of -20dB (868MHz)

1: Does it have good urban coverage? Extreme Urban: Subways and In-buildings



2: Is it robust against interference?
Field Test- Bartlesville Oklahoma- 868MHz

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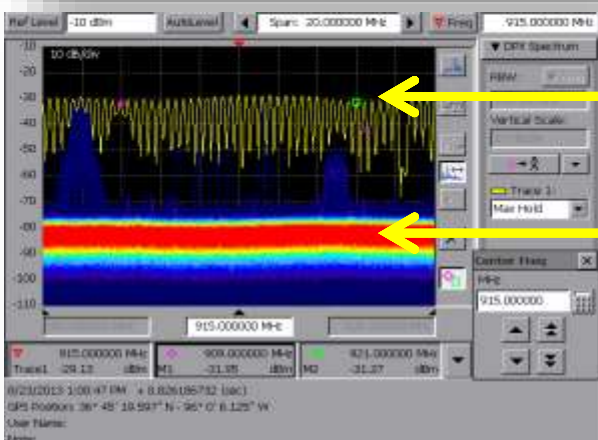
Target:
Reach 2 miles to water pit in the presence of extreme interferes



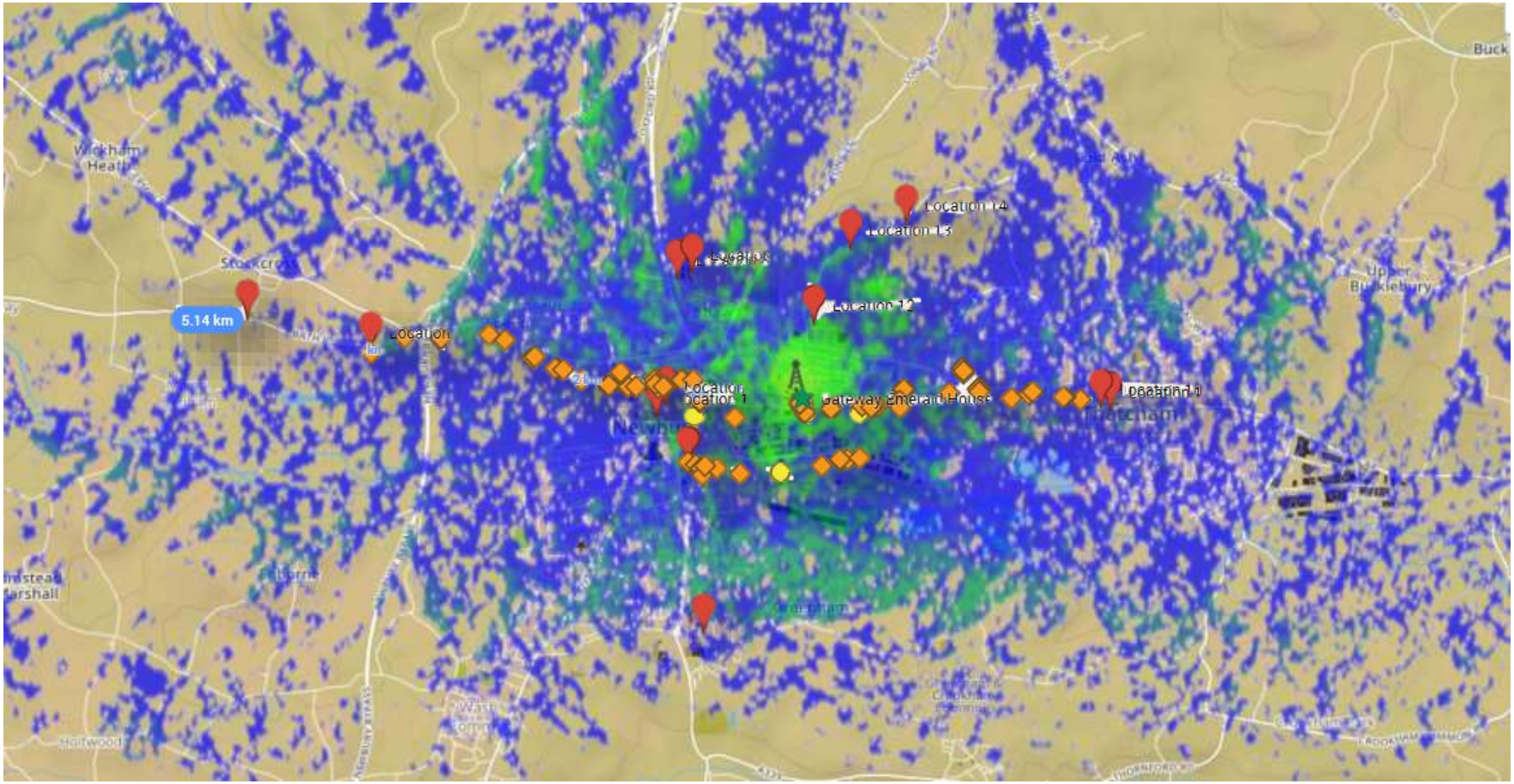
-30 dBm interferers

-80 dBm Ambient Noise Floor

Theory tells us that this technology has some of the highest known immunity to interference- in practice it seems to work

3: Is it predictable?
Do measurements align with predictions?

Theoretical model of single gateway in Newbury, UK. And the measured results…



The 3 parameters are looking good:

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1. **Can we get good urban coverage and in-building penetration?**
   - Link budget significantly greater than GSM

2. **Is it robust to interference and aggressive blocking?**
   - Extremely robust to interference

3. **Is coverage predictable?**
   - Better than 95% alignment between predicted and measured results

IoT technology looks like a good candidate to transport synchronization

Next Steps:

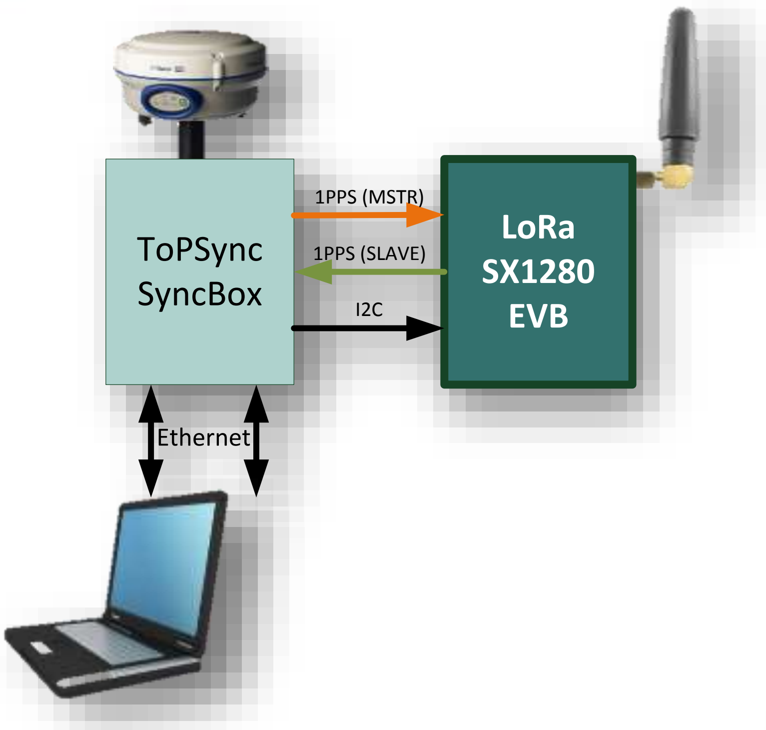
1. Build an experimental platform

2. Run experiments

3. Present the results
   (look around you now)

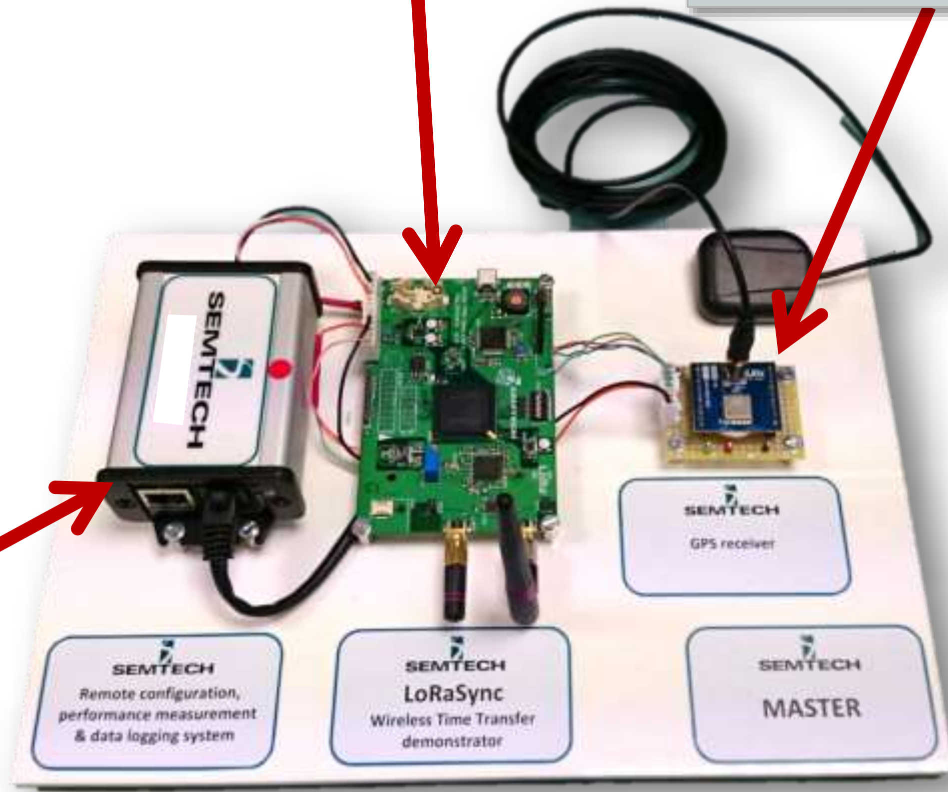
4. Gather feedback

LoRaSync Trial and Demo system: The ‘wireless time transport system’



LoRa Transceiver

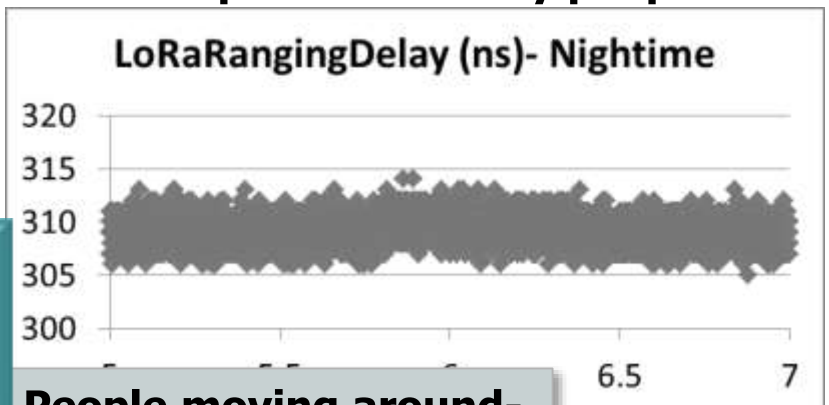
GPS Receiver- provided to Master, & compared to Slave



ToPSync management, performance monitoring and PTP system

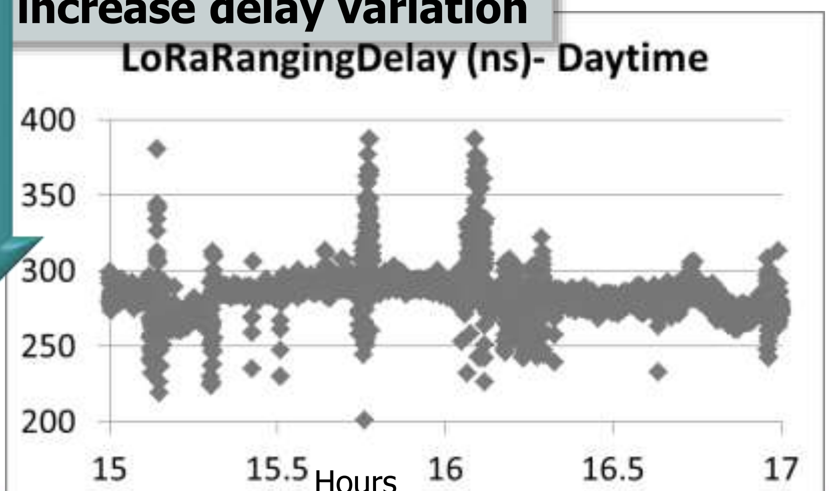
First test of time transport:
San Diego In-building, Line of sight Test

Short range 2.4GHz, 10dBm Tx power in-building test.
Straight path across one floor in building with strong direct path.
Horizontal path with many people walking in signal path.

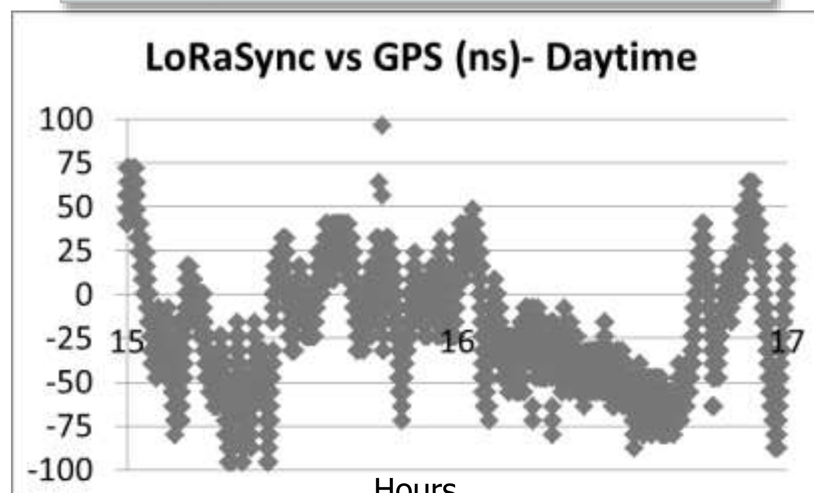


20 X increase

People moving around- increase delay variation



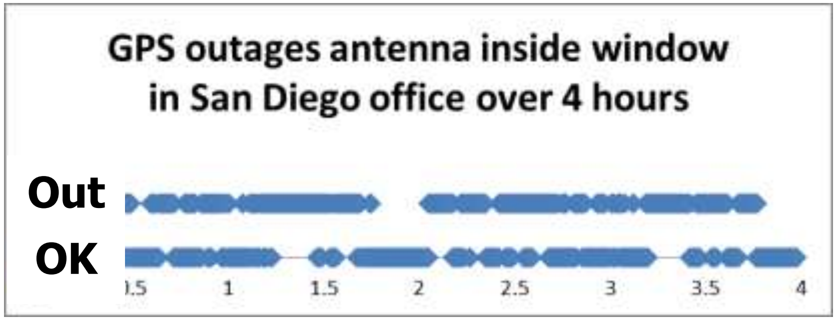
Unfiltered LoRaSync vs GPS Daytime: +/- 50 to 100ns



San Diego In-building, Line of sight Test

Observation 1: Line-of sight performance is good; unfiltered results are OK

Observation 2: Solar window film wreaks havoc on GPS & GLONASS

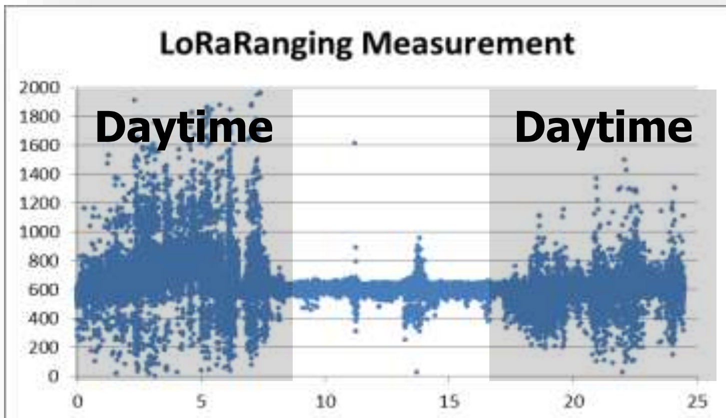


Antenna placed outside window had only one 5 second outage in 18 hours

Antenna placed right inside window had around 50% outage

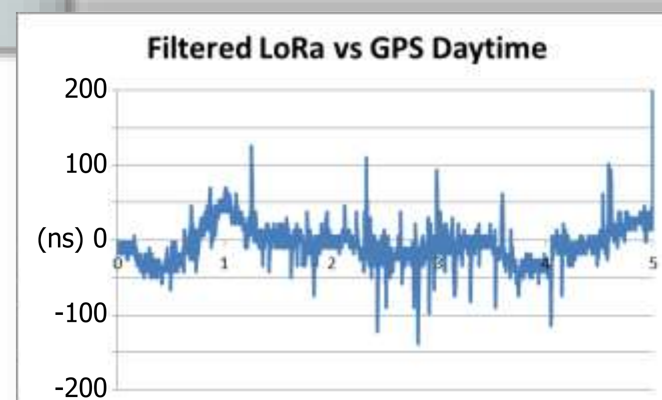
Romsey, UK In-building test

Short range 2.4GHz, 10dBm in-building test.
Set up path diagonally across building with no direct path (only multipath).
Production test suite and laboratory within direct path.



Ranging results vary much more with movement of people and objects

50mHz filtered results are acceptable



Romsey, UK In-building test

Observation 1: Multipath creates a lot of noise on the ranging mechanism but a simple filter with a 50mHz pass-band gives good results.

Observation 2: People and general activity increases multipaths and delay variation a lot. It is significantly quieter at night.
Multi-path algorithms can significantly reduce this effect. So far no algorithms have been tested.

Current Status & Next Steps

Current Status

- So far, LoRaSync has only been tested at 2.4GHz, therefore range was limited
- LoRa IoT radio technology range at sub-1GHz frequencies is best
- We are currently building a sub-1GHz LoRaSync test system

1. **Create 868MHz version of LoRaSync demo system**
2. **Perform longer range measurements**
3. **Characterize long-range in-building penetration**
4. **Discuss integration testing with LoRa IoT deployed systems**

Summary

- It is feasible to use low power wireless technology to transport time
- Nationwide IoT network could sync small cells and many others
- Power, size and cost savings would likely be significant