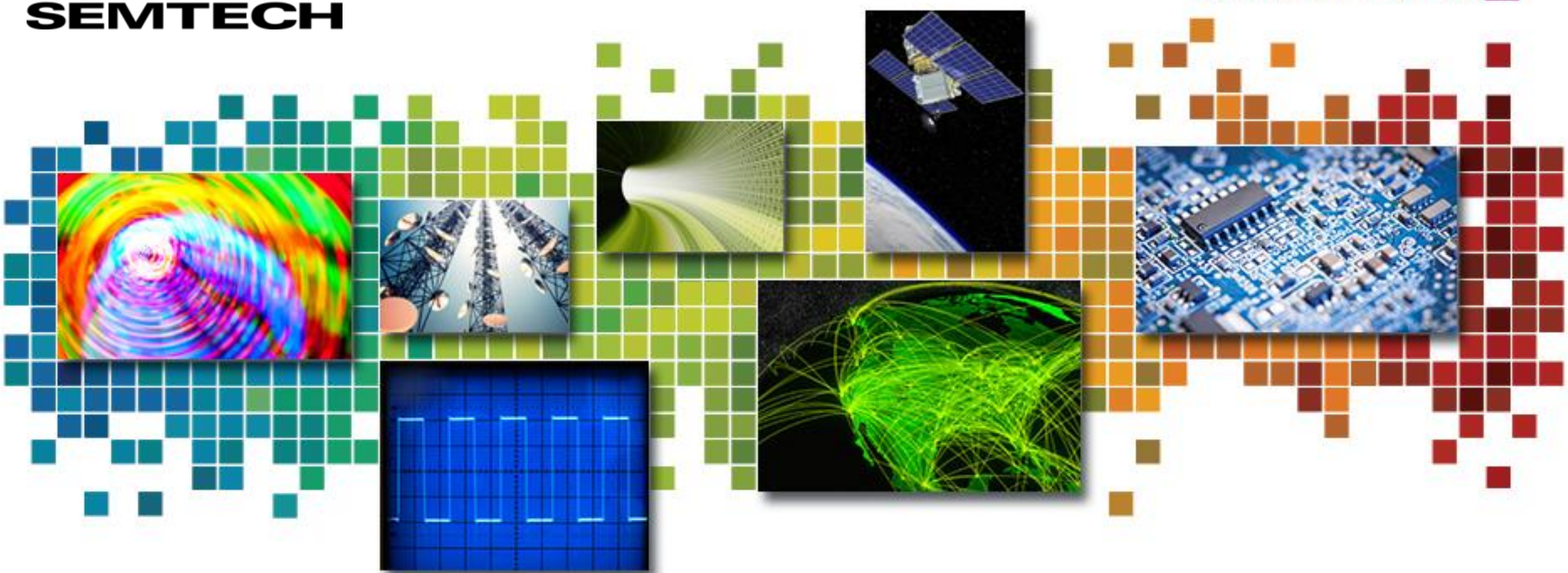
www.semtech.com



LoRaWAN, IoT & Synchronization

ITSF 2015

Richard Lansdowne, Senior Director Network System Solutions

Agenda

- **Introduction to LoRaWAN**
  - The LoRa Alliance
  - Radio Parameters
  - Network Architecture
  - Classes of devices
  - Summary
- **Impacts on Synchronisation**
  - Frequency accuracy
  - Time-slotted access (class B)
  - Localisation and the requirements on synchronisation
  - Summary

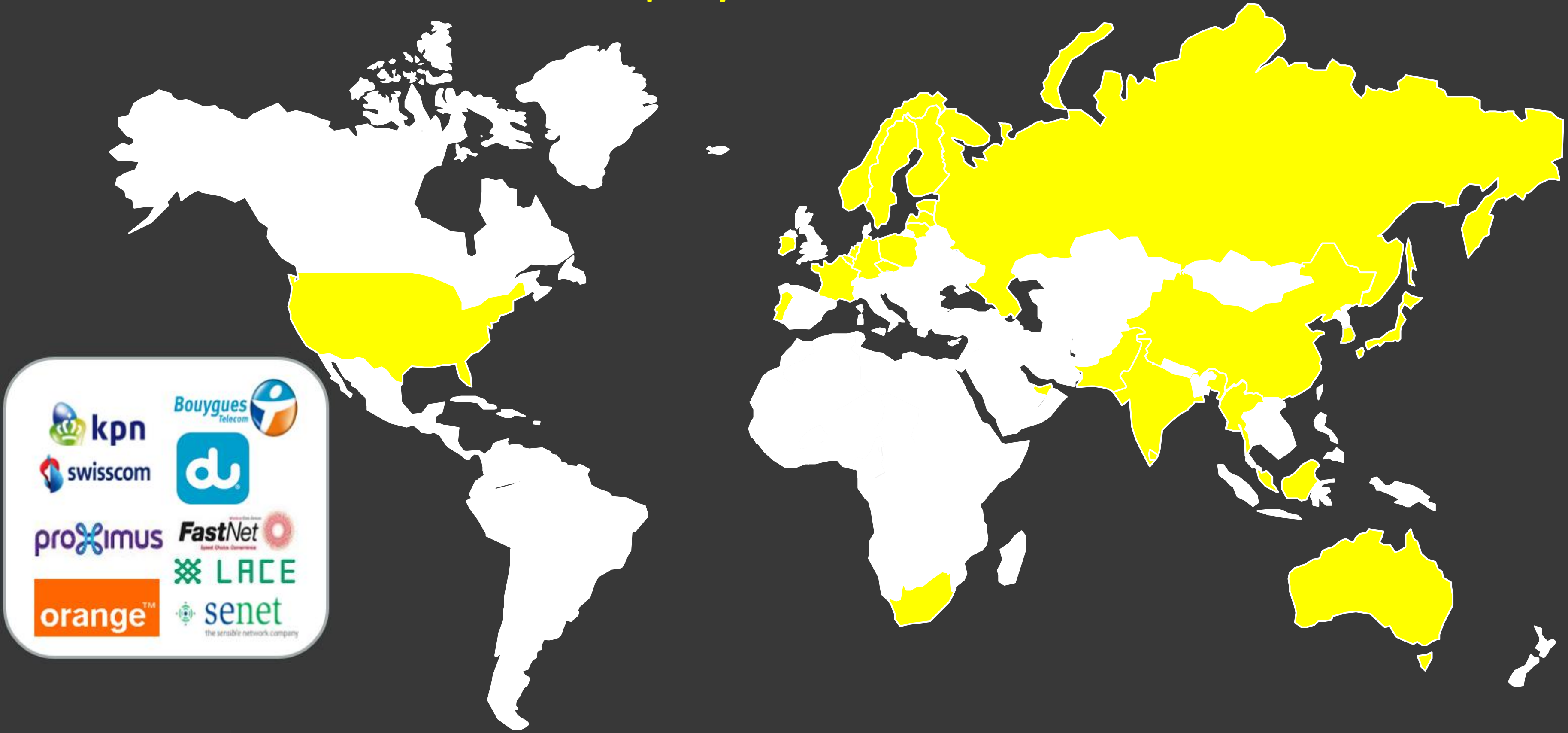
LoRa Alliance™ and LoRaWAN ™

LoRa™Alliance

- Open & Non-Profit, Founded: March 2015
- Board
  - IBM, Cisco, Bouygues Telecom, KPN, Semtech Proximus, Actility, Kerlink,Agutek, Homerider, Sagemcom
- Chairman: Geoff Mulligan
- Committee Chairs
  - **Technical:** Nicolas Sornin, Semtech
  - **Marketing:** Tracy Hopkins, Stream Technologies
  - **Strategy:** Stephen Cadwell, Microchip
  - **Certification:** Derek Hunt, Semtech
- Specification: LoRaWAN R1.0

LoRa Alliance™: >140 members
Specification downloads: >3000

LoRaWAN: 9 Announced Deployments… three live



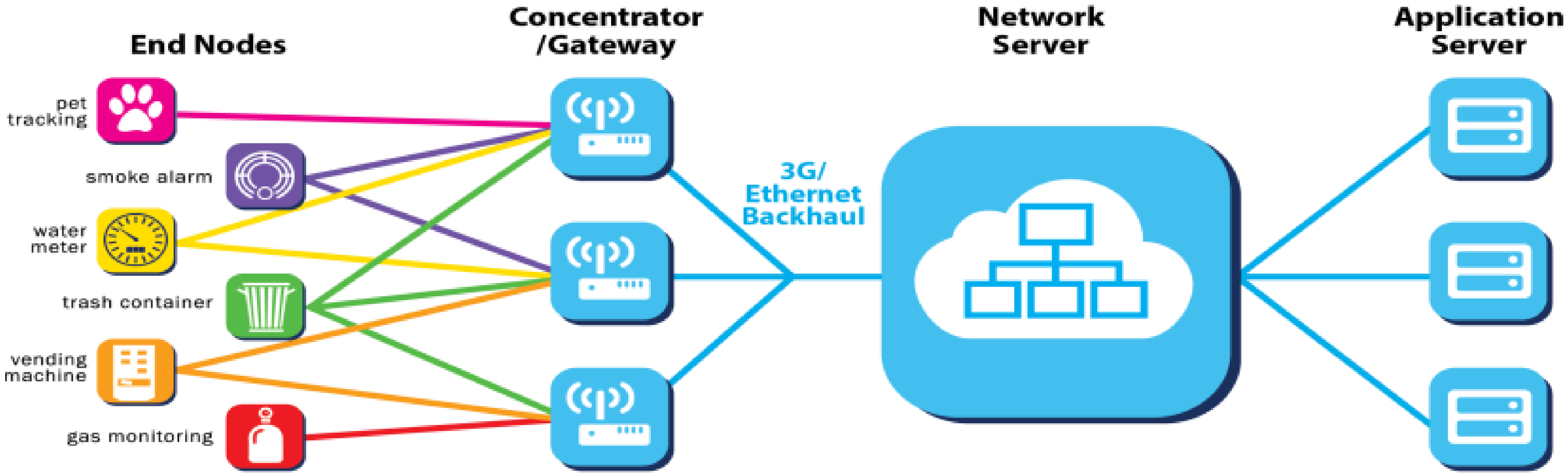
True location
- ✓ Low power
- ✓ In/out door
- ✓ Low cost

Bidirectional
- ✓ Bidirectional
- ✓ Time slotted
- ✓ Broadcast

Global mobility
- ✓ True mobility
- ✓ Seamless
- ✓ Roaming

Security
- ✓ Full encryption
- ✓ Authentication
- ✓ Unique ID

LoRaWAN Network Architecture



Sensor-Gateway (Base station) Interface

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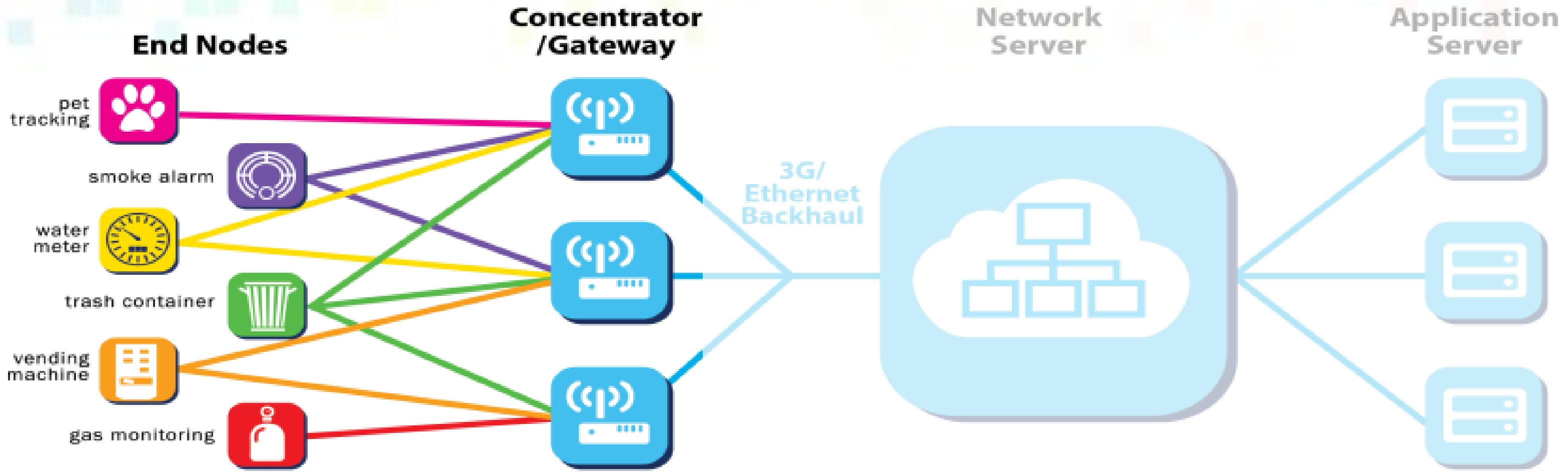
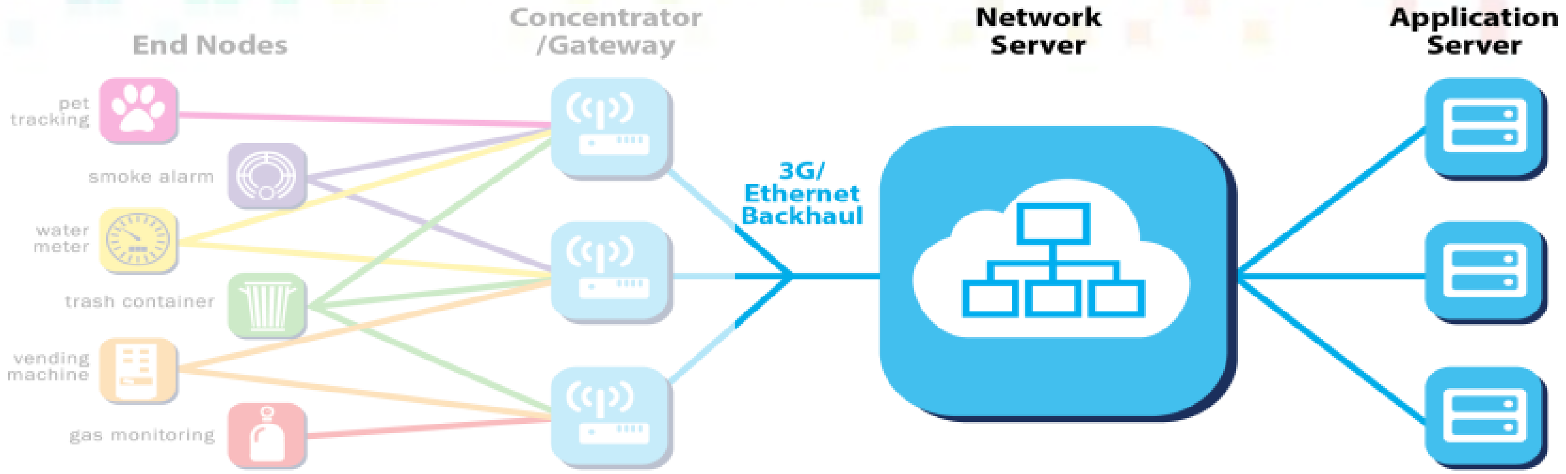


ALL GW receive on ALL channels ALL of the time → **Zero network overhead- Sensor transmits a packet at any time**

No GW controller necessary- Operate on same channels → **Add capacity with more GW, anytime anywhere. No reuse planning reqd.**

Sensors operate continuous low power, vary data rates → **Super-low peak current allows 10 years on a 'coin cell'**

Network Solution



Network Server removes redundancy where required → **A single packet received on many antennas can be processed if reqd.**

GW are dumb & perform no data validation uplink or downlink → **Network behaviour is determined by the server per application, low cost GW**

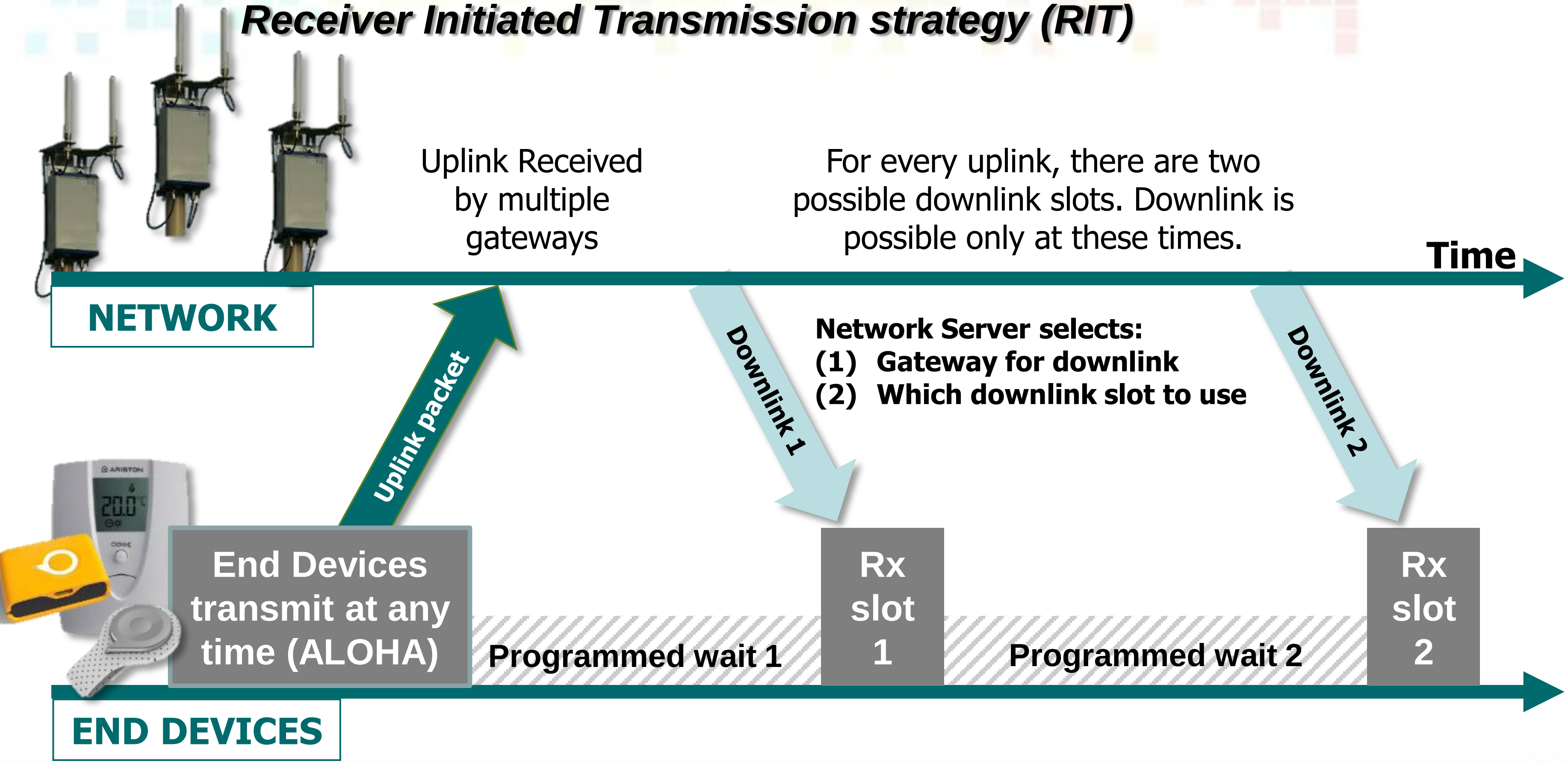
Separation of data by application or user in server → **Single or multiple providers per network allow choice by application**

LoRaWAN device classes

Class name	Intended usage	
A (« all »)	**Battery powered sensors** (or actuators with no latency constraint) Most energy efficient communication class. Must be supported by all devices	***Mainly uplink with two potential downlink slots after each uplink***
B (« beacon »)	**Battery powered actuators** Energy efficient communication class for latency controlled downlink. Based on slotted communication synchronized with a network beacon.	***Programmed downlink slots to allow control within certain latency limits***
C (« continuous »)	**Mains powered actuators** Devices which can afford to listen continuously. No latency for downlink communication.	***Lowest latency command and control for less power critical devices.***

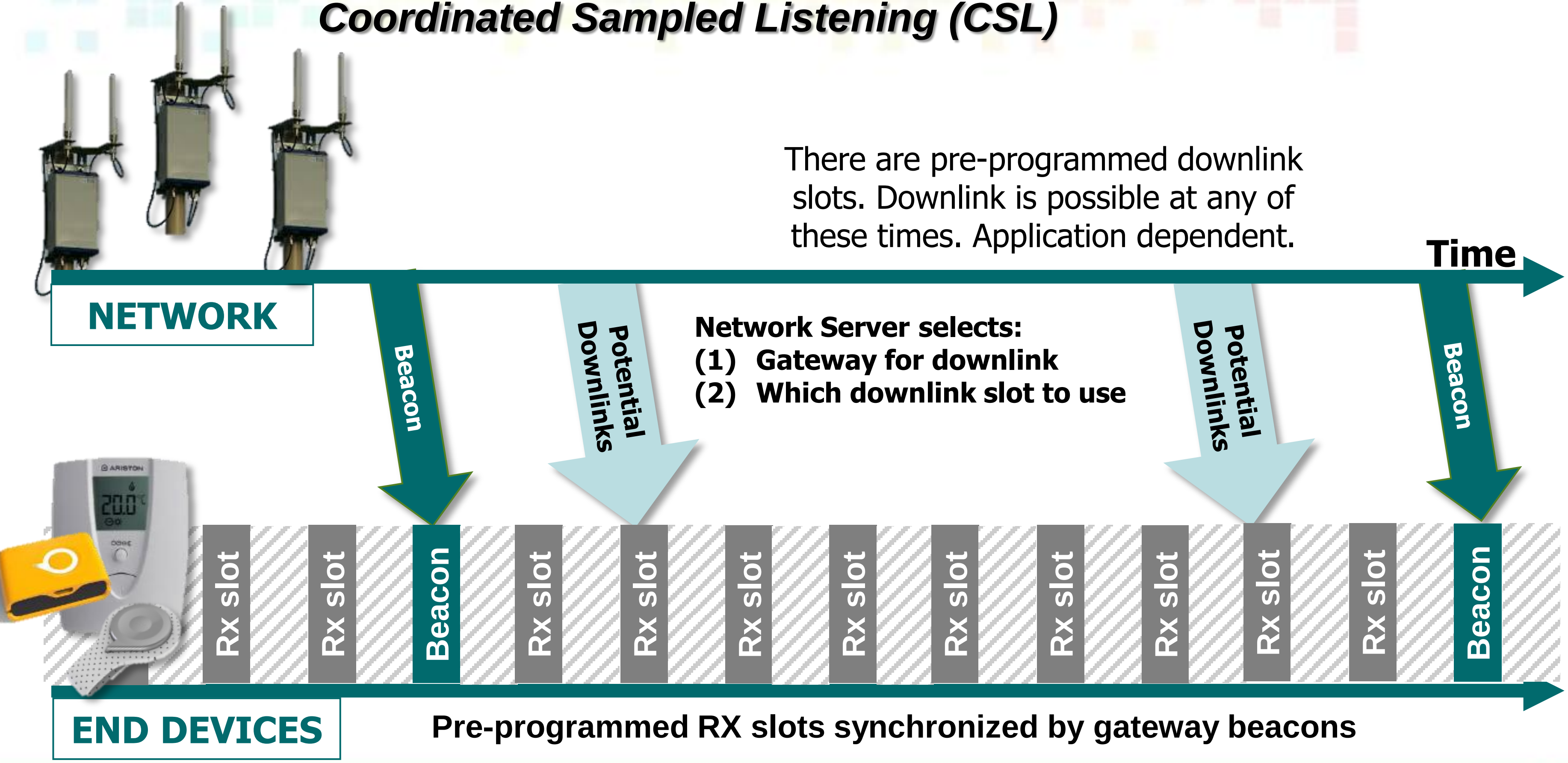
Class A- Bidirectional communication;

Receiver Initiated Transmission strategy (RIT)



Class B- Bidirectional communication;

Coordinated Sampled Listening (CSL)



Summary on LoRaWAN

- **Highest link budget- for deep indoor coverage**
  - ‘better than GSM range’ with 25mW output power and ultra-low peak battery current
- **Simple deployment & densification**
  - All gateways operate on same channels- simply ‘switch on’ a new one to increase density
- **In-built support for localisation**
  - Time-stamping very slow signals is inaccurate, LoRa spread-spectrum allows time-stamping
- **Simple, low cost sensors**
  - Lowest cost electronics and battery- similar cost to Zigbee but with much greater range

National Networks Now Being rolled out

Roaming, and world-wide coverage are all being addressed by The Alliance

Frequency Accuracy and Synchronisation

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- **LoRaWAN uses ‘chirp spread-spectrum’- highly tolerant**
  - Unlike ultra-narrow-band IoT technologies, frequency offset is not a problem
  - Low power, low cost & low accuracy crystals are perfect for Class A & Class C
  - Also Mobile devices with Doppler effects are no problem

- **Class B requires 1us timing accuracy at each Gateway**
  - Similar requirements to many cellular applications
  - Local oscillator and synchronisation requirements can easily map across from cellular
  - Unlike cellular, better accuracy does not map to ‘more efficient’, either it works or it doesn’t

- **Class B also requires sensor to keep time**
  - Beacons from gateways are on a 128s period
  - The node must keep sub-micro-second time in between beacons

Localisation- ‘Game Changing IoT’
… driving synchronisation requirements

Reception by multiple GW enables zero overhead localisation

- **A well designed network can locate ANY sensor without GNSS**
  - Zero additional cost
  - Zero additional power
  - Indoors and outdoors

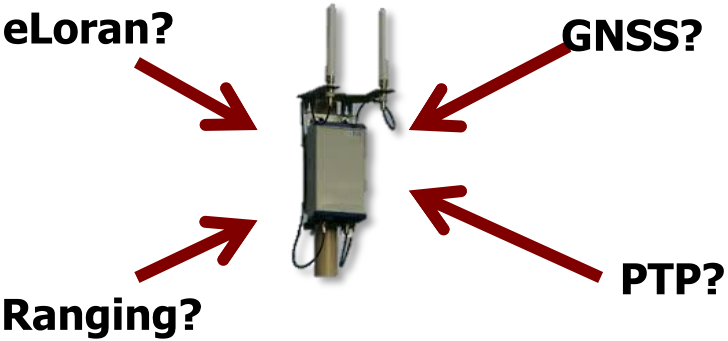
- **How?**
  … Time-stamping of packet arrivals… plus other parameters
  - Combination of differential time of arrival and received signal strength plus ….

LoRa & Localisation: Problem number 1
Accurate time-base to the Gateway

Required accuracy-

'as good as possible'

10ns error = 3 metres error!



What's important, & what's not?

Absolute time is NOT

Local consistency IS- differential time-stamping is used

=> GNSS receivers absolute accuracy is likely good enough

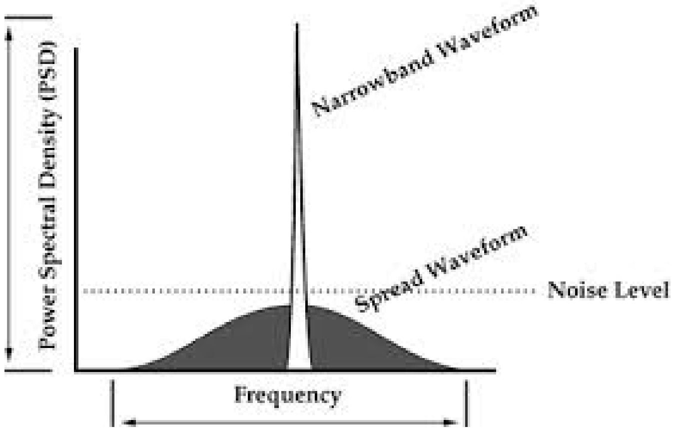
=> Other options-
PTP, ranging between GW, ensemble calculations etc.

LoRa & Localisation: Problem number 2
How to time-stamp accurately enough?

Required accuracy-

'as good as possible'

10ns error = 3 metres error!



LoRa is a 150kHz spread-spectrum signal

=> Sample interval of ~ 6.7us

Semtech has developed over-sampling I.P. (256x)

=> error < 30ns

(narrow-band IoT is much lower bandwidth, hence it is impossible to accurately time-stamp)

LoRa & Localisation: Problem number 3 Multi-path transmission

Multipath effects cause issues:

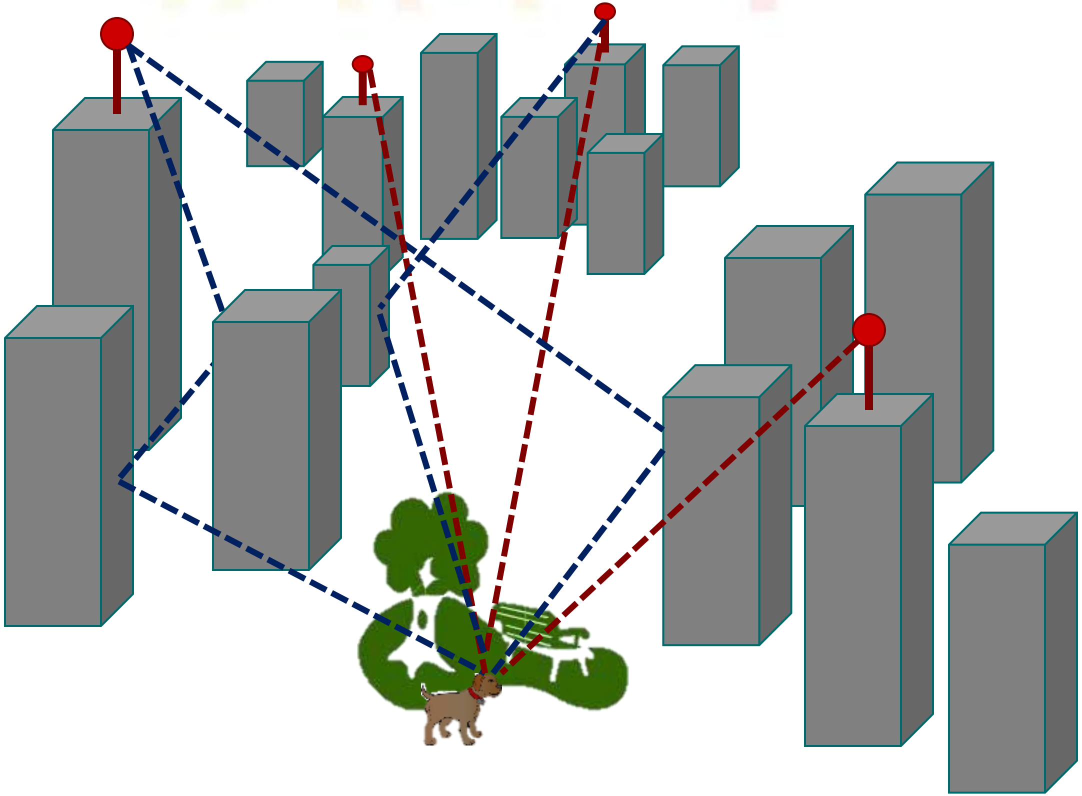
- **Longer perceived delay**
- **Weaker signal strength**

GW receiving *only* multipath signals cause unknown errors

GW deploying antenna diversity helps a lot

Differential signal strength helps

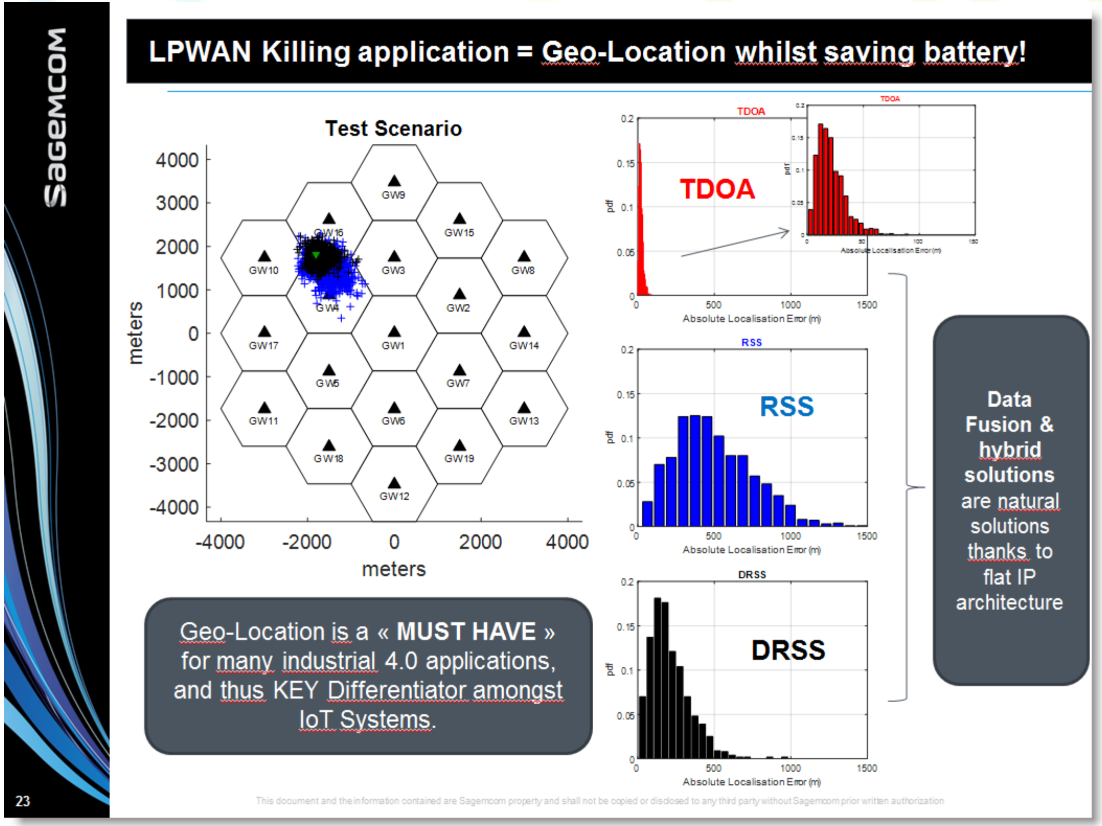
Complex algorithms can be deployed to gain improvement in location accuracy.



Sagemcom at M2M Innovation World

By Kind permission of Thierry Lestable of Sagemcom, some slides from M2M World: here

Calculating Position

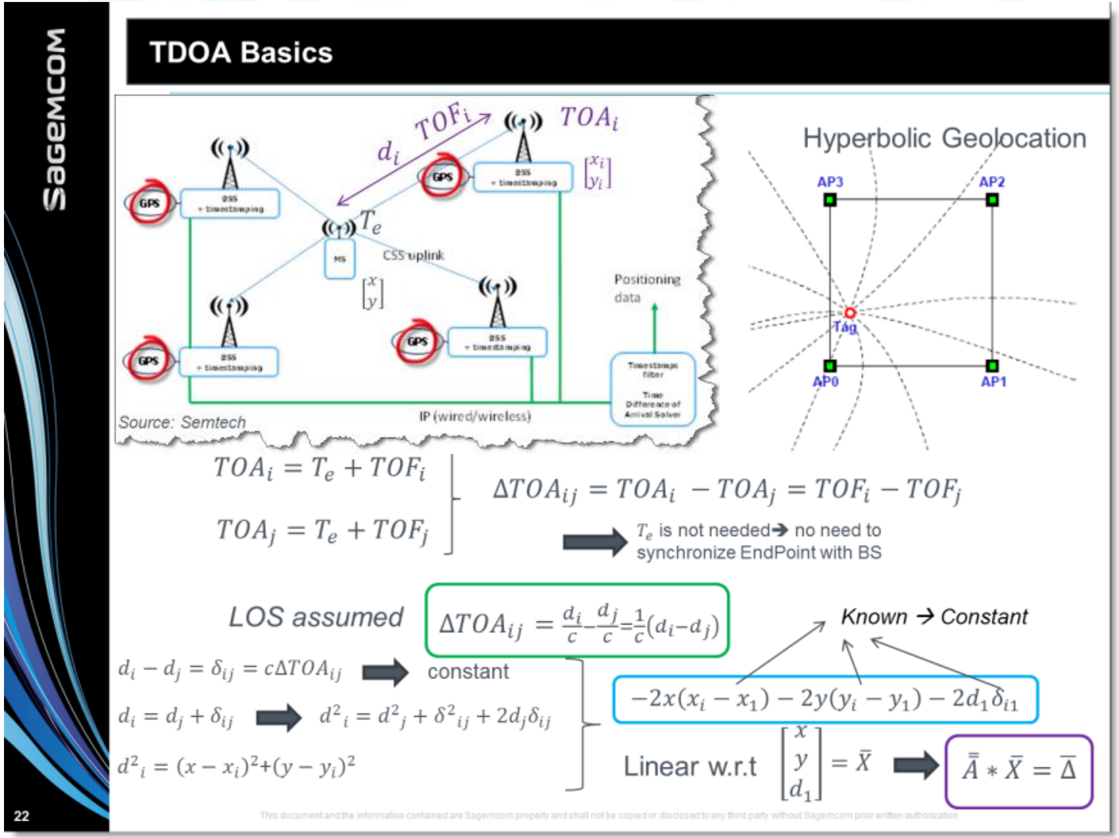


Many groups will work on localisation with different techniques and data requirements.

Here, Sagemcom list:

- **TDOA (time difference of arrival),**
- **RSS (received signal strength),**
- **DRSS (differential RSS)**

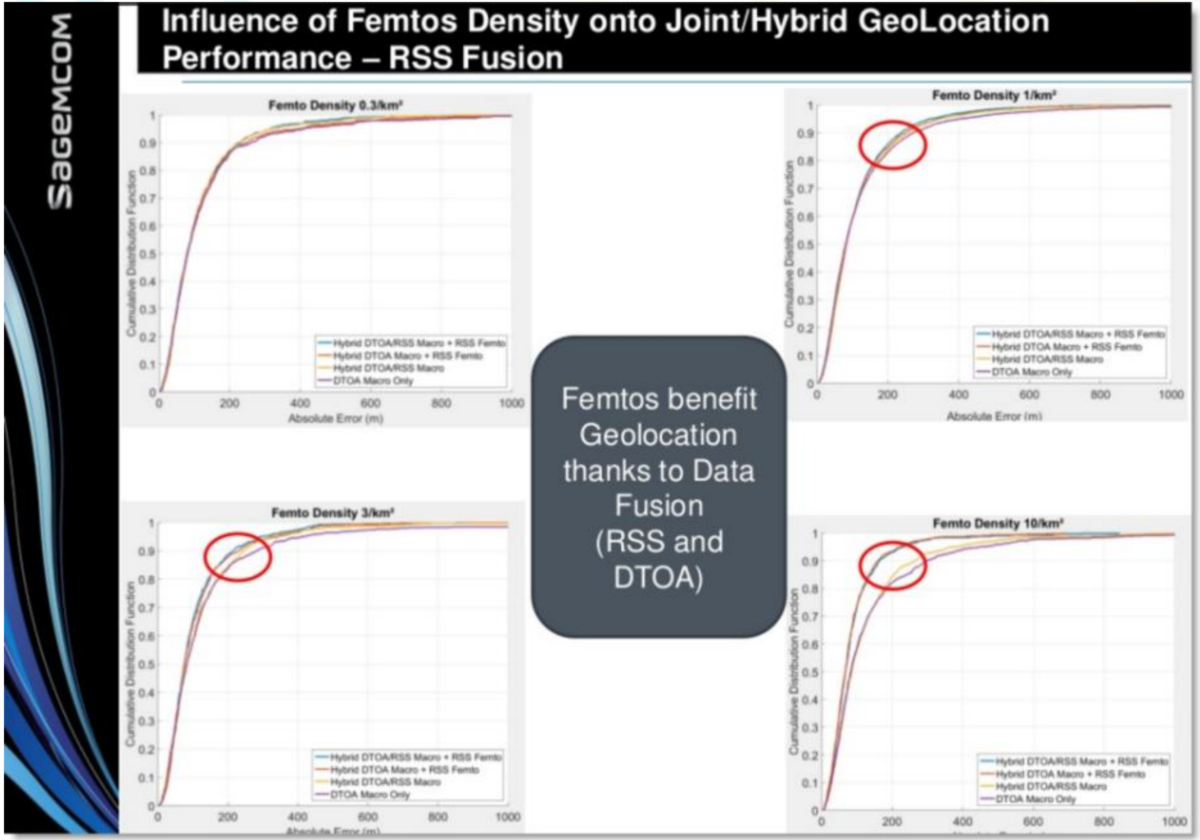
Time Difference of Arrival



GPS shown as a timing reference to all gateways!

Timing accuracies with (GNSS) are expected to be significantly better than 100ns (relative)

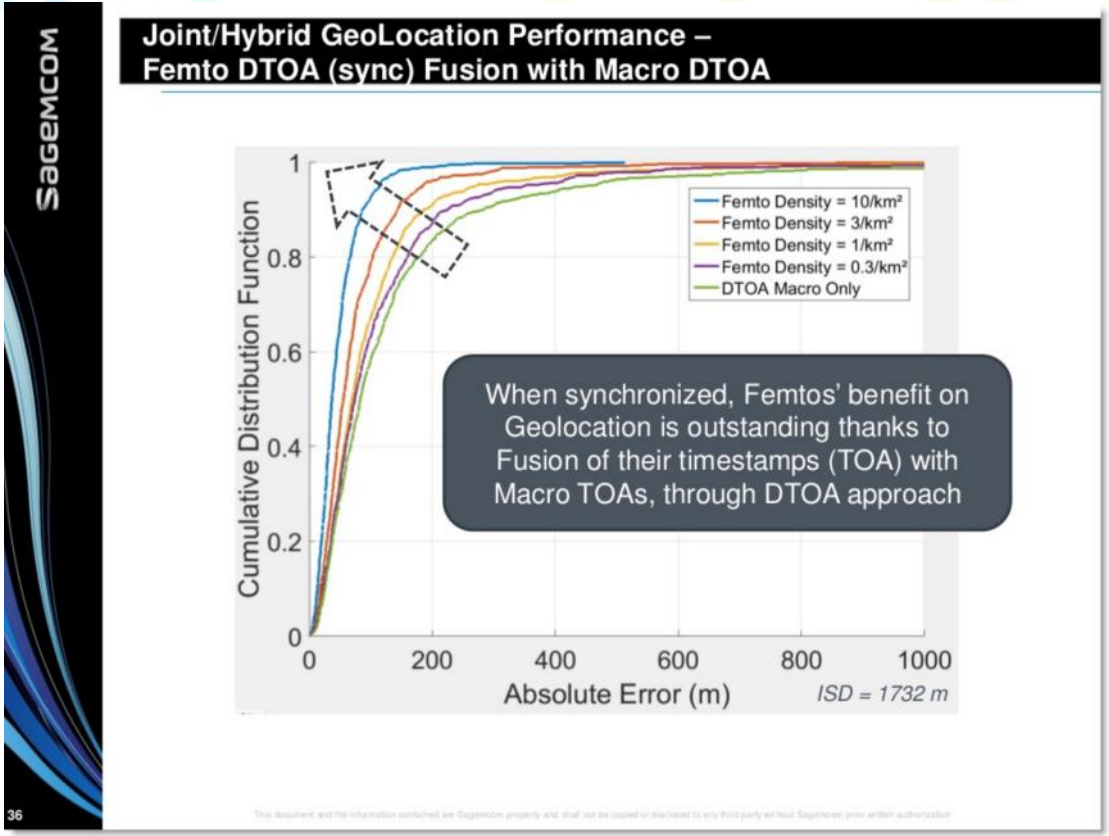
Sagemcom:
Mixing Macro and Femto cells



In this example it is shown that adding together unsynchronised femtocells with the synchronised macrocells has some benefit with increasing deployment

Sagemcom:
Synchronising femtocells for greater effect

SEMTECH



Marked improvement with synchronised femtocells.

Conclusion:
We need an indoor femtocell synchronisation scheme to give better than 100ns alignment!

Summary:
LoRaWAN requirements on synchronization

- This important technology offers the combination of multi-year coin cell battery life, geo-location with low cost sensors

- In order to make full use of indoor location, dense deployment of gateways will be necessary

- Gateways need ‘better than 100ns’ alignment…

The requirements on synchronisation just got tougher!

Thank you!

References

LoRa Alliance Introduction

LoRa Alliance YouTube channel

Sagemcom M2M Innovation world

LoRa community Overview