AntTail

# White paper:

## Technology scan Datacommunications LoRa/NB-IoT/GPRS + mesh

### Suitability for temperature monitoring solutions

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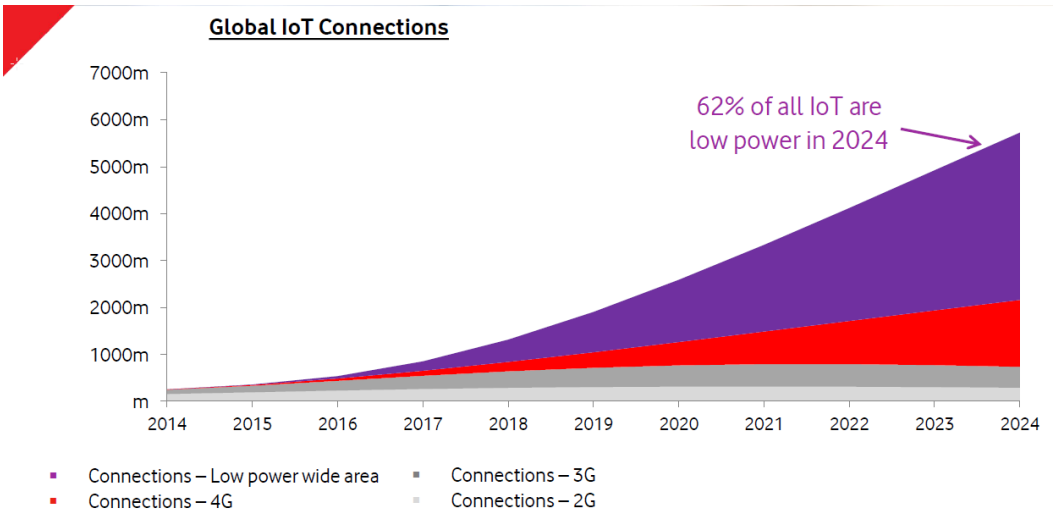
## The Internet of Things: data connections are vital to success

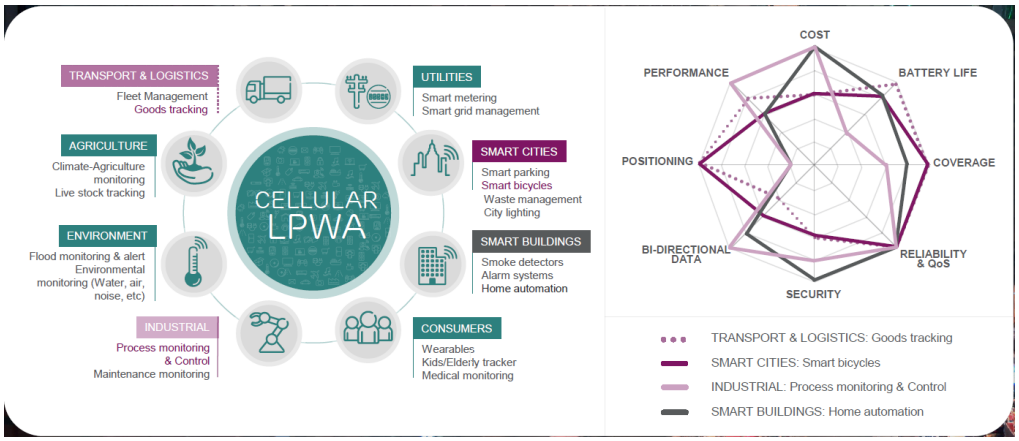
A future where everything is connected and every machine, tool, appliance, packaging and maybe even people carry sensors and chips, is probably closer than we think. Endless possibilities to improve our business and maybe more importantly our lives are at our doorstep but apart from great ideas and applications, we need connectivity.

This technology scan gives an overview of new solutions provided by telecom operators to support the “Internet of Things” (IoT) vision. The predicted 50 billion IoT devices in 2020 will in general be battery powered and will send/receive a very limited amount of data to the server. Whereas in the past telecom operators were focused on providing higher data speed to facilitate voice and video transmission, their roadmap focus is now shifting to solutions which support low data rate and low battery use. This scan describes the developments and planning and compares three technologies; AntTail’meshnetworks, LORA and NB-IoT.




Machina Research Forecasts – Jan 2016

As the number of IoT devices will increase very fast to billions of devices (currently there are 4 billion mobile phone users world wide), it is expected that not one single operator or single technology will dominate the huge market. The choice for the “right” technology depends on the application and expected use and cost.



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# 1. Architecture

This chapter describes the key elements of different solutions and, for reference, the AntTail mesh solution with GPRS gateway that is now available. The AntTail solution for temperature monitoring of vaccines in the pharmaceutical supply chain relies on dependable and secure data transmission to monitor shipments from manufacturer to patient.

## AntTail current solution

AntTail now uses a mesh sensor network for communication between sensors and a gateway. This mesh network is propriety and secured. Over the mesh network many sensors can send their measurement values to a gateway. The gateway combines data of several sensors and sends the data every 5 minutes via GPRS to the AntTail server. As GPRS coverage is good, fully operational and provided by several Telecom Operators in Europe, gateway connectivity is in general no issue anymore.

## Lora

Lora is a communication standard for which currently chips sets are available (from Semtech). Lora uses the free (unlicensed) 868 MHz frequency band in which a radio range of 2 kilometer (low data rate) up to 10 kilometer (outdoor at very low data rates) can be reached.

KPN has adopted Lora and will install Lora gateways/towers to cover the Netherlands. First roll-out is expected by the end of 2016, but the second generation with full functionality is planned for 2018/2019. The Lora gateways will be connected via a wired infrastructure to the KPN backbone server, which will forward KPN Lora messages to the client server via a publish-subscribe mechanism.

Lora chipset prices are significantly lower than GPRS chipset prices and uses significantly lower power. When coverage by the Lora infrastructure is complete, a single (mobile) Lora sensor can be connected with an AntTail server without using a gateway. However, the data rate that can be achieved is very low. KPN does not support sending messages every 5 minutes in their current offerings. Although Lora is a standard, there is a lock-in at the KPN infrastructure when the sensors are activated: they can then only communicate with KPN Lora gateways. The KPN Lora infrastructure will be restricted to the Netherlands, hence there is no complete European coverage and no roaming concept exist for Lora. When the infrastructure of Lora is completely installed, complete outdoor coverage is expected. However deep indoor coverage (e.g. in a fridge in a house, inside a trailer with metal walls) is, based on the radio technology used, questionable.

Although Lora uses significantly less power (for less data) than a GPRS gateway, a much bigger battery is required to reach a lifetime of 2 years compared to the mesh solution where sensors communicate locally via the 2.4 Ghz radio.

Lora will support geo-location requests. Based on the arrival time of a Lora message at different Lora towers (needs at least 3 towers in range of the sender !) the geo-location can be calculated. KPN aims for high outdoor accuracy (< 1 meter) but has, according to current information, yet not achieved outdoor accuracy better than 30 meters.

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## NB-IoT

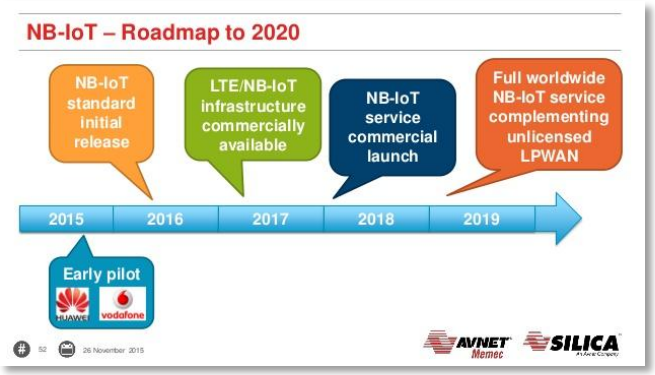
Narrow Band IoT is a new standard which is an extension based on the current 4G standards. Several telecom operators (including Vodafone and T-mobile) will adopt this standard and upgrade their existing European infrastructure (software update) to support this new standard. The planning is end 2016/beginning 2017. NB-Iot uses a small part of the existing, licensed radio spectrum. NB-IoT is suited for bi-directional transfer at a low data rate, but an order higher data rate than Lora. Compared to Lora, sending a message every 5 minutes will not be an issue with NB-IoT.

As data rate is low and less frequent than with GPRS, power consumption will decrease significantly. Another advantage of the lower data rate compared to GPRS is that extra signal modulation can be added and that this yields a better “deep indoor coverage” than current GPRS infrastructure and Lora.

As NB-IoT is focused on low data rate only (and not voice, sms or other) the chip makers can realize new low power chipsets for a significantly lower cost price than the current GPRS chipsets. Such chipsets are expected by the end of 2016 or early 2017. The lower chipset prices will make it possible to realize sensors with NB-IoT integrated directly within them. However, compared with a mesh solution still a 10 to 30 times bigger (volume) battery is required.


*Battery for Mesh sensor (coin cell) versus battery for NB-IoT or Lora sensor (2xAA)*

NB-IoT will be introduced by the telecom operators via a software upgrade of their existing infrastructure. Compared to Lora, each cell/tower can handle much more devices and a cell can easily be scaled up for more sensors by making more bandwidth available in the licensed spectrum. Hence congestion issues are significantly less likely than with Lora. The NB-IoT hardware is open standard and hence there is no lock-in to a single telecom operator after installation.



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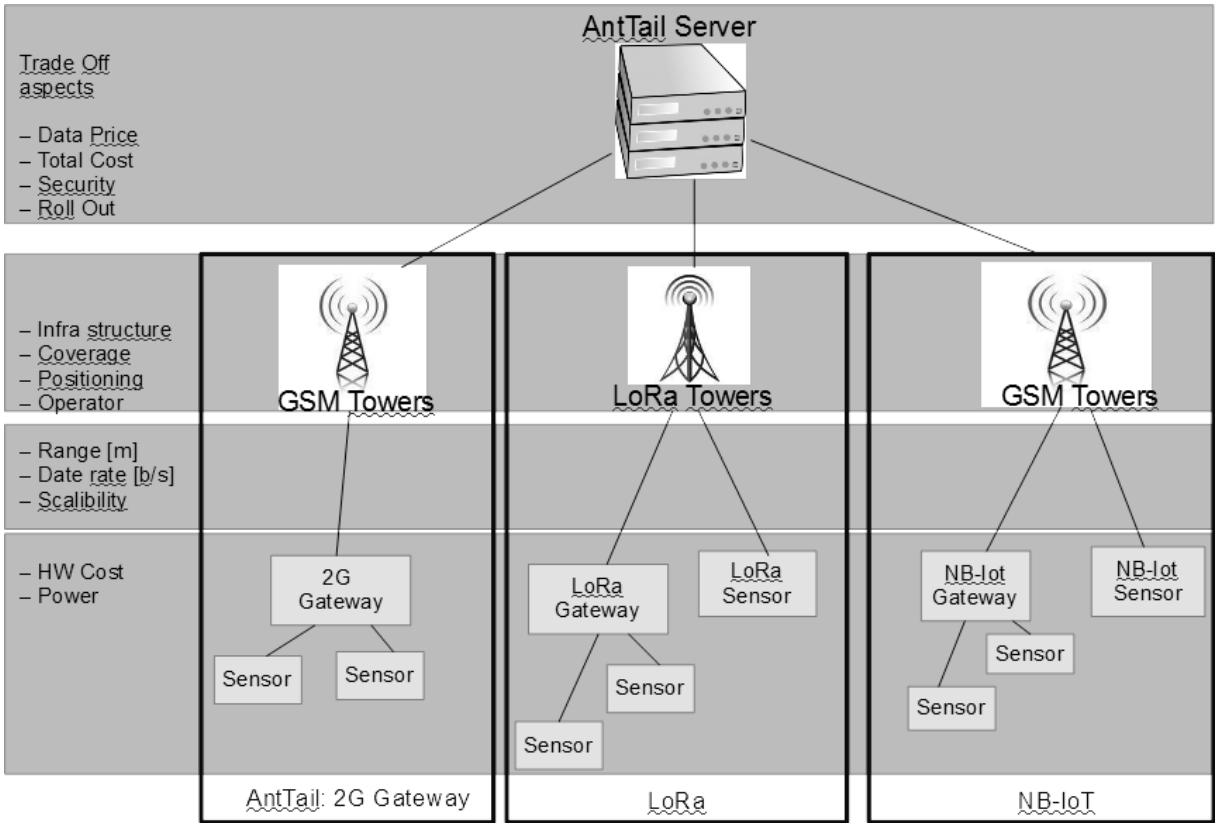


| Aspects | Mesh Network with 2G Gateway | Lora | NB-IOT |
|---|---|---|---|
| **Infrastructure** | World wide coverage, operational | New infra, operator per country. Roll out predicted | Software update of GSM network, European roll out predicted |
| **Radio frequency** | Operator owned, radio spectrum license | Free radio frequency (congestion risk) | Operator owned, radio spectrum license |
| **Battery lifetime Gateway** | NA | 1 year @ 1 message hour (2xAA) | 1 year @ 1 message hour (2xAA) |
| **Bandwidth** | High, two way, low latency | Low, in basic only upload, highest latency | Low, two way, high latency |
| **Message rate** | Continuous | Day / hour rate | Minute/ second rate |
| **Range /Coverage** | Standard (outdoor oke) | Standard (outdoor oke) | Deep indoor |
| **Gateway cost** | 100% (2G) | 20% -10% | 20% - 10% |
| **Sensor cost** | 100% (2.4 Ghz Mesh) | 250% (Lora) | 250% (NB-IOT) |
| **Size sensor** | In mesh, CR2032 based | 2xAA based, | 2xAA based |
| **Sensor life time** | 2 years, @ 12 message hour (CR2032) | 1 year @ 1 message hour (2xAA) | 1 year @ 1 message hour (2xAA) |

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# 2. Cost comparison

The cost comparison is complex as many aspects should be included and prices for new technology and operation are not yet officially released. Cost aspects are:

1. Start up costs: reflects to hardware cost of sensor and/or gateway
2. Installation costs: SIM cost, administration cost
3. Operation costs: Monthly cost of data traffic
4. Maintenance costs: Battery, battery replacement
5. Quality of service costs: cost related with the service not operational, not functional

Even without quantifying the costs, several trends can be seen.

- Hardware costs for gateways based on Lora or NB-IoT will be significantly lower than GPRS gateways;
- Sensor costs based on Lora and NB-IoT will be 2 to 3 times more expensive than sensors based on mesh radios
- Battery size and cost for sensors based on Lora and NB-IoT will be of a higher order than for mesh sensors, and battery life time will still be lower (replacement cost)

## Mesh network with gateway

For situations where several sensors are used within the radio vicinity of a gateway, the mesh solution will outperform the Lora sensor or NB-IoT sensor based on costs. Battery costs will be lower, battery lifetime longer and mesh communication is free from telecom operator costs. As data is combined in the gateway, the available bandwidth is used more efficiency, making even the GPRS data cost lower or compatible with Lora or NB-IoT.

A gateway based on Lora is not efficient, as available data rate is too low (data throughput). An NB-IoT gateway can become an option, as the cost price of a gateway will drop and in particular in situations where a battery-powered gateway (for months/year) is required. NB-IoT technology enables a new application.

Mesh networks with a gateway will maintain the right solution for temperature measuring in e.g. warehouses, distribution locations, cooling warehouses where multiple units are placed, or arrive at a regular interval (to offload stored temperature information).

## Single sensor with Lora/ NB-IoT

Lora and NB-IoT will be more suited and cost effective for situations where a single sensor is used on either a fixed place or a single mobile sensor is required which needs to send its data at a regular interval to the server. The extra sensor costs and battery related costs are less than the extra gateway costs required when a single mesh sensor is used. Actual data cost difference between Lora an NB-IoT cannot yet be compared, but NB-IoT has some technology and infrastructure advantages compared to Lora, such as “deep indoor coverage”, European infrastructure, no telecom lock-in, low latency, and 2-way data.

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# 3. AntTail Roadmap

Both Lora and NB-IoT infrastructures are not fully operational and chip sets are just announced on the market. As far as we know, there are no pharma certified sensors on the market, based on Lora or NB-IoT. Given the infrastructure planning, a full operational solution based on both technologies is not to be expected before Q3-2017. Lora is ahead of NB-IoT with roll out, but as NB-IoT "only" requires a software update of the existing infrastructure, they can probably catch up fast.

The current AntTail mesh network and the AntTail server do maintain their value even when the new technologies become operational. These new technologies offer new opportunities to extend the temperature monitoring in pharma. The following options are identified:

1. Sensors which connect directly to telecom infrastructure via either NB-IoT or Lora. NB-IoT has technology and operational advantages, but for special customer demands also Lora can be considered. Technology integration with AntTail server is possible. With current roll out of Lora by KPN a customer should restrict use to the Netherlands and skip their GMP demand to receive the temperature samples every 5 minutes directly. Size of sensor will increase and/or battery lifetime will reduce.
2. NB-IoT gateway for either low cost gateways or gateways that needs to be battery powered.
3. Combination of sensors that support mesh network (when in range of a gateway) and NB-IoT or Lora when used not in range of a mesh gateway.

**About AntTail**

AntTail provides transparancy in the supply chain. AntTail designs and delivers products and services that monitor the temperature of medicine during transport and storage from manufacturer to end user. Smart sensors allow pharmaceutical companies, health providers and logistic service providers to monitor the temperature of shipments online and assure product quality. AntTails cloud based secure SaaS-solution works with existing cold chain solutions, avoiding investments and complex implementations. For more information: info@anttail.com; www.anttail.com or follow AntTail on LinkedIn and Twitter.