BUILDING A **CARRIER CLASS LOW POWER WIDE AREA NETWORK** FOR **INTERNET OF THINGS**

beecham research

Shaping the IoT future

The IoT (Internet of Things) is destined to be everywhere and include even the smallest things. So long as they have useful data, they can be connected so that data is shared and used to create new value. That includes meters of all sorts, white goods, sensors in public parking spaces, in street lights, in waste bins and many more. Figure 1 gives an idea of just a few of the things that could usefully be connected and their diversity, together with their global population numbers. Some of these, like Commercial Buildings, include literally thousands of additional devices within them.

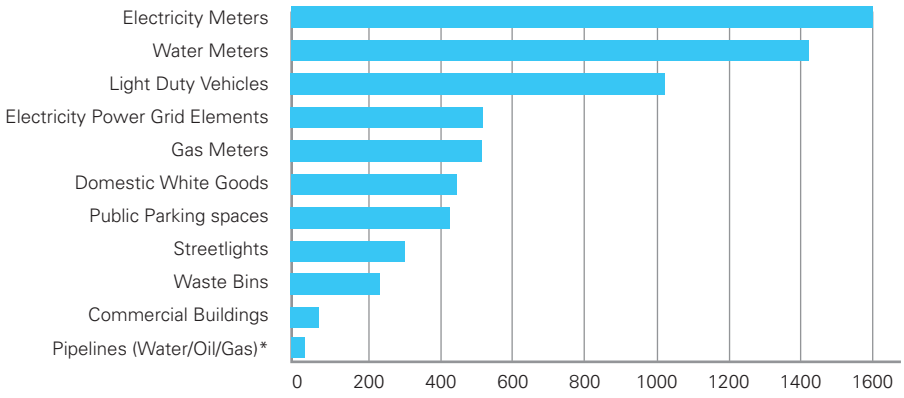

Figure 1: Some of the "things" that can usefully be connected – most aren't
(*One sensor per 100 metres of pipeline)

The problem is, until now, it has been particularly difficult to get this right for all things that could connect to the internet, not just the big or perceived expensive things. There are literally billions of small data endpoints in our world that together can offer a rich picture of what's happening. To do this effectively, cost effective wireless connectivity is absolutely essential, especially if you consider the endpoints may need to connect over long distances. They may be underground, across bodies of water, in remote locations and often inaccessible once installed, and device battery power that last for years, not hours. At the same time, the connection must be reliable. If the data is used as part of a business process or a commercial service, it's often vital that message be reliably received. Service revenue and customer relationships often depend on that. At the same time, the connectivity needs to be low cost and easily deployed. Ideally, it needs to be a fraction of the cost of the "thing" it is connecting and it needs to be available anywhere – everywhere. LPWA (Low Power Wide Area) network technology is designed to meet these challenges.

SIGFOX – CARRIER CLASS IOT CONNECTIVITY THROUGHOUT THE US

This is what Sigfox has been working on in the US over the last three years. Building a highly reliable carrier class national public low power wide area network (LPWAN) that cost effectively connects things that only need to communicate small amounts of data, such as a status update or check-in. Sigfox USA is the US network operator for their parent company Sigfox, where they are deploying and operating the LPWAN in the US region. As of November 2018 this includes network deployment in over 24 of the largest US cities, including 40 of the busiest airports, providing network access to 30% of the population over more than 150,000 square miles. These cities are:

Atlanta	Detroit	Minneapolis	Pittsburg
Austin	Indianapolis	Nashville	San Diego
Boston	Las Vegas	New Orleans	San Francisco
Chicago	Los Angeles	NYC	Seattle
Dallas	Miami	Philadelphia	St. Louis
Denver	Milwaukee	Phoenix	Washington DC

Figure 2: A sampling of markets where Sigfox USA is deployed in the U.S. as of November 2018, with more to come

Many smaller metro areas are also covered, such as Buffalo, NY and Fort Wayne, IN. An up to date coverage picture is available at the following link:
https://www.sigfox.com/en/coverage

In addition to the national network, Sigfox USA offers 'Connectivity as a Service' (CaaS), which is another carrier class connectivity service for areas not currently covered. CaaS is a simple, self-install subscription-based solution that provides the option to purchase on-demand Sigfox connectivity anywhere in the US. With CaaS, US customers can connect thousands of devices at the same per-device subscription fee as the national network, with the added flexibility of getting coverage where it's needed. CaaS is available for both indoor and outdoor deployments, for rural, remote or even deep indoor applications. With CaaS, network equipment is maintained and monitored by Sigfox as well as network uptime and message delivery SLAs, consistent with the benefits offered to customers on the Sigfox network.

SERVICE LEVEL AGREEMENTS – GUARANTEEING THE MESSAGE GETS THROUGH

There are several different implementations of LPWA. Sigfox uses an Ultra Narrow Band (UNB) technology where the network 'listens' to one narrow part of the spectrum. This takes longer than competing schemes to complete a message transfer but does so with higher reliability than other wireless technologies. This approach allows Sigfox USA to offer two Service Level Agreements (SLAs) to its customers: an 'IoT uplink delivery time' commitment of no less than 98%, and a service availability guarantee of 99% per calendar quarter. In the US, the Sigfox service allows for 12-byte (96 bit) message payloads to be sent at a data rate of

600 bps for traffic coming from the IoT device (uplink) to the network. Downlink traffic from the network to the device is carried in 8-byte (64 bit) payloads, as determined by FCC regulations.

COMPLEMENTARY TO TRADITIONAL CONNECTIVITY

Sigfox LPWA services do not compete with existing connectivity services such as Wi-Fi or cellular, rather they complement them. While cellular networks and WiFi operate in synchronous mode, requiring hand-shake protocols to request access to the channel for message transmission and constant 'keep alive' signalling to and from remote devices, Sigfox works in asynchronous mode with its Ultra Narrow Band (UNB) technology. This delivers short messages with high reliability and minimum use of power. IoT applications benefit from the complementary nature of Sigfox and cellular services when deployed in tandem, while new applications for cellular operators are enabled by collaboration with Sigfox.

An example is the tracking of assets in the case of loss or theft. The asset is monitored using a Sigfox connected tracker with a cellular network SIM, which remains quiescent while the object stays within a pre-determined or geo-fenced location. In this mode it is using very little battery power. If the asset is moved out of its allocated area, the Sigfox network will alert the customer while the cellular network begins GPS or A-GPS (using cellular network triangulation) tracking of its location. Using Sigfox services in conjunction with cellular services also maximises connectivity 'up time', essential for mission critical or business critical applications, while conserving battery power.

This approach is already feeding through to product announcements. At MWC Americas in September 2018 GCT Semiconductor, a leading designer and supplier of mobile semiconductor solutions, announced the world's first hybrid (Cellular + Sigfox) solution. GCT's highly integrated single chip GDM72431will support LTE Category M1/NB1/EC-GSM and Sigfox wireless connectivity. For further details about the announcement, follow this link:

http://bit.ly/2RnbCwm

This chipset has passed certification with Tier 1 operators in the US and is available for both module manufacturers and device makers of hardware for tracking, wearables, security, agriculture, healthcare, industrial and consumer applications. At Sigfox Connect event in Berlin on 25th October 2018, a joint announcement with GCT confirmed new module makers, device manufacturers, and SIM card vendors are part of the emerging hybrid connectivity ecosystem and available for customer deployments. See announcement here:

http://bit.ly/2ShY4Te

The partnership with GCT Semiconductor underpins the complementary nature of Sigfox services with existing cellular services, offering a unique capability for IoT applications requiring ultra-long battery life and global coverage at no additional Bill of Material (BOM) cost.

EXAMPLE USE CASES IN US

There are many applications where providing a connection for objects having no or intermittent access to mains or vehicular power supply is critical for operational reasons. Also, for applications where the object is moving some of the time but static at others. An example of this is in Supply Chain monitoring where a product or asset can be in a warehouse, at a dockside, in a retail outlet or in transit. The objective of the customer is to reduce inventory, control timings of deliveries and turn stock or assets into revenue as rapidly as possible.

Examples already running on the Sigfox USA network include the tracking of oxygen cylinders within one of the largest hospitals in Texas. This has saved money and time for the hospital and its suppliers. In another, late season frost has driven the need for commercial apple farmers in Colorado region to monitor temperature upstream from orchards. Threshold alerts are sent to farmers who are able to take protective measures, saving crops and hundreds of thousands of dollars in unnecessary heating. Billboard lighting systems, waste management and ocean floor data harvesting are some of many applications running on the Sigfox network today in the US.

RAPID ON-BOARDING, AND IN BULK

For customers wishing to connect their assets to the Sigfox network, Sigfox offers rapid on-boarding which can be managed in two ways:

- Bundled Subscriptions. The device is pre-on-boarded and auto activates when it sends its first message.

- A la Carte. If a customer decides to purchase devices that do not have subscriptions at time of purchase, the on-boarding process requires an additional step where a file is uploaded to the global Sigfox on-boarding portal. This associates the unique device ID and PAC stored in the NVRAM of the device, along with the external bar code. This provides a unique, secret and encrypted token for authentication against the subscription level purchased. After loading this file, the device sends its first message and the process completes as for Bundled Subscriptions.

The Sigfox network supports bulk on-boarding and can accommodate up to 200,000 device uploads at a time, taking approximately 3 to 5 minutes to complete.

LONG BATTERY LIFE

Sigfox USA offers pricing depending on the number of messages the customer expects to send each day and the number of devices required to connect. The reliability and predictability of the Sigfox network allows a very accurate prediction of battery life for any given application.

Example Applications	Messages/Day	Expected battery life (using same size battery in each application case)
Alarm Notification	1-5	> 10 years
Low Use Sensors	5-25	> 7 years
High Use Sensors	25-100	> 5 years
Location/Tracking	> 100	> 2 years

Figure 3: Estimated device battery life on the Sigfox LPWA network

WIDE RANGE OF DEVICES ALREADY CERTIFIED

The Sigfox protocol is available to chip makers and device manufacturers free of charge with no licensing fee and no follow-on royalties. This has resulted in an extensive ecosystem of semiconductor modules and devices capable of connecting to Sigfox services with some 600 devices either already certified or going through the certification process. The cost of certification is upwards of 10 time lower than cellular certification and varies based on whether the device is a module or chip on-board design. Certification of devices includes not only validation of a product to regulatory standards, such as FCC in the U.S., it also covers certification at the service level, ensuring interoperability for customer applications across the Sigfox global network.

The devices certified today cover a wide range of applications, including:

- Over 60 different Temperature Monitors
- Over 30 different Consumption Meters
- Near 40 various Asset Trackers
- 20+ options for Asset Monitors
- More than 20 Environmental Monitors
- Upwards of 10 Parking & Traffic Monitors
- 10 different Waste Monitors

SIGFOX NETWORK IS SURPRISINGLY SECURE

Security is a complex subject, and in IoT needs to be addressed within all layers of the IoT ecosystem from the semiconductor, to the network, device and platform. These involve working with 3rd party security experts alongside in-house specialists.

Robin Duke-Woolley, CEO, Beecham Research

David Parker, Senior Analyst, Beecham Research

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In the Sigfox network, 12-byte message payloads are split into two with each 6-byte segment encrypted before transmission. As with cellular (3GPP) services, AES is supported at the network level with customers having the option to add additional security at the device level. Sigfox supports custom designed secure element chips from ST Microelectronics and WiseKey that come preloaded with Sigfox network keys, and provide secure tamper-resistant services for data exchanges on the Sigfox network ensuring data integrity and confidentiality. From a security perspective, devices on the Sigfox network are not connected to the Internet and spend 90% of their life sleeping, which also significantly extending battery life. Regarding data in motion, security measures built into the Sigfox protocol include: authentication, integrity, encryption, anti-replay, anti-jamming, data protection at rest via cryptographic storage of data and credentials in devices, base stations, and Sigfox Core Network. Reliability and reliance are both native in Sigfox data centers and intrinsic to the Sigfox network architecture.

For more information on the Sigfox approach to security, follow this link:
http://bit.ly/2BD76ok

For more information on Sigfox and WiseKey and ST Microelectronics, follow these links:
http://bit.ly/2QoCBKV

http://bit.ly/2BHrlkD

IN SUMMARY

- Sigfox offers IoT connectivity on a resilient global carrier class, highly secure, low power wide area network.
- In the US, Sigfox USA is building and operating their own network, in contrast to most other countries where Sigfox networks are built and operated by a partner known as a SO (Sigfox Operator). In just three years, and as of November 2018, Sigfox USA has rolled out coverage across more than 24 major US metros and 40 of the busiest airports, covering 30% of the population and over 150,000 square miles. They continue to expand and densify the network, offering CaaS in areas where coverage is not available.
- Sigfox enables new IoT applications to be deployed which were not feasible previously due to high battery power requirements and high connectivity cost.
- The reliability of the network technology underpinning Sigfox services insures customer data will be delivered to contracted service levels, underwritten by SLAs.
- Customers have a growing choice of Sigfox certified devices for off-the-shelf connection to Sigfox LPWA connectivity.
- Sigfox IoT network services are complementary with existing cellular services and can enable innovative new applications in partnership with them.