

Wi-Fi & LoRaWAN[®] trials

An overview of use cases across regions
combining two powerful technologies

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Founded in 2003, the vision of the Wireless Broadband Alliance (WBA) is to drive seamless, interoperable service experiences via Wi-Fi within the global wireless ecosystem. WBA's mission is to enable collaboration between service providers, technology companies and organizations to achieve that vision. WBA undertakes programs and activities to address business and technical issues, as well as opportunities, for member companies.

WBA work areas include industry guidelines, standards development, trials certification and advocacy. Its key programs include NextGen Wi-Fi, 5G, IoT, Testing & Interoperability, Roaming and Policy & Regulatory Affairs, with member-led Work Groups dedicated to enable interoperability, resolving standards and technical issues to promote end-to-end services and accelerate business opportunities. WBA's membership is comprised of major operators, identity providers and leading technology companies, including, Commscope, Facebook, HPE Aruba, Nokia, Orange, Qualcomm, Rogers, Samsung, Shaw, Swisscom, Softbank, Telstra, Telus and T-Mobile US.

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Its members closely collaborate and share experiences to promote and drive the success of the LoRaWAN protocol as the leading open global standard for secure, carrier-grade IoT LPWAN connectivity. With the technical flexibility to address a broad range of IoT applications, both static and mobile, and a certification program to guarantee interoperability, LoRaWAN has already been deployed by major mobile network operators globally, with continuing wide expansion into 2019 and beyond.

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1. Executive Summary

Selecting an intelligent multi-radio strategy is becoming increasingly more important to succeed in a connected world.

Operators and enterprises are looking to identify, assess, and deploy the optimum form of connectivity that meets the best quality of service for their application at the most compelling total cost of ownership (TCO), primarily including coverage and cost (for both implementation and maintenance). Selecting the wrong radio strategy can have a negative impact on the quality of service, increase costs and deteriorate security.

Until a few years ago, radio connectivity options were focused primarily on cellular connectivity, Wi-Fi connectivity or customized/proprietary private-network connectivity. Today's connectivity options however are able to take advantage of licensed and license-exempt spectrums to include cellular IoT, private LTE, private 5G, Wi-Fi and Low Power Wide Area (LPWA) IoT networks such as LoRaWAN[®].

Wi-Fi and LoRaWAN are two of the most widely adopted license-exempt technologies and together they address a large proportion of current IoT use cases. Both technologies are disrupting private-public business models and enable participation in the 5G spectrum.

In September 2019, the LoRa Alliance and the Wireless Broadband Alliance (WBA) jointly published **“The Wi-Fi & LoRaWAN Deployment Synergies”** white paper, intended to demonstrate how these two widely deployed IoT connectivity technologies can be utilized to effectively support a vast array of use cases. This paper shows to Wi-Fi network owners and/or network service providers how LoRaWAN can be deployed on top of an existing Wi-Fi network and, as a complement, allows for operational cost optimization. It summarizes the strengths of each technology, their individual positions in the IoT ecosystem, their complimentary nature, and the way that both technologies can be easily deployed simultaneously. It also provides testimonials to illustrate successful real use case deployment.

The current white paper **“Wi-Fi & LoRaWAN Trials - An overview of use cases across regions combining two technologies”** takes it a step further and provides details on **practical trials and proof of concept deployments (POC's)**, representing a variety of uses cases implemented across different geographies and verticals.

As Service Providers (operators, ISPs) and businesses are looking to deploy digital transformation programs and are facing increasing complexities around security, large scale deployments, cloud/edge architecture, quality of service (QoS), whilst ROI benefits are not always clear, these trials aim to demonstrate best practices and enable the market to seamlessly develop Wi-Fi & LoRaWAN commercial opportunities.

The trials have demonstrated that hybrid connectivity options can increase the market potential overall and provide a stronger ROI and enhanced solutions. The Wi-Fi & LoRaWAN trials paper outlines best practise deployment approaches, explains the practicalities of network planning for multi-radio access network (RAN) access points and sensors, and includes clear examples of the return on investment.

A brief overview of the trial structure and procedures:

- Assembling the team & leaders—dependency on players from both ecosystems
- Selecting the deployment scenario/vertical
- Selecting the use cases to be tested
- Writing down the test cases and correspondent aggregation in the test plan
- Defining KPIs to be measured and worked on to build tangible ROI metrics
- Executing the trials
- Reporting the results
- Guidelines & best practices

2. Wi-Fi & LoRaWAN® Use Cases

In the Wi-Fi & LoRaWAN Synergies white paper we identified a series of use cases which are summarised as below:

Smart building / Smart hospitality

Wi-Fi use cases

- Personal Area Networks
- High speed surfing
- Broadband services
- Passpoint 2.0 roaming
- Security (cameras)
- Lift shaft monitoring
- Door / locker closure



Hybrid use cases

- Hybrid asset tracking and location services
- Leverage existing Wi-Fi networks
- Hybrid video streaming on demand

LoRaWAN® use cases

- Leak detection
- Sub-metering
- Smoke detection
- Intrusion / presence
- Rodent trap
- Predictive cleaning and maintenance
- Parking management
- Lighting
- Asset / Vehicle tracking
- Irrigation monitoring
- Desk / room usage
- Compliance check / Safety
- Structure monitoring
- Room energy monitoring
- Door / windows openings
- Air quality monitoring
- Cold chain monitoring
- Customer satisfaction

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Smart City / Smart Village

Wi-Fi use cases

- Personal Area Networks
- High speed surfing
- Broadband services for citizens and tourists
- Land page promotion and additional services
- Seamless roaming
- Citizen communication
- Free Wi-Fi programs
- Tourism survey
- Smart building
- Smart health (hospitals)
- Smart village



Hybrid use cases

- Hybrid asset tracking and location services
- Leverage existing Wi-Fi networks
- Hybrid video streaming on demand
- Hybrid video camera piloting

LoRaWAN® use cases

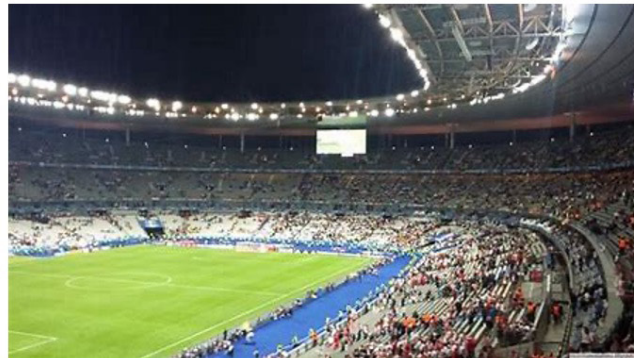
- Water/ gas/ electricity metering
- Streetlights energy and maintenance
- Traffic light monitoring
- Predictive maintenance
- Waste management
- Noise and air quality monitoring
- Optimized Parking management
- People counting
- Manhole monitoring
- Social adult and elderly people care
- Smart building
- Smart health (hospitals)
- Traffic optimization

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Smart Venue

Wi-Fi use cases

- Personal Area Networks
- High speed surfing
- Broadband services for citizens and tourists.
- Land page promotion and addition services
- Citizen feedback collection
- Free Wi-Fi programs
- People checking, counting and authentication
- Cellular traffic off-load
- Seamless roaming
- Big data and analytic



Hybrid use cases

- Hybrid asset tracking and location services
- Leverage existing Wi-Fi networks
- Hybrid video streaming on demand

LoRaWAN® use cases

- Smart building use cases
- Traffic direction
- Entry/ Exit direction
- Lighting
- Trash collection

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Automotive/ Smart transportation

Wi-Fi use cases

- Connected car
- Access control
- Wi-Fi hubs
- Broadband services
- Land page promotion services
- People counting
- Security (cameras)
- Seamless roaming (open authentication)
- Tracking and location
- Asset tracking and logistics
- Passenger entertainment
- Reservation
- Car sharing



LoRaWAN® use cases

- Asset tracking/ logistics
- Inventory / supply chain
- Fleet tracking
- Vehicle maintenance
- Speed management
- Vehicle tire pressure
- Guidance and control systems
- Compliance management
- Parking management
- Smart vehicle
- Toll / ticketing system monitoring
- Driver safety

Hybrid use cases

- Location services.
- Leverage existing Wi-Fi networks

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Smart home

Wi-Fi use cases

- Billions of personal and professional devices deployed in the home
- Home safety
- Entertainment



LoRaWAN® use cases

- Home security and access control
- Energy saving
- Water Leak detection
- Smart lock
- Outdoor garage, gate status
- Door/ window opening
- Alarm system back-up and anti-jamming.
- Smart lighting
- Asset tracking and people / pet geo-fencing
- Garden irrigation monitoring
- Swimming pool monitoring
- Pest traps
- Mail box/ Drop box monitoring
- Insurance use cases

Hybrid use cases

- Embed LoRaWAN® Pico gateway in home hubs relying on Wi-Fi back-haul

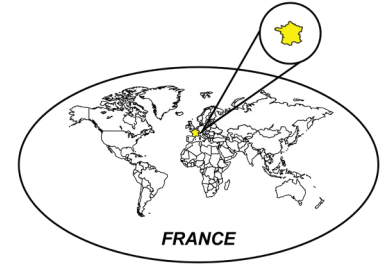
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3. Wi-Fi & LoRaWAN Trials

In this chapter, we present eight trials combining Wi-Fi and LoRaWAN.

We'd like to thank the 11 contributing members that joined us in this adventure: Actility, Abeeway, Boingo Wireless, Charter, Cisco, Kerlink, Lacuna Space, Nesten, Semtech, Simplycity and Skyhook, who actively participated in building this white paper during nine months of intensive teamwork.

Despite the impact of Covid-19, all eight cases in this paper have been implemented, tested and approved and many have moved on to commercial phases.



SMART TRANSPORTATION

INDOOR & OUTDOOR ASSET TRACKING FOR AUTOMOTIVE INDUSTRY

Description

The automotive industry uses many expensive assets that are essential to the production process.

In Venissieux Volvo Trucks factory, hundreds of special racks are used to carry engines along the production chain, spreading over 25,000 sq. meters fully covered by 60 Wi-Fi APs. They can easily get lost, and a missing rack can block the entire production chain.

Volvo, Abeeway, Actility and HERE Technologies collaborated to build the indoor tracking infrastructure leveraging Wi-Fi fingerprinting technology and an industrial grade LoRaWAN network. Abeeway's industrial trackers collected the Wi-Fi AP information and relayed the measurements over LoRaWAN for accurate position determination by HERE. The main challenges of the project were the usage conditions (+70°C when racks go through the painting process) and 5m target location accuracy.

Key Primary Indicators

- Rapid Roll through production process optimization
- Indoor & outdoor geolocation combined with Abeeway tracker technology
- Accurate indoor location in a 35,000 sq. m. facility
- Harsh temperature and RF industrial conditions where Wi-Fi and LoRaWAN macro-diversity was key to achieve QoS.

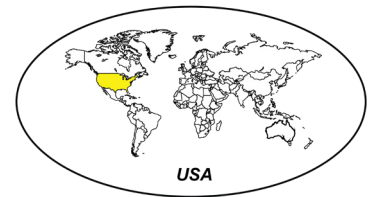
Key Takeaways & Next Steps

- Indoor location leverages existing Wi-Fi APs
- ThingPark® optimized LoRaWAN® controller leverages macro-diversity to provide reliable communication throughout the factory with few gateways.
- Abeeway trackers' low-power consumption and motion-optimized algorithms allows multi-technology trackers to operate for years.
- BLE beacons can complement the location infrastructure at strategic points.

See more about this use case

<https://www.youtube.com/watch?v=M1TUEzcc5Q0>





Description

As part of its Smart Building strategy, Boingo is exploring opportunities to leverage its existing network infrastructure in multifamily projects to provide a service beyond Wi-Fi that includes LoRaWAN IoT devices like thermostats, door locks, lighting, hubs, and sensors that help owners increase revenue and decrease costs.

Potential use-cases for the integration of Wi-Fi & LoRaWAN technologies in multifamily properties include:

- Leak detection sensors located in difficult-to-reach places where replacing batteries is challenging for multifamily property managers
- Temperature, humidity, carbon monoxide and other sensors that might be in stairwells, HVAC rooms or parking garages without Wi-Fi coverage.
- LaaS (LoRaWAN-as-a-Service) where Boingo could place LoRaWAN antennas and gateways on rooftops or even indoors in IDF closets to offload traffic from sensors that are external to a multifamily property equipped with Boingo Wi-Fi network infrastructure (e.g., sensors in other buildings, smart city sensors, etc.).

Deployment

Smart Building multifamily properties have three components (See figure 1):

- Wi-Fi subsystem (AP's, Client devices, remote (or local) WLC, & remote NOC)
- LoRaWAN subsystem (Gateways, sensors & remote Network & Application Servers)
- Common Network Infrastructure (Ethernet switches, cabling and remote diagnostic & monitoring management)
- "A typical Smart Building multifamily property for the Boingo Wi-Fi and LoRaWAN field is shown in Figure 2."

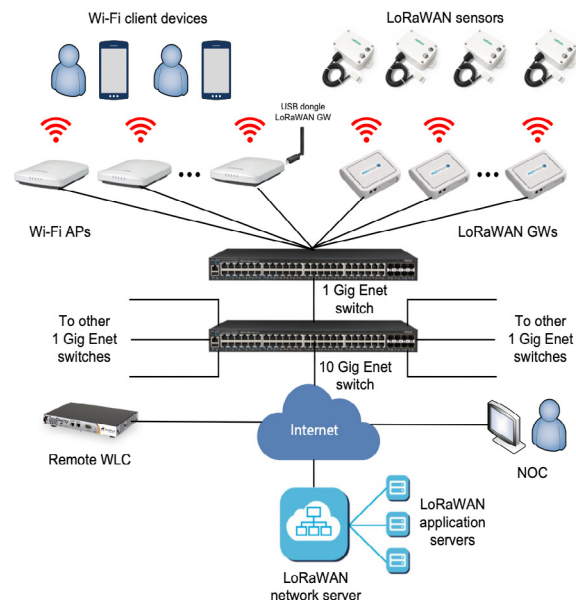


Figure 1 Wi-Fi and LoRaWAN network architecture for multifamily property



Figure 2 West Half multifamily property in the Ballpark District of Washington, D.C.

- Ethernet network infrastructure: average data rate, network capacity
- RF coverage metrics: Wi-Fi AP RF coverage and LoRaWAN gateway coverage
- Reduction in number of interventions for remote control use cases
- Reduction in damage costs (e.g., flood detection)
- Battery life
- Security alerts

Key Performance Indicators

The KPIs tracked during the field trial were:

- LoRaWAN: RSSI, SINR, average data rate, average delay, network capacity, range, projected battery life, deep building penetration
- Wi-Fi: RSSI, SINR, average data rate, average delay, network capacity

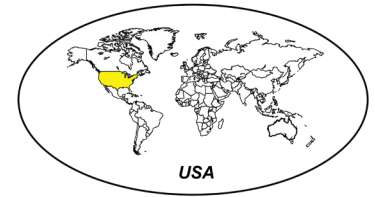
Key Takeaways & Next Steps

Key takeaways:

- Ease of customer operations
- Cost reduction
- IoT device proliferation and new services

Next steps:

- ROI for this use case needs to be evaluated before proceeding further
- Design methodology and tools for integrated Wi-Fi & LoRaWAN networks need to be developed



SMART CITY SMART LIGHT POLE

Description

As part of its Smart City strategy, Charter Communications is offering solutions to cities and businesses based on multi-Radio Access Network technologies. Two of the key technologies that are used for smart city applications are Wi-Fi & LoRaWAN.

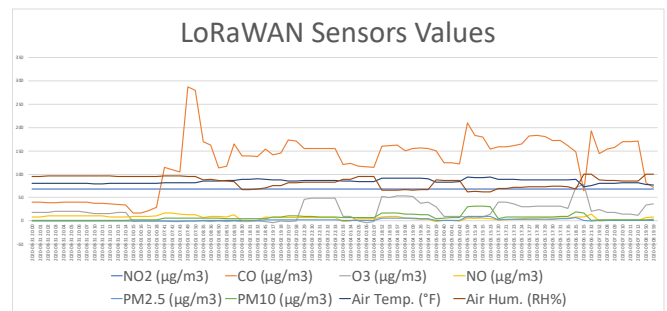
An example of the innovation that Charter is driving with its partners for the city of tomorrow is the Smart Light Pole. In this initiative, the pole is not only used for lighting, but its real estate is used to fit more sensors and devices to help cities understand their levels of noise, pollution and to engage in motion sensors (to optimize brightness of the lighting) and panic buttons (to enable citizens engagements and alerts real-time). The pole should fit in with public access points to deliver connectivity to other city applications such as video/roads monitoring services and enable smart intersections (to reduce and prevent road accidents) as well as high-speed connectivity for consumers.

Future Development

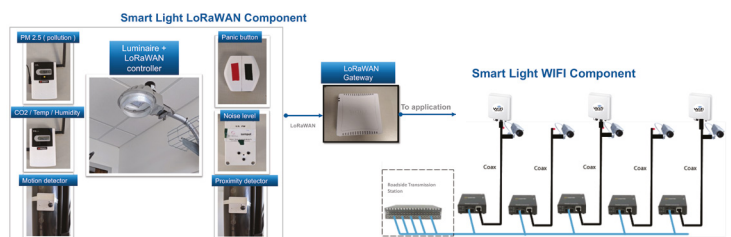
The Smart Light Pole has two components: a LoRaWAN subsystem for the battery powered sensors, and a Wi-Fi subsystem to serve the higher throughputs for demanding city applications.

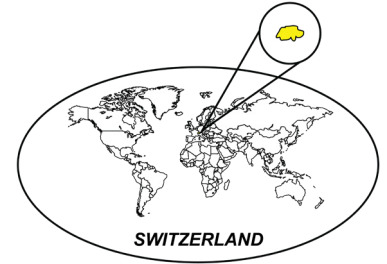
Key KPIs & Takeaways

The KPIs that we're tracking throughout this PoC are End-to-End latencies, throughput and mitigation of the pop-corn effect capability for lights in LoRaWAN; and Wi-Fi AP average loading, average user throughput and average needed backhaul bandwidth for the Wi-Fi subsystem



Smart Light Pole and its control dashboard – SCTE Demo





SMART INTERCONNECTION

OPENROAMING™ & LoRaWAN (ORL)

Description

This use case describes field trials of extensions to WBA's **OpenRoaming™** platform for LoRaWAN networks. Comprised of a federation of identity and network service providers, OpenRoaming provides seamless, secure and scalable, standards based roaming of end-devices between federated LoRaWAN networks.

Deployment

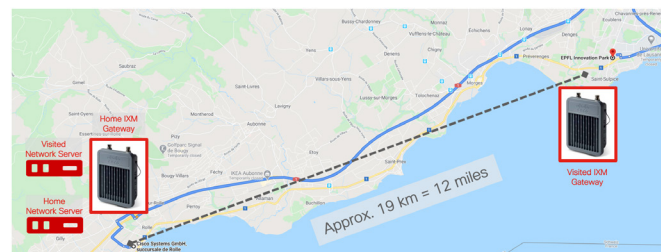
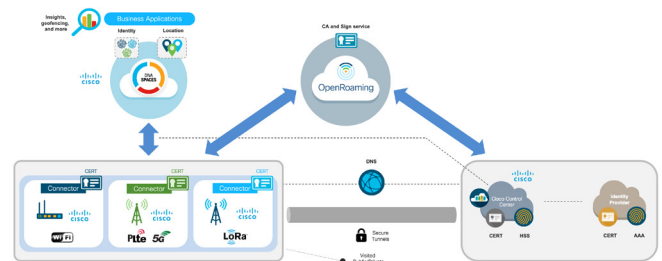
The Cisco field trial of ORL is currently servicing two networks, using two LNS providers, and located 20km apart on Lake Geneva, Switzerland. ORL is successfully activating and roaming devices between their home and visited networks.

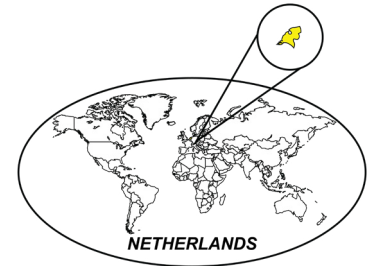
Key Primary Indicator

Once connected to the federation, ORL provides standards based roaming without the need for centralized communication hubs. Scale is achieved as home and visited networks communicate directly. ORL further provides a multi-RAN network operator; the ability to support multi-technology end-device roaming with a single set of backend infrastructure.

Key Takeaways & Next Steps

- Extends WBA's OpenRoaming standard.
- Federates identity and network providers.
- Leverages LoRa Alliance Passive Roaming.
- Multi-RAN providers can use a single roaming infrastructure.
- Providers are centrally authenticated.
- Once authenticated, scale is provided as networks communicate directly.





SMART RETAIL

Wi-Fi & LoRaWAN IN STORE RETAIL ANALYTICS, BY KERLINK & SMART TRAFFIK

Description

Kerlink, a specialist in solutions dedicated to the Internet of Things (IoT), and Smart Traffik, a retail-analytics solution provider for brick-and-mortar merchants, have built a responsive end-to-end system combining Wi-Fi & LoRaWAN to enable retail outlets to create personalized shopper experiences and build brand loyalty by enhancing visitor in-store journeys.

Leveraging Kerlink's **Low Power IoT Reference Design**, the two companies designed the Smart-Box™, a plug-and-play anchor that anonymously collects store visitors' smartphone Wi-Fi signals in real-time and transmits the information through its LoRaWAN link. The system then combines Kerlink's **Wirnet™ iFemtoCell-evolution** indoor gateways and its **Wanesy™ Management Center** to transfer the information to Smart Traffik's instore data analytics solution.

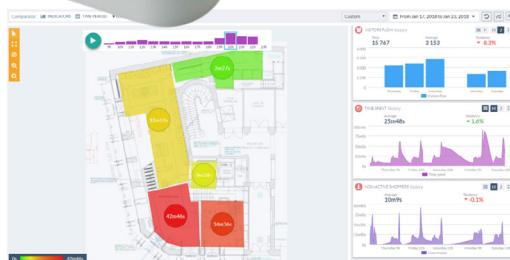
Benefits

- GDPR compliant solution
- No app needed: anonymized tracking of smartphones Wi-Fi probe requests*
- Cost-efficient and easy to deploy end-to-end solution: small size and long range
- Best combination of several complementary technologies: Wi-Fi, LoRaWAN & 3G/4G
- Non-intrusive installation, independent from the retail shop IT
- Merge drive-to-store and in-store data
- LoRaWAN in-store private network enabling multiple additional use cases (energy, tracking, fire detection...)

*A probe request is a network frame automatically sent by a smartphone to find a new Wi-Fi service in order to pair to it

Key Takeaways & Next Steps

Increase share-of-pocket. By digitalizing point of sales, retailers seek to optimize and to measure the effectiveness of their marketing strategy and commercial campaigns, to attract new customers, to improve their customer journey and to increase their overall spending. **Phygital** leverages innovative tools and puts cutting-edge technologies within reach of the general public to improve customer instore shopping experience, to create interactivity and responsiveness, to strengthen customer loyalty, deepen customer intimacy and adoption of in store analytics shall be generalized in the coming months.





SMART TRACKING

TRACKING WITH LoRa EDGE™ AND SATELLITES TO RESOLVE HUMAN-WILDLIFE CONFLICT

Description

Since 2018, Smart Parks has been using the IR-NAS OpenCollar tracker for the protection of endangered species, humans, and the environment. The device also uses Lacuna Space LoRaWAN satellite connectivity when it falls outside network coverage.

For this deployment the product was upgraded with the LoRa Edge geolocation platform and the LR1110 chip, also featuring GNSS and Wi-Fi scanning. This means that the device was able to acquire the position coordinates of animals through GNSS scanning or Wi-Fi signals from beacons or inhabited areas, when close by. Data was communicated over either terrestrial or Lacuna Space LoRaWAN.

Beyond expanding the trial to other wildlife parks, IRNAS is launching a series of asset trackers using LoRa Edge and Lacuna Space. Tracking seamlessly from indoor (Wi-Fi) to outdoor (LoRaWAN) to Everywhere (satellite).

Key Primary Indicators

The product performance was validated in the field with 10+ elephants to prove:

- Battery life increase from 5 years to 10 years
- Equal positioning performance as the currently used U-blox M8Q for positioning
- Impact on cost and ease of customer operations

Key Takeaways & Next Steps

IRNAS feedbacks have so far shown:

- For 4 hour position fixes—13 times more power efficient and 5 times for 30 minute fixes
- Extending battery life from 1 year to over 8 years without noticeable impact on geolocation performance.
- Saving on cost and effort of monitoring and replacing batteries in sensors
- Enhanced security





SMART CITY

ENERGY MANAGEMENT AND PEOPLE ATTENDANCE MONITORING

Description

Smart Energy Management

This project aims to track energy consumption across 11 buildings belonging to a Local Government (local council) in Western Australia.

Local Government wanted to add new data streams and display data on a simple, easy to understand platform that would work without multiple license fees.

The various data streams come from solar systems, energy management systems, sensors for energy consumption, and crowd density monitors for events. One of the requirements was future expansion of the system to potentially add irrigation, soil monitoring and other possible sources of data.

The overall system is a mix of technologies; the solar inverters send data using Wi-Fi technology while energy consumption sensors are LoRaWAN based devices.

Smart Park Project

The goal of this project was to build, design, implement and measure efficiency (people attendance) of new parks in cities. Furthermore, the system was designed to provide water quality and air quality data to the Local Government departments as well as the Western Australian water authority.

Key Primary Indicators

Project design has been coordinated with horticultural specialists, electrical consultants and

representatives of the Local Government. The entire project revolves around the purpose of converting an unused storm drain area into a place of relaxation, an interactive park where local residents can relax and enjoy their natural surroundings. In order to measure the benefits and the success of this project as well as expand environmental data collection capabilities, SimplyCity Australia proposed a hybrid solution.

Environmental sensors collected data from the existing waterways as well as air related data and send it through the newly deployed Wi-Fi network. Other sensors such as crowd density counters (people counters) and control relays for local pumps used the existing LoRaWAN network.

They detected the presence of smart Wi-Fi devices (such as phones, tablets, watches) within a dedicated detection area and transmitted the count of these devices via LoRaWAN network to the dedicated dashboard. The information collected during these events has been an invaluable tool for the organisers as it provided a clear image over the crowd movement, the success of certain exhibits and the general visit trends. The data collection and transmission is seamless and the end result is fast, accurate, and plentiful information regarding environment, usage and energy efficiency.

By implementing a combination of technologies, the Local Government maximised the use of the investment and proved that when necessary, a hybrid technology can deliver excellent results.

Key Learnings

Smart Energy Management

Hybrid technologies with Wi-Fi & LoRaWAN allow fast integration of various devices from many vendors. The customer benefits included a reduction in spend on single-use of non-proprietary software platforms. As long as the equipment communicates using an open protocol, new IoT platforms will provide better functionality for a reduced investment. This particular project was an excellent learning experience outlining the importance of cross-platform development and protocol integration.

Smart Park Project

It is proofed that there is no single technology solution for all. The Smart Park Project makes use of the Wi-Fi infrastructure for high volume data transfer. This traditional wireless technology approach allows the customer to provide visitors with free Wi-Fi connectivity as well as aggregate and transfer its own data.

The deployed LoRaWAN technology facilitates the temporary installation of crowd density sensors. Once the park is fully functional and the measuring time window has lapsed, the sensors will be re-deployed in other areas of the same Council with no need for investment in infrastructure. Furthermore, due to the fact that there is LoRaWAN coverage in the park, other temporary or even fixed sensors can be quickly deployed without the need to implement TCP/IP security policies on very small devices.

Future Development

Smart Energy Management

The ease of integration of the newly implemented system has opened up a plethora of possibilities. Some of the actions already flagged as avenues for increased utilisation of the system are:

- Water usage monitoring/water efficiency monitoring for leisure centres and public water parks
- Energy monitoring of public spaces
- Energy and usage monitoring of places that are hired to the public and organisations

All these are ready to be integrated. Already, SimplyCity Australia has trialled a public pool water consumption monitoring application interfacing directly into the pump control system. The results have been extremely well received. This ensures that the platform has multiple uses and that technologies are used to their full potential.

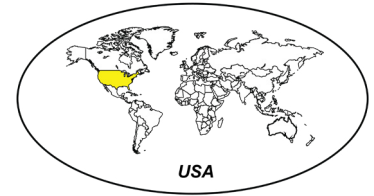
Such a broad project also demonstrates without a shadow of a doubt that hybrid systems where communications paths such as LoRaWAN and Wi-Fi are complementary and when used in the right context can deliver the best return on investment for the customer.

Smart Park Project

The Smart Park Project has already been earmarked for future opportunities, particularly around citizen science and environmental monitoring.

The Local Government plans to share the data collected by the various sensors with local schools and citizen researchers to stimulate and encourage scientific analysis. Furthermore, the grounds of the park will potentially be used for school studies, science based field trips and also to test the community's response to various events organised.

The in-house platform allows for easy integration and addition of new sensors. This will harness the ease of deployment of LoRaWAN sensors and combine it with the high-volume transfer capabilities of the Wi-Fi technologies.



SMART CITY

INTEROPERABILITY BETWEEN WI-FI & LoRaWAN AT THE NETWORK LEVEL

Description

Two of the key technologies that are used today for IoT use cases and applications are Wi-Fi & LoRaWAN.

Nestén's intelligent network provides access across both technologies. **Skyhook** location services allow geo-locating IoT devices across either technology using Wi-Fi scans.

Nestén and Skyhook partnered to demonstrate and study interoperability between Wi-Fi & LoRaWAN in this trial. The goal of this trial was to improve the handover process by geo-locating the IoT tags (using Wi-Fi scans) and determine if they were within coverage of any LoRaWAN Gateway. Signal-strength handover criteria was also explored.

Deployment

The Nestén's wireless nodes and tags can support both LoRaWAN and Wi-Fi and handle the interoperability based on signal strength and packet error metrics as well as Skyhook's geolocation databases.



Key Primary Indicators

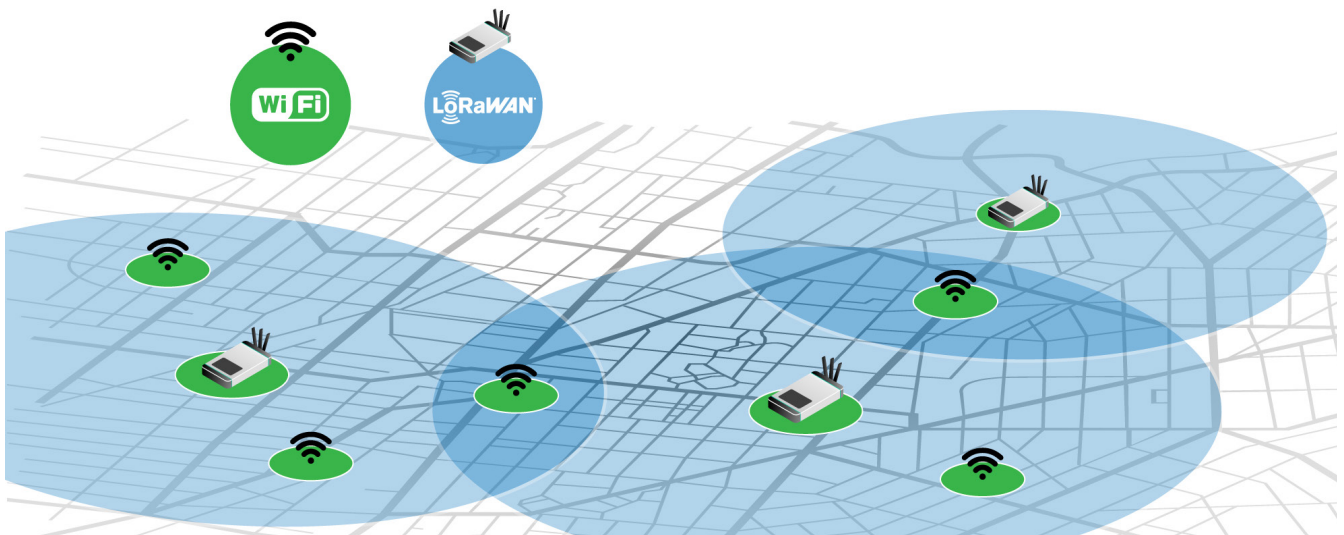
KPIs that were tracked throughout this Proof of Concept are:

- Interoperability/Roaming:
 - Handover from LoRaWAN to Wi-Fi
 - Handover from Wi-Fi to LoRaWAN
 - Signal Strength metric for roaming
 - Packet error metrics for predefined data patterns when handover
 - Wi-Fi coverage for roaming
 - LoRaWAN coverage for roaming
 - Data throttling when transitioning from Wi-Fi to LoRaWAN and vice versa
- Coverage Metrics:
 - Wi-Fi AP coverage
 - LoRaWAN gateway coverage

These KPIs were used to monitor & evaluate Nestén network coverage. In addition, the KPIs were used to optimize IoT devices bandwidth utilization by allowing apps to send more traffic while devices connect on Wi-Fi and less when connected on LoRaWAN. Handover and coverage decisions are based on low power Wi-Fi sniffing and Skyhook crowd-sourced global databases of access points.

Takeaways

- Demonstrated the value of Wi-Fi to LoRaWAN and vice versa handover for device applications. Handover support allowed dynamic data traffic increase when device connected to Wi-Fi and data throttling when out of Wi-Fi coverage and only LoRaWAN coverage.
- Understanding of hardware/software resources, processing steps, data throttling, and management packets required for successful handover from LoRaWAN to Wi-Fi and vice versa
- Results from field test demonstrate the benefit of aggregation of geo-coverage KPIs and signal based KPIs for optimal handover and coverage decision. Combining multiple KPIs allows to increase successful handover rate.
- Trial data provides characterization on handover process associated latency and RAT handover support for applications that are delay tolerant (in tens or hundreds of milliseconds range).



4. Conclusion and Key Learnings

As frequently highlighted in many IoT papers, the key challenge of IoT is to unlock the benefits of the data through analytics and also to serve use cases in different verticals. It raises the question of how to merge valuable information coming from Wi-Fi & LoRaWAN networks. The interconnection may happen at multiple levels, as illustrated in the **8 trials presented in this white paper**.

- **Silicon level:** dual/multi-radio access technology (RAT) modules embedding Wi-Fi and LoRa chipsets on the same silicon or module to address combined use cases. Location services mentioned in this document are a good example of implementation. **We see this Interconnection option in Actility, Kerlink, and Lacuna Space use cases.**
- **Edge compute level:** It means that LoRaWAN network server and Wi-Fi IoT controller functions are collocated on-premises (gateway, MEC, fog). This architecture makes sense in scenarios where the deployment is in remote areas where back-haul latency is an issue and Cloud functionalities can be directly backhauled through satellite connection or scenarios where decision is time-sensitive and data needs to be processed locally. As mentioned earlier, LoRaWAN gateways and Wi-Fi Access Points can also be embedded in the same hardware. **Charter Communications, Simplicity, and Boingo use cases aim to collocate Wi-Fi Access Points and LoRaWAN Gateways when possible and relevant.**
- **Cloud/platform level:** application servers are able to manage payloads coming from different IoT technologies and process and store this data. **This option to leverage multi-network deployments while collecting data on the same IoT platform have been chosen by all contributors and became a wide IoT trend.**

Through these trials, we showed that LoRaWAN and Wi-Fi collaboration can address a large and diverse set of use cases based on the above types of architectural choices. One particular use case addressed the expansion of **Wi-Fi OpenRoaming™ to LoRaWAN**. This topic deserves to be further investigated in the next months to see how it will support **LoRaWAN** ecosystem interconnections.

Based on the success of the **Wi-Fi & LoRaWAN** trials, we expect to publish a second version of **Wi-Fi & LoRaWAN Trials** with more use cases in 2021, as well as bringing more data on the eight already completed.

5. Summary

Wi-Fi & LoRaWAN are two of the most adopted license-exempt technologies and together they address a large proportion of IoT use cases. The approach for these technologies is disrupting private-public business models and enabling participation in 5G success.

As mentioned in the Introduction, our purpose in writing this white paper was to demonstrate across trials how Wi-Fi & LoRaWAN technologies are complimentary in nature, illustrate the potential deployment options and highlight key takeaways for each of the trials.

Our goal is to inspire Network Operators, Enterprises or Communities who have deployed either Wi-Fi or LoRaWAN Networks to consider extending their offerings by deploying the other complementary technology and to give an existing market player who has deployed both technologies new ideas for how to leverage their networks to support innovative use cases.

We want to thank and congratulate the **11 companies** of both Alliances from all regions, contributing and bringing meaningful and insightful content. The Americas, Europe and Asia are represented with all types of market actors: Actility, Abeeway, Boingo Wireless, Charter Communications, Cisco, Kerlink, Lacuna Space, Nesten, Simplycity, Skyhook and Semtech.

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We hope that the white paper will help to accelerate IoT adoption. Stay tuned, more contributors are working on a second version of Wi-Fi & LoRaWAN Trials!

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