

# India

## Smart AMI Water Meter LoRaWAN<sup>™</sup> Whitepaper

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Release Date: 10 February 2018

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## 1 Introduction

In today's India, the Government of India has implemented a program to enable the development of smarter cities leveraging cutting edge technology which will create a more scalable and sustainable environment for an ever-growing population. The Smart Cities Mission is an urban renewal and retrofitting program sponsored by the Government of India with a mission to develop 100 cities across the country making them citizen friendly and sustainable. This effort will bring forward many advancements to cities to include smart infrastructure, smart governance, smart utilities, and smart citizens.

This white paper makes an effort to demonstrate how smart technologies can solve current problems present in India and also contribute to the overall Smart Cities Mission leveraging creative analytics, cloud-based data processing, and cost-effective infrastructure and solutions.

## 2 Audience

The audience for this whitepaper is Smart City decision makers, Community Leaders, System Integrators, Service and Solution Providers, Enterprises, and others intending to contribute to India's Smart Cities Mission by leveraging Low-Power Wide-Area Network (LPWAN) technology. This whitepaper will describe the technical capabilities of LPWAN technologies with focus on the LoRaWAN<sup>™</sup> protocol and how it has successfully been deployed in a live Proof of Concept (PoC) using Smart Ultrasonic Water Meters leveraging Advanced Metering Infrastructure (AMI) in India.

## 3 India's Water Challenges

Water has become one of India's leading topics of discussion amongst government, cities, and urban decision makers in the recent years. Water scarcity, water pollution, and water consumption have fast become some of the most challenging issues to address for cities in India today. Currently, India ranks 133<sup>rd</sup> out of 180 nations for its water availability and 120<sup>th</sup> out of 122 nations for its water quality. Some of the key factors to this crisis are related to increased water consumption and wastage in urban areas, industrial growth, political and regulatory disputes, water cycle imbalances, increased irrigation due to agricultural demands, and lack of technology. In addition to mentioned factors above, the overall population, which is expected to increase to 1.6 billion by year 2050, is also contributing to the water crisis in India. According to Central Water Commission (CWC) report, water levels in 91 major reservoirs in the country are at just 25% of capacity, 30% lower than last year and 25% less than the average storage in a decade. It is estimated that India's water sector requires an investment worth US \$13 billion to tackle these difficult problems. Hence the need to put technology in the fore front of this problem is the need of the hour.

## 4 Introduction to Smart Water

The term "Smart Water" describes how water and water infrastructure can efficiently be transported, distributed and effectively managed to ensure water is saved and leveraged properly. Incorporated into the smart water process are systems designed to gather, analyze, detect, and notify concerned parties about the current water flow, consumption, distribution and cleanliness of a city's water. Leveraging cutting edge technology to send water data over long distances, wirelessly, at low-cost are key factors in creating an efficient solution for water management and related water maintenance activities.

## 5 Leveraging Smart Things

In recent years, the “Internet of Things” (IoT) has come to the fore front of discussion as an innovative and sustainable approach in addressing Smart City initiatives such as water metering and water management. Many cities have begun leveraging “Smart Things” to transform their way of thinking and living in a smarter and more digital way. Smart Things are typically comprised of sensors, devices, gateways, and other intelligent hardware which have the ability to send information in a smart way to a system where processing of the data takes place. Most of the time these Smart Things send their data wirelessly to the Internet or “Cloud” for processing. Although wireless solutions have existed for over 25 years in certain industries, the way data is sent, collected, stored, analyzed, and then viewed has evolved over time and has been one of the main driving factors of today’s Smart Things. One key area which cities have begun to focus on in order to support the data sent from these Smart Things is the communication infrastructure and the associated technologies which provide the means to communicate this ever so important data.

## 6 Low-Power Wide-Area Networks

To address the communication infrastructure element, several wireless technologies were analyzed to determine which provided cities a low cost, long range, and low power consumption solution. It was decided that Low-Power Wide-Area Network solutions provided what was necessary to deploy city wide solutions with minimal impact on financial commitments, infrastructure, maintenance, and management of deployed solutions. LPWAN technology also was suited for solutions which only require devices to send small data over a wide area while maintaining battery life over many years. This made LPWAN more interesting in comparison to the other wireless network protocols like Bluetooth, RFID, cellular M2M, and ZigBee, shown below with regards to bandwidth and range capability.

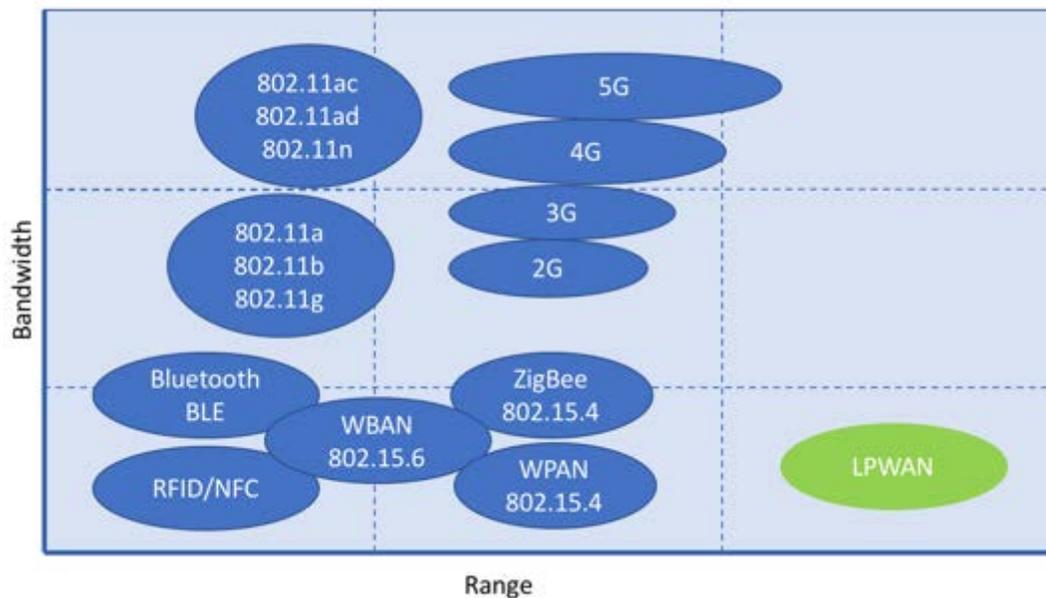


Figure 1: Wireless Network Protocol Comparisons

## 6.1 LPWAN Comparisons

The next step in selection of the correct communication protocol was to conduct a more detailed review of the leading LPWAN technologies to determine the most suitable option for smart cities within the Indian market. Based on Table 1 comparisons, as well as current city policies and requirements driving the decision making, several capabilities were looked at during this process.

Smart City Requirements	LoRaWAN™	SigFox	Ingenu	LTE NB-IoT	Cellular	LAN (Wi-Fi / BLE)
Standards	Yes, Open (Lora Alliance)	No, Proprietary	No, Proprietary	Yes	Yes	Yes
Built in Security	Yes	No	Yes	TBD	No	Varies
Bi-Directional Communication	Yes	Limited	Yes	Yes	Yes	Yes
Interference	Unlicensed 865MHz	Unlicensed 865MHz	Unlicensed 2.4GHz	Licensed Regionalized	Licensed Regionalized	Unlicensed 2.4GHz

Table 1: LPWAN Technology Comparisons

Standards, security, communication capabilities, and spectrum inference were some of the main factors which lead the selection of LoRaWAN™ as the technology which would be used during this Proof of Concept. By implementing Low-Power Wide-area Networks based on the LoRaWAN™ protocol, solutions such as smart water metering allow cities to reduce operational cost dramatically while still obtaining the necessary data to make better water management decisions. LoRaWAN™ infrastructure enables smart water solutions while maintaining the integrity of the data and reliability of the communication all while reducing the overall impact on the processes involved in managing smart water infrastructures.

## 6.2 LoRaWAN™ Protocol

LoRa® is the physical layer or the wireless modulation utilized to create the long-range communication link. Many legacy wireless systems use frequency shifting keying (FSK) modulation as the physical layer because it is a very efficient modulation for achieving low power. LoRa® is based on chirp spread spectrum modulation, which maintains the same low power characteristics as FSK modulation but significantly increases the communication range. Chirp spread spectrum has been used in military and space communication for decades due to the long communication distances that can be achieved and robustness to interference, but LoRa® is the first low cost implementation for commercial usage.

LoRaWAN™ defines the communication protocol and system architecture for the network while the LoRa® physical layer enables the long-range communication link. The protocol and network architecture have the most influence in determining the battery lifetime of a device, the network capacity, the quality of service, the security, and the variety of applications served by the network.

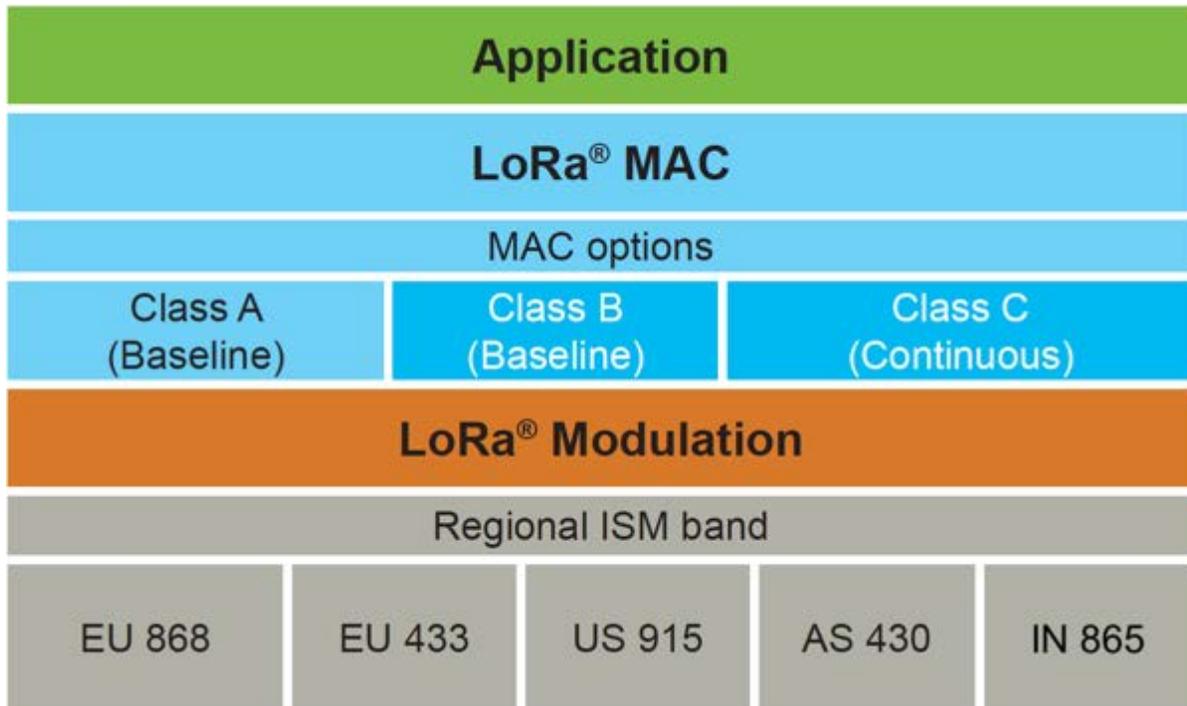


Figure 2: LoRa<sup>®</sup> Communication Protocol

### 6.3 LoRaWAN<sup>™</sup> Architecture

Many existing deployed networks utilize a mesh network architecture. In a mesh network, the individual end-nodes forward the information of other nodes to increase the communication range and cell size of the network. While this increases the range, it also adds complexity, reduces network capacity, and reduces battery lifetime as nodes receive and forward information from other nodes that is likely irrelevant for them. Long range star architecture makes the most sense for preserving battery lifetime when long-range connectivity can be achieved.

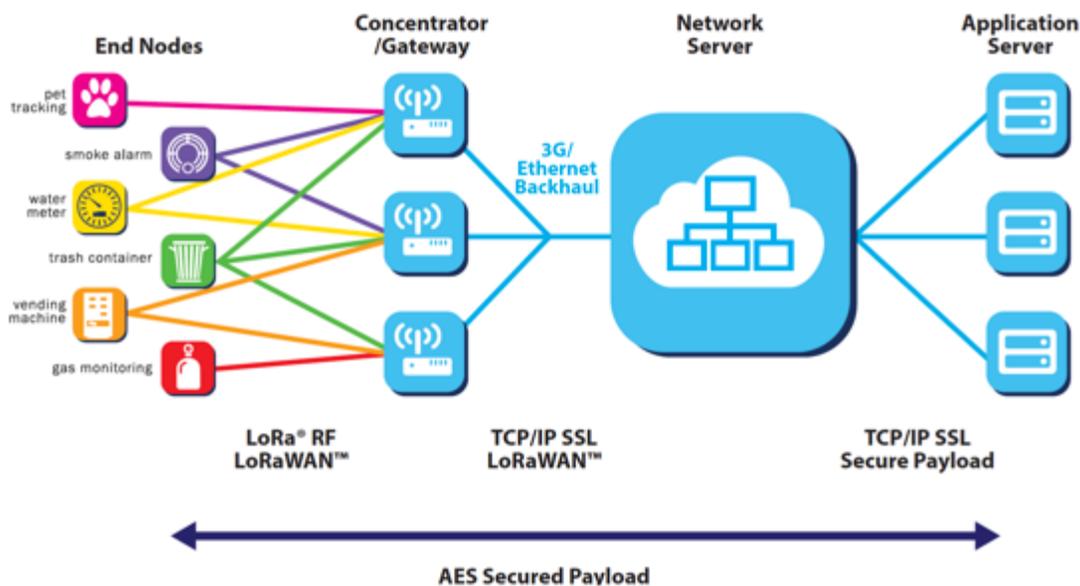


Figure 3: LoRaWAN<sup>™</sup> Network Architecture

In a LoRaWAN™ network nodes are not associated with a specific gateway. Instead, data transmitted by a node is typically received by multiple gateways. Each gateway will forward the received packet from the end node to the cloud-based network server via some backhaul (either cellular, Ethernet, satellite, or Wi-Fi). The intelligence and complexity are pushed to the network server, which manages the network and will filter redundant received packets, perform security checks, schedule acknowledgments through the optimal gateway, and perform adaptive data rate, etc. If a node is mobile or moving, there is no handover needed from gateway to gateway which addresses other major target application verticals for IoT.

The benefit of a LoRaWAN™ network is immense considering the fact that a city-wide network or an area-based network will be able to provide multiple services to the citizens such as smart street lights, smart parking sensors, smart environmental sensors, smart metering on a single network deployment. This also allows the city administrators to have a clear insight on the device and network management without worrying about managing multiple protocols and layers of data streams from a host of varied technologies. LoRaWAN™ is the only technology which caters to smart city requirements and is currently available for commercial deployments.

#### **6.4 LoRaWAN™ India 865-867 MHz ISM Band**

Based on the Government of India's Ministry of Communications and Information Technology (Wireless Planning and Coordination Wing) notification which took place on the January 10<sup>th</sup> 2007, the use of low power equipment in the frequency 865-867 MHz is exempt from licensing requirements. This is critical to Smart City decision makers as current tenders and requests for proposals are highlighting that use of the unlicensed ISM band is preferred and sometimes required. Based on this information, The LoRa Alliance™, an open, nonprofit association comprised of over 500 companies to date, defined in the LoRaWAN™ regional specifications 1.0.2 that development for the India region should use the unlicensed spectrum defined by the Indian government (865-867 MHz).

## **7 Water Meter Proof of Concept**

In India today, the majority of the meter management and meter reading are still being accomplished in an old fashion manual process which requires resources to physically visit the meter sites and take the readings manually. This process is considerably high in the case of water metering vs electricity distribution companies, as they in their quest to cut transmission and distribution costs have shifted to smart metering solutions long ago. One of the main challenges for water distribution companies is the non-revenue losses. These companies are realizing the only way to control and increase their revenue base is to bring in smart meters which can provide real-time feedback of water consumption and promote water conservation methods.

The most efficient manner in order to achieve the above is to deploy Advanced Metering Infrastructure (AMI) instead of the old fashioned Automated Meter Reading (AMR) methodology. Smart AMI water meters provide end-to-end automated mechanisms including wireless communication, secure data transfer, and real-time analytics. These mechanisms provided the end customer, in this case typically the utilities companies, distribution companies, and city administrators, a clear view in their day to day processes. This information will provide insights for managing the entire distribution eco-system in a much more efficient manner enabling the city administration to predict behavior of the consumption, loss, and most importantly influence behavioral changes of the consumers creating a better awareness of water saving strategies.

### **7.1 Water Meter Site Locations**

This Proof of Concept is being conducted in a city located in the central part of India. The city selected 41 sites within their city limits where they requested to replace existing water meters or install new meters using LoRaWAN™ enabled Smart AMI Ultrasonic Water Meters. Site locations for deployed water meters are illustrated in Figure 4.



Figure 4: Smart AMI Water Meter Site Locations

## 7.2 Gateway Site Locations

Based on the site locations provided, a survey was conducted of the area to determine where the LoRaWAN™ network infrastructure would be deployed to provide reliable, stable connectivity. Things that were looked at included accessibility of the site, power availability, backhaul capabilities, elevation above sea-level and ground-level, obstructions and clear line of site. Two sites were selected for this network deployment. Based on elevation above ground, gateways being deployed, and other factors mentioned above, a green field planning of the LoRaWAN™ RF propagation was done and is illustrated below in Figure 5 and Figure 6.

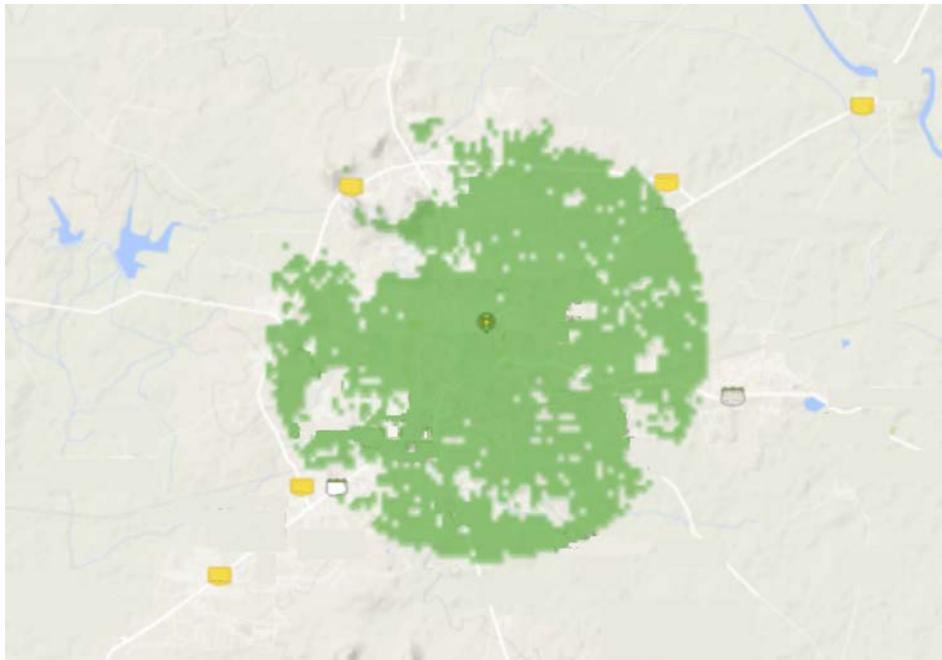


Figure 5: LoRaWAN™ Gateway Site 1

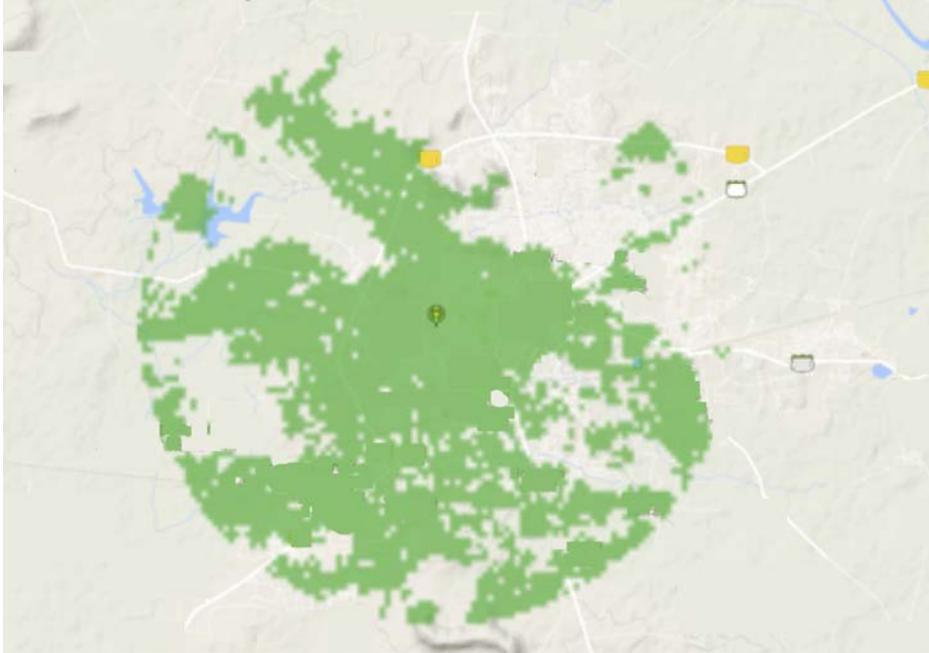


Figure 6: LoRaWAN™ Gateway Site 2

The following table provides details of both sites and their coverage achievements. Note the availability of the gateway sites in the city limited the ability to install gateways above 100 feet creating suboptimal network coverage then desired. Fortunately, due to the site locations of the devices, the deployment at 75 feet above ground was sufficient to provide the device reliable network connectivity.

Site	Height	Elevation	Altitude	Coverage (Radius)	Coverage (Circumference)
1	75 ft.	957 ft.	4236 ft.	2.72 km	17.04 km
2	75 ft.	945 ft.	4223 ft.	2.85 km	17.88 km

Table 2: Gateway Site Coverage Details

### 7.3 Water Meter Installation Procedures

This Proof of Concept was carried out as a green field installation and was only limited to the existing water distribution network in the city. The locations were identified randomly and in diverse areas for better understanding of the network deployment topology, network capability, and the transmit power of the actual smart ultrasonic water meters. The new ultrasonic water meters were deployed by the same deployment personnel deploying the traditional water meters in the city and it was noted that the installation of the new meters was completed without any issues, highlighting the ease of deploying these meters in comparison to traditional deployment manners. The smart meters were installed in between existing piping leveraging pipe extenders to incorporate the new meters (see Figure 7 and Figure 8 below).



Figure 7: Water meter pipe installation



Figure 8: Water meter pipe installation

After installation, a magnet was used to activate the LoRaWAN™ module incorporated in the ultrasonic water meter, which in turn registered the device(s) successfully to the network. Figure 9 illustrates devices successfully communicating packets on the network provider’s platform after registration.

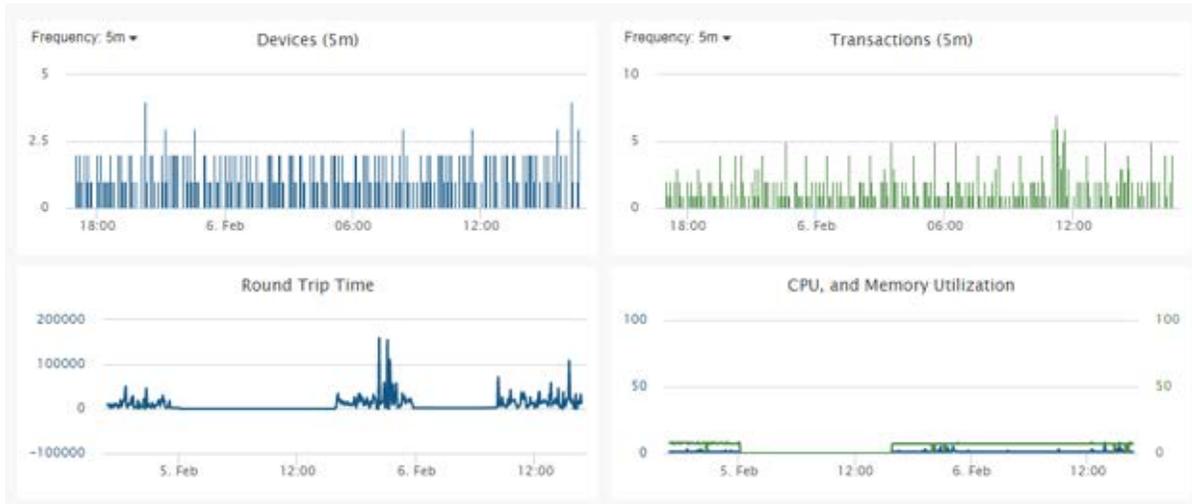


Figure 9: Device communication activity on network

## 7.4 Data analytics and post-processing

In the past, access to water meter data was a very resource heavy process, requiring a lot of man-power to physically obtain information directly off the meter. With this old process, there was no real time data visibility and there were many opportunities for data to be incorrectly captured and/or altered. With the LoRaWAN™ enabled smart AMI water meters deployed in this PoC, the city is now for the first time able to obtain insight on the water metering data in real-time and make water management decisions virtually in a matter of seconds. The following table below explains the pitfalls in leveraging existing water meter solutions and explains the benefits of leveraging a smart AMI water meter solution.

Existing Water Meter Solution	Smart AMI Water Meter Solution
No real time data availability	Real time data availability
Huge investment on CAPEX and OPEX	Reduced CAPEX and OPEX
No proper billing cycle	Automated bill generation
Increased Non-Revenue Water	Minimized Non-Revenue Water
High error rates	Minimal error rates
Manual device reading	Real time reading
Minimal battery life	Up to 12 years of battery life
Data analysis is slow and process heavy	Real time data analytics leveraging artificial intelligence
Limited consumption visibility for end user	Detailed analysis of consumption provided to end user
No integrated theft detection	Theft and tampering detection available
No leak detection	Real time leak detection
High maintenance needed	Minimal maintenance required

Table 3: Water Meter Solution Comparison

Through the course of this PoC, the integrated application server / platform has been able to provide the city with information which had never been available prior to this deployment. Leveraging cloud computing, artificial intelligence, complicated algorithms, and big data processing, the solution provider demonstrated several data sets which helped the city improve the existing water management, distribution, and consumption. Below is a list of key highlights which the platform has been able to provide to the city to date. Note: This PoC is still in progress

and analysis of water meter data is ongoing. At the completion of the PoC, a follow-on report will be distributed with a more complete set of data points which the platform was able to capture, analyze, and provide to the city.

- Water consumption in specific areas of the city consistently had higher consumption levels providing insight on how to properly distribute water throughout the city
- Details of specific end user water consumption was available and provided insight on a day-to-day basis as well as month-to-month analysis on consumption levels.
- Comparisons of individual tenant’s water consumption in multi-dwelling units were available allowing for proper billing management
- Water consumption was on average 3 times more during holidays which allows the city to conduct proper planning of water availability
- Flow of water in some installations were abnormal providing insight on potential leakage in the water pipe at specific locations
- Some water meters were improperly installed which in-turn triggered automated notifications in the system allowing for maintenance teams to know when and where to correct the installation issues.

## 7.5 Data Visualization

In order to properly communicate the analysis of data to the city, the solution provider developed a clear and efficient interface for data visualization where data sets are processed and represented in graphs, charts, and reports. The below image is a captured screen shot of the platform dashboard providing real-time data processed during the PoC.

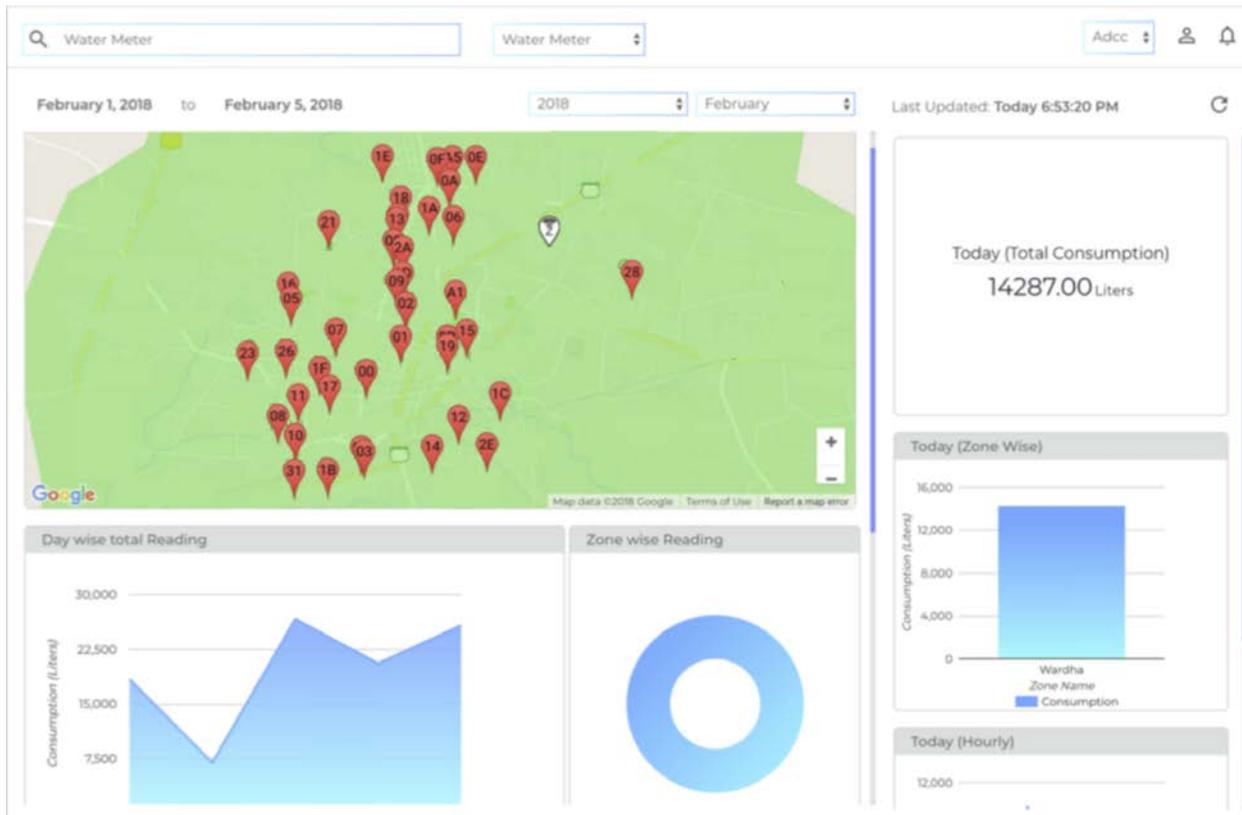


Figure 10: Platform Dashboard

The solution provider was also to demonstrate how end users can access their water meter data by simply accessing a mobile application which is integrated with their platform. With this application, the end user is able to see their water consumption on a daily, weekly, or monthly basis and determine how much their monthly bill will be. Other features have been implemented to educate the end user and provide incentives related to water conservation and cost savings. Below are screen shots of an end user’s water meter data which was obtained by one of the water meters deployed as part of this PoC. Data is displayed for two consecutive days providing a comparison on how much water was consumed each day.

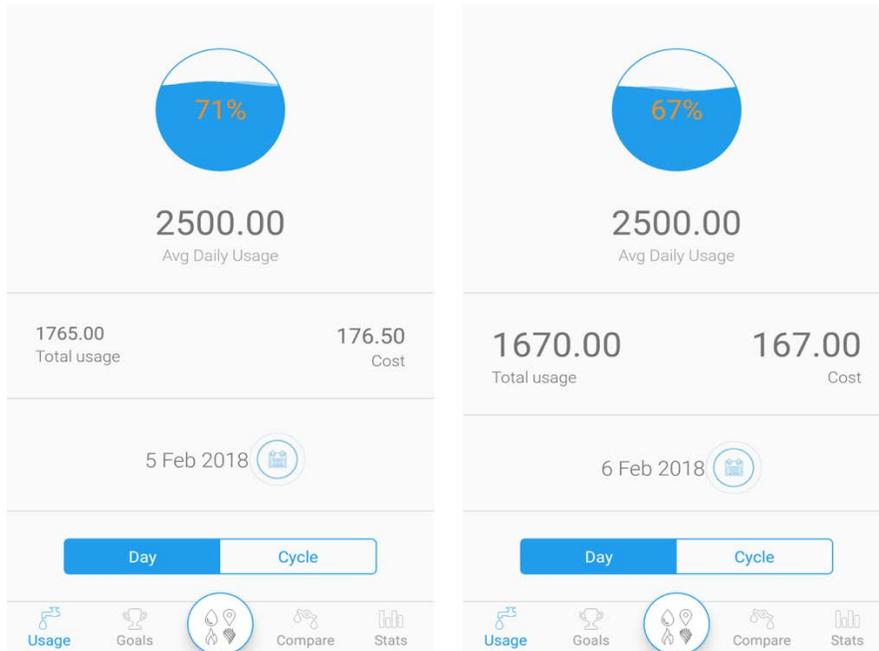


Figure 11: End User Water Meter Consumption

## 8 Conclusion

In conclusion, many technological advancements have been made to date to provide City decisions makers with the right tools to properly plan, manage, maintain their city as well as ensure a better quality of life for their citizens. In the case of wide area deployments of Smart Things, to include Smart City deployments, one needs to assess the available technologies present today and determine which solutions are best suited to address each set of requirements. In a true Smart City, one cannot limit themselves to a single technology or solution to address all of the City’s requirements and needs. However, in the case of solutions which require long range and low data communication, it is believed that LPWAN, specifically LoRaWAN™, is the best technology and has been demonstrated successfully in the case of this Smart Water Meter PoC. Collaboration between several parties is required for a successful deployment and can be achieved with the right expertise and technology. As this white paper comes to an end, the PoC continues and plans of a follow-up report will be distributed at the end of the PoC to provide a complete view on how an end-to-end smart solution leveraging LoRaWAN™ can be successful and fruitful for cities providing better visibility in their city infrastructure and activities.