Long Range Wireless Area Network: LoRaWAN Revolution 1

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Long Range Wireless Area Network: LoRaWAN Revolution 2

Introduction

LoRa, more specifically LoRaWAN, is the implementation of a low power wide area network for the Internet of Things. This networking standard is intended to completely revolutionize the way we connect with the IOT by utilizing a low power, low cost solution to increase adoption for this new wireless standard.

The concept behind LoRa is straightforward, but how does it work? LoRaWAN is a wireless Data collection protocol ("LoRa/LoRaWAN Timing," n.d.) that operates on a handful of megahertz radio frequency bands. In Asia - it is the 169 MHz and 433 MHz Frequency. In Europe, it is the 868 MHz Frequency. For North America, it operates on a 915 MHz Frequency. These frequencies are the bands that data is transmitted on. The existence of said technology is a result of the LoRa Alliance, an amalgamation of multiple LoRaWAN Advocate corporations with the intent to maintain said service (LoRa Alliance, n.d.).

To connect to this service, one must apply a physical LoRaWAN Module to the operating devices and connect through a LoRaWAN Gateway. The LoRaWAN Gateway is a decentralized technology that connects devices to the LoRa WAN. To help visualize this process - imagine installing a PCIe Wi-Fi adapter to a Personal Computer. One does this so the device can communicate with their Router, which can provide you internet via communicating to your Internet Service Provider. It is very similar to connecting to LoRaWAN, as it is one device requiring specific hardware to connect to a gateway. Then, the gateway connects with a provider after verifying the end device. This technology, as previously stated, is intended to be low in

complexity. However, due to its nature - its capabilities are restricted which can be seen by its current use cases.

Current Use

LoRaWAN is used across various sectors for its long-range, low-power IoT applications. In smart cities, it manages street lighting and monitors traffic. For environmental monitoring, it tracks air quality and water levels. In agriculture, it aids in crop condition monitoring and livestock tracking. Utilities use it for smart metering of water, gas, and electricity. Additionally, it's employed in asset tracking, waste management, and parking space detection. (Ayoub, Alam, et al. 2023) LoRaWAN's efficiency in power usage and its ability to cover wide areas make it ideal for these applications.

LoRaWAN is a data transmission protocol, with a wide variety of uses, and a handful of restrictions. The current IOT Technology that revolves around the use of the LoRa Network is mostly applied to basic Input-Output technologies. There is a necessity to know how this technology fits within the LoRaWAN network, to better understand it. There are sensors that read input from specific conditions based on the outside world. Be it a GPS value for livestock tracking, or integers in regards to smart metering, the data collected and transmitted by nature is of low byte size. (Haystack Technologies, n.d., slides 24-27) This is important to note for LoRaWAN as the network sacrifices total bandwidth for range, and has a limited byte size per message. However, given that the main implementation is low byte data transmission - it is perfect for LoRa.

There is a pattern here to be recognized in regards to the application and implementation of LoRaWAN technology. Simple Data Collection Devices is the main idea behind the population of this Network. Low byte size, low power, and high availability. The pragmatic use case appears to not only reside in the range benefits of this technology, but also in the security it provides for the current use cases.

Security Aspect

Long Range WAN security relies on a low maintenance approach derived from a perceived fundamental nature of the said device. LoRA WAN is designed to be low power, low cost, and have low implementation complexity. This requires a design that is able to be “not” maintained. The LoRAWAN Alliance has stated that each and every LoRaWAN End device comes with its own AES 128 bit key and a unique identifier. These two mechanisms, per the LoRAWan Whitepaper, are utilized for a future proof mutual authentication system. (LoRa Alliance, n.d.)

This level of security, combined with the use cases, and references to current technologies outline how beneficial LoRaWAN is from a security standpoint. Cybersecurity is a must in this world. Traditionally speaking, the methodology for hacking computers has evolved from the conception of said technology. Furthermore, the evolution of hacking has planted its feet into the sector of Radio Frequency Hacking. (Felch, 2020) A plethora of devices operate on general radio frequencies, many on sub-GHz waves, and some of these devices are vulnerable to

RF Hacking Techniques. Whether it is a jam, or a replay, this poses an issue to one operating a device on a given network.

LoRaWAN differs from most Radio Frequency technology as it requires a second level of authentication - in the MAC level. (LoRa Alliance, n.d.) This differs from most other devices which simply operate via installation of a Physical Level module - effectively putting the device onto the Frequency Wave as soon as it turns on. We can see with the development of RF Hacking using tools like the Flipper Zero, or Operating Systems such as SIGINT-OS, that an extra layer of security is crucial for devices communicating through radio waves.

Many of the current use cases for LoRa revolve around collecting data for metrics. The integrity of one's data, especially to a corporation, is crucial to operations. If someone can jam, or replay/forge the signal for said data - it threatens the integrity. However, when a device is on the LoRa Network - it can only send messages through the network if the key and MAC are verified. This eliminates any sort of MAC Spoofing, as spoofing a LoRa connected MAC Address is not enough to forge a signal across the LoRaWAN - one needs the AES 128 bit key on their hardware too. (LoRa Alliance, n.d.)

Ethical and Social Implications

A few of the ethical and social implications, good and bad, revolve around the fundamental nature of the technology. The concept here appears to be the democratization of wireless IOT devices. These pieces of Long Range Wireless technology can do everything from warn us about wildfires to tracking our parents in their assisted living homes. The devices keep a

tab on data, which is great for society - as long as there is an ethical concern in regards to the data collected. We can see techno-thriller shows like Black Mirror become a reality with technology such as this. For example - if the technology is used by a government to enable a surveillance state that might be an issue. This could be achieved through already available human tracking LoRA systems. (Ida Syafiza Binti & Hanani, 2022) LoRA WAN is a technology that opens up many doors as it closes the gaps of communicative inefficiencies, however there must be caution when handling such technology.

The use case of LoRa WAN technology in regards to the transmission of data poses a few Ethical and Social Risks. At face value one can see that there is a decentralized, democratized, intent for this new technology. For example, the Things Network map shows the local LoRa Gateways around the world.(The Things Network, 2024) In this paper we will operationalize “Northern Virginia” as the Metropolitan area extending from The District of Columbia to cities: Leesburg, Manassas, and Woodbridge. In Northern Virginia. one can see that two gateways exist. Furthermore, when one zooms in on their exact location - they are at residential homes. The implications are that anyone can bolster the LoRaWAN network if they want to set up a node/gateway - making this decentralized.

The benefits of a decentralized nature can regrettably be seen as threats by larger entities be it Government or Corporate. For the Government, there is a security risk in regards to the types of devices and the secure nature of LoRaWAN. If the Government is not able to monitor, nor investigate, XYZ transmission across the network - they may take dire action to hinder its progress. The Government can ultimately decide whether or not its society can have access to

this technology, as most Governments can immutably enforce any decisions they choose.(Senate Appropriations Committee, 2023) Furthermore, corporations that provide large current networking technologies may also threaten the progress of this technology if it negatively impacts their bottom dollar. The main social and ethical concerns here stem mostly from larger, impactful, actors that act as “gatekeepers” to certain technologies.

Future Use

LoRa-based IoT applications are expanding into various sectors, including smart grids, smart meters, and smart street lighting, contributing to the development of smart cities. They play a significant role in environmental monitoring, such as water quality, and agricultural advancements through smart agriculture, temperature, and soil monitoring systems. These applications demonstrate LoRa's versatility and potential in enhancing efficiency, sustainability, and data-driven decision-making across multiple domains. This emerging technology has the potential to overlap into a platitude of areas due to the versatility it provides.

Conclusion

LoRaWAN represents a significant advancement in the realm of Internet of Things (IoT) technology, offering a practical, secure, and efficient method for connecting a wide array of devices across vast distances. Its implementation across various sectors—from smart cities and agriculture to environmental monitoring and utility management—underscores its versatility and the broad applicability of its low-power, long-range capabilities. The security features inherent to LoRaWAN provide a robust defense against the evolving landscape of cyber threats, particularly in the context of radio frequency technology. Moreover, the ethical and social implications of

LoRaWAN highlight the potential for both positive and negative impacts on society, underscoring the importance of responsible deployment and governance to maximize benefits while mitigating risks. As LoRaWAN continues to expand its footprint, pushing the boundaries of what is possible within the IoT ecosystem, its role in driving innovation, enhancing operational efficiencies, and contributing to sustainable development cannot be overstated. The future of LoRaWAN is not only about technological evolution but also about how it shapes the ethical and social contours of our increasingly connected world.

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Annotated bibliography

Semtech Corporation. (n.d.). LoRa. Retrieved from https://www.semtech.com/lora

This webpage is introductory information about the Long Range Wireless Area Network Technology known as LoRaWAN. It serves as a basic reference to a layman understanding of this protocol. The webpage introduces the authority of the delegating body, Semtech Corporation as well. It is noted that Semtech is a member of the LoRa WAN Alliance, which is intended to maintain and promote the new technological Standard. Semtech is one of the many alliance members that provides aid in the maintenance of said technology. The article provides a beneficial, starting point to understand and gauge LoRaWAN on a basic level.

Muhammad, A. K., Muhammad, M. A., Aznida Abu, B. S., & Mazliham Mohd Su'ud. (2023). Requirements, Deployments, and Challenges of LoRa Technology: A Survey. Computational Intelligence and Neuroscience : CIN, 2023https://doi.org/10.1155/2023/5183062

This article touches on the wide array of uses of LoRA WAN Technology whilst also giving a brief introduction to the topic. Furthermore this article dives deeper into the capabilities of LoRa Technology and the LPWAN Protocol by highlighting its capabilities and how it is superior to the current standard. LoRa is an ISM-band based LPWAN communication protocol. Despite their wide network penetration of approximately 20 kilometers or higher using lower than 14 decibels transmitting power, it has been extensively documented and used in academia and industry. With a wide variety of deployment, this article outlines the implementations of LoRaWAN.

LoRa Alliance. (2017, February). A white paper prepared for the LoRa Alliance™ by Gemalto, Actility, and Semtech. LoRaWAN™ Specification, v1.0.2, July 2016. Retrieved from https://lora-alliance.org/wp-content/uploads/2020/11/lorawan_security_whitepaper.pdf

This PDF from Gemalto outlines a basic understanding of the LoRaWAN security standard and why it is so important to its functionality. The whitepaper states that the low cost, low power, and low complexity would be nothing without the high security it boasts. It outlines a 128-bit AES key, a unique global identifier, and the ability to end-to-end encrypt whatever data you are sending. This level of security is crucial to understand said technology. The proactive security by nature is a key feature to highlight with LoRA WAN Technology.

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Hashim, N., Idris, F., Tuan Nur Anisa Tuan,Ab Aziz, Siti, H. J., Rozilawati, M. N., & Wahab, N. A. (2021). Location tracking using LoRa. International Journal of Electrical and Computer Engineering, 11(4), 3123-3128. https://doi.org/10.11591/ijece.v11i4.pp3123-3128

Local area network (LAN) as Bluetooth, WiFi and ZigBee are well established technology. The biggest problem with many LAN is the battery consumption and short ranges link budgets. LoRa is a new, private, unlicensed and spread spectrum modulation technique which allows sending low rates at extremely long ranges with minimal power Consumption. This study presents a thorough overview of LoRa networking, covering the technological difficulties in setting up LoRa infrastructures and current solutions. Several outstanding challenges of LoRa communication are presented depending on our thorough research of the available solutions.

Arisandi, D., Syamsuadi, A., & Trisnawati, L. (2023). Enhancing peatland fire prevention: an incremental LoRa and mobile-based early warning system. International Journal of Advanced Technology and Engineering Exploration, 10(108), 1368-1391. https://doi.org/10.19101/IJATEE.2023.10101900

Peatland fires present a significant threat in Indonesia, arising from human activities or adverse weather conditions. An early warning system using long-range (LoRa) and mobile technology can help avert peatland fires through continuous environmental monitoring and rapid detection of fire risks. One of the many IoT functions that LoRa provides is the ability to send and transmit data. This study develops an incremental LoRa and mobile-based early warning system for peatlands. Temperature, humidity, and other environmental data are gathered by strategically placed node sensors and gateways in high-risk areas.

Ida Syafiza Binti, M. I., & Hanani, A. (2022). Development of real-time indoor human tracking system using LoRa technology. International Journal of Electrical and Computer Engineering, 12(1), 845-852. https://doi.org/10.11591/ijece.v12i1.pp845-852

Industrial growth has increased the number of jobs hence increase the number of employees. In this work, a real-time indoor human tracking system is developed to determine the location of employees in a real-time implementation. In this work, the long-range (LoRa) technology is used as the communication medium to establish the communication between the tracker and the gateway in the developed system due to its low power with high coverage range besides requires low cost for deployment. The received signal strength indicator (RSSI) based positioning method is used to measure the power level at the receiver which is the

gateway to determine the location of the employees. Different scenarios have been considered to evaluate the performance of the developed system in terms of precision and reliability.

Semtech Corporation, Microsoft, & Digital Matter. (n.d.). IoT-optimized ultra-low power asset tracking [Webinar]. Presented by Tom Patton. Retrieved from https://videos.semtech.com/watch/Hku51jMMA5dvE5iemLZTzX?

The video described is a presentation from a joint operation by Semtech, Microsoft, and Digital Matter. Tom Patton outlines the benefits out asset tracking and how LoRa helps assist in said problem. He speaks about how the low power low complexity technology is by foundation something that is innately beneficial to tracking supply chain assets. Furthermore, he outlines the future potential for LoRaWAN technology as the joint operation is beginning to move from an eclectic private nature to a more widely utilized standard. Tom Patton outlines this by stating the progress of Microsoft implementing LoRaWAN servers, so anyone can leverage this technology via the cloud.

ECS Inc. International. (n.d.). LoRa/LoRaWAN Timing. Retrieved from https://ecsxtal.com/lora-lorawan-timing/

This is a commercial IT company outlining the use cases and capabilities of LoRaWAN capable technology. It breaks down the network topology of LoRaWAN and establishes bit by bit how this works. Visual aids and graphics help by exemplifying the nature and means of the technology to better grasp how the MAC level authentication interacts with LoRa Network. It outlines Node types by class. Then it outlines the advantages and disadvantages.

LoRa Alliance. (n.d.). About LoRa Alliance. Retrieved from https://lora-alliance.org/about-lora-alliance/

This is the website that is home to the LoRa Alliance. The LoRa Alliance is a non-profit association of companies that collaboratively work to standardize and promote the LoRaWAN protocol, a key technology for enabling low-power, long-range Internet of Things (IoT) networks worldwide. Established in 2015, the Alliance has rapidly grown to include hundreds of members from various sectors, including technology, telecommunications, and manufacturing, all committed to driving the global adoption of the LoRaWAN standard. The organization plays a crucial role in ensuring interoperability between various LoRaWAN products and services, facilitating the deployment of IoT solutions that can communicate across different networks and regions. Through its certification program, the LoRa Alliance guarantees that devices and applications are compliant with its technical specifications, thereby ensuring reliability and efficiency in IoT deployments.

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Felch, R. (2020, January 23). How to Replay RF Signals Using SDR. Black Hills Information Security. https://www.blackhillsinfosec.com/how-to-replay-rf-signals-using-sdr/

Black Hills Information Security is an IT firm that specializes in penetration testing. In this case, they are reporting on the use of Replay attacks on everyday Radio Frequency devices. This citation aids in the comparison between current RF Technologies and incoming future LoRa RF Technology. This is a necessity to outline for this paper. This is because of the difference between current RF Fallbacks and new RF technology.

Haystack Technologies. (n.d.). How to Triple the Range of LoRa [SlideShare presentation]. SlideShare. Slides 24-27. https://www.slideshare.net/haystacktech/how-to-triple-the-range-of-lora

Haystack Technology provides the data for tests on their LoRa Network that can aid in quantifying the capabilities of a LoRa device given the scenario. When referring to these slides, the information outlines the concept of Line of Sight (LOS). This concept is very important with LoRaWAN as the network efficacy almost depends on the consideration of LOS. The slides outline the test conclusions of adjusting the LOS in a variety of ways. One can see this by the visual aids provided on the link.

The Things Network. (n.d.). The Things Network Map. Retrieved from https://www.thethingsnetwork.org/map

This is a decentralized map to help locate and facilitate LoRaWAN transmissions. One large concept behind LoRaWAN is a decentralized means of providing service. We can see here that there is not only available service, but service derived from everyday people. With this map, one can further conceptualize the practicality of setting up gateways. Furthermore we can see that the general availability is on the website too. This can also aid in understanding the implications and applications for this technology, when considering where it is - and where it is not.

Senate Appropriations Committee. (2023, July 27). Bill Summary: Defense Fiscal Year 2024 Appropriations Bill. Retrieved from https://www.appropriations.senate.gov/news/m

This is a report on the Defense Bill Fiscal Year 2024 Budget spending for the United States of America. It helps quantify the sheer difference in actor resources when discussing the ethical implications. This is noted by the $831.781 Billion in total funding for Defense. When considering any party and their ability to mold their society at their whim, fiscal considerations are of necessity. This technology can benefit or hurt a society or government, therefore the implications of actions via government should be considered. Furthermore, the magnitude of the acting parties' capabilities should be highlighted - in this case, it is the egregious defense spending budget.