IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

IOT ready infrastructure for home security system in clustered housing complex

To cite this article: Lukas Tanutama *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **195** 012049

IOT ready infrastructure for home security system in clustered housing complex

Lukas Tanutama, Widjaja Atmadja, James Anthony, Jacksen

Department of Computer Engineering, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia 11480

Corresponding author: lukast12@binus.edu

Abstract. Various Home security system is deployed for landed houses in a clustered housing system. IOT applications for Home Security and Smart Home applications are of interest. Both applications are sensor rich and those sensors face the problem of transmitting data related to their task. Hence, this research concern providing solution of data transmission infrastructure within the house and ultimately to a centralized control and monitoring site. Infrastructure is important as each sensor has its specific task and generally made by different vendors. The infrastructure selection methods is based on the logic that wireless infrastructure is preferred to avoid costly installation and aesthetics reasons. Energy consumption for green compliance is another consideration. Sensors that are IOT ready are low power for green compliance. IOT ready sensors have intelligence embedded to it and could receive and transmit data according to its needs. In this research Lorawan is selected as the solution of providing the wireless infrastructure within a house due to its readiness for IOT and fulfil other requirements as well. The behaviour of Lorawan in terms of data transmission reliability and coverage is measured. Experiments are conducted for determining transmission coverage. The result shows Lorawan is suitable for implementing in house wireless infrastructure.

Keywords: Keywords: Infrastructure, Lorawan, Sensors, IOT, Home Security

1. Introduction

A system that can monitor and warn the security guards concerning fire, gas leak or intruders can increase the security of houses. The system should monitor the houses under its surveillance for 24 hours. If necessary it should have the capability to prevent intrusion, breaking or forcing entry into the house. If this system is implemented in a cluster housing complex, a centralized security guard could have responsibility to care for the cluster complex. A number of houses will be monitored and controlled from a centralized location or a guard house. Preferably the system installation is simple, fast and economic as well.

Home Security does not only concern about intruder or theft but also its environment such as fire or gas leakage. To provide security to a house there are various sensors that must be installed [1]. [2]. [3].

One of the identified problem in developing a Home Security system in a clustered housing complex is that each individual house has sensors that monitor certain aspect that deemed essential by its owner or inhabitants. Each sensor has its specific task and generally made by different vendors. Sensors must send data to a controller for monitoring and actions. Hence, an infrastructure will be needed. The infrastructure should be flexible in terms of adding, upgrading or removing sensors. Sensors that are IOT ready need proper infrastructure to enable reliable data transmission to the centralized controller. IOT ready sensors have intelligence embedded to it and could receive and transmit data according to [4].[5] its needs.

A wireless infrastructure for data communication is preferred to avoid costly installation and aesthetics reasons and little energy consumption for green compliance. The infrastructure should consume little power. The system implementation should consider IOT technology as a number of environment sensors are used to monitor a house. Low power infrastructure is needed as the sensors must operate autonomously or in other words on batteries instead of public power. Sensor should be added or removed easily but under reliable control. The technology selected should wirelessly transmit sensors' data and are IOT ready. The infrastructure must be energy efficient and supports the various types of sensors. The technology has to overcome several major limitations such as coverage, data size, and transmission time.

An emerging technology known called LoRa (Long Range Communication) is introduced as physical layer technology that supports IOT. Its power consumption and distance coverage is appealing. Its applications has been specified as open standard by LoRa Alliance and known as Lorawan [6], [7]. The physical layer specification is still proprietary. Lorawan is developed for IOT use and primarily smart city application. The sensors will transmit the data wirelessly to the collection device which is functionally a concentrator. The concentrator is generally a subsystem of a controller where intelligent processing is performed. The sensors normally provide only essential information to save energy and maximum coverage [8]. [9], [10]. The central control has normal ICT (Information and Communication Technology) facilities.

2. General Description and characteristics of Lorawan

Lorawan is a wireless low power network infrastructure. Lorawan defines the communication protocol and the system architecture, while Lora defines the physical layer [6]. It can fulfil the major requirements of Internet of Things in providing bi-directional communication and mobility services. It also provides the possibilities of interoperability among the Internet of Things easily. Lorawan network architecture is arranged as star network [6]. It needs gateways that function as concentrators. The gateways are carrying data of sensors which are end-devices to a central network server. The end-devices use single-hop wireless communication to the gateways. The communication between end-devices and gateways is diversified to different frequency channels and data rates. The data rate is a trade-off between communication range and message duration. Lorawan supports data rates range from 0.3 kbps to 50 kbps [06], [11]. To conserve battery life of the end-devices, the Lorawan network server is managing the data rate and RF output for each end-device individually.

Lorawan devices can have various capabilities. They will depend on the device roles. The end nodes can have device classes. Each device class is a trade-off between network downlink communication latency to battery-life. The end-point devices are classified according to their capabilities to fulfil the application requirements. End-devices classified as Class A is known as bi-directional end-device. It allow for bi-directional communications, suitable for battery power sensors. It is most energy efficient and can have long battery-life. Devices in Lorawan network support this device class. The downlink or receiving mode is available only after the sensor transmits information. The uplink transmission is followed by two short downlink receive windows. The end-device transmission slot is scheduled based on its own communication needs. The power consumption is the lowest for end-device system.

Class A is purely asynchronous known as pure ALOHA system. There is a small variation based on a random time. It is similar to ALOHA-type of protocol. The end nodes do not wait for a particular time to send to the gateway. They simply transmit whenever they need to and lie dormant until then. As soon as one node completes its transmission, another starts immediately. It is known that the theoretical maximum capacity of a pure ALOHA network is about 18.4% of this maximum. This is due largely to collisions.

Lorawan is fit for public, wide-area networks and all channels are tuned to the same frequencies. All of the gateways in a network are tied back to the same server. The server is job to decide which gateway should respond to a transmission. In a large network, any given transmission is typically heard by multiple receivers. The server then tells one gateway to respond and the others to ignore the transmission. This process helps to avoid downlink and uplink collisions as a single gateway is transmitting. It is also possible the network operators to limit the amount of downlink in their networks. The server side ensures low priority endpoints do not clog the network with downlink traffic. A single gateway or base station is expected to provide service to a large coverage.

LoRa network consists of LoRa nodes or End Points: They are usually the sensors or application where sensing and control takes place. These nodes will transmit data and certain applications need to receive data. They are often placed remotely. Lorawan nodes are associated with a specific gateway similar to cellular communication where the mobile devices are associated with serving base stations. Any data transmitted by the Lora nodes are sent to all gateways. Each gateway that receives the signal transmits it to a network server. The gateways and network servers are connected as intranet or cloud. All the intelligence is placed in the network servers. The network servers filter-out the duplicate packets from different gateways and if necessary perform security check send acknowledgement to the gateways. Packets intended for an application server are sent to the packet to the specific application server. All gateways can send the same packet to the network server.

If a downlink message or an acknowledgement is sent in a Lorawan system, it happens at a fixed offset from the uplink message. The message is transmitted, the gateway receives it, and then it waits a fixed interval (either 1 or 2 seconds) before it transmits back down. The gateway cannot hear anything when transmitting. During message transmission the receiver is shut down and it is temporarily off the air. Talking to a single node takes the whole receiver out of the picture. Lorawan is best suited for uplink-focused networks.

Based on the general description, characteristics, operations and network configuration, Lorawan is selected for use as IoT infrastructure within a house. It will be then tested whether it is indeed suitable as in house infrastructure and what are the environmental requirements and limitations [6].

3. Methodology

To test if Lorawan is suitable as the infrastructure for the home security network the system, the configuration as depicted in Figure 1 is used.

Figure 1 System Diagram

As the infrastructure is the backbone for data transmission its coverage, reliability and response will determine system performance. All sensors must be able to send or receive reliably data via this infrastructure. It is therefore imperative to determine some of the parameters that support reliable data transmission. The essential parameters are data size, time interval, and coverage. These parameters are loosely related one to another. Lorawan generally is specified for outdoor application whereas it is now being assigned for infrastructure within a house. Its capability to cover inside a house must be determine in order to ensure that the data of sensors can reach its destination.

A sensor is connected or become part of End Node of Lora. End Node is responsible to transmit data from the sensor to Lora concentrator. Data transmission from any End Node will be received by the Concentrator for further processing or if necessary stored in a database.

A Lorawan product known as UM-402 [12] is selected for testing. Its End Node is called Slave Nodes and has a Concentrator called Master Node. Master receives information concerning its environment from the Slaves have sensors with specific task. A Slave besides sending data can also receive command from a Master.

4. Results

The experiments conducted consist of having the master waiting for user input to send to the slave. The slave node will read the command sent by the Master. The Slave will then send the requested data to the Master for further processing. The experiment is repeated several times to obtain reliable result for various parameters of interest. The experiment environment is kept as constant as possible including selecting the geographical location for the experiment measurement. The experiment objective is finding Lorawan coverage, data transmission time, and data reliability of the Master and Slave.

Analysing the experiment measurements result showed that the coverage capability of Lorawan implemented with UM-402 product in sending and receiving. The results showed that the maximum coverage distance is 1000m. Time transmission time depend on the distance, distance of 50m need 2 seconds and 1000m need 6 seconds. The transmission line is practically line of sight and internal of a house. Internal a house the transmission coverage 250m.

The next experiments concern data size. Time interval for Lora to send data depends on its size. The maximum byte size that can be send by Lora is 255 bytes. Practically the maximum data or payload by UM-402 must be smaller than 254 bytes as 2 bytes is used for data frame.

Table-1 Distance covered by UM402 - Line of Sight

Data Length	Distance Covered	Signal detected
10 byte	1 m	Yes
10 byte	10 m	Yes
10 byte	50 m	Yes
10 byte	100 m	Yes
10 byte	200 m	Yes
10 byte	500 m	Yes
10 byte	750 m	Yes
10 byte	1 km	Yes
10 byte	1,1 km	No

Tabel-2 RSSI of UM402

Distance	RSSI (dBm)
1 m	-8
10 m	-18
50 m	-37
100 m	-52
200 m	-71
250 m	-81

5. Conclusions

Implementing Lorawan as an infrastructure within a house for home security shows that there are essential parameters that should be considered. The essential parameters of interest are data transmission time (or interval time), transmission data reliability and coverage. Direct measurements (without sensors) for parameters of interest are performed to eliminate the sensor factor. The research showed that UM-402 has reasonable data transmission rate, high percentage of accepted data (reliable data), coverage distance and low operational power for communications, Lorawan as data transmission infrastructure within a house is promising. Lorawan can be implemented especially if UM-402 is selected. The whole house can be covered both externally and internally. Coverage of external premises or line of sight is up to 1 km and internal a house is up to 250m. Lorawan has low power consumption which is environmentally friendly or eco-green.

Further research is needed to find what parameters determine the coverage and reliability of data. Performance of the infrastructure should be determined further with the inclusion of sensors. The performance of the infrastructure in handling sensors demand must be determined for real live traffic.

References

1. Demiris, G., & Hensel, B. K., Technologies for an aging society: a systematic review of “smart home” applications. *Year book Med Inform,* 2008,*3,* 33-40.

2. Robles, R. J., & Kim, T. H. Applications, Systems and Methods in Smart Home Technology: A. Int. Journal of Advanced Science And Technology, 2010,15.

3. Robles, R. J., Kim, T. H., Cook, D., & Das, S. A review on security in smart home development. *International Journal of Advanced Science and Technology*, 2010, *15.*

4. Xia, F., Yang, L. T., Wang, L., & Vinel, A. Internet of things. *International Journal of Communication Systems, 2012, 25*(9), 1101.

5. Tsai, C. W., Lai, C. F., & Vasilakos, A. V. Future Internet of Things: open issues and challenges. *Wireless Networks*, 2014, 20(8), 2201-2217.

6. Sornin, N., Luis,M., Eirich, T., Kramp, T., Hersent, O. LoRaWAN Specification, Version: V1.0.2., 2016, *LoRa Alliance*

7. Augustin, A., Yi, J., Clausen, T., & Townsley, W. M. A study of LoRa: Long range & low power networks for the internet of things. *Sensors,* 2016, 16(9), 1466.

8. Adelantado, F., Vilajosana, X., Tuset-Peiro, P., Martinez, B., & Melia, J. Understanding the limits of LoRaWAN. arXiv preprint arXiv:1607.08011, 2016

9. Voigt, T., Bor, M., Roedig, U., & Alonso, J. *Mitigating inter-network interference in LoRa networks*. arXiv preprint arXiv:1611.00688, 2016

10. Petajajarvi, J., Mikhaylov, K., Pettissalo, M., Janhunen, J., & Iinatti, J. Performance of a low-power wide-area network based on LoRa technology: Doppler robustness, scalability, and coverage. *International Journal of Distributed Sensor Networks*, 2017, *13*(3), 1550147717699412.

11. Semtech. Application Note AN1200-22, LoRa Modulation Basics. *Semtech.,2015*

12. Manthink. Introduction to UM-402 v.1.65 downloaded from http://www.manthink.com.cn/uploads/2016/05/261605565407.pdf