Proposal of Seamless Communication Method in Shadow Area Using LoRaWAN

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Abstract —Low-Power Wide-Area Networking (LPWAN) technology is attracting attention as a communication technology for IoT(Internet of Things) by enabling low-power and long-distance transmission. In this paper, based on Long Range (LoRa) technologies, one of representative technologies in LPWAN area, we suggest the need for multi-hop communication class to solve the communication shadow area and discuss the concept of it. Also, we are going to discuss the "challenges" which are proposed the concept of communication class would not violate the existing LPWAN requirements.

***Index Terms*—**LPWAN, LoRa, LoRaWAN, Multi-hop, communication shadow area

I. Introduction

While the existing network/communication research has discussed about communication method between human and machine or between humans focused on Human Type Communication (HTC), the importance of the Machine Type Communication (MTC) has been increased in the IoT environment. [1] This is because that the definition of things has expanded beyond human and computer to everything existing in our daily lives, which in turn expanded the subjects participating in communication. The diversification of things has made communication environments more complex and led to a lot of research to deal with situation where the existing protocol or solution does not work according to the environment where things present.

The main reason behind this situation started from the limited resources problem that resulted from the communication method for IoT consuming and sharing extreme amount of resources with many things, therefore, the limited resources.

The final aim of this paper is not to construct and form the additional infra for the better IoT environment but to look at the those growing objects themselves as an infra of IoT. Specifically, using the LoRa communication technology of LPWAN (Lowe-Power Wide-Area Network) which was developed by targeting the blue ocean of IoT network/communication area, we suggest a method to support seamless communication between objects within communication shadow area.

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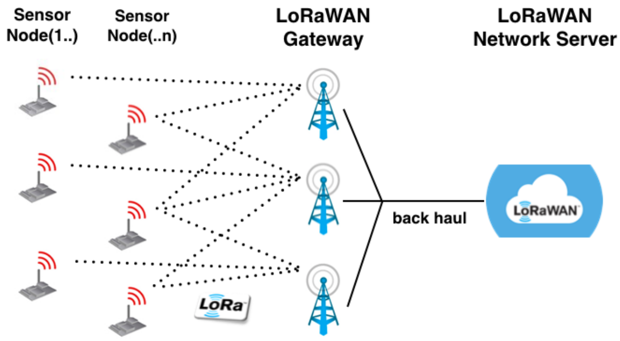

Figure 1. LoRaWAN network topology

II. Related Works

A. LoRaWAN

LoRa technology uses radio modulation technology based on Chirp Spread Spectrum (CSS), which is strong against noise and has excellent reception sensitivity, which is advantageous for long distance communication over 10km and low power consumption. [2]-[5]

On the other hand, due to its low bandwidth, it is advantageous for small data transmissions such as telemetry and position tracking.

LoRaWAN technology is a protocol that defines upper layers using LoRa Chirp Spread Spectrum radio technology. By defining communication classes A, B and C devices can choose communication method according to the situation and adopt star-of-star topology [Fig. 1]. The end-device selects multiple base stations, and all data concentrated on the network server. The LoRaWAN standard specifies the communication flow from end-devices to gateways and network servers. [6]

1) LoRaWAN Class

The LoRaWAN protocol supports communication classes A, B, and C according to the requirements of the end-device. Each class classified according to the trade-off relationship between latency and battery lifetime. Fig. 2. show that class A is capable of bi-directional communication and always receives ACK after up-link transmission occurs from device to base station first, and class B periodically performs down-link communication to send beacons from the base station to the device to synchronize, and class C always enables up-link and down-link channels to perform full duplex bi-directional communication. [7]

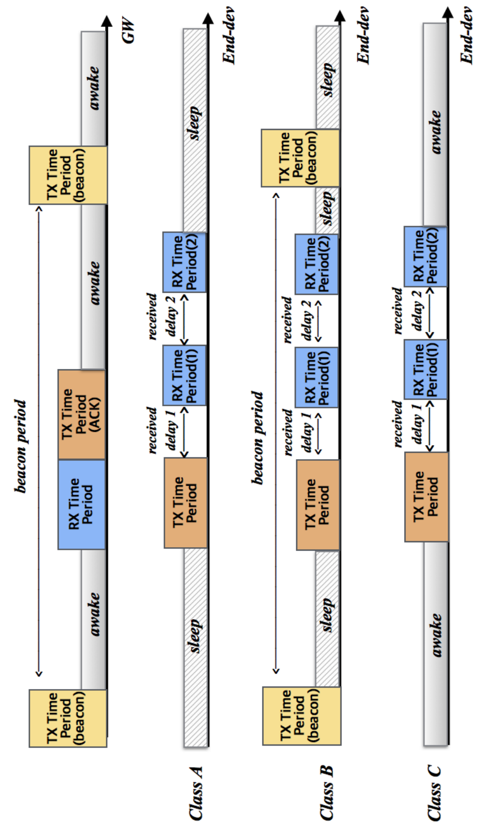

Figure 2. LoRa communication class flow (A, B, C)

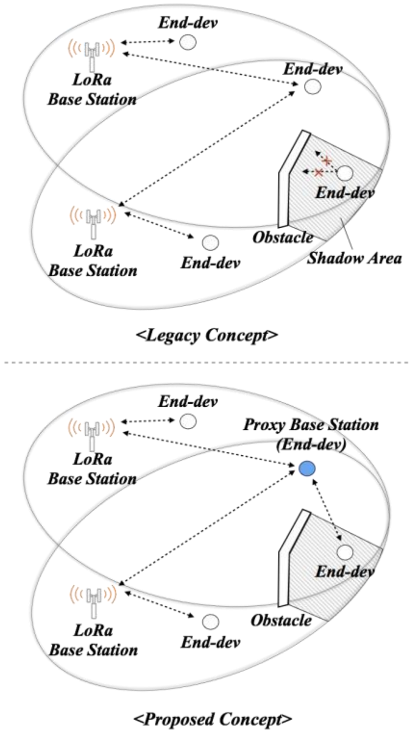

Figure 3. Concept of proposed LoRaWAN communication class

III. Suggestion New Type of Class

In many existing wireless networks, an amplifier is installed to relay communication signals to the underground, stairway, elevator, tunnel, etc. to solve the communication shadow area.

However, as the range of coverage becomes broader and more detailed, more and more gateways and amplifiers are required, which is costly. This approach is not suitable for achieving low network construction costs, which is a requirement of LPWAN.

Thus, in this paper, we propose a method to organizationally cover the communication shadow area by using many neighboring nodes without using a communication amplifier.

A. Proposed Communication Class Concept

The concept of the proposed communication class ultimately relates to a methodology for switching from a star-of-star topology to a multi-hop approach [Fig. 3]. The final goal is to pass the data of the node located in the shadow area to the network server via the gateway.

The proposed communication class is divided into 5 steps of detail. Firstly, determines that cognition of node located in shadow area, and selects a node to perform the 'proxy base station' among nearby nodes, and switch communication class, and relays the data. Finally, returns to the original class mode.

1) Cognition of node located in shadow area

It is impossible for a node located in a shadow area to notify the situation directly to the gateway. Therefore, there is a need for a method to recognize the situation of the shaded area node.

2) Selecting proxy base station

If the nodes located in the shadow area are recognized, a proxy base station node among nearby nodes should be selected. Since LoRaWAN employs a star-of-star topology, sometimes there can be more than one proxy base station node.

3) Requesting of switch communication class

After one or more serving base station nodes are selected, the communication class should be changed so that it can perform the base station role. Most nodes in LoRaWAN will be operating in Class A or Class B for low power operation and should be changed to a C class that can always be Rx/Tx to work with a gateway.

4) Relaying transmission

Relaying the data received from the node in the shadow area to the actual base station by the selected proxy base station.

5) Return to original class

After serving as a proxy base station's role, the node itself must return to the original communication mode by self-decision or by another entity's request.

IV. Research Challenges

In this chapter, we discuss the challenges to keep the requirements of the LPWAN about describe the communication class of the concept presented in chapter3.

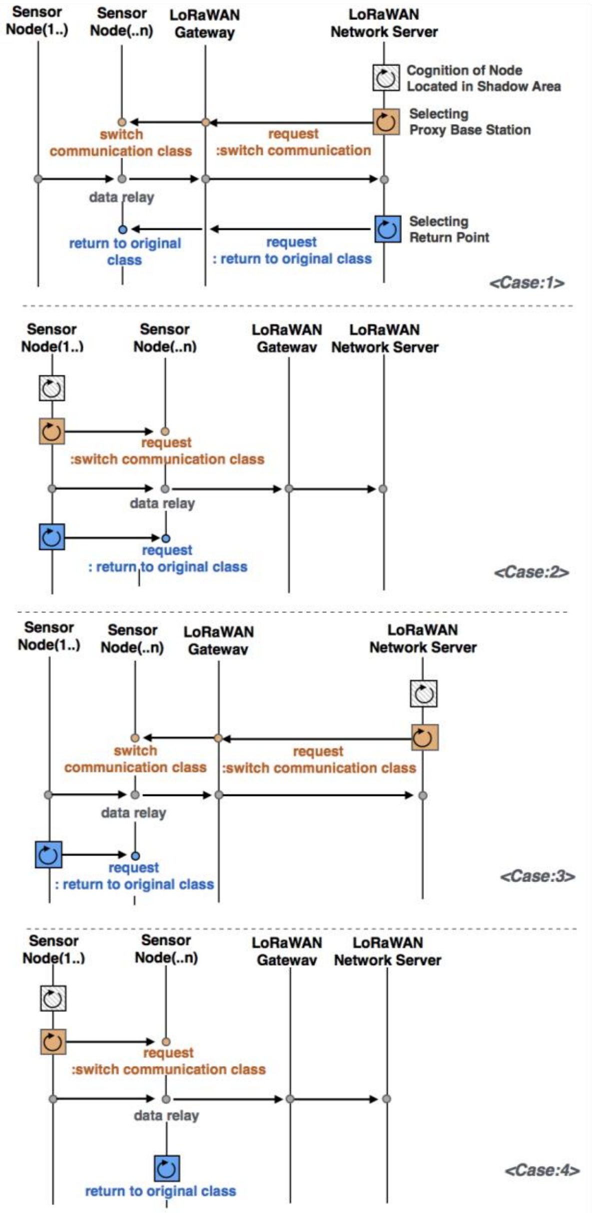

Figure 4. Change of communication flow according to decision subjects

1) Power consumption aspect

The most important part to consider is part of the proposed communication class using LoRaWAN based multi-hop is power consumption. Most nodes in the LoRaWAN environment are in the Sleep state. This means is that it is difficult to expect '*request*' or '*response*' for any object in the desired situation Therefore, when a new communication flow is added, naturally an additional communication slot is needed and additional power consumption occurs.

The process of detecting a proxy base station node, selecting a proxy base station, requesting a class change to a serving base station, and determining a point in time to return to the original state is closely related to power consumption. Therefore, the class of communication should be designed by carefully considering the type of the power source of each node, whether it is battery or phase, and how much power is left.

As a result, if the specific policy is determined according to the 5 steps proposed in Section 3, it is necessary to study the effect of each step on the power consumption of the node.

2) Channel utilization aspect

In conclusion, if a multi-hop topology is used, repeated data transfers occur as many as the number of relays. Therefore, congestion occurs due to repeated occupation of the medium. Therefore, it is necessary to measure the appropriate number of multi-hop through simulation based on various LoRa parameters (spreading factor, coding rate, payload size, etc.), the number of nodes, the number of base stations and the number of multi-hop.

3) Decision subject aspect

In *Fig. 4*, there are four cases according to the subjects that determine the request/response to performed in each step proposed in *Section 3*. *<case:1-4>* is a kind of communication flow example. There may be substantially more combinations of cases.

In *<case: 1>*, all decisions are made by the Network Server. In *<case: 2>*, all decisions are made by the Sensor Node in the shadow area. It is determined that the node itself is in the shadow area, and the neighboring node instructs to perform the proxy base station, and then command to return original class mode. In *<case: 3>*, all decisions are made by the Network Server except for the return command, and the return command is performed under the judgment of the sensor node. In *<case: 4>*, all decisions are made by the sensor node except for the return command, and the return command performed under the judgment of the proxy base station itself.

The important point here is that the methodology for constructing the communication class changes as the subject is changed. When receiving commands from other entities, most nodes are in a low-power Sleep state, so the synchronous/asynchronous state between the nodes must be considered. In the case of self-determination, the accuracy of the way the node predicts situation itself should be considered.

As there are many cases, there is a need for a variety of perspectives on who will decide the situation to change from star-of-star topology to adaptive multi-hop topology.

V. Application Needs

This section discusses the need for a multi-hop communication class for each application needs.

1) Telemetry service

The telemetry service remote monitors the status of the object. However, the location of telemetry equipment can locate in the communication shadow area, which is the outside of the coverage of the base station such as the basement, the compartment, and the coming and going into the shadow area when the object moves. Therefore, there is a need to provide a telemetry services without using additional infrastructure by using seamless services.

2) Location tracking service

A widely used method for location tracking is to attach a GPS sensor to a moving object, transmit it, and express the position of the object based on the information. However, if the object is in a communication shadow area, it is impossible to transmit GPS information originally. Therefore, there is a need to provide a flexible location tracking service.

3) Emergency alerting service

The primary purpose of the emergency alert service is to inform the emergency situation. An example of an emergency alert service is the "Child Risk Warning Necklace." The service is to notify the child of the danger by pressing a button on the necklace when the child is in a dangerous situation. The characteristic of these services is that they must be serviced. Therefore, various communication methods should be provided depending on the characteristics of the service.

VI. Conclusions

In this paper, we discuss the concept of communication class that allows information located in the shadow area of communication in LoRa network, which is a representative technology of LPWAN, to be able to transmit information without constructing additional infrastructure.

Instead of installing an additional amplifier or relay device to solve the shadow area like the existing method, it aimed to build a more flexible network environment by using an increasing 'Things' as a communication infrastructure, saving construction cost. For this purpose, we defined the concept of multi-hop based communication class and proposed 5 steps to achieve this. Also, by specifying various communication flows that can be changed according to 'decision subjects', directions for various researches are suggested in the future.

Finally, we described 'Challenges' from various viewpoints such as power consumption, channel utilization and various decision subject aspect to present communication class.

In the following paper, based on this, propose a multi-hop communication class and plan to performance simulation for LoRaWAN.

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