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# An Efficient Transmission Method of Sensor Network in Common Duct

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## Abstract

When introducing a sensor network as a method to manage accidents in underground public facilities, the most carefully considered technical matter is overcoming the limitations of power and processing resources. In the service area with a linear data transfer path, an ad-hoc based network topology is available, so the efficiency of using radio link resources between nodes can be improved. On the other hand, there is a limit to the delivery of various large capacity services in the future due to the limitation of the transmission bandwidth. As a method to improve this limitation, an efficient data transmission method was introduced in the common duct, and the existing power line was used in consideration of the fast return on investment, and it was intended to be used as a medium for sensing information and high-speed data transmission. During performance evaluation, there was a problem of deterioration of the desired signal due to changes in impedance level when connecting a load to the existing power line, background noise caused by electric motors, and impulse noise due to switch operation. It was able to get a stable signal by separating the power source in the form of a connection using a neutral wire (3-phase 4-wire) type. In thefuture, according to the digital transformation trend of public institutions, it is necessary to improve the OFDM type power line communication infrastructure with frequency selective characteristics to support stable transmission of Full-HD video signals.

**keywords :** Common duct, IoT, PLC, single phase 2-wire, 3-phase 4-wire, DT(digital transformation)

## 1. Introduction

The recent underground communication tunnel fire accident and thermal pipe rupture accident have been an opportunity to raise the awareness of stakeholders in the urban management field in that aging underground facilities in the residential environment led to disasters to the extent that it causes paralysis of urban functions[1]. This is a structure in which the risk of fire and leakage accidents increases as the size of the underground facility is larger, and in the case of a new city, the facilities that manage the lifeline of citizens

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such as electricity, heat pipe, water supply, and communication are installed. The function of the city is being improved by installing the seina tunnel that can be managed at all times, called “Common Duct”.

However, tunnels installed underground always present a risk factor for another accident due to seasonal environmental changes and deterioration of occupancy facilities. Therefore, it can be said that it is an important time to recognize changes in the environment of the common duct and the state of the facilities in advance, secure accurate maintenance planning data especially for summer, winter, and thawing seasons, and to implement quantitative improvement in the management of the common duct through this. The sensor network solution can be operated at areas on able investment cost in a tunnel environment with a large extension length because the sensor network solution can process the physical measurement amount and the corresponding information in the common duct environment and use it at the right time. A sensor network is a network platform where sensor nodes with wireless communication capability and data processing capability are composed of a series of information distribution clusters and can be used to monitor a wide range of environments or physical conditions. It has a basic structure of distributing information by transferring the data measured by each sensor node to the sink node, which is a data processing base in cooperation with each other.

There is no disagreement that the sensor network is a technology that can be used to monitor physical quantities of various environments or to use it for precise positioning in indoor or underground spaces that are shaded zones of satellite positioning signals. However, sensor networks have technical limitations, and the reality is that there are not many cases that have been demonstrated and operated to overcome them. The purpose of this paper is to utilize a sensor network that compensates for the technical limitations of sensor nodes that support efficient data transmission in a common duct environment through this, it is intended to suggest a method for implementing an advanced management system in a more stable transmission method and low maintenance cost for underground urban infrastructure.

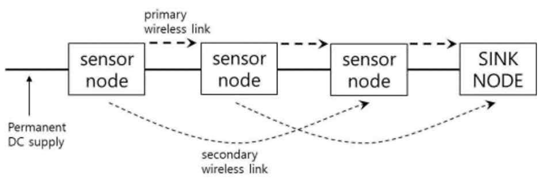



Fig. 1. Overview of ad-hoc based WSN in common duct.

## 2. Related Works

Sensor nodes in wireless sensor networks are usually battery-powered, so power is a very limited system. Therefore, for low power consumption, there is an issue of compensating for the limited radio link distance and narrow transmission bandwidth by lowering the RF output or reception sensitivity. In addition, because the network topology changes frequently due to link changes between sensor nodes, processing resources, that is, memory and data processing speed, required for recognizing the change and performing the routing protocol to update topology information are involved[2-4].

Fig. 1 shows the basic configuration for compensating for the power-limiting factors of each sensor node and minimizing routing resources bysetting a proactive routing. This configuration can support data flow from an ad-hoc based topology environment with a linear dataflow to the sink node of the infrastructure, but the alternating arrangement interval and maximum separation distance of nodes to provide a detour path between sensor nodes must be presented and secondary link because a pre-route must be established to support the data flow, it is difficult to secure the reliability of a sustainable link due to the change of the radio link according to the change of the environment, and there is a problem of a rather complicated pre-setting[5]. Considering that the technical limitations of the wireless sensor network are compensated by the existing facilities for power supply in a linear service area such as a common duct, it will be possible to implement a low-cost, high-efficiency and advanced environmental monitoring system by utilizing the power line communication technology[6-9]. Thus, a power line was used to transmit and receive data of the environmental information detected by the sensor node.

Considering the linear service area with little change into pology, we focused on the reliability of stable data transmission and carried out the research that requires the minimum resource of the sensor node. In the research method, a power line communication platform was selected, and its performance was evaluated to secure the sustainability of the communication link in the underground common duct environment.

## 3. System Model and Description

First of all, it is designed to offset the power supply problem of the sensor node by utilizing the power line installed in the underground common duct. This does not require routing resources for path selection in the data flow. Since the data flow can bypass this, the reliability of transmission is maintained, making it a structure that can be said to replace the advantages of a sensor network. As shown in fig. 2, a PLC modem is installed in the existing power line outlets and distribution boxes that are operating at equal intervals based on power line communication, and the PLC modem is connected to a smart sensor. Smart sensors focus on the versatility of the system so that they can be easily implemented according to various future sensing demands, such as temperature, humidity, and gas detection, to operate based on IP. As the PLC modem device used, a device from Enernet Co., Ltd. was used, and for the smart sensor, a temperature and humidity sensor from Tuya Co., Ltd. was used. The main specifications of the devices are shown in table 1 below.

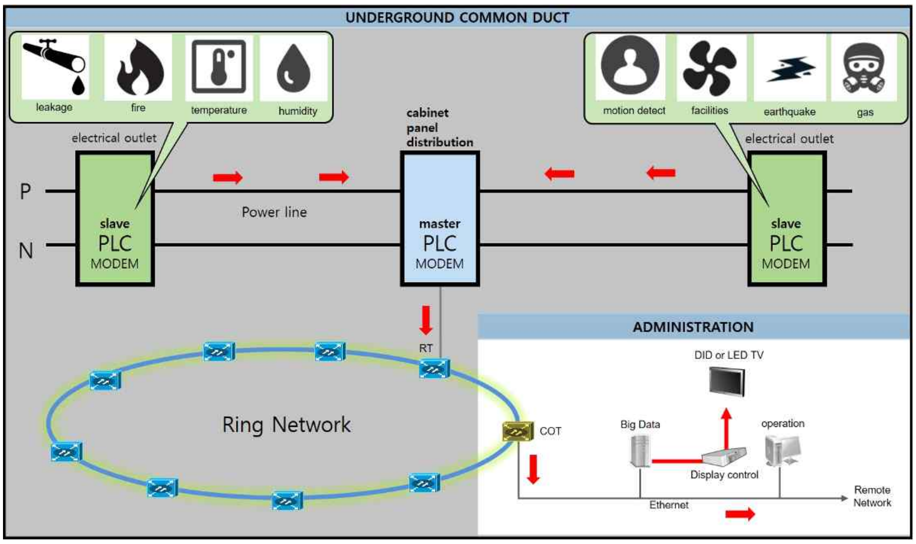



Fig. 2. Common duct environmental monitoring system based on PLC

Table 1. Specification of equipment

| Device | Specification |
|---|---|
| Master modem for PLC | Frequency: 9kHz - 68MHz<br>Interface: IEEE 802.3<br>Input voltage: 3-phase 4-wire 380V<br>Max PHY rate(Mbps): 1000 |
| Slave modem for PLC | Frequency: 9kHz - 68MHz<br>Interface:<br>IEEE 802.3,<br>IEEE802.11b/g/n<br>Input voltage: single phase 2-wire 220V<br>Max PHY rate(Mbps): 1000 |
| Smart sensor | Temperature 0 - 60℃,<br>humidity 0 - 95%<br>Input power: USB 5V/1A<br>Interface: Wi-Fi 2.4GHz |

In this study, an appropriate demonstration section was set to evaluate the performance of sensing data collection smoothly, and the extension of the service section in which the end-to-end information distribution system was established so that the manager could recognize it later and the video signal transmission level to be dealt with in subsequent studies The power line communication system was constructed with the potential to be used as an infrastructure and grafting with the security system for authentication of authorized devices and users in mind[10].

## 4. Problem Statement

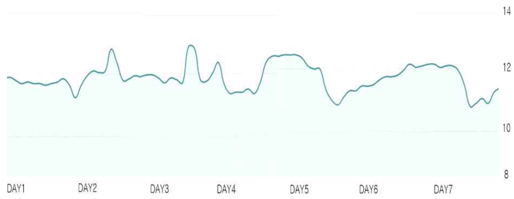
What power line communication needs to overcome is that the desired signal may be deteriorated due to changes in impedance level when connecting a load, background noise induced by electric motors, and impulse noise caused by power line switch operation. Therefore, the influence of various signal degradation factors when operating the power line communication infrastructure by separating the power supply source was analyzed. In order to bypass and prevent the effects of impedance level and background noise caused by the use of electric motors, which are various signal degradation factors, the performance evaluation environment was implemented by accommodating devices using 380V for the 3-phase 4-wire power supply and common duct monitoring devices using 220V for the single-phase 2-wire power supply sources respectively.

## 5. Result and Discussion

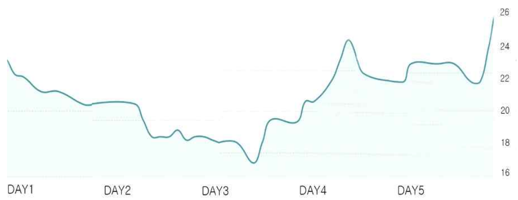
The purpose of the power line communication based common duct environmental monitoring system is to implement an efficient automation system through the minimum initial investment cost by utilizing the existing facilities in the common duct. The following is a summary of the performance evaluation results so far. The following fig. 3 shows the internal temperature of the common duct measured for 7 days under an external temperature of 0°C to 10°C and humidity measurement is as follow.

In fact, the external environment in this study is not important because the research was focused on whether the information was correctly distributed through power lines. Note that external humidity is 42% to 58% for 5 days.

As described above, in power line communication, the desired signal may be deteriorated due to various noises. These factors did not significantly affect the transmission of intermittent and periodic




(a) Temperature




(b) Humidity

Fig. 3. Temperature & Humidity in common duct

sensing data especially in separated power environments. In order for the PLC-based common duct environmental monitoring system to develop into a fully automated system, it is necessary to extend to the fault management system through SNMP and ICMP, etc., and to link with the authentication system to block unauthorized wireless access. In addition, the problem of supplying power to the smart sensor cluster is a task to be solved. Additional research is needed to more efficiently apply PoE (IEEE802.3af)-based power supply system or short-distance RF charging method.

The future research direction will be a study on the implementation of high-speed PLC infrastructure for transmitting images of Full-HD or higher level of mobile CCTV in a linear service environment such as a common duct.

## 6. Conclusion

The power line communication based common duct environmental monitoring system is implemented in a basic structure in which one master modem and several slave modems are arranged linearly, and wirelessly connected to the sensor located at the end of each base where the slave modem is installed in a star topology. In this study, research was conducted under the IEEE802.3 Ethernet environment. Physical information measured according to the sensing demand that can be used in the common duct environment, such as temperature and humidity, nitrogen, oxygen, carbon monoxide, carbon dioxide, earthquake detection, smoke and motion detection, etc., can be used to implement automatic and intelligent management of smart city infrastructure.

Since, in connection with big data technology, it is possible to reduce social costs of accidents handling by securing quantitative maintenance planning data and by pre-detecting signs of accidents and responding in advance, it will be possible to automate the management of the existing common duct and it will be possible to manage the risk due to the aging of the underground urban infrastructure. It is hoped that this research will be used for intelligent environmental monitoring system by applying it to linear service areas such as bridges and tunnels.

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