Design and Simulation of a Platform Technology for the Mobile WiMAX-based Micro Grid Home Network System Using OPNET Simulation

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Abstract

Currently, ICT (Information & Communication Technology), IoT (Internet of Things), Smart Grid and Micro Grid technologies are seen as the technologies that will dominate the IT industry of the Republic of Korea till 2020. There are communication technologies such as Mobile WiMAX, PLC, Zigbee, NFC, ANT, Mobile Wi-Fi, Bluetooth, RFID applicable for Smart Grids but we are proposing a Mobile WiMAX-based Micro Grid Home network system in this paper. As a result of simulation, we were able to confirm that the propose system worked normally. The platform technology used in this study can be used for the Smart Grids and Micro grids, as well as other IoT-applied fields. Also, many other simulations in relation to healthcare, building and facility management, disaster and accident monitoring, weather observation and other areas can be conducted using this platform technology prior to constructing an actual system to save costs by checking system’s feasibility.

Keywords : Smart Grid, Micro Grid, IoT, OPNET, ICT.

1. Introduction

Recently, IoT and Smart Grid are attracting attention of IT industries and considered as important technologies of the future. Especially, with the wireless sensor networking technology, it is able to establish an autonomous network by deploying the sensor nodes that have computing and wireless communication capabilities in an application environment. The obtained
data through the sensor nodes will be then collected wirelessly to be used for the monitoring and controlling purposes. The ultimate goal of such technologies is to achieve a ubiquitous environment where communications can be established everywhere.

Thus, the wireless sensor networking technology is fundamental to development of IoT technology and plays a vital role in establishment of a network where ‘Things’ are being sensed, and information (data) is process and exchanged without human intervention, or with the least of it.

The core issue in IoT application is to determine how to link existing devices (e.g., home appliances) to internet with what kind of technology. The possible candidates at the moment are the Mobile WiMAX, Zigbee, NFC, ANT, Wi-Fi, Bluetooth, and RFID technologies. The major technological feature of Mobile WiMAX is that the mobility has been added to wireless internet access function so that it is being regarded as one of the main technologies applicable to sophisticated household appliances such as automated vacuum cleaners, mobile Smart CCTV, and the systems like inventory management systems for the future Smart Refrigerators or Closets. For this reason, Mobile WiMAX technology has been used as one of the platform technology when the Jeju island Smart Grid Complex was constructed [1-15].

Therefore, we've constructed and simulated a network communication environment by using Mobile WiMAX and relevant OPNET simulation model will be disclosed in our future extended study where more traffics and routing algorithms will be added and the model is to be compared and analyzed with other models of different technologies.

2. Related Research

2.1. Mobile WiMAX (WiBro)

As internet develops, users are increasingly demanding a system(s) that can provide higher data transfer rate in a wireless environment. Therefore, to meet such demands in a wireless access network, the IEEE 802.16 Working Group has been newly established by the IEEE 802 LAN/MAN Standard Committee (LMSC), also known as IEEE Project 802, to standardize IEEE 802.16 series [9]. This technology is domestically referred as ‘Wibro’, or ‘Mobile WiMAX’ in overseas. Since the existing 3rd generation wireless technologies have already exposed their limitations in providing the data services to the users in current wireless communications market, both domestic and foreign mobile telecommunications companies are commercializing
the 4th generation technologies such as Long Term Evolution (LTE) and WiMAX (Wibro) in priority to resolve the situation.

2.2. Structure of terminal nodes in Mobile WiMAX nodes

[Fig. 1] shows the deployed terminal nodes in a network of Mobile WiMAX nodes. For Mobile WiMAX, a separate PHY process model will not be used on the PHY layer while using OPNET 14.5 PL8 modeler so that most of the functions are implemented at the pipeline stage, or on the MAC layer if it’s difficult to implement them at that stage.

On the other hand, a typical example of a function that seems to belong to PHY layer but implemented at the MAC stage instead is ‘Time Division Duplex (TDD)’, which is utilized in our simulation. TDD refers to a function of time sharing a single frequency internally by
designating it as transmission or reception frequency to enable bi-directional communications. Both the framing and transmission timing functions are needed to implement TDD and they are being achieved at the MAC stage in OPNET model.

2.3. WiMAX_MAC process model

[Fig. 2] represents implemented WiMAX_MAC process model in which all the transmission and reception packets pass through. The packets received from the IP layer are of pure data packets but those from the PHY layer are mixed with the control packets. The former will be processed directly in this model but the latter will be handed over to the child-process.

![WiMAX_MAC process model](image)

The state transition from idle state to hl_pk state will take place when data packet is received from the IP layer. At this state, a suitable CID will be determined based on the service class and MAC address and the packet will be stored in this CID. CID is composed of information concerning the bandwidth, data storage queue, and QoS. The data stored in each
CID will be transmitted to the PHY layer after acquiring a bandwidth and adapting to QoS while the packet received from the PHY layer will be sent directly to the IP layer after going through the reassembly process, without acquiring any bandwidth.

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A comparative analysis of performances between Zigbee and WiMAX has been conducted by deploying twelve terminal nodes in each home network that uses one of these two communication technology. For the Zigbee-scenario, one Zigbee Coordinator, six Zigbee Routers and twelve Zigbee End-devices were deployed whereas one Server, two Routers, and six base stations, and 12 terminal nodes were deployed for the WiMAX scenario, to compare data transfer rates between a coffee pot and the server.

[Fig. 3] and [Fig. 4] represent Mobile WiMAX and Zigbee scenarios respectively and shows the complex network systems in a Micro Grid Home Network System. The Mobile WiMAX-based node model and router model will be demonstrated in the future extended study. The four separate electric cookers are being displayed in each scenario but these are to show the readers that other appliances can be used in the system replacing the coffee pot but the same interface will be used for the system. Applicable appliances could be automated vacuum cleaners, Smart Closets, or CCTVs with mobility and intelligence, expected to be produced in the future. We expect that the described interface technology will be foundational to more complex future simulations in our future study.
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[Fig. 3] Mobile WiMAX scenario [14]

[Fig. 4] Zigbee scenario [14]
4. Performance Evaluation

A platform technology for a Mobile WiMAX-based Micro Grid Home Network has been introduced in this study using OPNET. [Fig. 5] shows the traffic transmission/reception Rates. The average traffic generation rate for both networks was 1Kpbs, equivalently. Transmission/Reception rates may not coincide with each other in wireless conditions but in Mobile WiMAX networks, the rates were consistent and no losses have been found due to the HARQ and ARQ functions of Mobile WiMAX.

![Traffic Transmit/Receive Rates](image)

[Fig. 5] Traffic Transmit/Receive Rates

This difference can be explained with the difference in design objective of each wireless technology. That is, while Zigbee is usually used for the networks where low transmission speed satisfies network’s requirements and designed to be used for simple signal deliveries from the sensors, intermittent data transmissions and home networking, Mobile WiMAX was designed to perform long-distance communications similar to mobile phone service, high-speed transmission and QoS, etc.
5. Conclusion and Future Work

Another notable difference between these two networks can be found in the technical standards on which they are based. The Mobile WiMAX used in the simulations adopts IEEE 802.16e standard and the Zigbee follows IEEE 802.15.4 standard. As far as the analysis result is concerned, Mobile WiMAX may seem superior to Zigbee but considering Zigbee’s low-cost and low-power consumption characteristics, Zigbee can be more efficient and suitable for certain areas. To be specific, the network scalability can be increased by installing many Zigbee equipments widely due to its low-cost characteristic and the size of battery can be reduced while extending equipment’s operation lifetime owing to its low-power consumption characteristic.

Our simulation has proven that the proposed system worked without flaw and the platform technology used in this simulation can also be applied to other systems such as Smart Grid, Micro Grid and Smart Homes. Additionally, it is possible to check both the practicability and the feasibility of preliminary system designs by using this platform technology for the simulations which deal with various conceivable environments in healthcare, building and facility management, disaster and accident monitoring and weather observation fields before putting the system into actual scene, not to mention its cost-saving effect.

References


