논문 2006-43TC-5-7

RoF 및 PON 기술 기반 통합 도심 관리 시스템 (IUMS)의 설계와 그 응용

(Design of Integrated Urban Management System and its Applications Based on RoF and PON Technologies)

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요 약

효율적인 도심 관리를 위해 다양한 시스템들이 사용되어 왔다. 본고에서는, radio over fiber (RoF) 와 passive optical network (PON) 기술을 결합하여 각 시스템 장점들을 이용하는 통합 도심 관리 시스템 (IUMS)을 소개한다. 아울러, 미래 ubiquitous city (U-city)의 실현을 위한 통합 도심 관리 시스템 적용의 타당성을 부여하기 위해 버스 정보 시스템 (BIS), 유무선 방재 시스템 (DDPS) 및 실시간 위치 정보 추적 시스템 (RTLS) 등을 포함한 다양한 통합 도심 관리 시스템을 적용한 서비스들을 상세히 기술한다.

Abstract

A variety of systems have been attempted for effective urban management. In this paper we introduce the Integrated Urban Management System (IUMS), which consists mainly of an optical line terminal (OLT), optical network terminals (ONTs) and wireless access points (APs), by combining passive optical network (PON) and radio over fiber (RoF) technologies so as to take advantage of both systems. Further, several IUMS services such as a disaster detection and prevention system (DDPS), a bus information system (BIS) and a real time location system (RTLS) are demonstrated in order to verify the employment of IUMS for the realization of a future ubiquitous city (U-city).

Keywords: Passive optical network (PON), radio over fiber (RoF), ubiquitous services.

Ⅰ. Introduction

Recently, as cities have become more populated and complicated, demands have arisen for effective urban management such as maintaining public security, detecting and preventing disasters, and providing ubiquitous information and communication services. Also, it is inevitable that we will integrate these systems, which target for a specific demand, and control them under a single communication network to realize extensive and simultaneous urban management. Further, as the number of applications and services attached to the network increases, the urban management system will be required to support broadband and high data rate as well as being flexible and highly scalable.

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※ This research was supported by the MIC (Ministry of Information and Communication), Korea, under the ITRC (Information Technology Research Center) support program supervised by the IITA (Institute of Information Technology Assessment) (IITA-2005-C1090-0502-0029)
접수일자: 2006년4월8일, 수정완료일: 2006년5월15일

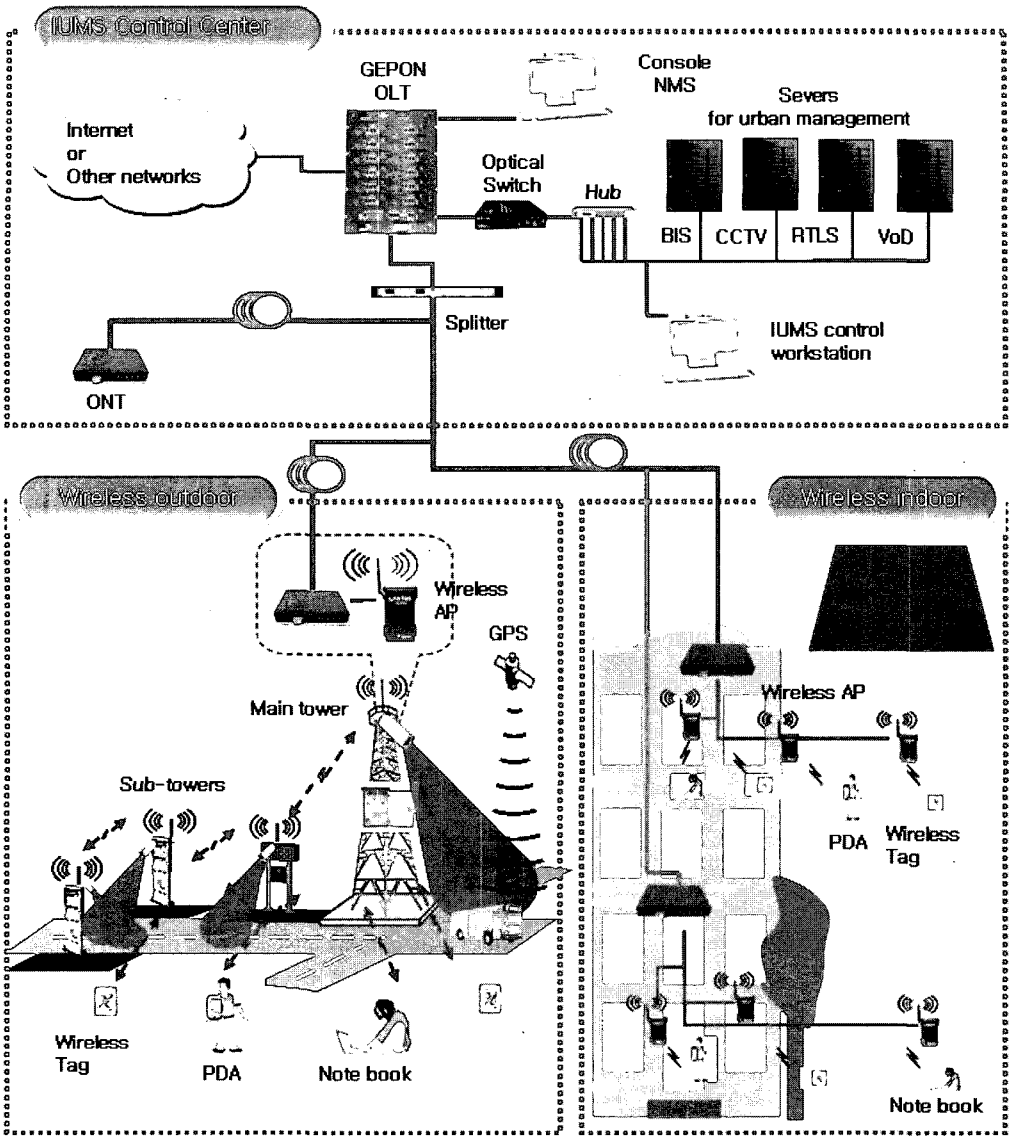

그림 1. IUMS 통제 센터, 무선 내부 및 외부 환경을 포함한 전체적은 IUMS 구조 소개
Fig. 1. The overall architecture of IUMS including the IUMS control center, wireless outdoor and wireless indoor.

To resolve those situations, the urban management system has been executed based on both optical and wireless communication systems. The optical communication system for urban management can provide broadband and high-speed multimedia services due to significantly low loss and large bandwidth of an optical fiber[1]. However, initial installation of the system infrastructure is costly, and it has low flexibility to provide a mobility to end users. A wireless communication system entails a small initial installation expense, high mobility and flexibility[2], but it cannot guarantee broadband or fast data rate, it has poor reliability, and its equipment and maintenance costs are burdensome. In this regard, the urban management system can be optimized by the fusion of optical and wireless communication systems for cost-effectiveness. Namely, the optical communication system can be utilized to collect a large amount of information from diverse urban management services and to control the overall services in the system. The wireless communication system can be applied to execute a single service or as a medium to gather several services and deliver them to the optical

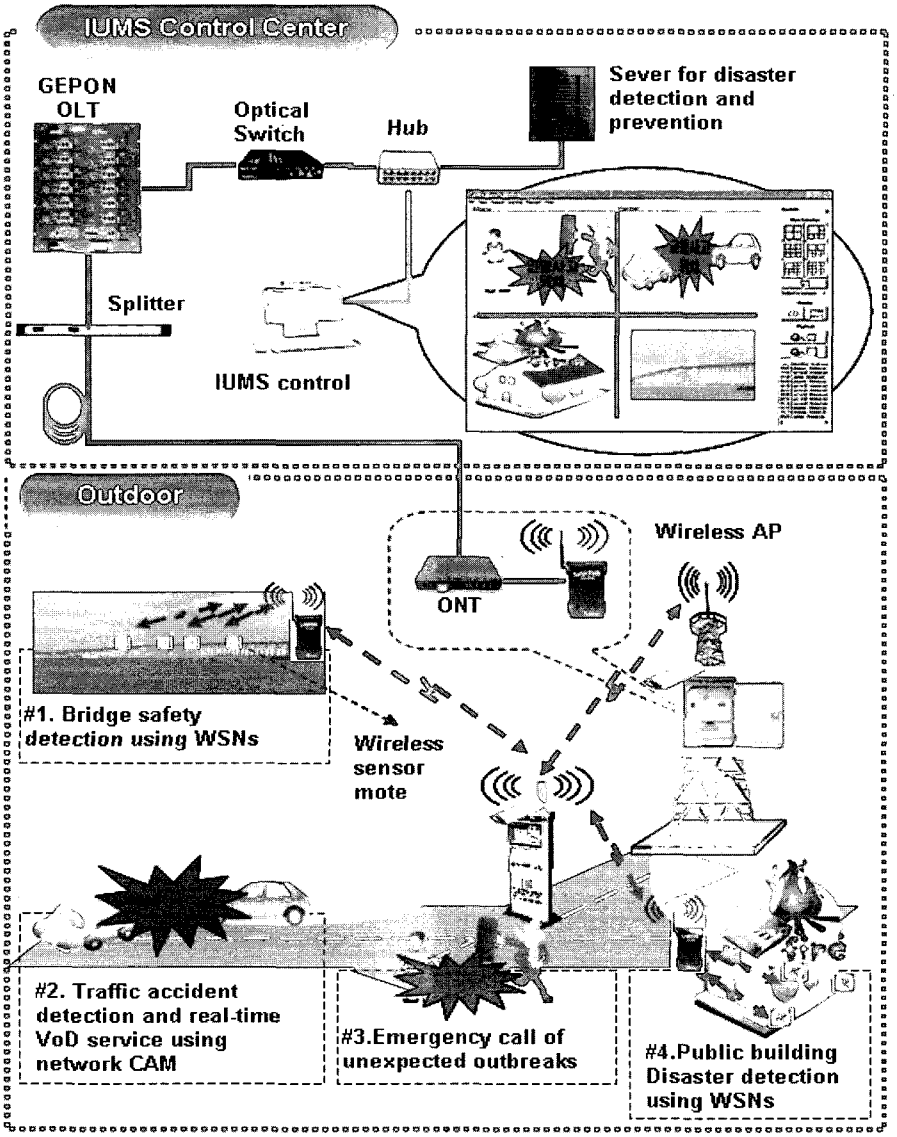

그림 2. IUMS 통제 센터가 안전 사고, 교통 사고 및 비상 전화 공공 건물 재해에 대해 주로 감시를 하는 IUMS를 이용한 DDPS 서비스의 예

Fig. 2. DDPS services using IUMS, where the IUMS control center mainly monitors such events as safety detection, traffic accident, emergency calls and public disasters.

communication system.

In practice, the hybrid of state-of-the-art passive optical network (PON) and radio over fiber (RoF) technologies can be a good candidate for an urban management system in terms of cost-effectiveness because these two systems have been designed to reduce network cost as well as improve performance over existing communication systems[3], [4]. PON is a system that brings optical fiber cables and signals all or most of the ways to the end users[5], and RoF is a fiber based wireless access scheme in which the optical signal is modulated at radio frequencies and transmitted via the optical fiber[6]. Thus, we can take advantages of the PON system, which enables us to deal with broadband multimedia traffic such as triple-play services (i. e., voice, data and video), with high data rate so that the system can accommodate a huge amount of information resulting from diverse urban management services[7]. In addition, the RoF system ensures multimedia services with flexible access and detecting of geographically or architecturally limited areas as well as mobile objects

because the optical link of RoF system provides low loss and large bandwidth, and radio signal guarantees high mobility[8].

In this paper we introduce the Integrated Urban Management System (IUMS), which is devised to cover a plethora of urban management applications by combining the PON and RoF systems, in order to construct a future ubiquitous city (U-city). In addition, several applications using IUMS including a bus information system (BIS), a disaster detection and prevention system (DDPS) and indoor or outdoor real time location systems (RTLSs) are explained to show its versatile usages. This paper is organized into the following sections. Section Ⅱ explains the architecture of IUMS, and various applications of IUMS are demonstrated case by case in Section Ⅲ. Finally, we conclude this paper in Section Ⅳ.

Ⅱ. Architecture of IUMS

Figure 1 demonstrates the overall architecture of IUMS. In terms of structure, IUMS is simply composed of an IUMS control center, a main tower and several sub-towers which are deployed outside the IUMS control center. The IUMS control center is responsible for supervising various services as well as preserving and providing information to end users executed by several network servers. The main tower provides the space to connect the optical communication system terminal to the wireless communication system, and sub-towers support spaces to connect the main tower to end users who try to use urban management services. In addition, IUMS mainly consists of two parts, the optical and wireless communication systems in the view of communication systems. In following two sub-sections, the optical and wireless communication systems of IUMS are explained in detail.

1. optical communication system of IUMS

The optical communication system is implemented by a gigabit Ethernet PON (GEPON) system, and consists of one optical line terminal (OLT), a fiber distribution splitter and several optical network terminals (ONTs)[9]. The OLT routes traffics of IUMS to other networks or distributes the information from diverse service servers to ONTs. The fiber distribution splitter splits information in terms of optical power into several ONTs. ONTs broadcast the information from IUMS control center or collect that from wireless access points (APs). The OLT is equipped in the IUMS control center and the fiber distribution splitter can be located inside or outside the IUMS control center. Additionally, the ONTs can be also deployed inside the building or attached to the main tower according to service needs. Thus, the optical communication system is mainly located in the IUMS control center except for a few ONTs.

2. Wireless communication system of IUMS

The wireless communication system is detailed by considering two cases, wireless indoor and outdoor. First, in the wireless indoor case, a wireless AP is applied to management service, and it is connected to the optical communication system terminal by electrical cables. According to service purposes, various wireless APs can be adopted such as those based on 802. 11a, b, g or 802. 15, etc. In the wireless outdoor case, wireless APs, a global positioning system (GPS) or wireless sensor nodes are deployed to obtain the information gathered by IUMS services, and they are attached to the main tower or sub-towers as shown in Fig. 2. Considering cellular and mesh networking, several wireless APs in sub-towers communicate with the wireless AP in the main tower through more than one hop.

Ⅲ. Applications of IUMS

1. DDPS service using IUMS

Figure 2 describes a disaster detection and prevention system (DDPS) based on IUMS. First, the DDPS service incorporating wireless sensor network (WSN) includes detecting public buildings or structures that are threatened by severe disasters. As

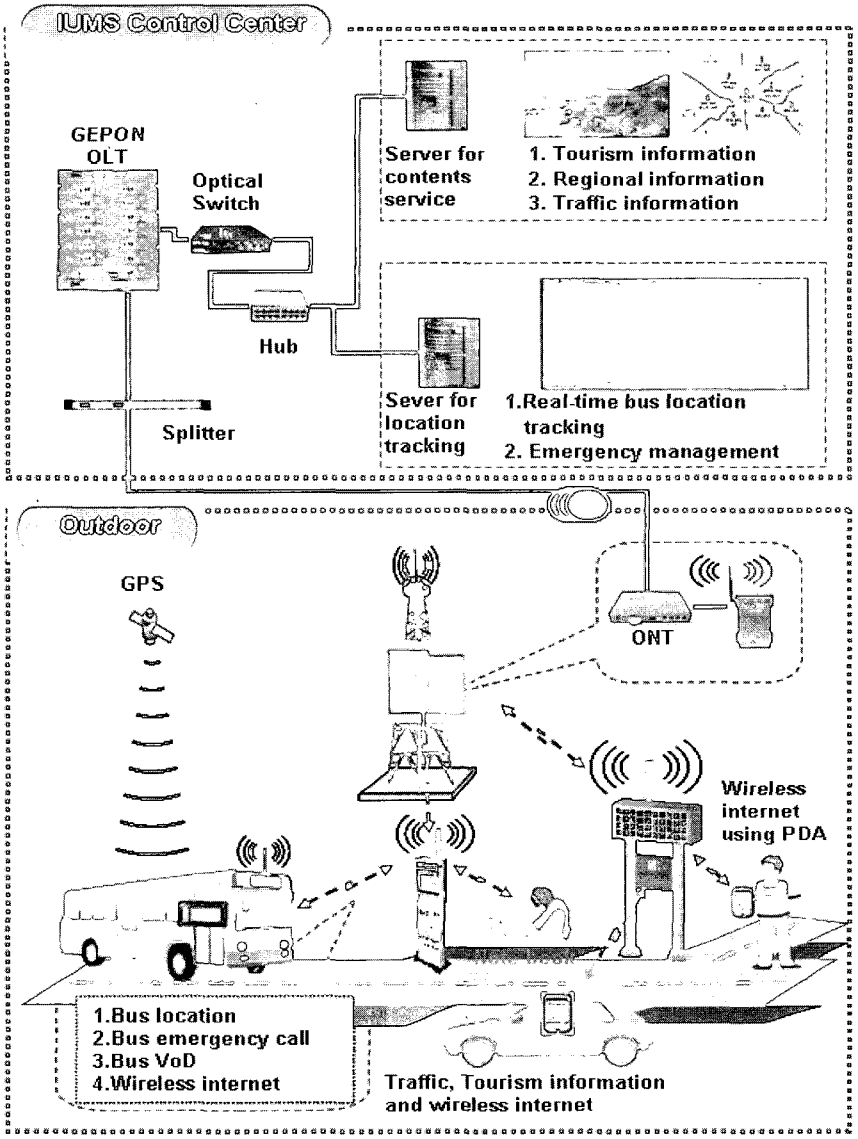

그림 3. IUMS 통제 센터가 관광정보, 교통 정보 및 위치 정보까지 관리하는 IUMS를 이용한 BIS 서비스 예

Fig. 3. BIS services using IUMS, where the IUMS control center mainly provides tourist information, traffic information and location-based management.

shown in Fig. 2, for example, wireless sensor motes sense twisting angle, vibration, or safe loads are attached to the bridge, and they send the information to the 'bridge's wireless AP[10]. After processing several hops, the detected information is optically passed to the IUMS control center. Futhermore, the application of DDPS employing WSN can be employed to public building fire detection using temperature sensing motes.

Second, IUMS performs as real-time monitoring of the areas by a top of the range network camcoder, at which traffic accidents or crimes frequently occur. This heavily loaded real-time video traffic is transmitted reliably by the PON and RoF technologies. In particular, the methodology of monitoring hot spots or hidden ones of the DDPS service in [11] can be applied in IUMS. Further, an emergency call to report unexpected outbreaks is possible by a buzzer on the remote sub-tower or on mobile equipment like a notebook or PDA. Because most applications are implemented in a wireless region, the upgrade of other services is quite flexible

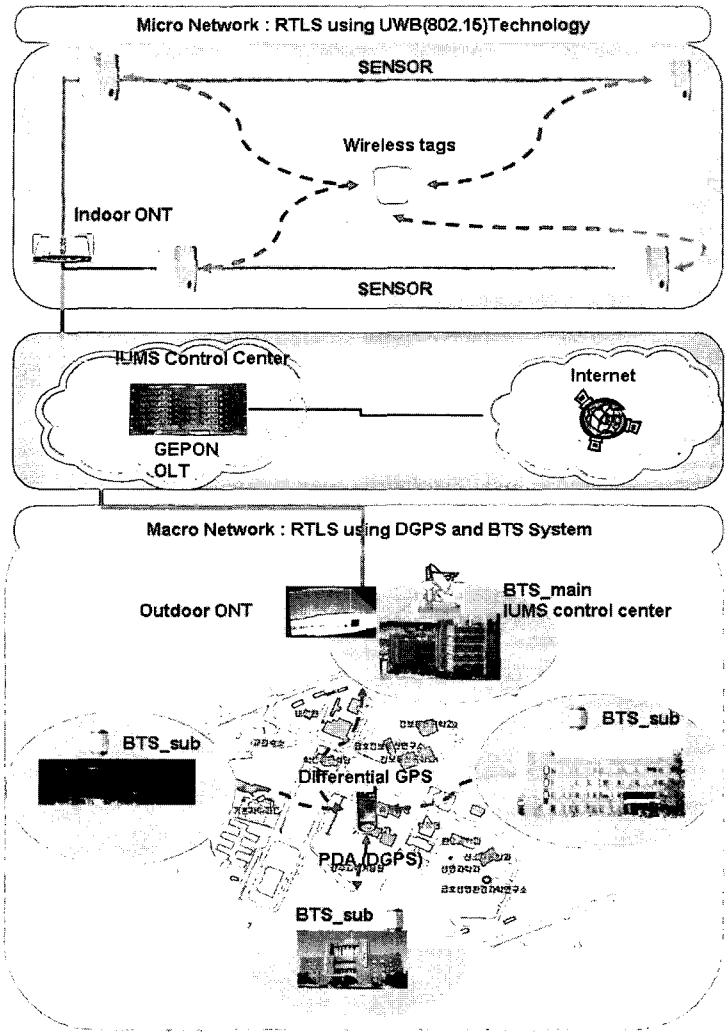

그림 4. 균일한 내, 외부 위치 정보 서비스를 제공하는 IUMS를 이용한 RTLS 서비스 예

Fig. 4. RTLS services using IUMS, where indoor and outdoor locationing services are available seamlessly.

by simply adding more wireless APs in the remote sub-tower.

2. BIS service using IUMS

As is DDPS, urban transportation control is a significant issue for urban management. Especially, we employ IUMS for one of the most common urban transportation methods, a bus information system (BIS). As show in Fig. 3, the bus sends its location information and emergency call to the IUMS control center by using its wireless AP. Then, the IUMS control center gathers all the information from different buses, and broadcasts real-time bus location information to other buses or bus stops. In particular, the methods of BIS service in IUMS for the management of bus information, and communication between buses and the IUMS control center, can be important issues in BIS system.

Additionally, the IUMS control center can immediately respond to bus emergency calls, and provide internet and VoD services to bus passengers. Further, newcomers to the city can try wireless access at the nearest bus stop where wireless AP is equipped, and they can access the internet or download a variety of information including traffic, regional, or tourism information by wireless APs.

3. RTLS service using IUMS

A real time location service is also executed by applying IUMS as shown in Fig. 4. The location information is obtained both indoors and outdoors by employing wireless communication techniques such as a global positioning system (GPS) and base transceiver station (BTS) systems, or RFID based location tracking systems based on WI-FI or UWB. By tracking targets, IUMS can easily monitor and detect their exact positions. The targets of RTLS can be a PDA, wireless tags, notebooks, or even cellular phones. Particularly, the method of transmitting location information is explained in detail in [12]. Additionally, the location records are stored and referred in the RTLS server in the IUMS control center. Expanding the RTLS service to the entire urban area and all buildings, as well as networking and controlling them under the IUMS enables the construction of a ubiquitous location based service for U-city. Further, whether it is indoors or outdoors, we can easily access the internet and upload-download our data near indoor wireless APs or outdoor BTSs.

IV. Conclusions

In this paper we have introduced the IUMS urban management system based on state-of-the-art PON and RoF technologies in order to cost-effectively achieve a future U-city. Three IUMS services including BIS, DDPS and RTLS have also been demonstrated to show its versatile applications. Although IUMS is exemplified by only three services, other applications are freely interconnected to IUMS because it is highly scalable and upgradeable. When demands arise for additional urban management services, they can be met providing that a number of ONTs and wireless APs are additionally deployed. Also, if the urban management services are beyond what an OLT in the IUMS control center can accommodate, it can be made possible by realizing a super PON in which several sub-OLTs are connected to the main OLT to increase the number of ONTs so that the number of wireless APs or wireless applications are significantly increasing. Particularly, it is noteworthy that the supplemental ONTs or wireless APs do not significantly increase the cost of upgrading urban management services. However, there is a still limitation in IUMS, the limited data rate of wireless APs which may cause a bottleneck problem among end users. Therefore, we should consider the development of a wireless AP which guarantees reliable and high data rate communication. Further, a unified user interface (UI) should be considered to commonly control various services in a stand-alone IUMS.

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