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System Management of Human Object on the Industrial Safety

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Abstract

In dangerous industry fields such as construction, shipbuilding, the mining industry, and other field, many employees have lost their life due to risky environment. As result, the costing of social and industry have been increased. To solve this problem, wireless body area network technology can implement by converging ubiquitous sensor network and wireless data communications. The wireless body area network technology has been issued recently and studied by standard institutes (e.g. IEEE TG 802.15.6), universities, and research labs. This paper studies management issues in wireless body area network for industry safety. We design human object as wireless body area network on the employee's body and propose management method for industry safety.

Keywords*: wireless body area network, sensor network, industry safety, management, mobility*

1. Introduction

The study of sensor network and ubiquitous service has recently been emerging as an important research area. As a result, applications or services of sensor network and ubiquitous grow rapidly in worldwide as well as Korea like as u-city, u-home, u-health and so on. In addition to this, nano-technology, femto-network, and body area network come into being as more new technology. In November 2007, the IEEE 802.15 Task Group 6 was created to start developing a communication standard optimized for low power devices and operation on, in, or around the human body to serve a variety of applications including medical, consumer electronics personal entertainment and others. When applied to human body, a WBAN (Wireless Body Area Network) can be described as a number of a small wireless sensors or actuators, strategically placed on the body(wearable) or in the body (implanted) providing real-time(on-line) feedback to the user or medical personal [1].

WBAN has focus on medical or personal entertainment. But this paper discusses aspect of employee or human safety in the dangerous industry fields by WBAN. As ministry of labor in KOREA, the cases of death and injury by industrial disaster are increased from 89,910 in 2006 to 90,147 in 2007. To solve this problem, we design human object (HO) in the ubiquitous industry sensor network and proposed management method. The HO organizes WBAN using sensing devices on the body for human safety. The sensing devices are accessed as a part of human object hierarchically.

In recent years, the disaster in the industry has occurred in a variety of ways due to a diversity of equipment, the complexity of the human configuration and change of the working environment, *etc.* Especially to the SME's who are vulnerable to economic independence, organization, management and education of safety are emerging as a major problem due to the lack of management skills. In Korea, an entire industrial accidents

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since 1960s have shown a steady increase and according to the industrial accident statistics by the Ministry of Labor, since 1964 when the Workers' Compensation Insurance was introduced, the number of death, injuries and diseased workers due to industrial accidents have exceeded 5 million people resulting in a direct and indirect losses of 150 trillion won. In 2012, according to the industrial accident analysis data published by the Ministry of Employment and Labor, the number of victims in mining and manufacturing industries in 2011 accounted for approximately 92,256 people with death of 1,864 people. Among them, the number of accidents occurred in the manufacturing, construction and mining accounted for about 70%. As seen in Figure 1 and 2, most of fatalities and industrial accidents have occurred in mining, manufacturing and construction industries and especially in mining sector, it has shown highest ratio of fatalities compared to entire industrial accidents. This shows that the cause of fatalities to the workers in mining and construction industries occur from dust, gases and fall, etc, and especially it is believed that the damage is more severe since the workers cannot detect the hazard conditions of work sites in advance.

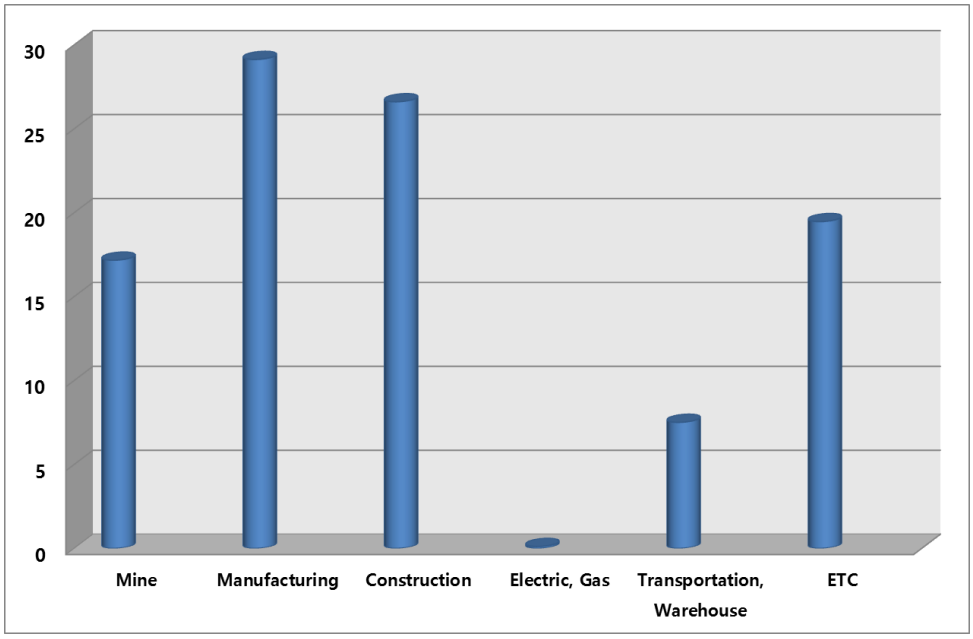

Figure 1. 2012 Distribution of Fatalities Per Industry Proportion(%), Mining, Manufacturing, Construction, Electricity, Gas, Water, Transportation, Warehouse, Communication, other Industries(100 People)

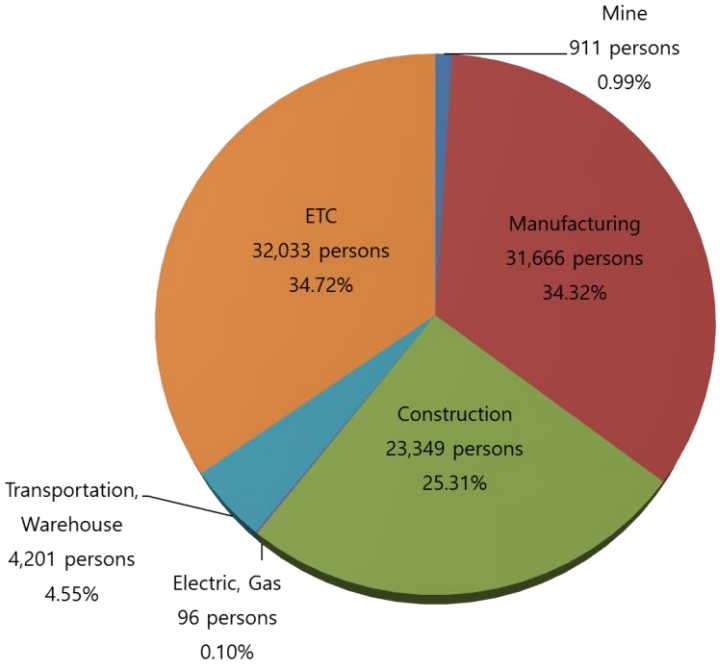

Figure 2. 2012 Distribution of Industrial Accidents by Industry

The rest of the paper is organized as following. The section 2 discusses the management of sensor network as related work. In the section 3, we provide an overview and propose management method ofHO as WBAN. Our conclusions are presented in the section 4.

2. Related Work

Tolle and Culler [3] propose SNMP, a Sensor Network Management System. SNMS is an interactive system for monitoring the health of sensor networks. SNMP provides two main management functions as query-based network health data collection and event logging. The query system allows the user to collect and monitor physical parameters of the node environment. For example, the value of a nodes remaining battery power can be used to predict node failures. Furthermore, temperature and humidity surrounding the sensor node can be indicators of upcoming failure. The event parameters and nodes in the network will report their data if they meet the specified event thresholds. SNMS proposes the Drip protocol reliably disseminate messages, commands, and queries to a set of managed nodes in the network. When a component wants to make a query, it selects a specific identifier that represents a reliable delivery channel. The Drip protocol then transports messages or replies received on that channel to the component by requiring every sensor node to regularly check the channel it subscribes to, cache and extract data from the latest message received on that channel and return a reply.

Deb *et al* [4] propose a management framework called Sensor Network Management Protocol (sNMP). The sNMP framework has two functions. First, it defines sensor models that represent the current state of the network and defines various network management functions. Second, it provides algorithms and tools for retrieving network state through the execution of the network management functions. Models for sensors include network topology, energy map, and usage patterns. In the sNMP framework, sensor models from the Management Information Base (MIB) for sensor network that are useful for determining the number of active nodes and the connectivity of nodes in the network.

Louis Lee *et al.* [5] propose an adaptive policy-based management system for WSNs called Wireless Sensor Network Management System (WinMS). The end user predefines management parameter thresholds on sensor nodes that are used as event triggers, and specifies management tasks to be executed with the events occur. WinMS adapts to changing network conditions by allowing the network to reconfigure itself according to current events as well as predicting future events, in order to maintain the performance of the network and achieve effective networked node operations.

MANNA (a Management Architecture for Wireless Sensor Networks)[6] is a policy-based management system that collects dynamic management information, maps this into WSN models, and executes management functions and services based on WSN models. MANNA's management policy specifies management functions that should be executed if certain network conditions are met. WSN models maintain the information about the state of the network. MANNA defines the relationship among WSN models in a Management Information Base (MIB). MANNA adapts to dynamic WSN behaviors by analyzing and updating the MIB. MANNA network management protocol (MNMP) is a lightweight protocol for managing information exchange among management entities(cluster heads, common nodes, and manager). MNMP places management agents on the cluster-heads and each cluster-head acts as a manager for a cluster (local manager). Custer-heads are responsible for executing local management functions and they aggregate management data received from sensor nodes. Cluster heads forward management data directly to the base station. Furthermore cluster-heads can work cooperatively with other cluster-heads to achieve an overall management goal, for example, forming groups of nodes. A manager is a powerful management entity located outside the WSN responsible for complex management tasks requiring global knowledge of the network.

ANMP (Ad Hoc Network Management Protocol)[7] is to manage ad hoc networks. ANMP is compatible management architecture is based on three-level hierarchy(manager, cluster heads and simple nodes). ANMP introduces the concept of cluster-based management where nodes in the network participate in the cluster construction and cluster head election process. Management is based on a hierarchical approach where cluster heads poll management information from their cluster members in a centralized manner.

Guerrilla framework [8] is a self-managed approach for ad hoc networks. The management intelligence is spread over the network nodes according to their capabilities. This two-tier architecture proposal is composed of nomadic managers that maintain connectivity in the management plane with other managers, and active probes, which perform the localized management operations.

TinyDB[9,10] is query processing system for extracting information from a network of TinyOS sensors. TinyDB provides a simple, SQL-like interface to specify the data to extract, along with additional parameters, like the rate at which data should be refreshed. Given a query specifying, TinyDB collects that data from motes in the environment, filters it, aggregates it together, and routes it out to a personal computer.

3. Management WBAN in Human Object

In this section, we consider management of WBAN in HO(Human Object). Not in-body area network but on-body area network is focused. The WBAN in the HO has a little bit difference to general sensor network to aspect of management. The sensor nodes are treated not independent in the sensor network, but belong to WBAN in HO. This section discusses management of WBAN in the HO including this characteristic.

3.1. Overview of WBAN in HO

We design the ubiquitous industry network architecture for saving of employee's life. The diagram of ubiquitous industry concept with sensor network is shown in Figure 1. The components of ubiquitous industry sensor network we proposed are HOs. EOs(Environmental Objects), and the industry fields with environment monitoring sensor nodes as infrastructure network. The HO is constructed by wireless body sensor network and implemented on the body of human respectively. The HO is implemented as set of a safety helmet, shoes, belt, glove, and vest and the HO's components communicate with each other by wireless body area network on the employee. The components of HO detect and collect temperature, humidity, harmful gasses, illumination, the magnetic field changes, and the image around employee. Also accelerometer sensor or gyro sensor may be implemented in order to inference activity or location of employees.

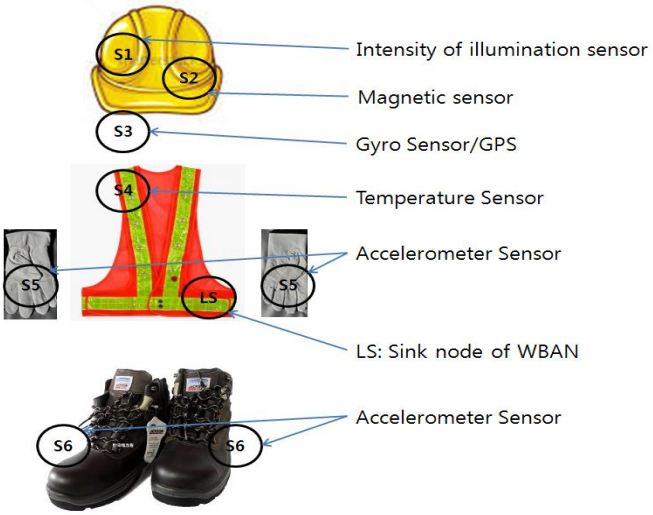

Figure 3. Example of WBAN in the HO for Human Safety

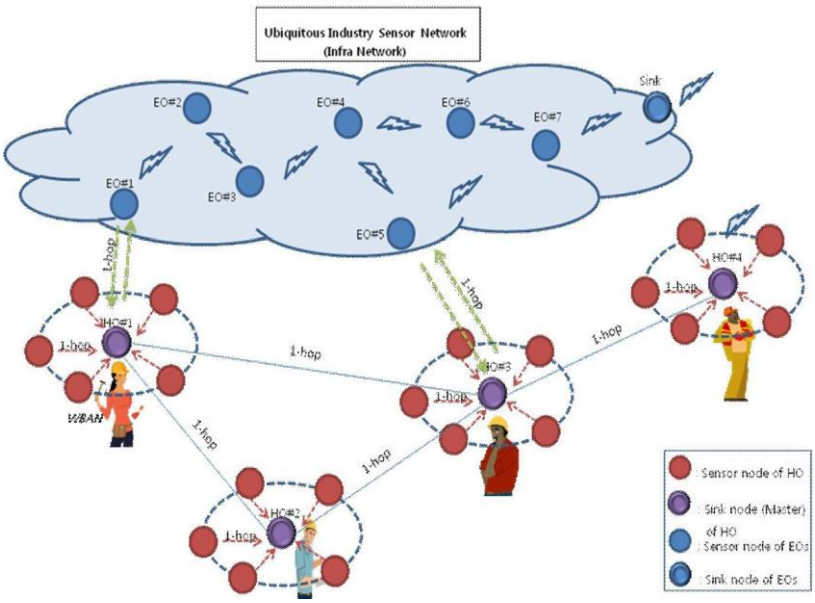

Figure 4. Ubiquitous Industry Network

The HOs operate with different channel number, network ID, and time clock respectively as WBAN and can move around ubiquitous industry sensor network freely. The sensors of HO's components detect dangerous environment condition and transmit the sensing data to sink node /master of HO. The sink nodes/masters of HOs may share information with neighbor HOs or to remote monitoring station via ubiquitous industry sensor network infrastructure.

3.2. Characteristics of HO as WBAN

WBAN in the HO has not only many characteristics of sensor network but also a little bit different characteristics as compared with general sensor network. First, WBAN in the HO is mobile body area sensor network. We consider that mobility is not node level but network level and that sensor node of WBAN is static. Second, sensor nodes of HO as WBAN are not globalized and only accessed via sink node/master of HO. That is to say, sensor nodes of WBAN cannot be accessed by unique ID or address to outside world.

(1) Mobility

Due to movement of human or employee, network mobility of WBAN is considered. The WBAN has unique network ID and RF channel range. Due to this characteristic, the interference with other HO or industry sensor network may occur. Also because the connection to outer network is unstable, the master or sink node of HO must store the status information like DB-style. To reduce RF interference, the RF channel of HO must be changed dynamically. The master of WBAN has the role of management. The master creates WBAN and manipulates sensor nodes as well as network.

(2) Access of sensor nodes

The sensor nodes of HO as WBAN are not accessed respectively. The sensor nodes registered to master and are managed as part of HO. Once the sensor nodes are equipped on the human body, they are not moved frequently. The sensor nodes of WBAN in the HO are critical for human safety, management of them is very important.

3.3 Hazard Detection Algorithm

Hazard detection technology provides independent detection of hazards from harmful environment in industrial work sites using the intelligent safety management equipment (worker). By collecting surrounding environmental values of workers, the sensor of intelligent safety management equipment detects the hazard conditions. Our system technology recognizes the environmental sensing information from industrial safety sensors of intelligent safety management equipment, current location information and the hazards from behavioral information.

Hazard alarm sharing function is required between the objects in order to share the hazards between the workers at the site and this function is made through a dynamic virtual sharing network(WBAN). Sharing network has the concept of virtual reserved network.

It holds local sink node of each WBAN as a member. For this reason, the local sink node of each WBAN must be able to support the WBAN model for communicating with the sensor node of WBAN and to sharing network mode for communicating with the local sink node of other WBAN on the shared network. In WBAN mode, it collects the environmental sensing data from each WBAN's configuration sensor node and determines the hazard. The Figure 4 explains the alarm sharing protocol for spreading the hazard conditions.

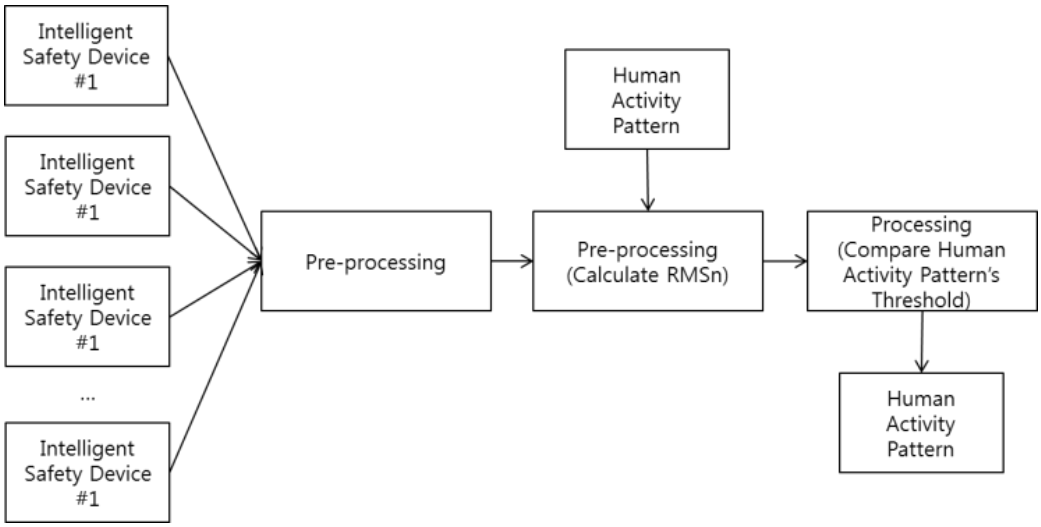

Figure 5. Behavioral Detection Block Diagram of Intelligent Safety Management Equipment

3.4. Proposed Method

We propose the hierarchical management method for sensor nodes of HOs and network. Because sensors of HOs components have low power and limit resources like sensor nodes of sensor network, the development of normal SNMP on the sensor nodes is not appropriated. In this application for industry safety, sink node/master of HO as WBAN has more powerful resources and capabilities than sensor nodes of WBAN. Therefore we design the sink node/master of HO as WBAN for management of sink nodes and WBAN. The sensor nodes of WBAN are presented hierarchically like a Figure 3. The identification of HO/WBAN is top level of tree structure in Figure 3 and represented HO #n. The symbol of n is a numerical expression of distinction. The second level is objects of WBAN as glove, shoes, vest, and so on. They are components of HO and have sensors or sensor nodes for monitoring environmental conditions. The third level is identification of nodes of HO's components and network as WBAN. They are expressed ID, address, or roles. The fourth level is represented as elements managed. They are types of sensor, battery, channel, quality, protocol and topology. The last level express attributes of elements managed. They contain values of elements managed as current value, threshold value, and alarm status. The managed component may be different according to sensor types. The managed components are accessed by hierarchical method like a tree. For example, the temperature value of HO's left glove shows is expressed as "HO#l glove(L).node#l.temperature.current". This status information is stored in master of WBAN. The master collects the information periodically or event-driven. To share with other HOs or industry sensor network infrastructure, the schema of information is exchanged. The elements managed or attributes in the Figure 3 may be extended. According to pre-defined structure of status information, other Hos, sensor nodes of industry sensor network infrastructure, or remote monitoring station can parse and understand the syntax and semantics. This sentence may be encoded by binary or hexadecimal expression for efficient communication. In that case, the delimiter may be for example dot, "I", or special characters.

Figure 6 shows exchange status information between HOs (a) or industry sensor network (b). Because human or employee can move around workplace, WBAN in the HO

has mobility. In the Figure 6, we show that WBAN has star topology. As shown (a) of Figure 6, HOs can exchange status information of its sensors directly. The (b) of Figure 6 explains that HO notify status information of its sensor to other sensor node of infrastructure network. Then the sensor node received information of HO send to sink node of sensor network as infrastructure network by broadcast or multi-hop transmission. The Figure 7 shows message sequence chart of management and sharing protocol. Three phases exist. The initialization phase is to initialize H/W, S/W and N/W of sensor node or master of HO. Also DB in the master of HO is initialized in this phase. Sensor nodes of HO register their information, capabilities to manage after associate WBAN. Then master of HO creates DB table or schema and adds initial information to DB. The second phase is to collect status information and add to it DB. In that case, the collection of status information is based on policy. The policy is collection method like polling or event-driven and decided by master of HO or remote manager. The last of phase is to share status information among HOs or with the sensor node of infrastructure sensor network. Before sharing its status information, master of HO sends DB schema to the other HO or sensor node of infrastructure network in order to help parsing and understanding.

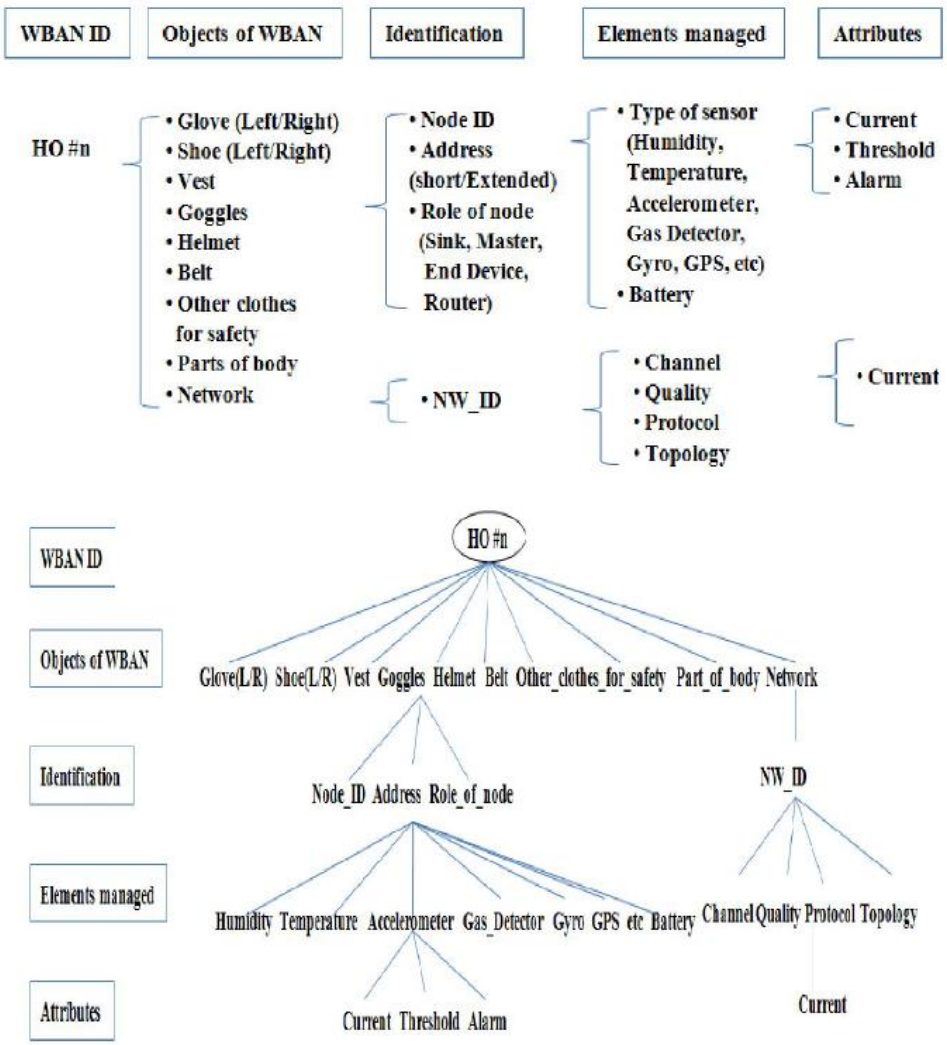

Figure 6. Example of Managed Data Structure for WBAN

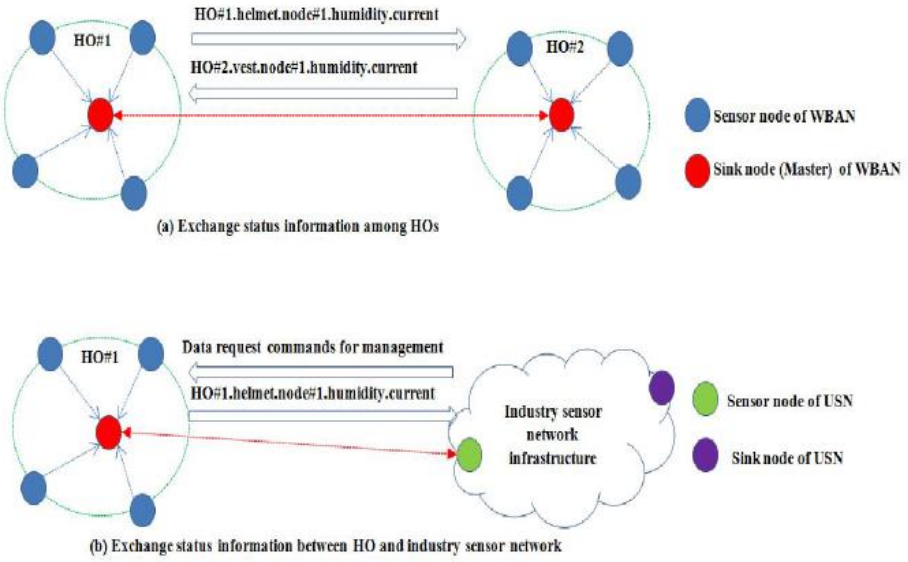

Figure 7. Exchanging Managed Data

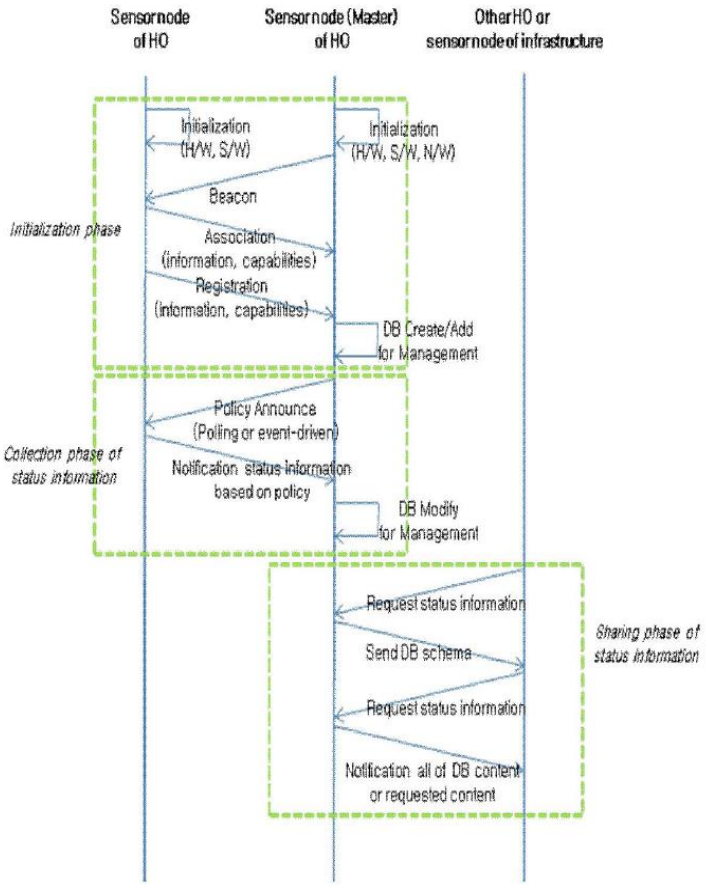

Figure 8. Message Sequence Chart of Management and Sharing Protocol

4. Conclusions

In this paper, we designed HO as WBAN and proposed management method for safety of employees in dangerous industry fields. The management of sensor nodes of HO is important due to help saving human life. The sensor nodes of HO are treated as part of human object but not independent node. Also due to mobility of HO and resource constraints of sensor nodes of HO, the sink node/master must have a DB for management. The future work is to verify our method by implementing it to simulation platform and real hardware platform.

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