Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 45 (2012) 748 – 754

Procedia Engineering

www.elsevier.com/locate/procedia

2012 International Symposium on Safety Science and Technology

Research on urban public safety emergency management early warning system based on technologies for the internet of things

DU Chunquan[a,b,*], ZHU Shunbing[a,b]

[a]*School of Urban Construction and Safety Engineering, Nanjing University of Technology, Nanjing 210009, China*
[b]*Jiangsu Key Laboratory of Urban and Industrial Safety, Nanjing University of Technology, Nanjing 210009, China*

Abstract

Urban public safety emergency management early warning system based on technologies for the Internet of Things(IOT) can realize the function of omni-directional monitoring and control, accurate prediction and efficient disposal. The rescue mechanism of a unified command, complete function and response sensitivity, and operate efficient be formed by the system. And improve the city's ability to withstand to public emergencies have great significance. In this paper, the current research situation for Internet of Things application in the field of public safety is introduced. The characteristic,structure and constitution are expatiated in details with illustration. Then the software and hardware platform,and the system function are analyzed. The key technologies and the technical research routes of the system are expounded.

Keywords: internet of things(IOT); emergency management; early warning system; wireless sensor network; standards; information fusion

Nomenclature

u_θ	velocity in the direction of (m/s)
A	radius of (m)
B	position of
C	further nomenclature continues down the page inside the text box
Greek symbols	
γ	stoichiometric coefficient
δ	boundary layer thicknesses(m)
Subscripts	
r	radial coordinate

1. Introduction

From the SARS and bird flu happened in 2003 to the earthquake and ice disaster have happened in current years and the incidents of Dalian oil pipeline explosion in past year as well as Nanjing propylene explosion accident happened in July 28th 2010 that all these incidents are alarming people to do further study on in emergency technology and management in

* Corresponding author. Tel.: +86-13912994036.
E-mail address: du.chunquan@163.com
Supported by Soft Science Research Projects Fundation of Nanjing Municipal Science &Technology Commission(2011), Jiangsu Province Science and Technology Support Programme and Social Development Project(201102021)

doi:10.1016/j.proeng.2012.08.234

order to form unity of command, functional, response sensitivity and efficient operation emergency response rescuing mechanism.

Internet of Things (IOT) has functions of overall perception of information, reliable transmission of information and intelligent processing of information which can achieve the object of intelligent control and management[1-2]. The functions will be used widely in urban public safety emergency management area. Study on in urban public safety emergency management early-warning system to realize Omni bearing monitoring and control, accurate prediction and efficient disposal for abrupt public emergencies. This study on has great significance for improving the technical content of the city emergency response platform and emergency response abilities. Also it can improve the city's ability to withstand sudden public events.

2. Analysis of the current research situation

At present, at home and abroad many researches about IOT application on public safety area have been taken.University of California, Berkeley has applied WSN for forest fire detection. The research result is FireBug system[3]. Standford University has developed a set of building monitoring system based on wireless sensor network (WSN) for extreme events and long periodical test. OU Jinping academician and her research group developed a WSN used for offshore platforms and other civil engineering of structure health monitoring. In Shanghai, Shandong and other places cylinders of hazardous chemicals and liquefied gas bottles have been installed RFID electronic tags to carry out dangerous goods detection. In addition, other facilities such as elevators and fire protection safety equipments (for example fire extinguishers, alarm equipments) have been conducted this technology[4].

In 2003, Willard South African Company posted RFID tags on miner's cap to carry out mine management. The demonstration project constructed by Chinese company of IOT technology in the mineral has been implemented in Jiahe Coal Mine. Through sensing mine disasters signals the system can achieve early-warning and forecast for a variety of disasters and accidents. Also it can provide proactive safety. Zhangliang etc for the problems of rescue persons and materials management inconvenient existing in geological disasters and other sudden emergencies provide that introducing RFID to WSN to design then realize a temporary emergency management system based on WSID network. This system can carry out efficient management to staff and materials installed ID tags[5].

Throughout these researches, most of them are aiming to study on a specific issue but not reach a system level. Domestic and oversea scholars both have not presented a complete theory system of study oning and applying IOT in public safety emergency management early-warning area.

3. Emergency management early-warning system based on IOT

According to the requirements of urban public safety emergency management early-warning system based on IOT must have emergency management abilities of information obtained, reported and processed, tracking and feedback and emergency response, forecast and early-warning, information reporting, comprehensive judgments, command scheduling and remote consultation should be finished. In addition, according to the national emergency platform requirements the function of providing needed professional data and real time images or other information should be achieved[6-7].

3.1. System structure

Fig.1 shows the structure of public safety emergency management early-warning system based on IOT[8-9]. The system is consisted of sensing layer, network layer and application layer. Among them, sensing layer is the area with the ability of perception and installing information collected devices in public facilities, production sites and circulation of dangerous goods. Network layer is the channel of achieving application layer communication with sensing layer including PAN network, LAN network and WAN network. Application layer is the platform for some relevant regulatory authorities analyzing data, disposing of accidents and making a decision and command for accidents. The core of the platform is public safety monitoring service center including database system, integrated application system and information transmission system. Database system mainly collects basic disasters history information, basic disaster prevention force, information of personal organization, information of on-site monitoring and controlling, basic geographical, hydrological, and meteorological information to provide theory support for prediction simulation, pre-arranged planning optimization and disposal and decision-making. Integrated application system consists of intelligent assistance, emergency assessment, simulation exercises, dispatching and other subsystems. Information transmission system is responsible for the communication of regulatory authorities and the center, receiving outside information and disposal of information dissemination.

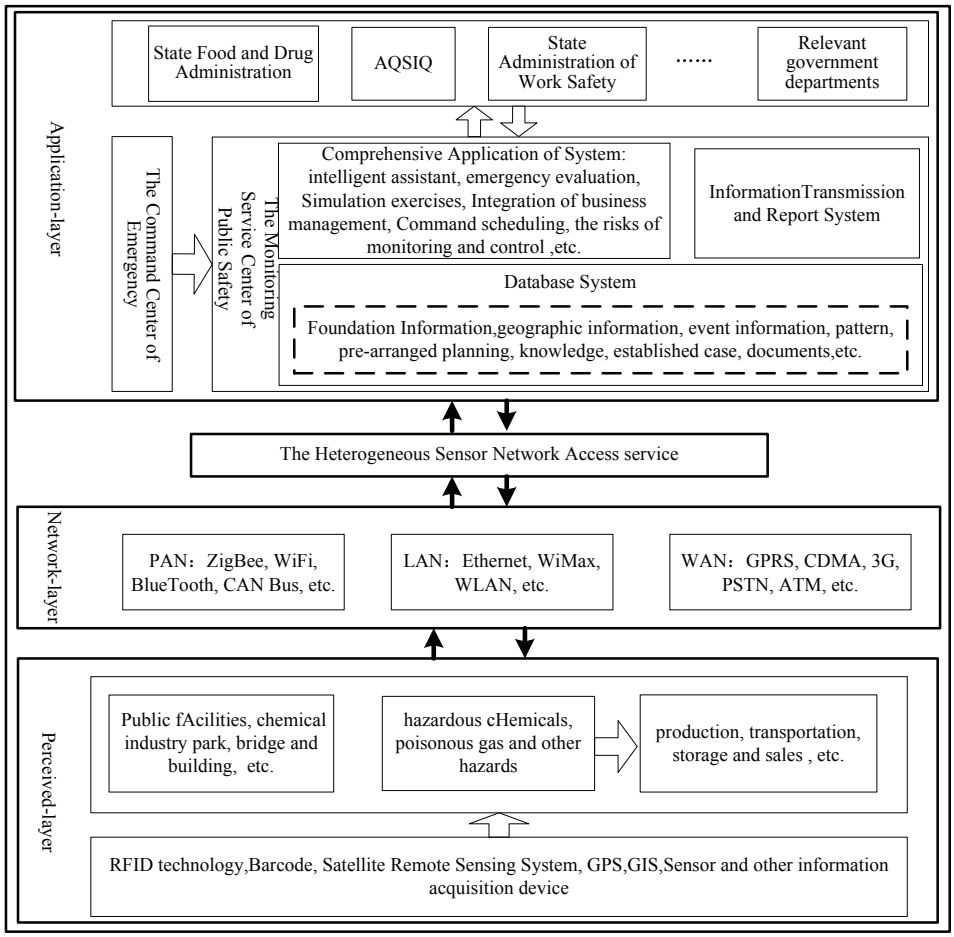

Fig. 1. Overall system architecture.

3.2. Software and hardware of system

The hardware basis of system is information collected devices arranged in different environments. The performance of the hardware sets plays a direct impact on regulatory authorities to obtain accurate information on the site and the efficient disposal of accidents. Due to information collected devices are often arranged in different hostile environments, signal stability and the nodes energy are key issues of the system. Therefore, selecting micro-controllers with characteristics of strong communication ability, low power consumption, accuracy information collected and appropriate price such as CC2530/ CC2431, the series of AVR and ARM then coupled with wireless communication protocol interface such as ZigBee, Bluetooth, WiFi is a good method.

Software includes three parts which are dynamic node PDA portable device software, sensor node software and system management software. PDA portable device software development platform often used Microsoft's open, scalable 32-bit embedded WindowsCE operation system. The software development platform of WSN has two kinds. First, open source operating system TinyOS developedby UC Berkeley. The second is using Linux software to develop. TinyOS is designed specially for embedded WSN. The structure of the operation system based on components makes quickly update possible which has been widely used in WSN study on and application area. Linux is a clone system of UNIX operation system. Its development depends on UNIX operation system, MINIX operation system, GNU plan, POSIX standards and internet. It is difficult to develop Linux. But because the source is open that researches can make changes to the structure of the system according to needs to form specific operating system which can bring hardware functions of the system better.

3.3. Functional orientation

3.3.1. Sensing layer

Sensing layer is used for acquisition physical events and data occur in the physical world, including various types of physical quantities (for example, fire source, temperature, humidity etc), logos, audio and video data. But also sensing layer takes responsible for collecting data and information including transmission, display, interpretation, identification and screening.

Through the radio frequency identification (RFID), infrared sensors, global positioning systems, laser scanners and other information sensing devices arranged at the bottom, sensing layer can achieve Omni bearing accessibility detection, monitoring and accuracy location of various hazardous resources. In addition, it can collect data information for abrupt fire, explosion, toxic gas leak and many disasters public events then dispose and analyze of information of abrupt emergencies. Use the sub layer of sensor networks self-organizing and cooperating with information can achieve short-distance data transmission for the data acquired from sensors, RFID and other data collection devices. It means that intelligent nodes sense information (temperature, humidity, images, etc) and self-organize to pass data to the point of the upper gateway. The collected induction information will be submitted to the background through the network layer by gateway.

3.3.2. Network layer

Network layer established in the basis of current mobile communication network, internet and other private network (for example, PAN network, LAN network, WSN network etc). Through heterogeneous sensor network access network layer to service equipments and connect it with infrastructure network to transmit different kinds of information obtained from sensing layer to application layer accessibility, high reliability and high security.

3.3.3. Application layer

The application layer mainly consists of application support platform sub-tier and application services sub-layer which uses analyzed and deal perceived information to provide users with information collaboration, sharing, exchange and other special functional services supporting for cross-industry, cross-application, and cross-system. Application layer also has these functions such as issued/upload emergency decision-making conducting data and command, take responsible for data information on the site feedback, hierarchical command and decision-making, collaborative command information sharing, scheduling allocation of available resources, assessment of emergency overall effectiveness, command recording and event summary, etc. Various functional departments should transmit real-time data acquired from sensing layer to public safety monitoring service center. Through integrated application system and database system to model and predict the development of disasters, predict the risk and analyze its influence, assess evacuation and shelter of persons. On the basis to carry through optimization pre-arranged planning, conducting, decision-making and management of recommendations. By using of information transmission system to grade early-warning, issue an instruction rapidly, dynamic emergency decision-making command and allocate resources. Also it can realize that rescue persons can acquire comprehensive information on site timely and connect smooth information contact with the command center and the trapped to ensure emergency rescue proceed rapidly and efficiently.

4. Key technologies

The characteristic of public safety emergency early-warning system based on IOT is system's intelligent ability. To achieve higher intelligent ability, the system has referred to several computing technologies such as distributed and infusion "sea computing" in front of the system used to integration with the physical world and the "cloud computing" technology used to provide higher performance data services and support services in the back-end support system. Combined with the characteristics of the system and framework, the following key technologies should be focused. Fig.2 shows its logical connection and research route.

4.1. Construction of IOT application standards

How to improve the technologies of IOT application in the field of public safety emergency management earl-warning is the current needed solved urgent problem. Specially speaking, common technical characteristics and application specific requirements of each industry can be firstly separated to form corresponding basic technical standards to ensure the necessary unity. Then based on common technical standards and according to different industries maturity and characteristics build various industrial application standards (such as in the area of public safety and industrial safety) and

form uniform application standards for the public. At the same time plan the construction of industrial IOT management center for public safety and industrial safety as soon as possible[10].

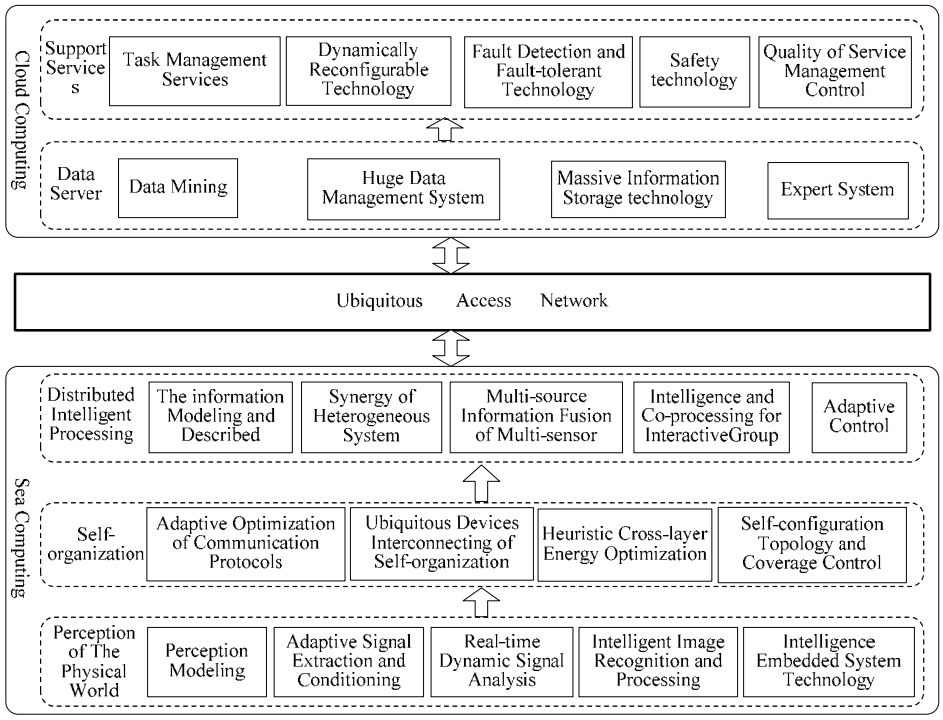

Fig. 2. Logical connection of the key technologies and research route.

4.2. Coverage optimization and self-organization

4.2.1. Technology of WSN link layer and network layer

Based on short-range wireless link characteristics on the complex environment, high density short message sending application features, and the characteristics of network topology which is controlled dynamic changing, Medium Access Control (MAC) layer protocol which can use network capacity efficiently and reduce energy consumption was researched [11-12]. Take a research in routing protocol which can reduce the number of forward and improve network capacity and efficiency through the use of technologies of cross-layer design, network coding, single-hop multicasting.

4.2.2. Networking technology of WSN

According to different IOT application characteristics and considering communication modes between materials, objects mobility, information perceived frequency and delay performance or if there are infrastructure support and other a variety of factors, applicative networking model and its properties are researched. The time control, airspace control and logic control technologies of the network topology according to the requirements of low power operation have been studied[13].

4.3. IOT mixed information fusion and decision-making

The information characteristics of IOT are multi-source, multi-granularity and multi-application domain[14]. Research of IOT information processing and service model then study on fusion information mixed, mining complex relevance chain, proactive decision-making and interactive controlling.

4.3.1. Information processing and service model of IOT

Research of multi-level, active and open model for IOT information processing, information modeling methods for

materials interactive exercises, the modeling theory and methods of multi-source heterogeneous, multi-granularity and multi-dimensions data for mining and decision-making in real-time, the analysis modeling for multi-application domains, the service expressing, publishing and application modeling based on semantic and semantic understanding and analysis mechanisms based on service model.

4.3.2. IOT mixed information fusion

Study on analysis and abstract multi-source heterogeneous data in the fusion situation, the data mining methods for mixed and decision-making services, distributed context awareness, integration and reasoning mechanisms under non-deterministic situation, the scene analysis method for specific IOT application and the methods of knowledge-based construction and self-learning.

4.3.3. Mining IOT complex chain

Study on the modeling and presentation methods of IOT chain, the excavation and discovery methods of chain in real-time interaction scenarios, the reasoning rules and decision-making modeling based on chain.

4.3.4 Proactive decision-making and interactive controlling of IOT

Study on the mechanism of reverse analysis and task decomposition for semantic information and decision-making needs based on services, active decision-making and coordination mechanism for granularity IOT, and efficient active layer processing and integration methods.

4.4. Three dimensional positioning technology

IOT can monitor, perceive and collect different environment or monitoring objects information collaborate and in real-time in the coverage area of network and then dispose the information. Through the wireless way transmit disposed information and convey the information to observers in self-organization multi-hop network way. Using the technology characteristics of IOT makes rapid accurate three dimensional positioning for accidents address and personal distribution when accidents happened which will effectively improve the relevance and accuracy of the rescue operations and will have high application value for persons rescue and incidents efficient disposal.

4.5. Security technology

4.5.1 Technology of WSN Q0S protection and reliability

Do studies in some technologies. A kind of technology can ensure nodes and networks working for a long time in harsh environment. The reliability technology can control the nodes′ perceived probability of false alarm. The one can detect failure nodes and the other can reduce the impact of failure nodes[15-16].

4.5.2 Privacy protection for IOT data processing

Study on the data hiding methods of multi-source heterogeneous data. Study on the privacy protection methods in the process of mining the chain of IOT. Study on data processing mechanisms and collaborative computing algorithms with different privacy protection security scales.

5. Conclusions

(1) Urban public safety emergency management early warning system based on IOT can realize the functions of Omni-directional monitoring and controlling, accurate prediction and disposing abrupt emergencies efficiently. In the environment of complex and having strong requirements for real-time the system can strengthen the city's ability to withstand public emergencies and improve the emergency management efficient to reduce personnel and property losses.

(2) Guidance construction of the technology of IOT in city public safety emergency management early warning application in the form of standards. Between the standardization work and application engineering form positive interaction to avoid a number of different technical systems redundant similar application projects construction.

(3) To improve the intelligent ability of public safety emergency early warning system, different computing technologies involved in the system must be studied more. The authors have presented the key technologies′ logical connection and research route referring to the contents of the best coverage and self-organization, IOT fusion information mixed and decision-making, the technology of three dimensional positioning and security technologies.

References

[1] GUSTAVO R G, MARIO M O, CARLOS D K, A., 2008. Early infrastructure of an internet of things in spaces for learning, Eighth IEEE Interna Conference on Advanced Learning Technologies C, pp. 381-383.
[2] AMARDEO C, SARMA J G, J., 2009. Identities in the Future Internet of Things, Wireless Personal Communications 49, pp. 353-363.
[3] Damian Gallegos. Enhanced Logistical Information in Fire Combat Post 911. Tech Review of College of Engineering University of Cali Berkeley, Sep 2003.
[4] Zhu Shunbing, Wei Qiuping, Du Chunquan, J., 2010. Study and prospect on the application of Internet of Things in perceiving safety, China Science Journel 20, pp. 164-170.
[5] ZHANG Liang, CAI Yue-ming, J., 2009. Design and Implementation of Emergency Management System Based on WSID Network, Communic Technology 42, pp. 147-176.
[6] YAO Guo-zhang, J., 2008. A Study on Building the Emergency Early Warning System of Jiangsu Province, Journal of Nanjing University of Pos Telecommunications 10, pp. 5-16.
[7] Long Yu, J.,2009. Some proposals about promoting the construction of national emergency platform, Engineering Sciences 11, pp. 87-96.
[8] SUN Qi-bo, LIU Jie, LI Shan, FAN Chun-xiao, SUN Juan-juan, J., 2010. Internet of Things:Summarize on Concepts,Architecture and Key Techn Problem, Journal of Beijing University of Posts and Telecommunications 33, pp. 1-9.
[9] Zhang Hui, Wang Li, J., 2011. Standard Systems and Standardization Promoting of Internet of Things, INTELLIGENT BUILDING 125, pp. 17-2
[10] Zhou Hong-bo, A., C., 2010. standard exchange of data and Middleware, 2010 Internet of Things China, ShangHai:SHAN COMMUNICATIONS ADMINISTRATION AND China Council For The Promotion Of International Trade, pp. 243-268.
[11] Zheng Guo-qiang, Li Jian-dong, Zhou Zhi-Li, J., 2008. Research Situation on MAC Protocols in Wireless Sensor Networks, Acta Automatica Si 34, pp. 305-316.
[12] W. Ye, J. Heidemann, D. Estrin, J., 2004. An Energy-Efficient. Medium Access Control With Coordinated Adaptive Sleeping for Wireless S Networks[J]. IEEE/ACM Transactions on Networking 12, pp. 493-506.
[13] SU Weiji, ZHAO Hai, ZHANG Wenbo, XU Ye, J., 2006. Wireless Sensor Networks Free Scale Routing Algorithm Based on Emb Technology[J]. Computer Engineering 32, pp. 87-89.
[14] Gong Jibing, Wang Rui, Cui Li, J., 2010. Research Advances and Challenges of Body Sensor Network (BSN)[J]. Journal of Computer Resear Development 47, 737-753.
[15] Elson J., Romer K, J., 2003. Wireless sensor networks: a new regime for time synchronization, ACM SIGCOMM Computer Communication R 33, pp. 149-154.
[16] M Wiebking, L., Gulden, P, Wieghardt, J., Hoffmann, C., Heide, P., 2003. Wireless local positioning[J]. Vossiek, IEEE Microwave Magazine 77-86.