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Intelligent Warehousing Operation Management System Based on Safety Monitoring

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Abstract: There are many problems in traditional warehousing operation management systems, such as poor management, equipment's lack of maintenance and scheduling repairing and invalid control of disasters. To solve problems above, it is important to bring environment monitoring and equipment monitoring into management system of warehousing operation and construct a triune management platform. In this way, the quality of goods, the efficiency and safety of warehousing operation can be guaranteed. A framework of an intelligent warehousing operation management system based on safety monitoring is proposed and technical solutions of the system are presented. At the same time, the structure and functions of monitoring node based on the technology of cyber-physical system are revealed. Through the fusion and processing of more information and by inspecting equipment and environment simultaneously, the system could make warehousing operation plans, optimize operation management and maximize the capacity of performance under the premise of commodities' safety. Therefore, operation monitoring is believed to be more intelligent by employing the new system.

Key words: Warehousing operation, safety monitoring, cyber-physical system, information processing

INTRODUCTION

As an important part of logistics, the major function of warehousing is reserving goods and the fundamental goal of warehousing is keeping commodities' value in use. Traditional systems of warehousing operation management focus on optimization and effective administration of warehousing operations and sometimes, they may extend to some other aspects like making delivery plans and so on; while modern warehousing operation management pays more attention to the safety of goods, facilities and equipment and operators, by utilizing advanced technologies (Mao and Xu, 2013; Song *et al*., 2011). Therefore, constructing a warehousing operation management system with the function of safety monitoring, composed of environment monitoring and equipment monitoring and building a triune management platform is of great significance to make warehousing operations run coordinately, safely and efficiently (Liu, 2010).

WAREHOUSING MANAGEMENT

Warehousing management refers to plan, arrangement, coordination and regulation against the layout, design of storage facilities and warehousing operations. The objects of warehousing management mainly include goods, facilities and equipment and so on. The basic tasks of warehousing management include preservation of goods, regulation of goods' circulation, supervision of goods' quantity and quality, distribution and loading of goods, etc. (Zhou and Zhang, 2012).

Warehousing equipment: Warehousing equipment refers to all the technical devices, machines and tools needed in warehousing operation. In other words, it is the general definition of various kinds of mechanical, informationized and automated equipment, which are demanded in manufacturing, auxiliary production, or safeguard against the breakdown of warehouses and operations. According to the main uses and characteristics of equipment, warehousing equipment consists of handing equipment, keeping equipment, gages and test/inspection instruments, automatic sorting equipment, ventilating/lighting/heating devices, fire prevention facilities, informationized and automated equipment etc. (Zhang, 2013).

Warehousing operation management: As one of the main operating systems, warehousing operation management system is built for better management of goods, space resources, human resources, equipment resources and so on. That is to say, it is used in receiving preparations,

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checking, storing, stacking, safe keeping, stocktaking, delivery preparations, fixing cargos, shipping, warehouse-swapping and some other operation management in warehouses.

Typical warehousing operation management systems keep detailed record of various kinds of data, such as goods' category and quantity, time, frequency and inventory etc., based on which the systems can carry out effective control of each operation link. Through dealing with information, formulating and implementing reasonable operating strategies, the systems maintain a necessary inventory level and goods movement, thus making all of the operations connect smoothly (Liu, 2011).

SAFETY MONITORING OF WAREHOUSING

Safety monitoring of warehousing is the basis and premise of all the other warehousing management activities. Valid monitoring of warehouses' environmental parameters can not only guarantee commodities' quality and prolong their life, but also can protect operators and equipment from environmental damages. Valid monitoring of warehouses' equipment can ensure more efficient and safer operations, by real-time monitoring and addressing potential safety hazard of key equipment with advanced equipment and technologies.

Environment monitoring of warehousing: Logistics of oil products, grain, dangerous materials and some other temperature or humidity sensitive products, like fresh agricultural products and drugs, are developing quickly. Therefore, the demand of environment monitoring in warehouses is increasing day by day. Protection against moist, corrosion, mold, explosion or toxic gas is a vital part of normal warehouses' safety management, which directly affects the quality and life of goods. In order to minimize the bad impacts on goods, we need to monitor the changes of warehousing condition constantly and provide a good environment through adjusting measures. Creating suitable environment for storage in accordance with different characteristics of the goods can reduce losses and cut the cost. There are plenty of parameters which can indicate environmental conditions in warehouses, such as temperature, humidity, light, level of oxygen in the atmosphere, vibration, location and so on. Environment monitoring measure, record, calculate those parameters and give alarms to operators by various kinds of advanced detection means, so as to supervise the safety of the environment and provide historical data for environment improvement. However, a good storage condition can ensure the safety of operators and equipment at the same time (Liu, 2010).

Equipment monitoring of warehousing: The working state of warehousing equipment, especially conveyors and sorting devices, directly affects the whole warehousing operation. Under continuous high voltage and heavy current, some high power equipment can easily catch fire or blow up, if leakage or over-friction takes place; cargo damage and casualty are prone to be caused, if the engines of some heavy lifting equipment are not powerful enough or any chain fractures; a conveyor's efficiency can be reduced directly with a lower friction factor; the rotating equipment can't run well if some failure modes happen, such as fracture of gear wheel, abrasion of teeth surface, or plastic deformation (Miao *et al*., 2010).

Warehousing equipment is developing towards large-scale, continuous, high speed and automation and has more claims on reliability and stability. Therefore, it is particularly important to monitor the operation of warehousing equipment in real time. There are plenty parameters which can indicate the running states of equipment, such as the temperature of bearings, voltage, current, power, rotation rate, oil pressure, oil temperature, vibration, noise level and so on (Zhang *et al*., 2010). Equipment monitoring includes observing, recording, giving alarms and dealing with those parameters in real time, so as to calculate the running efficiency of equipment and improve their utilization rate. Analyzing the running states of key storage devices can not only help to form a mechanism of periodic preventive maintenance, worksheet management, equipment scheduling, but also can standardize the procedures of equipment management and maintenance (Chen *et al*., 2008).

AN INTELLIGENT WAREHOUSING OPERATION MANAGEMENT SYSTEM

The process of warehousing systems includes handling, conveying, stacking, sorting, packaging, etc. These activities can hardly get away from acquisition, preprocessing, transmission, storage, display of information, even some deep processing of information. Although traditional warehousing management systems are able to meet the basic need of information processing, the informatization and intelligent level will be further improved undoubtedly, if environment monitoring and equipment monitoring are both introduced into the operation management in warehouses.

Influences of warehousing conditions to operation capacity: The operation capacity of warehouses is determined by the configuration and operating status of facilities, human resources and managerial capacity etc. If

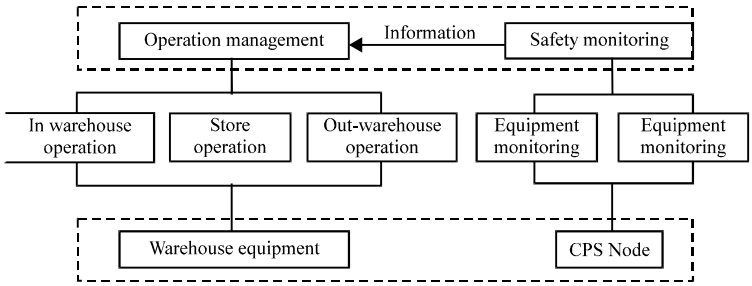

Fig. 1: Framework of an intelligent warehousing operation management system

equipment goes abnormal or can't run with designed capacity, work efficiency will get reduced greatly; if circumstances go abnormal and can't meet storage requirements or cause negative impact on operators, work efficiency will also get reduced enormously. Therefore, warehousing conditions, i.e., equipment's running status and environment, may influence operation capacity. Good warehousing conditions may make warehousing operations run coordinately, safely and efficiently; on the contrary, bad warehousing conditions may reduce operation capacity, even may threaten the safety of operators, equipment and goods.

Framework of an intelligent warehousing operation management system: During the formulation of operation scheduling and implementation of operation monitoring, warehousing operation management systems should make dynamic adjustments according to the effects of equipment's running status and environment in real time, so as to ensure the safety and efficiency of warehousing operations.

Intelligent warehousing operation management system is a cyber-physical system under warehousing environment, as shown in Fig. 1. In this system, technologies of IoT (Internet of things) were introduced into safety monitoring in warehouses. By integrating safety monitoring into traditional warehousing operation management system, this system constructs a triune management platform, therefore can realize smarter operation monitoring and management. Through the fusion and processing of more information and by inspecting equipment and environment at the same time, this intelligent system could make warehousing operation plans, optimize operation management and maximize the capacity of performance, however, under the premise of commodities' safety.

Technologies of safety monitoring in warehouses: Cyber-Physical Systems (CPS) is controllable, reliable and extendible network connected physical systems, which integrates computation, communication and control deeply based on context-aware sensors. With feedback loops where physical processes affect computations and vice versa, the systems may achieve some sound effects: (a) deep integration and real-time interaction to add or extend new function, (b) monitor or control the physical entities in a safe, reliable, efficient and real-time way, (c) complete the fusion of cyber systems and physical systems and change the way people construct physical and engineered systems fundamentally (He, 2010). CPS has a broad application prospect in the area of safety monitoring, such as medical devices and systems (Sha *et al*., 2008), assisted living, traffic control and safety, advanced automotive systems, process control, energy conservation, environmental control, avionics, critical infrastructure control (electric power, water resources and communications systems for example), etc. (Lee, 2008) Hence, applying CPS to safety monitoring systems in warehouses is feasible in technology.

Figure 2 shows the structure of a warehousing safety monitoring system based on Cyber-Physical Systems. In this architecture, the key element is CPS nodes. Agents are formed by the integration of physical entities and CPS nodes, which have the capability of collecting and transmitting information, controlling and computing. High autonomous is one character of CPS nodes. Different nodes or nodes with other agents connect through wired/wireless network and share the information of the whole network (Chen *et al*., 2011).

Figure 3 shows the structure of a CPS node used in safety monitoring in warehouses, which consists of sensor unit, processor unit, communication unit, extensive interface unit, actuator unit and power unit:

- The sensor unit is in charge of collecting information from environmental parameters and operating status of equipment in warehouses. It includes on-board temperature/humidity sensor, light sensor and other AD/DI channels to get signals from other sensors or equipment outside

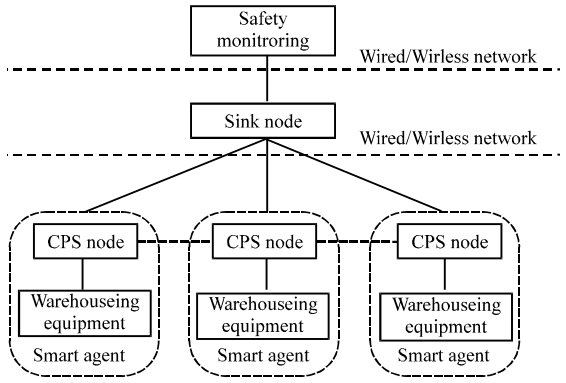

Fig. 2: Functional structure of a warehousing safety monitoring system based on CPS

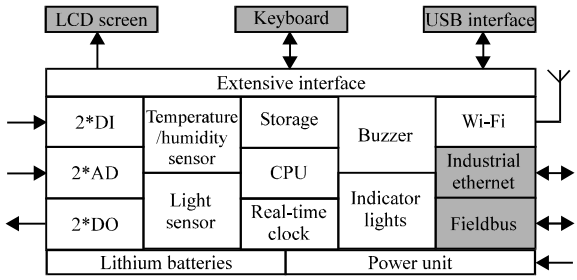

Fig. 3: Module structure of CPS node used in warehousing safety monitoring system

- The processor unit is in charge of computing, storing, scheduling tasks among nodes, etc. It is the core of a CPS node, which includes microprocessor, storage and real-time clock
- The communication unit is in charge of communicating with other CPS nodes or smart devices. It includes a Wi-Fi unit, industrial Ethernet interface and fieldbus interface, which can be used alone or simultaneously
- The extensive interface unit links LCD screen, keyboard, module with USB interface, etc., which can be chosen in this CPS node.
- The actuator unit can output two-channel digit signals, which can be used as channels for outputting alarm signals or control instructions
- The power unit consists of lithium batteries and charging unit, providing energy for CPS node

Distributed processing of information: Successful implementation of the system (Fig. 1), not only depends on designing CPS nodes with high reliability and excellent performance, but also on devising scientific, reasonable information processing and transmission mechanism. Distributed processing of information can reduce transmission of redundant information and prolong the network's service life, thus improving the efficiency of the whole system.

If the information processing ability of each CPS node is fully utilized and local information is transmitted to the sink node after processed, data traffic and delay-time will be reduced greatly. CPS nodes take charge of locating, identifying, collecting dynamic information, preprocessing data, judging and alarming when data are beyond proper limit and some other primary information processing; while host computers take charge of handing, merging and monitoring information produced by interactions between warehousing operations and safety monitoring and some other higher processing demands (Liu, 2010). This kind of processing mechanism is able to meet the demand of a safe operating environment, raise the ability to deal with information collected by CPS nodes, guarantee group working among CPS nodes, middleware and upper supervisory software and finally improve the efficiency of the whole system.

CONCLUSION

An intelligent warehousing operation management system based on safety monitoring has many advantages: (a) is able to carry out optimized operation management in warehouses by using more real-time information; (b) could improve quick reaction ability to accidents based on the security of products and (c) provide protection for precise regulation of environment, effective scheduling and safe maintenance of equipment and effective running of warehousing operations. In this study, the architecture of a new system is proposed, technical design is completed and node structure of CPS is designed in accordance with unified standard of hardware model. Validity of the new system can be verified by comparing some parameter with traditional systems, such as error rate of information dealing, work efficiency, control effect of environment and equipment and so on. It is of great adaptability and feasibility to apply CPS to safety monitoring in warehouses, while CPS provides a new solution for the implementation of intelligent logistics systems (Lai *et al*., 2011).

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REFERENCES

Chen, L.N., L.X. Wang and S. Deng, 2011. Cyber-physical system architecture design. Comput. Sci., 38: 295-300.

Chen, Y., X. Chen, X.D. Chen and P. Zhang, 2008. Research on real-time production equipment maintenance management system for manufacturing enterprise. Syst. Eng. Theory Pract., 4: 65-72.

He, J.F., 2010. Cyber-physical system. Commun. China Comput. Federation, 6: 25-29.

Lai, M.Y., C.F. Jin and K. Nie, 2011. Cyber physical logistics system: The implementation and challenges of next-generation logistics system. Syst. Eng., 29: 60-65.

Lee, E.A., 2008. Cyber physical systems: Design challenges. Proceedings of the 11th IEEE International Symposium on Object Oriented Real-Time Distributed Computing, May 5-7, 2008, Orlando, FL., USA., pp: 363-369.

Liu, J., 2010. Research on the key technology of warehouse monitoring and management system based on WSN. China Bus. Market, 7: 17-19.

Liu, J., 2011. Research and application of warehouse monitoring and management system based on CPS. China Bus. Market, 7: 104-106.

Mao, J.K. and Y.F. Xu, 2013. Study on the equipment management system based on internet of things. Proceedings of the 2nd International Symposium on Computer, Communication, Control and Automation, December 1-2, 2013, Singapore, pp: 7-10.

Miao, Q., D. Wang and R. Sun, 2010. On-line health monitoring index of rotating machinery. J. Univ. Electron. Sci. Technol. China, 39: 157-160.

Sha, L., S. Gopalakrishnan, X. Liu and Q.X. Wang, 2008. Cyber-physical systems: A new frontier. Proceedings of the IEEE International Conference on Sensor Networks, Ubiquitous and Trustworthy Computing, June 11-13, 2008, Taichung, China, pp: 1-9.

Song, C.P., B.J. Wu and P.F. Wang, 2011. Study on safety management of condition-based maintenance based on internet of things technology. China Saf. Sci. J., 21: 77-80.

Zhang, S.T., Y.B. Liu, C.H. Jia and Z.D. Zhong, 2010. Distributed remote monitoring and fault diagnosis system for complicated equipment. J. Henan Univ. Sci. Technol. (Nat. Sci.), 31: 19-23.

Zhang, X.C., 2013. Technologies and Equipment of Modern Logistics. Version 2, Chemical Industry Press, China.

Zhou, X.J. and B.P. Zhang, 2012. Modern Warehousing Management and Practice. Version 1, Peking University Press, China.