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A New Architecture of Embedded RFID Technology for Materials Flow Management

Senibina Baru Teknologi RFID Terbenam untuk Pengurusan Pengaliran Bahan

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Abstract

Materials flow management in supply chain applications is a remarkable key as it contributes to the effectiveness and the success in some organisation profile. A dynamic architecture data acquisition network has been proposed as a modern technique during configuration setup without supplier's or vendor's configuration software so that the process of monitoring, integration and communication could be done in real time with the employment of Radio Frequency Identification (RFID) technology. The RFID technology was said to be capable of handling items problems including damage or loss, misplaced from inventory level, shortage during production, error communication and design changes. A new passive RFID Gen 2 with integrated Wireless Sensor Network (WSN) and ZigBee 2.4 GHz technology has also been introduced to enhance system connectivity and compatibilities. The RFID technology in materials flow management was reviewed in order to explore the possibilities of system implementation especially in the supply chain environment.

Keywords data acquisition, materials flow, passive RFID Gen 2, RFID, WSN, ZigBee 2.4GHz

Abstrak

Pengurusan pengaliran bahan di dalam aplikasi rantaian bekalan adalah kunci yang luar biasa kerana ia menyumbang kepada keberkesanan dan kejayaan dalam beberapa profil organisasi. Sebuah senibina rangkaian pemerolehan data dinamik telah dicadangkan sebagai persediaan konfigurasi tanpa perisian konfigurasi pembekal atau vendor supaya proses pemantauan, integrasi dan komunikasi boleh dilakukan dalam masa sebenar bekerja dengan penggunaan teknologi Pengenalan Frekuensi Radio (RFID) sebagai satu teknik yang terkini. Teknologi RFID dikatakan mampu mengendalikan masalah barangan termasuk kerosakan atau kerugian, hilang dari inventori, kekurangan semasa pengeluaran, kesalahan komunikasi dan perubahan reka bentuk. Satu RFID Gen 2 pasif baru yang tersepadu dengan Rangkaian Sensor Tanpa Wayar (WSN) dan teknologi ZigBee 2.4 GHz telah diperkenalkan untuk meningkatkan sambungan sistem dan kesesuaiannya. Teknologi RFID dalam pengurusan pengaliran bahan telah dikaji bagi menerokai kemungkinan pelaksanaan sistem terutamanya dalam persekitaran rantaian bekalan.

Kata kunci pemerolehan data, pengaliran bahan, RFID, RFID Gen 2 pasif, WSN, ZigBee 2.4 GHz

INTRODUCTION

This paper discusses the current technology developments used in the industry especially pertaining to the supply chain logistic management of materials flow and to develop an essential components which would help facilitate systematic structure of hardware and operating system. This includes views on the basic ideas involved for RFID management system and briefly covers a proposed solution to architecture system.

BACKGROUND

Organization management plays a very crucial role in allowing the system to receive and transmit important informations to database so that the overall supply chain operations operates smoothly (Park & Song, 2010). The RFID middleware is a set of architecture that is used to control RFID readers with data integration that responds between nodes and networks where overall database is controlled (Bolic, 2010). Companies must ensure RFID standards need to be executed as it is important to communicate with various kinds of tags, readers, softwares and other hardwares with computer systems. Figure 1 shows the position of middleware in the RFID system (Mitton et al., 2010):

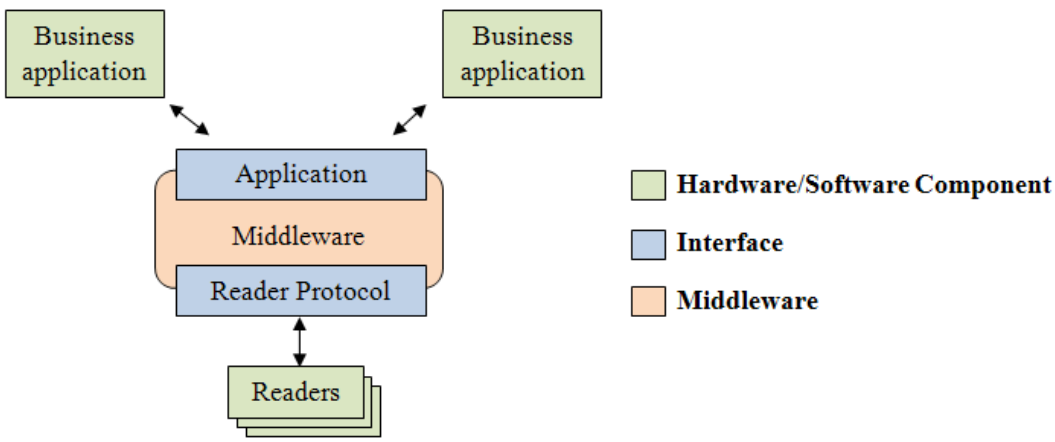

Figure 1 RFID Middleware

The middleware could be interfaced with the reader's protocol and the application associated with business applications. Middleware specification is related with the scope of architectural framework by EPCglobal which is a subscriber-driven organization comprised of industry leaders and organizations focusing on creating global standards for EPC global network (Jakkhupan et al., 2011). Problems such as misplaced, incorrect quantity, damaged or missing of items from inventory level usually caused by human errors always occurred in supply chain management (Kasim et al., 2013). Generally, Application Programmable Interface (API) and data acquisition RFID system are not linked with database management system, as such monitoring data synchronization, integration, transformation and communication are not easily done in real time. If any changes have to be made at the

database system or hardware, adjustments and restructuring are executed and reconfigured only by the vendor that owns the system. Due to this problem the vendor has to remove or reinstall the cables set and then reprogrammed it manually. Therefore, an effective material flow management system is required to avoid such problems by developing a software and hardware system that can retrieve important data directly from API in order to develop information exchange processes.

RESEARCH FRAMEWORK

The focus of this work was to recognize capabilities for research in the supply chain management fields which included features of organization, privacy and security. The purpose of developing a real time system was to obtain a real time data from the database in order to observe work in progress at the production line. Implementing the practical RFID system required comprehensive analysis connected to the particular ideal RFID system. By understanding the right selected RFID components, the effectiveness in material flow management may increase since many companies face this real-world challenges (Maniyan et al., 2012).

Data acquisition system is generally known as one of the important elements used in the laboratories, researches and tests, including in industrial automation applications (Bi & Wang, 2010). Currently, data acquisition system is much smaller and less expensive when compared with earlier versions because it relies on embedded system in order to operate well. Previously, components needed to form data acquisition had to support high data rates, complex processor needs, larger storage capacity and dependability of high-speed interface. The growth usage of computer system in various applications such as in industrial fields allows useful information to be exchanged between manufacturers, subsidiaries and suppliers (Yoon et al., 2013). As a result, the evolution of suitable techniques for the design and analysis the system are intensively researched in the aspect of accuracy and effectiveness of the system.

The API is a set of rules and specifications that a program can comply with to access and make use of the services and resources provided by a particular software program that implements the API (Arun & Nayagam, 2014). The functioning inside RFID system needs RFID API layer in order to communicate with all RFID readers. The database storage is used to collect the readings taken by RFID reader where important informations are stored such as tracking logs, process stages or surplus of raw materials. The middleware approach is used for the system software to process data production information as shown in Figure 2.

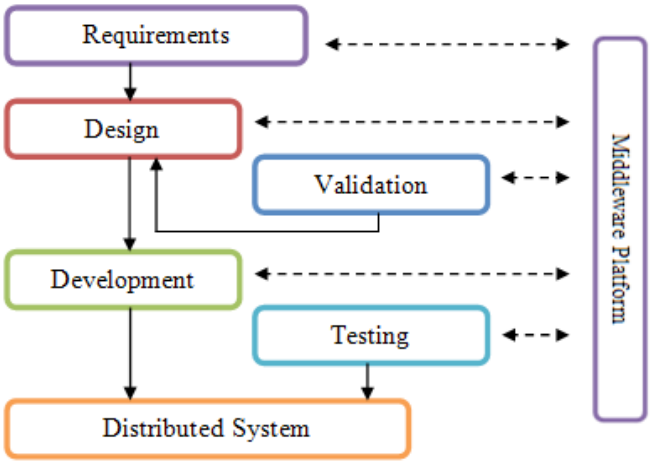

Figure 2 Distribution of system software process based on Middleware

The middleware architecture are divided in five phases. Firstly, a profound analysis of the requirements is conducted to recognize the functional and non-functional necessity of the allocated system and middleware. Secondly, the design phase is used to consider the requirement and restriction imposed by the system and middleware. Validation phase is then needed to be considered for both functional and non-functional requirements, and this is followed by the development phase where sources for code of classes are used for the programming techniques. Finally, the distribution system and the middleware platform are tested for the purpose of developing object-oriented testing approaches.

RESULTS AND PROPOSED ARCHITECTURE

The implementation of dynamic architecture data acquisition network for RFID system required variety input sensor channels with same or different data types. The programming and hardware configuration for the data acquisition system was done over a wired connection between a port on the master controller of database acquisition system on a personel computer (PC) provided by the vendors of configuration file software. This technique was done with the source code tested and compiled into loader files and programmed successfully. The data acquisition system was ready to be used once the programming cables set was removed.

The encountered issues as previously mentioned are faced by most organizations in the industrial field. Distributed real time technique in data acquisition system for materials flow control was challenging as some setting such as input resources were fixed where only certain measurements could be varied dynamically. A new passive RFID Gen 2 system was designed so as to be compatible with material flow in industry with implementation of the Wireless Sensor Network (WSN) and ZigBee2.4 GHz technology. As depicted in Figure 3, the arrangement and setup for pilot testing in real industrial environment was conducted to examine the capabilities of monitoring operation and to capture real time data for the whole process in the production line.

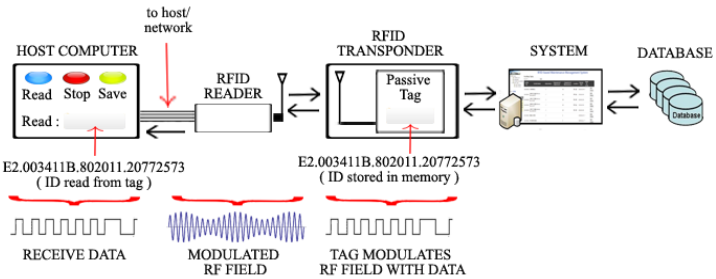

Figure 3 A graphical arrangement of a pilot test

The IP address was first set up for configuration to make sure that the connection between RFID components were functioning correctly and also to acknowledge the quantity unit of origin tagged pallets and ID for the raw materials. RFID uses radio frequency waves as a transmission of bit streams between readers and transportable tagged objects to recognize or categorize the ID. The capabilities of readers to receive modulated RF energy signal from each wireless tag depends on the power of signal backscattered so identification number can be retrieved (Catarinucci et al., 2011). Once confirmed, the information was stored at database storage system so that the in charge operators can monitor production output achievement in real time.

Figure 4 shows the tracking and monitoring of RFID data sample. The system programme that provides simple snapshot of interfaces window is compatible to run in Windows platform in order to get data logging information such as tag identification, reader number, product quantity, time in, time out and the operators in charge.

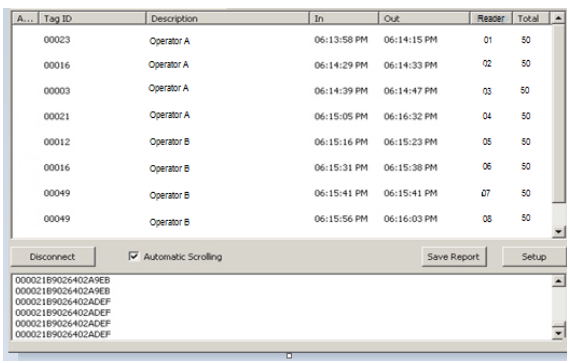

Figure 4 RFID tag status snapshot window

The system begins to operate when the operator in charge takes the production lot at assembly area where the reader scans the tagged pallets. After the process is done in the production line, the reader scans once again so that the remaining quantity of production lot is recorded in the database. The data is then retrieved from MySQL database storage which is an open-source database system that can work with API functions. Description of the reading time versus quantity for number tags between the conventional methods with the proposed system is shown in Figure 5.

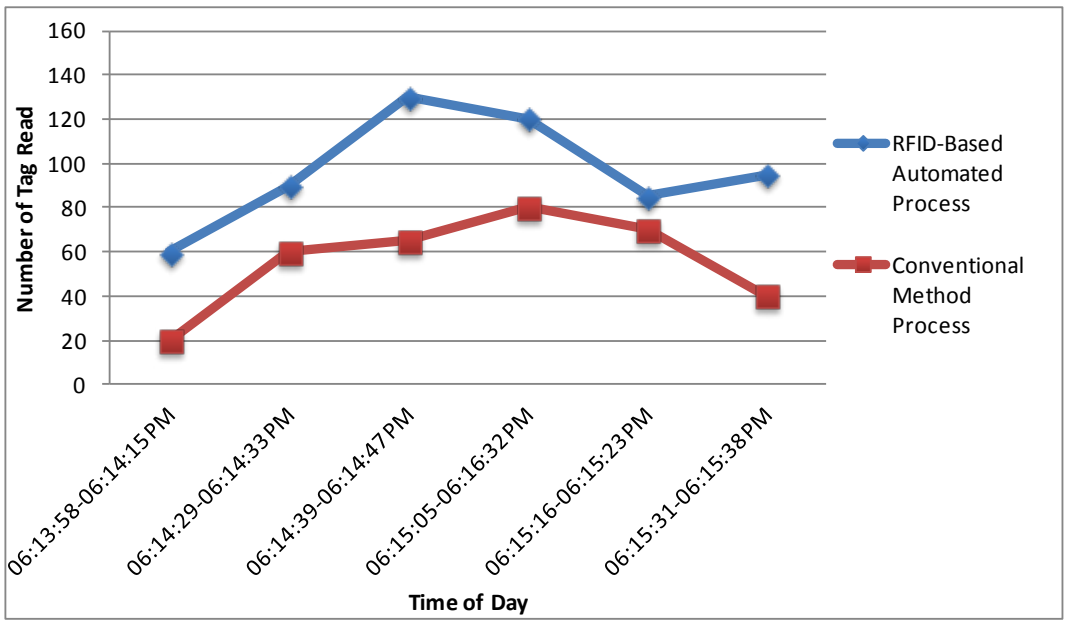

Figure 5 An analysis comparing total number of tags read every minute by RFID Readers

Based on the analysis, on the average the total number of tags read by the RFID reader used RFID-based automated process was about 30 percent higher compared to the total number of tags read by the RFID reader with the conventional method process. This difference was most likely because the proposed dynamic architecture data acquisition network provided great flexibility in a full arrangement system that could manage production lot processes other than giving fully automated real time monitoring flow.

RFID TECHNOLOGY IN MATERIALS FLOW MANAGEMENT

The used of RFID technology has grown dramatically and its system can be an effective solution in delivering and receiving information (Rosli et al., 2013). It has been developed in many applications such as waste management system, harvesting monitoring control and construction facilities management. Evolution of RFID technology in supply chain management and logistic for monitoring raw materials movement from the beginning of manufacturing process until it becomes finished goods is one of the best method to be implemented. Studies have been conducted to test the level of performance in determining the effects of pallets and case-level RFID taggings to overcome shortage and increase inventory used. Selected examples of RFID technology in material flow management for the past few years are as follows:

- Deployment of RFID technology in the supply chain by literature methods such as analytic modeling, computer simulations, case studies and experiments (Sarac et al., 2010).

- Implementation of RFID-POS system between retailers and a third group in tracking stocks and sales by the remaining cartons and pallets tagging in the food supply chain (Hong et al., 2011).
- Application of an automated model for materials management with operation of RFID technology (Nasir et al., 2010).
- Construction of a genetic algorithm to assign arcs weights between nodes by using fuzzy cognitive map (FCM) for real time data tracking in reverse logistics management (Trappey et al., 2010).

CONCLUSION

Materials flow management review was presented with the development of RFID technology as it could realise big potentials in the supply chain industry. The proposed architecture system consisted of emerging dynamic data acquisition system was connected with RFID API layer in order to communicate with all RFID readers which currently differ from conventional methods. These network mechanisms provide benefits to organization as the reprogrammed or modified system became faster hence reduced costs. The ZigBee technology is thus a rapid pace platform due to its being more flexible than Wi-Fi or Bluetooth technology for indoor applications. The performance of RFID technology in the supply chain environment of data management was crucial since it could help overcome manual handling errors by humans in addition to increase in real time monitoring for production flow.

REFERENCES

Arulogun, O. T., Olatunbosun, A., Fakolujo, O. A. & Olaniyi, O. M. (2013). RFID-based students attendance management system. *International Journal of Scientific & Engineering Research*, 4(2)

Arun, K. & Nayagam, M. G. (2014). Building applications with social networking API's. *International Journal of Advanced Networking & Applications*, 5(5), 2070-2075.

Bi, Z. M. & Wang, L. (2010). Advances in 3D data acquisition and processing for industrial applications. *Robotics and Computer-Integrated Manufacturing*, 26(5), 403-413.

Bolic, M., Simplot-Ryl, D. & Stojmenovic, I. (Eds.). (2010). *RFID systems: Research trends and challenges*. London: John Wiley & Sons.

Catarinucci, L., De Donno, D., Guadalupi, M., Ricciato, F. & Tarricone, L. (2011). Performance analysis of passive UHF RFID tags with GNU-radio. In *Antennas and Propagation (APSURSI), 2011 IEEE International Symposium*, pp. 541-544. IEEE.

Hong, I. H., Dang, J. F., Tsai, Y. H., Liu, C. S., Lee, W. T., Wang, M. L. & Chen, P. C. (2011). An RFID application in the food supply chain: A case study of convenience stores in Taiwan. *Journal of food engineering*, 106(2), 119-126.

Islam, M. S., Arebey, M., Hannan, M. A. & Basri, H. (2012). Overview for solid waste bin monitoring and collection system. In *Innovation Management and Technology Research (ICIMTR), 2012 International Conference*, pp. 258-262. IEEE.

Jakkhupan, W., Arch-int, S. & Li, Y. (2011). Business process analysis and simulation for the RFID and EPC global Network enabled supply chain: A proof-of-concept approach. *Journal of Network & Computer Applications*, 34(3), 949-957.

Jia, X., Feng, Q., Fan, T. & Lei, Q. (2012). RFID technology and its applications in Internet of Things (IoT). In *Consumer Electronics, Communications and Networks (CECNet), 2012 2nd International Conference*, pp. 1282-1285. IEEE.

Kasim, N., Latiffi, A. A. & Fathi, M. S. (2013). RFID technology for materials management in construction projects - A review. *International Journal of Construction Engineering & Management*, 2(A), 7-12.

Kim, S. & Garrison, G. (2010). Understanding users' behaviors regarding supply chain technology: Determinants impacting the adoption and implementation of RFID technology in South Korea. *International Journal of Information Management*, 30(5), 388-398.

Maniyan, A., Ghassemi, R. A. & Rahrovy, E. (2012). A survey of the role and the applications of Radio Frequency Identification (RFID) technology in the efficiency of supply chain management (SCM) with an emphasis on food industries. *International Journal of Learning &Development*, 2(5), Pages-129.

Mitton, N., Schmidt, L. & Simplot-Ryl, D. (2010). RFID middleware: Concepts and architecture. *RFID Systems-Research, Trends & Challenges*, 271-295.

Nasir, H., Haas, C. T., Young, D. A., Razavi, S. N., Caldas, C. & Goodrum, P. (2010). An implementation model for automated construction materials tracking and locating. *Canadian Journal of Civil Engineering*, 37(4), 588-599.

Park, N. & Song, Y. (2010). AONT encryption based application data management in mobile RFID environment. In *Computational Collective Intelligence. Technologies & Applications*, pp. 142-152. Springer Berlin Heidelberg.

Rosli, N. S. , Hashim, A. Y. B. & Jamaludin, Z. (2013). Tracking of pallets in manufacturing environment using RFID system. *American Journal of Industrial Engineering*, 1(2), 36-40.

Sarac, A., Absi, N. & Dauzère-Pérès, S. (2010). A literature review on the impact of RFID technologies on supply chain management. *International Journal of Production Economics*, 128(1), 77-95.

Trappey, A. J., Trappey, C. V. & Wu, C. R. (2010). Genetic algorithm dynamic performance evaluation for RFID reverse logistic management. *Expert Systems with Applications*, 37(11), 7329-7335.

Yoon, M. K., Mohan, S., Choi, J., Kim, J. E. & Sha, L. (2013). SecureCore: A multicore-based intrusion detection architecture for real-time embedded systems. In *Real-Time and Embedded Technology and Applications Symposium (RTAS), 2013 IEEE 19th,* pp. 21-32. IEEE.