

A Fieldbus-Based Approach for the Integration between RFID and Industrial Control System

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ABSTRACT

RFID is infiltrating the core of the manufacture industry step by step. It collects real-time data of tags attached on the products in batches, which ensures matter-flow be consistent with info-flow. Integrated with MES and DCS, RFID make the production process be visible and punctual. Despite possibly being a subversive technology for manufacture industry, RFID has not shows its great superiorities. All the same, RFID is posing many challenges for extensive applications at industrial production: i) RFID don't integrates with control system so tightly and efficiently that RFID shows unreliable and inefficient to the existent systems at workshop; ii)The existent RFID interrogators almost do not support network-connecting at the equipment layer; iii)There exist various tags with various protocols and criterions which desires intelligent interrogators with the capacity of supporting multi-protocols. Thus, a general approach of RFID applications in industry is needed to efficiently automate the integration between RFID system with the control systems and business applications. In this paper, we put forward a fieldbus-based approach for the integration between RFID with the control system. RFID control unit connects with other instruments (meters, PLC, etc.) to composing a bottom fieldbus network, and it transmits the collected data to control system by fieldbus instantly. RFID integration and application panel runs at the workshop monitoring layer, it executes the configuration of the unit and user's protocol, communicates with business applications at the top layer, and monitors the state of the whole RFID system. According to new approach, RFID application adopts the mode of closed-loop band together open-loop but the simplex closed-loop mode, and RFID equipments transmit data to the control system by the fieldbus network directly, which evidently reduces the frequency of communication among the RFID equipments, control system and business applications. The approach makes RFID play the real role of info-carrier, and reliable and real-time data transmission could be realized, then RFID really becomes the vivid 'eye' of control system. Thereby, the declarative approach should be a feasible resolution to the problem above.

Keywords: RFID, industrial control, integration, fieldbus

1 INTRODUCTION

Radio frequency identification (RFID) technology is hotting up in recent years. In contrast with barcode, RFID tags have many traits, such as big memory, long operational distance, long life-span, capacity of penetrating through non-conducting medium, etc [1]. RFID can provide an effective identification for multiple objectives simultaneously and moving objectives, with internet, it can trace materials and share the information of materials in world-wide. Because of the above advantages of RFID, it is unassailable that RFID be popularly used in industrial control and play important role in the automatic production.

RFID technology has the great potential for the automotive industry. There are huge opportunities to leverage RFID on the plant floor in manufacturing [2]. The key areas that will be immediately impacted by RFID are: manufacturing information management, manufacturing Execution, quality control and compliance, tracking and genealogy, plant asset management, inventory visibility, labor usage, etc.[2][3][4]. If RFID technique applied in production process, the managements of manufacturing process, quality management, transport and sales can be realized efficiently, various real-time information data can be collected and recorded, and after that, with the further data-processing, the production process and business process can be monitored in the whole production periodic.

In the world, many large manufacturers carry through active attempts to RFID applications in automatic manufacturing. Ford Essex engine plant used RFID to trace engines, tags storage the process information such as the screwing moment of a nut [12]. Hewlett-Packard printer plant in Brazil linked RFID interrogators to machines at product lines, which aimed at tracing and analysis for production process, as a result, the efficiency of product assembly was increased and management cost was reduced at the same time [12]. Aircraft enterprises, such as Airbus, Boeing, also attempt to fitting tags on components to strengthen the warehousing and logistics managements [13]. Though RFID has been integrated with industry control system at many occasions, there are still some limits in such integrations. In the section 2, we discuss the conventional mode of RFID application in industrial control and its limits.

Fieldbus is the bus topological network which is the common channel for the communications between the control system and the controllers and instruments. Regarding the field apparatus as network nodes and the bus as the bridge for communications among nodes, it builds a digital, bipolar, distributed and multi-divergence control network. The fieldbus has the characteristics of openness, interaction, autonomisation of equipments and decentralized system structure, etc [9]. Due to the merits, the fieldbus technique heightens the communication capability of the industrial control system, and it is compliant with the development trend of the intellectualized equipments. Today, fieldbus is becoming increasingly popular in industrial automation and robotics for decentralized control of field devices. So the fieldbus is a possible technique by which RFID is integrated with the industrial control system.

In this paper, we analyze the conventional mode of RFID application in industrial control and indicate the trend of RFID application in industrial control. Then, for building transparent and direct information flow between RFID and control system, and realizing their seamless integration, we present an approach based on fieldbus to integrate RFID with the existing industrial control system and describe the integration architecture. At the last, we give an

integration and application case using new approach and point out its merits compared with the conventional mode.

2 CONVENTIONAL MODE OF RFID APPLICATION IN INDUSTRIAL CONTROL AND ITS INDEVELOPMENT TREND

RFID is entering into the core business of automatic manufacturing process [4]. Applying the RFID technique in the workshop step by step, manufacture can continuously integrate the information captured by RFID and connect them to the existing industrial control system, at the mean time, correct and reliable real-time information flow can be formed without updating the MES, consequently it creates added value and raises the productivity.

2.1 Conventional RFID application mode in the industrial control

In the recent years, RFID has been applied in the industrial control system increasingly. Figure 1 shows a typical product line control system which integrates RFID system. It denotes a conventional mode for RFID application in industrial control.

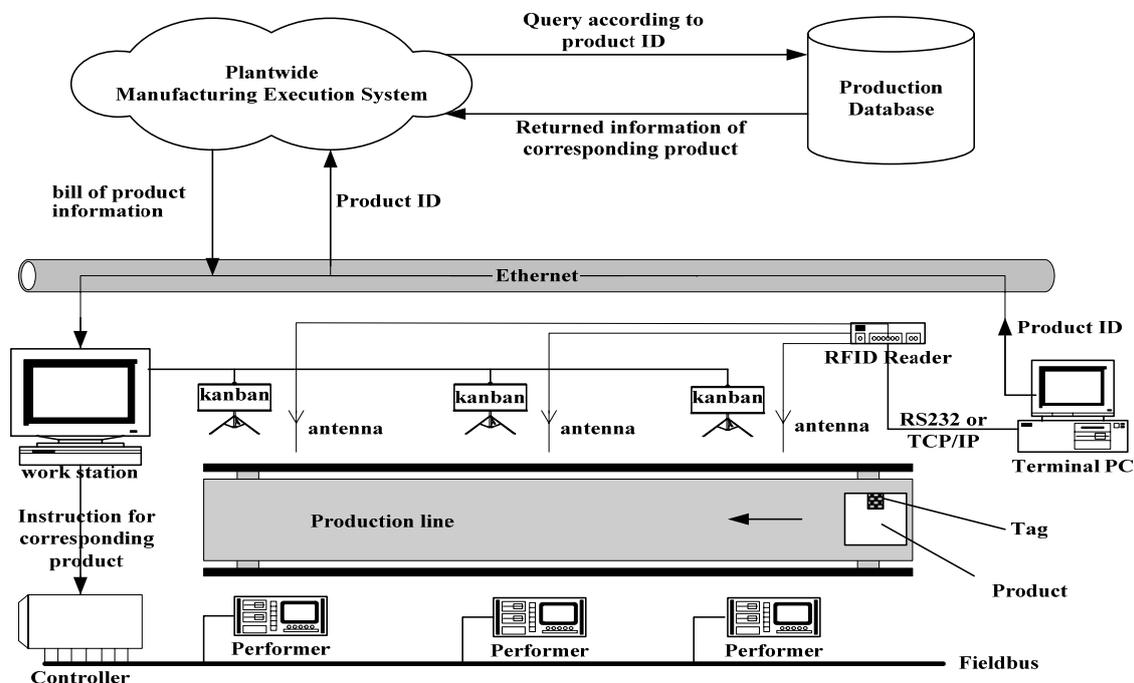


Fig. 1 Product line control system integrates RFID system

The procedure is: a product with a tag on it moves on the product line, in case the tag enter into the interrogation range, it will be captured by the reader fixed on the product line, the reader reads the product ID on the tag and transmit them to the terminal PC by RS232 or TCP/IP interface, the PC then transmits the ID information up to MES which will later query the product database according to the ID to acquire specific information of the corresponding product, the information would be generated into a product information list and transmitted down to work station in the plant, then the latter generates operation command based on the information and transmit them to the controller, at the meantime, the Kanbans show the product information and operation commands, the controller drives the manipulator to

complete correct operation procedure after received the commands. By now a general procedure is completed.

2.2 Trend of RFID applications in industrial control

Firstly, compared to other bands, the UHF band tags possess longer read range, bigger memory capacity and higher read rate. So it is competent for the applications in the industrial control system, particularly in the control of automatic product lines.

Secondly, big memory is an important merit of the RFID tag. However, all the existing applications in industry are almost only use the identifier field of the tag data, the rest of the tag memory is not used to save useful information. In the future, the tag applied in industrial control, liking a small moving hard disk, must storage abundant information besides the product ID.

Lastly, RFID is a data acquisition technology in nature. If RFID intends to serve the industry control well, it must go deep into the bottom layer of the production. RFID equipments need to exchange information with the instruments and controllers directly, which can largely reduce the communications between enterprise information system and bottom control system, and overcome the large network load of the existing applications, consequently, can enhance the intelligence and real-time performance of the RFID system integrated with the control system. Future RFID equipments to be applied in the industry control will possess popular interface to the control system and capability of being configured together other controllers and sensors by configuration software, then RFID system can be seamlessly integrated with the control system.

3 PROPOSED RFID INTEGRATION APPROACH BASED ON FIELDBUS

Considering the limits of the conventional RFID integration mode and the trend of the RFID applications in industrial control, we put forward an approach based on the fieldbus to integrate the RFID system with the control system.

3.1 Architecture of proposed RFID integration approach

Figure 2 shows the architecture of proposed integration approach between RFID and industrial control. RFID system consists of two parts, one is RFID control unit with fieldbus interface, the other is RFID integration and application panel. The integration mainly occurs in the two inferior layers. The RFID control unit, networked with other instruments and controllers, works at the field equipment layer, collects the tag data on products or components, and provides the collected tag data for the control system by fieldbus network. The RFID integration and application panel, running at the workshop monitoring layer, is engaged in configuring the parameters and user protocols of RFID control unit and monitoring its running states. The two parts are presented in detail at the following text.

3.2 RFID control unit with fieldbus interface

The unit is divided into three modules by function. One is the Collect and control module, the other two modules are embedded data processor and fieldbus communication interface

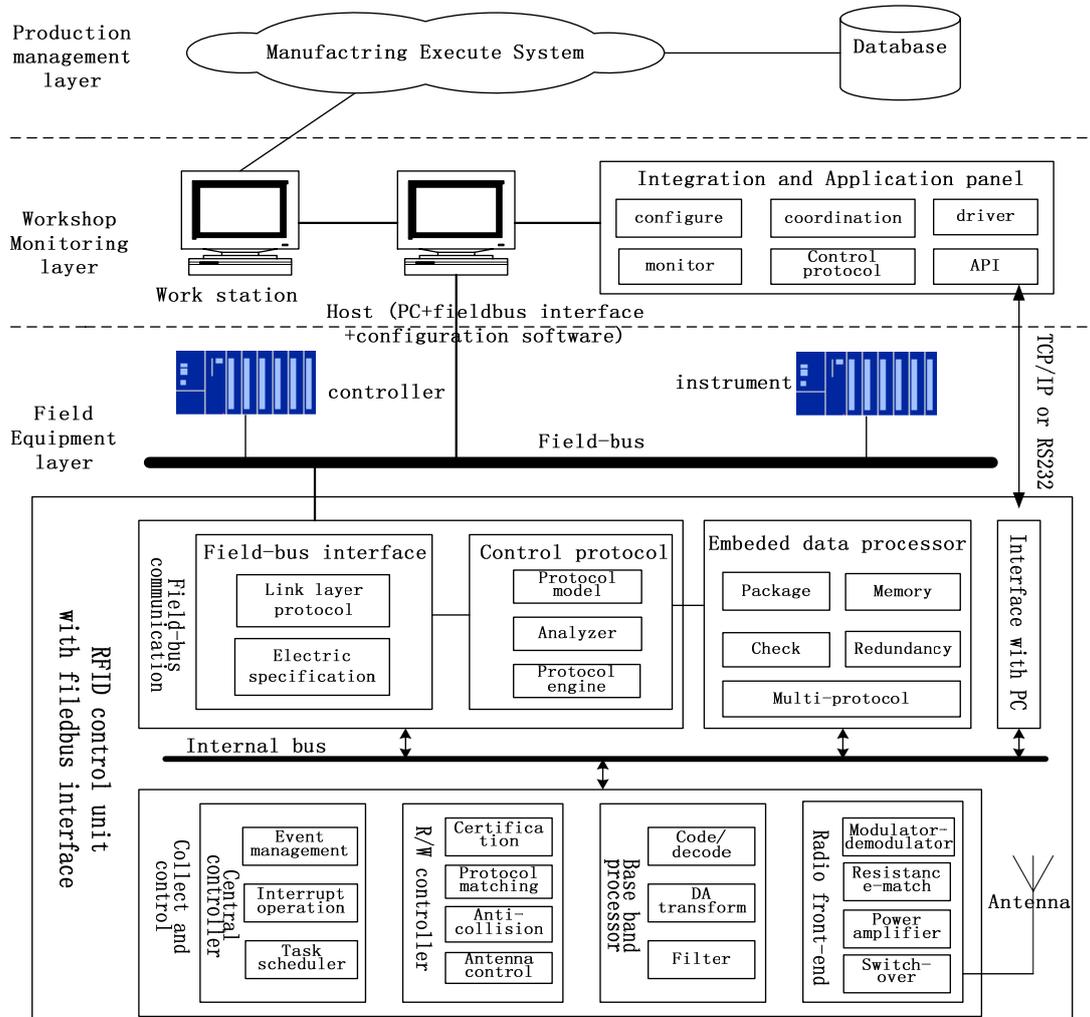


Fig. 2 Architecture of RFID integrated with industrial control by fieldbus

3.2.1 Collect and control module

The collect and control module consists of the radio front-end, base band signal processor, R/W controller and central controller. Its functions include emitting and receiving radio signal, modulating and demodulating the radio signal. The contents of the base band signal processing are coding/decoding of the signal, signal filtering and D/A converting. R/W controller issues all of the working commands which realizes the functions of basic reading/writing, tag anti-collision and authority certification.

3.2.2 Embedded data processor

This module recognizes and processes the multi-protocol data. There are various tags with various data storage specifications following various protocols, such as IS0180000 series, EPC and UID, etc[12]. The embedded data processor of RFID control unit firstly recognizes the protocol which the tag to be read keeps to and read the tag data according to the protocol. Then the data processor make data error checking and correction and clear the redundant tag data due to the iterative reading, after that, it changes the tag data into the user data according to the format which the control protocol has defined in advance. The user data then are transmitted to the fieldbus communication module.

3.2.3 Fieldbus communication module

This module consists of the fieldbus interface and the user control protocol. The fieldbus interface includes the physical hardware interface and link layer protocol. The hardware interface is the physical and electrical media that measures up to the corresponding electrical specification of a certain kind fieldbus, it also takes charge of coding and transmitting the signals and controls the rate of transmission. The link layer protocol controls the signal sending and receiving on the transmission medium, and ensures that the data frame be sent accurately to the appointed equipment in the fieldbus network.

The user control protocol is very important for the interactive operation between the control system and RFID system. It defines the method for sending commands to RFID control unit and the scheme for dispatching the read tag data to other controllers and instruments, and provides the configuration software interface for the users. The user control protocol consists of protocol model, event analysis and responder. The former builds the models of various business events related to the control unit and the state parameters for the corresponding events. The latter defines the event processing rules and builds the event processing engine to generate corresponding actions to responding the events occurred in the fieldbus network.

3.3 RFID integration and application panel

RFID integration and application panel is the software installed in the work station or the fieldbus host station (composed of PC, fieldbus interface and configuration software) at the workshop. It consists of user driver, application programming interface (API), configuration interface, control protocol management, equipment monitoring and coordination optimizer. It provides the RFID control unit with the services of parameters initialization, user control protocol management, and on-line configuration.

The coordination optimizer manages and schedules the heterogeneous RFID equipments in the distributed environment at workshop, and processing the anti-collision problem among the equipments. The configuration interface, just as its name implies, provides the RFID control unit with the tools and methods to configure its applications in the production control. The user driver, based on the middleware technique, provides the enterprise user with the installation guide and the interface to the configuration software. The monitor supports the assembled management and supervisory for the equipments and diagnoses the functional exceptions or communication exceptions. The control protocol management is the most important functional module in the integration and application panel, it provides the protocol programming tool to modeling various data events, defining the event trigger rules and building the event processing engine for the given applications. The API takes charge of the function calling and data communication between RFID control unit and the panel and provides the secondary programming methods which are convenient for the user's developing the upper applications. The panel also provides the configurable and expandable human-machine interface (HMI), which makes the technicians easy to configure and manage the whole system by the RFID integration and application panel.

In additional, the RFID control unit has a PC interface by which the unit can communicate with RFID integration and application panel. Generally, the PC interface only works during the configuration and transmission of the historical data from the unit to the work station.

4 A PRACTICAL SYSTEM INTEGRATING THE RFID SYSTEM BY CAN BUS

According to the methods mentioned at section 3, we build a tobacco logistics sorting system integrating the RFID system by CAN bus. The system consists of a sorting line with three operating locations, three cigarette containers that storage respectively three kinds of cigarettes, three manipulators at every operating location, and a RFID control unit. Of course, all the equipments have the CAN bus interfaces. In this system, C1,C2,C3 denotes three containers, A1,A2,A3 denotes three antennas, M1,M2,M3 denotes three manipulators.

RFID system chooses a kind of Phillips tag named UCODE EPCG2 SL3 IC, it includes 96 bits EPC memory and 128 bits user memory. In the system, the assignments of EPC memory is described in table 1. The first 8 bits is the header field, the following 16 bits is the identifier field for the sorting pallet, the third segment has 24 bits, every 3 bits of which denotes a type of cigarette to be sorted, so the number of the types of cigarettes in one pallet can be eight at most.

8bits	16bits	24bits	48bits
Header	Pallet ID	Type of tobacco	Reserved

Table.1 Assignment of the EPC memory of tag

The user memory, 12 bits in total, is used to storage the sorting information. Table 2 shows the assignments of the user memory. There are eight words every of which is 16 bits. Corresponding to the third segment of the EPC memory, the every word respectively denotes the sorting number and finishing number of a kind of cigarette.

Word1		...	...	...	Word8	
8bit	8bit	...	...	...	8bit	8bit
Amount1	State 1	...	...	...	Amount8	State8

Table.2 Assignment of the user memory of tag

All CAN bus nodes of the tobacco logistics sorting practical system are working at PELICAN mode. Table 3 shows the address assignment of all nodes in the CAN bus network. And there are five kinds of CAN messages: the message of RFID tag data, the messages of control commands for the line, the messages of control commands for manipulators, the state messages, and the exception messages.

Node name	work station	master controller	motor controller	RFID control unit	M1	M2	M3
Address	0000h	0008h	0010h	0018h	0080h	0100h	0180h

Table.3 Address assignment of CAN bus network

The configuration software we used is MCGS by which all the equipments, including the RFID control unit, are configured into a tobacco sorting system. The figure 3 shows the running system after the configuration.

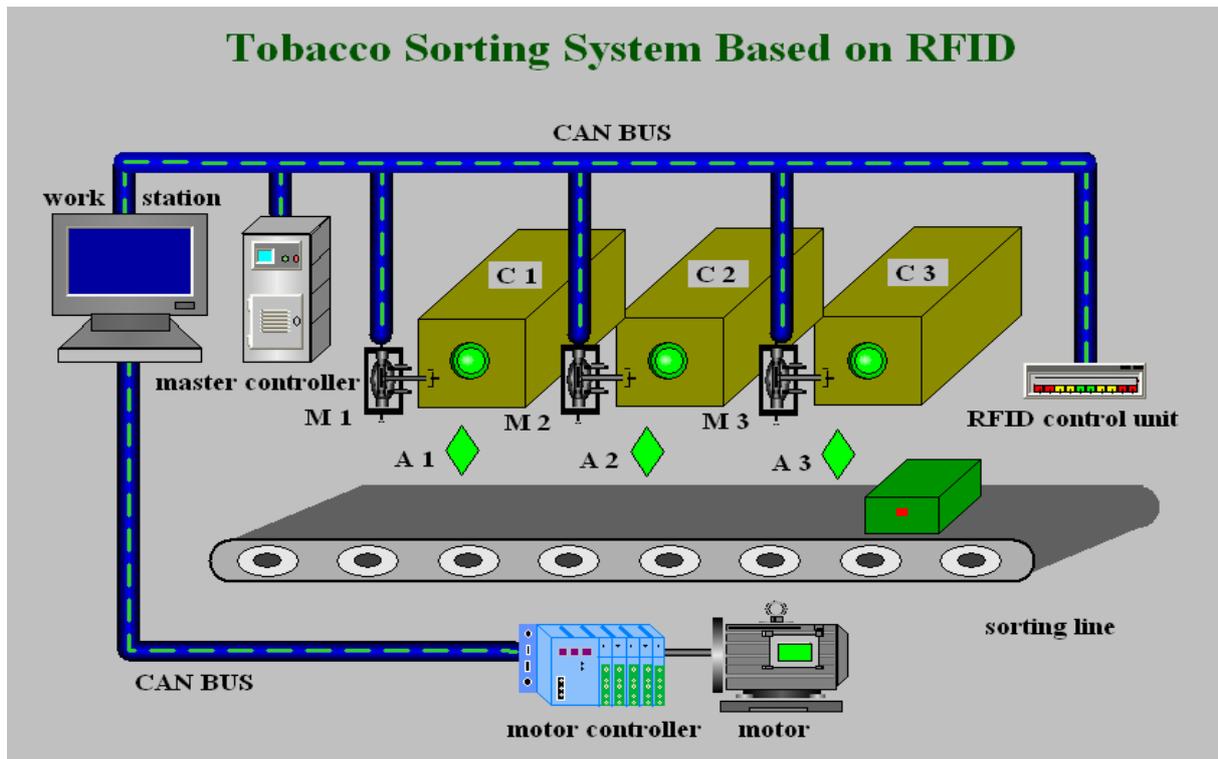


Fig.3 Tobacco sorting system based on RFID

The procedure of the tobacco sorting system in figure 3 is: the pallet with the RFID tag moves on the line from one operating location to the next. Once it enters into the interrogating area of one RFID antenna fixed on one location, the RFID control unit reads the tag data and sends a reading state CAN message to motor controller which stops the line as soon as the message was received. Then the control unit sends message of the tag data and the series number (it denotes the operating location where the pallet is situated currently) of antenna to the main controller. According to the user control protocol, the main controller generates sorting operation commands and sends them to the manipulator at the operating location, the manipulator returns the state message to the control unit after sorting operations. The RFID control unit writes the received state message into the user memory in the RFID tag on the pallet. Then the control unit notifies the main controller that the sorting task at the current operating location be completed. After verifying all sorting tasks at the three locations is completed, the main controller sends the command to motor controller to run the line again.

The next procedure occurs if any pallet with RFID tag enters into the interrogating area of the RFID control unit. When a pallet moves out the line, the tag on it has recorded all the sorting operation results.

5 SUMMARY

The proposed approach about the RFID integration with the industrial control conforms to the trend of flattening structure of enterprise information network. Compared to conventional integration mode, the new approach has obvious merits: firstly, tags store the specific parameters (procedure information, product state) of the product besides the product ID. Like a moving hard disk, every tag stores abundant data which can provide enough information for

the production control, which avoids the excessive data transmissions between the process control layer and the upper applications and reduces the frequency of database query. Secondly, the RFID control units with fieldbus interface, possessing the capability of networking and configuration, are linked with other controller, performer and instruments on the fieldbus, which ensures the reliable and real-time data transmission between RFID system and the control system. Lastly, embedded data processing and fieldbus interface make RFID control unit more intelligent than common RFID reader, so RFID control unit can integrate with the control system directly. Obviously, the proposed RFID integration mode make the RFID applications escape from the tight dependent on the MES and the background database, as a result, the whole integration control system is more robust than the conventional applications.

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