The Optimized RFID and WSN Integration Model

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Abstract. At present, there are four typical integrated models of RFID and WSN, which have some advantages while they have been integrated. To solve these problems, an optimized model is proposed, and a new dynamic RFID-WSN integrated system is designed based on the optimized strategies. The system is composed of a new integrated node, which is designed based on WSN network model and RFID protocol and can dynamically switch roles between WSN node, RFID reader and RFID tags. Through the design of dynamic construction mechanism to organize and manage these integrated nodes, the system realizes dynamic switching and adaptive construction between RFID and WSN. The new integrated system solves the problems existing in the four typical models and has better characteristics and more flexible applications.

Introduction

The rapid development of microelectronics, communication technology and the emergence of the Internet of things technology have greatly promoted the research and application of the two key technologies of wireless sensor networks (WSN) and radio frequency identification (RFID). RFID technology has been widely used in industry, WSN technology also plays an important role in a variety of environments, gradually began to explore the integrated technology. RFID technology can automatically and quickly identify key information objects within a short distance, is mainly used for tracking and management of the object, but in many areas of application, management object is sensitive to the environment, need to obtain the physical environment information [1] through remote monitoring, the traditional RFID technology cannot solve the problem. For example, in an asset management system using RFID (radio frequency identification) is used to track the current location of a particular asset, but not to obtain environmental information such as temperature and humidity. WSN consists of a number of small terminal nodes that have the ability to sense, compute, and communicate wirelessly. Wireless sensor networks can harvest, process and analyze environmental information for ambient monitoring and other field’s perceptions, but it cannot retrieve the identity and location of the key information of objects. In this case, through the integration of RFID and WSN, we can build a rich environment information of object tracking and management system [2], the two technologies complement each other, to maximize the efficiency of both technologies, provide a new perspective for the more extensive application. In this paper, four mainstream integrated models are summarized, analyzed and optimized, and a new RFID-WSN integrated system is designed based on the optimized model.

The Integrated of WSN and RFID Technologies

There are many kinds of integrated technology and application have been put forwarded [3]. Namely, the integrated intelligent sensing, RFID reader and WSN coordinator distributed intelligent node, will summarize the integrated of RFID tags and sensors for limited communication capabilities [4]. Through the analysis and summary of related research in recent years, the integrated technology is
summarized as sensor tag integrated model, WSN-Tag model, WSN-Reader integrated model, WSN-RFID system integration model. The four RFID and WSN integrated models are illustrated in figure 1. Additionally, the detailed integration processing is listed as follows.

Figure 1. Integrated models of WSN and RFID technologies.

- **Sensor-Tags Integrated Model**

  The sensor tag integrated model is shown in Figure 1 (1). Integrating RFID tags with sensors enables RFID tags to be equipped with environmental awareness, enabling tags to collect environmental information through sensors and quickly read as RFID information directly as identification information. Ferrer-Vidal designed sensors with ultra-low power paper-based RFID tags, designed by [5] and Cho to carry the sensor 5.1 W power UHF RFID tag [6], which is based on such models.

- **WSN-Tag Integrated Model**

  The WSN-Tag integrated model is shown in Figure 1 (2). RFID tags are integrated on the WSN nodes, and the integration methods are divided into two categories. One is to store identification information in the RFID standard format on the WSN node Flash; the other is to connect the RFID tag directly on the hardware. This kind of sensor node tag not only can realize tag information identification and tracking but also can perceive the environment and transfer information to each other. The SIWR model and RSN model proposed by [1] and [7] are based on this model to divide nodes into aggregation nodes, routing nodes and sensing nodes. The convergence node is responsible for information management, and the routing node is responsible for the information forwarding. Only the perceptual nodes integrate the RFID tags, and they are responsible for the perception and identification.

- **WSN-Reader Integrated Model**

  The WSN-Reader integrated model is shown in Figure 1 (3). Integrating WSN with RFID through the integration of the WSN node and the RFID reader. RFID extends the range of identification by remotely exchanging data over the WSN and RFID, a machine based state inspection system designed by Omar, and the factory safety system designed by Salvatore [8] [9], are examples of the application of this model. The model can also be with the sensor tag integrated model coexist, such as ZIGID model [10].

- **WSN-RFID system integrated model**

  The WSN-RFID system integrated model is shown in Figure 1 (4). To maintain the original structure of WSN and RFID, intelligent WSN coordinator is introduced for system integration. The intelligent WSN coordinator is equipped with integrated server integration framework, its main task is to control the WSN and RFID work together, WSN and RFID collected information through the integrated framework for data integration, showing a more comprehensive and intelligent
information. WSN and RFID integrated framework proposed by SARIF [2] is an example of the integrated model.

**Optimization of Integrated Model**

The four integrated models that combine RFID and WSN from different perspectives, which have enriched functionality or improved performance to compare with non-integration modes, but there are still some problems, so the model needs to be optimized.

**Existing Problems**

The sensor tag integrated model does not integrate WSN's wireless communication capability, so the system coverage is too small to be the most significant problem. The WSN-Tag integrated model WSN-Tag as a Wireless sensing node, need to follow the network, address allocation, handshake communication, back network protocol, resulting in the loss of characteristics of rapid identification of RFID tags, the number and mobility are constrained by the network load capacity. The WSN-Reader integrated model, WSN-Reader is the only model of the upper WSN and lower RFID hub connected data exchange, large load capacity, once the failure will lead to integrated system paralysis, so the model of load balancing and robustness. In the integration model of WSN-RFID system, WSN and RFID in hardware independent, the deployment cost is the sum of the two, and simply rely on the software level of data analysis and system collaboration to achieve integration, also need to coordinate server performance and cost.

**Optimization Model**

In view of the existing problems of the four models, combining the WSN-Tag integrated model and the WSN-Reader integrated model, the optimized model preserves the WSN nodes and introduces two fusion nodes, WSN-Tag and WSN-Reader, which is a composite fusion architecture. Each node in the model is based on the WSN node, which possesses both environmental sensing and wireless communication capabilities Force; WSN-Reader node and the WSN-nodes can be RFID tag, which is between the nodes not only can be set in accordance with the WSN framework, the remote collection, and transmission, can also be constructed in accordance with the RFID framework for rapid identification of object information, or at the same time. This solves the problem that the WSN-Tag model cannot support fast identification for a large number of RFID-tags. Compared to the WSN-Reader model, load balancing and robustness are improved.

Figure 2. The new integrated nodes’ framework.
The architecture integrates the RFID role layer (including the RFID reader and RFID tags) and the RFID application layer based on the WSN five Tier Network model. The new integrated nodes’ framework is illustrated in figure 2. WSN and RFID share the physical layer and data link layer so that the hardware cost of the fusion node is controlled. The raw data is distributed at the data link layer, the WSN data is transmitted to the upper layer, and the RFID data is sent directly to the RFID role layer to achieve rapid identification of the RFID. Therefore, according to the RFID application layer the integrated node that can dynamically switch to the WSN node, WSN-Reader, and WSN-Tags three roles. The RFID application layer and the WSN application layer can run independently of each other, and can also cooperate with the implementation task.

Construction Mechanism

Because of the ability, this new integrated node with dynamic switch roles and corresponding fusion system can dynamically transform its structure, so it is necessary to establish the corresponding dynamic mechanism, in order to make the system reflect the adaptability to different environments, improve work efficiency.

- **Initialized construction.** First, the node role table is created and maintained at the WSN coordinator, and the node roles are defined as WSN nodes, WSN-Readers or WSN-Tags in accordance with the RFID identification information. After the system is started, all nodes first organize themselves as WSN nodes and upload their own RFID identification information. Then, the system sends the corresponding role configuration command to each node according to the role of the node, so that the node can be switched to a specific role.

- **WSN switch to RFID.** When the need to switch a WSN role to RFID, it will send to the coordinator node in the region WSN-Reader start command, the start node RFID reader function through the RFID application layer, broadcast to all its child nodes of the WSN-Tags start command, the sub-nodes start RFID label function.

- **RFID switch to WSN.** When the RFID system need switch to WSN mode, it can send to the RFID reader WSN-Reader stop command, this node closed RFID reader function, and enable WSN to receive network function, at this point in the vicinity of all WSN-Tags will link its child nodes.

- **Adaptive construction.** It was connected to the WSN-Reader node, reducing load on the WSN-Reader and avoid collision with other tags.

There are some advantageous and disadvantageous that are analyzed as follows. First of all, the new integrated system can realize the basic purpose of the integration of RFID and WSN, that is, remote environment information collection and object recognition management. Secondly, compared with the four combined models before optimization, the new fusion systems solve their problems at the same time. Finally, the new integrated system expands the range of identification, supports the fast identification of a large number of tags, improves load balancing and robustness, and controls the cost very well.

Conclusion

This paper summarizes four kinds of typical RFID and WSN integration model, and the model of existing problems, put forward to optimize the fusion model and based on the optimization model of a novel RFID-WSN combined system. This study proposes an integrated system by novel combined nodes, integrated architecture design of the node based on WSN network model and RFID protocol, without increasing the hardware cost, the software will merge the WSN node, RFID tags and RFID reader three roles into one. Through the design of dynamic construction mechanism to organize and manage these nodes, the fusion system realizes the dynamic switching and adaptive construction of WSN and RFID. Finally, according to the advantages and disadvantages, we find that the new fusion model and system proposed in this study have better characteristics and more flexible applications in the field of active RFID. The optimized WSN+RFID integrated model will improve the efficiency of moving information monitoring with identification capacities.
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