Acta Technica *61*, No. 4B/2016, 281–290

Design and realization of pork anti-counterfeiting and traceability IoT system

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Abstract. In order to improve the correctness of pork traceability, the IoT is applied to construct the pork anti-counterfeiting and traceability system. Firstly, the basic theory of internet of things is analyzed. Secondly, the pork anti-counterfeiting and traceability system is constructed. Secondly, the main technologies of anti-counterfeiting and traceability system are discussed. The system tags are designed, the EPC coding is confirmed, and the sensor node location algorithm is designed.

Key words. RFID technology, EPC coding, anti-counterfeiting and traceability, pork.

1. Introduction

In recent years, the pork supplying market lacks the united management, and the health problem is every serious, and this phenomena prevent the healthy development of pork market badly. Pork tracking and identifying is carried out based on label, which is corresponding to the pork needed to be identified by a certain means, then the relating property of pork can be traced and managed timely. The pork anti-counterfeiting and traceability can offer an good condition for checking the healthy of pork and improve the breeding quality (Zhu et al. [1]).

In recent years, the pork safety events happen frequently, and the pork safety is paid attention by the whole society. The pork is necessary food for the dining table, and the safety of the pork is more and more concerned, and the pork anti-counterfeiting and traceability system is an critical technology for eating unworried pork by the consumer. In recent year the IoT technology has been developed quickly, the extensive consumers can be easy to find out the information of pork. The IoT can achieve the connection between the things and Internet based on a certain protocol based on radio frequency identification technology, positioning system, and infrared sensor. The functions of IoT conclude identification, location, tracking and

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management. The IoT can achieve the information management, and it can obtain the information of pork safety correctly (Huang [2]).

Some researching achievements have been obtained currently, Alavi et al. [3] analyzed the privacy of RFID authentication protocols that proposed in recent years, the privacy of all the analyzed protocols has some problems and can not offer user privacy, and two improved versions of analyzed protocols were proposed, privacy analysis showed that the privacy of improved protocols were resistance against different traceability attacks. Pang et al. [4] proposed a value-centric business technology joint design framework, and the assessed the income-centric added values, and the developed the corresponding sensor portfolios, and the field trials and an implemented prototype system showed the effectiveness of the system). Ray et al. [5] proposed a secure object tracking protocol to ensure the visibility and traceability of an object along the travel path to support IoT, the protocol is achieved based on radio frequency identification system, and the lightweight cryptographic primitives and physically unclonable function were applied by the system, and results showed that the new system is more secure. Zhang et al. [6] proposed a real-time production performance analysis and exception diagnosis model, and the hierarchical-timed-colored Petri net with smart tokens was applied, and the decision tree was applied to diagnose exceptions from the critical production performance. And simulation results showed that the new system had good performance. Kang et al. [7] proposed a sensor-integrated radio frequency identification data repository-implementation model using MongoDB, the data repository schema is revised to integrate and store the heterogeneous IoT data sources, and an effective shard key to maximize query speed and uniform data distribution over data servers, and simulation results showed that the new system is ana efficient for IoT generated RFID/Sensor big data.

2. Basic theory of internet of things

Pork-anti-counterfeiting and traceability system is constructed based on TCP/IP protocol, and achieves the in-formation exchange between the pork safety monitoring platform and pork safety status, can offer the corresponding data for pork safety management platform, and can manage the communication interface with different protocol underground coal mine, and the IoT communication platform of pork anti-counterfeiting and traceability is shown in Fig. 1 (Li et al. [8]).

The hierarchy diagram of pork anti-counterfeiting and traceability system based on IoT is shown in Fig. 2.

3. Construction of pork anti-counterfeiting and traceability system

Information model in Anti-counterfeiting and traceability system is shown in Fig. 3. As can be seen in Fig. 1, through information collection layer, information preprocessing layer, information transmission layer, information intelligence processing and storage layer, the pork information in the Anti-counterfeiting and traceability

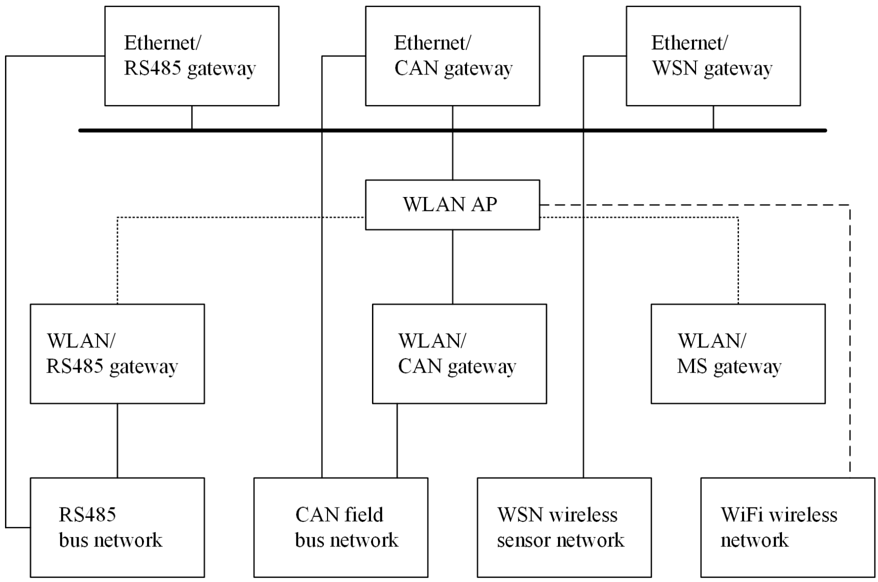

Fig. 1. Communication platform diagram of pork anti-counterfeiting and traceability

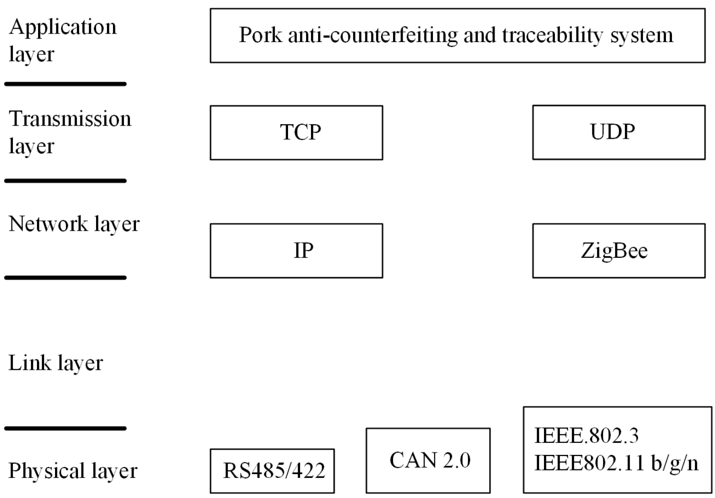

Fig. 2. Hierarchy diagram of pork anti-counterfeiting and traceability system based on IoT

system based on IoT technology is finally stored in the back-end database of WEB application system. The information collection layer mainly gathers information on pig farms and slaughter houses (birth information, feeding information, medical information, vaccination information), inspection and quarantine information, pork production time, pork transportation information (number of goods, transport vehicles, transport time), and sales information (Papanagiotou et al. [9]).

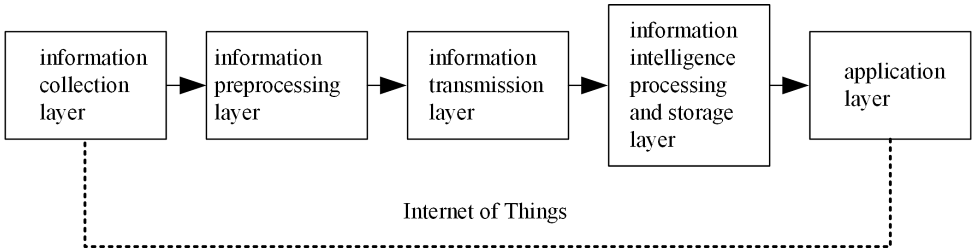

Fig. 3. Information model in the anti-counterfeiting and traceability system

Information preprocessing layer is mainly responsible for a series of processing work of necessary review, integration, conversion, and protocols of the original data before processing the data to complete the incomplete data, correct the data error, remove the redundant data and select the required data for data integration, convert the data format into the required format, remove redundant data attributes and hence to meet alienation of data type, consistency of data format, precision of data information standardization of data storage; Information transmission layer is responsible for transmitting the collected information and storing in the database; through regulation definition, Information Intelligent Processing processes repeating Read, Read failed, false readings, data validation and other issues on the same electronic tag, and makes high-speed processing for vast amounts of information through intelligent information processing technology in real-time, and intelligent mining, management, control and storage of data; and the Information storage layer will store the information collected from the physical aspects in the back-end database after preprocessing (Ren et al. [10]).

Given the respective advantages of NFC and RFID, the system uses a combination of NFC and RFID to achieve bidirectional traceability of pork. NFC tag is used to store pigs ID, each pig has a unique ID generated by the farm, subsequently attached a digital signature, and saved to NFC tag, and other feeding information, vaccination injection information, slaughter information, inspection and quarantine information, logistics distribution and other information stored in the RFID tag encoded by the EPC. NFC and RFID tag information will be written and uploaded to the back-end database system through middleware or hand-held reader. Through NFC smartphone or NFC reader terminal, consumers can inquiry information of pork. System architecture is shown in Fig. 4.

The traceability system mentioned in the literature is a one-way mode, while it is difficult to determine the direction of the condemned pork for the enterprise and total sales point once the pork has problem. The system designed in this paper can conduct upward anti-counterfeiting and traceability for customers to trace back to the logistics information, inspection and quarantine information, cultivation information and other information flows, in addition, downward decision-making of statistics and traceability to trace back to the distribution point information and

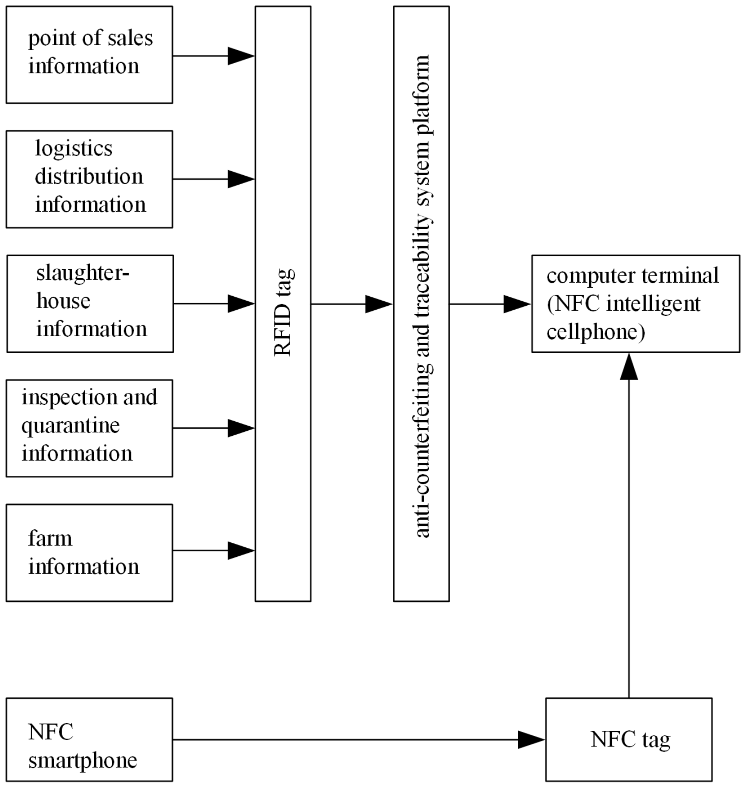

Fig. 4. Anti-counterfeiting and traceability system architecture diagram

consumer group for the enterprises and wholesale market. When problem was found in pork, we can help governments to deal with the problem, at the same time, to prevent the phenomenon of changing products in the supply chain. Bidirectional traceability pattern is shown in Fig. 5.

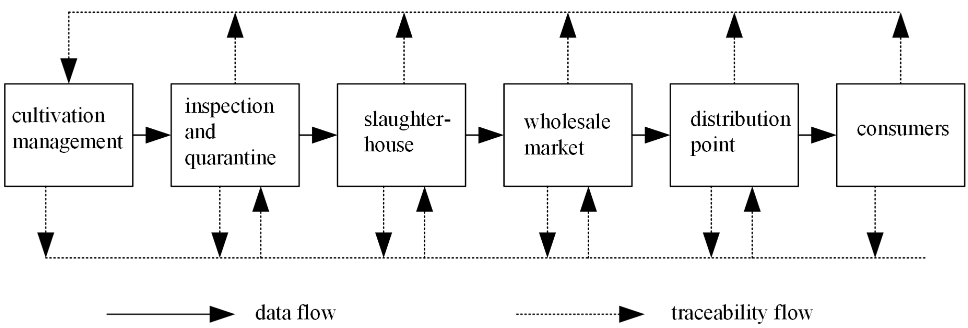

Fig. 5. Diagram of bidirectional traceability model

4. Key technology of anti-counterfeiting and traceability system

NFC tag has four main types (type 1 to type 4). Type 1 is based on ISO14443A, currently exclusively supplied by Innovision Research and Technology Company (TopazTM), which has 96 bytes of memory, with low cost and wide application. Type 2 is also based on ISO14443A, currently exclusively supplied by Philips (MIFARE UltraLight), whose memory is half of type 1 tag. type 3 is based on FeliCa, currently exclusively supplied by Sony, with larger memory (at present 2 kilobytes) and high transmission rate(212 kB/s), suitable for more complicated application. Type 4 is entirely compatible with ISO14443A/B, can be produced by most suppliers including Philips (typical products like MIFAREDESFire), with larger memory and reading rate between 106 kB to 424 kB per second. The anti-counterfeiting and traceability system designed in this paper mainly adopts NFC smart phone to read data, type 1 of NFC electronic tag, with 106KB/S transmission rate and whose recognition distance is about 10 cm (Xiao and Gao [11]).

According to operating frequency, RFID tag is mainly divided into low frequency RFID tag, medium-high frequency RFID tag, UHF and RFID microwave range tag. The typical frequency of low frequency tag is 125 kHz–134.2 kHz. Typical frequency of medium-high frequency tag is 13.56 MHz; UHF and RFID microwave range tag is generally short for “microwave tag”, typical UHF working frequency is 860 MHz–928 MHz, and microwave range working frequency is 2.45 GHz–5.8 GHz. Microwave tag mainly has two categories: passive tag and active tag. The working frequency of the microwave passive tag ranges between 902 MHz–928 MHz. Finally, the working frequency of the microwave active tag is mainly in the 5.8 GHz–2.45 GHz. Microwave tag works in the far field region of the reader antenna radiation. In this paper, RFID in the anti-counterfeiting traceability system mainly used to store cultivation information, inspection and quarantine information, logistics information, and select the ultra-high frequency RFID tag for RFID electronic tag.

EPC (electronic product code, the electronic product code) technology is developed by the US Auto ID, through the Internet platform, using wireless data communication technology and RFID technology to construct a network platform which can achieve information sharing of global items, and can realize the tracking and back-tracking of goods information. At current, coding models applied in EPC system mainly have 64 bits, 96 bits and 256 bits. EPC coding consists of version number, serial number, product domain name management and product classification. This system adopts 96 bit EPC code, as shown in Fig. 6, 8 bits are used to store the EPC version number, 28 used to store pork brand and farm information, 24 bits are used to store the pork classification code, 36 bits used to store pork inspection and quarantine, logistics and distribution information, date of slaughter, wholesale market, distribution points, and other information, and fill 0 in the back when the actual code length is less than the length of the reserved (Gu et al. [12]).

The sensor node is defined by $S = \{s_1, s_2 \cdots, s_n\}$ and sensor range of different node is defined by A_i. The sensor node number of IoT at mth moment is defined by X_n, where $\{X_n, n = 1, 2, \cdots\}$ is a Markov chain. When the Markov chain enters

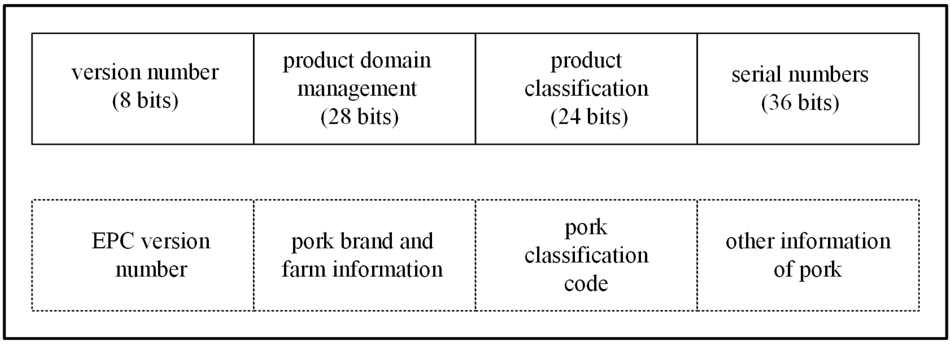

Fig. 6. EPC coding meaning diagram

the status j, the monitoring value of node s_j is changed based on probability $p(j|i)$.
If

$$s_j \in \mathrm{nbr}_{s_i}\,, \text{ then } \sum_{s_j \in \mathrm{nbr}_{s_i}} p(j|i) = 1\,,$$

while if

$$s_j \ni \mathrm{nbr}_{s_i}\,, \text{ then } \sum_{s_j \in \mathrm{nbr}_{s_i}} p(j|i) = 0\,,$$

symbol nbr denoting the neighborhood.

The monitoring value of node i at tth moment is defined as $Y_t^i \in \{0, 1\}$, where 1 denotes that the objective value is monitored, 0 shows that the objective value is not monitored. The whole monitoring vector of all sensor nodes in IoT before Tth moment os defined as $Y_{1,T} = \{Y_1, Y_2 \cdots, Y_T\}$ the status vector is defined as $X_{1,T} = \{X_1, X_2 \cdots, X_T\}$ and the combined distribution function is defined by Zhao et al. [13] as

$$P\left(X_{1,T}, Y_{1,T}\right) = P(X_1) \prod_{t=2}^{T} P\left(X_t | X_{t-1}\right) \prod_{t=2}^{T} P\left(Y_t | X_t\right) . \tag{1}$$

The maximum probability $\delta_t(i)$ at tth moment in i is expressed by the formula

$$\delta_t(i) = \left[\max_{j \neq nrb_i} P\left(z_t^i | z_{t-1^j}\right) \delta_{t-1}^j\right] \eta_i^{y_1^i} (1 - \eta_i)^{1 - y_1^i} . \tag{2}$$

Here, $P\left(z_t^i | z_{t-1^j}\right)$ is the probability that the object located at the jth node moves to the ith node and η_i is the monitoring probability of node S_i.

The weight value of $\delta_i(i)$ can be calculated using information of the ith node, which is expressed as

$$\delta_i(i) = \pi \eta_i^{y_1^i} (1 - \eta_i)^{1 - y_1^i} . \tag{3}$$

The weight value of different sensor node in IoT can be expressed as

$$\omega_i = \frac{\delta_t(i)}{\sum_{\delta_t(i)>0} \delta_t(i)} \,. \tag{4}$$

The coordinates x and y of the monitored object are given by the expressions

$$x = \sum_{i=1}^{n} \omega_i x_i \,, \quad y = \sum_{i=1}^{n} \omega_i y_i \,. \tag{5}$$

The sensor node location can be obtained using the above algorithm correctly.

5. Test of pork anti-counterfeiting and traceability IoT system

The system test can verify the performance of the pork anti-counterfeiting and traceability IoT system, the direct user of the system is the pork processing enterprises, and the indirect user of the system is consumer, the performance of the system can decide the satisfaction degree. Therefore it is important to carry out a test of the system. Every module of the system can cooperate, the test software and hardware environments are listed as follows:

Hardware environment: the processor of the application server is Intel Xeon quad core 2.83 GHz, the cache is 12 M, the internal storage is 8 GB, the hard disk capacity is 300 G. The processor of the database server is Intel 6500 quad core 2.66 GHz, the cache is 24 M, the internal storage is 4 GB, the hard disk capacity is 500 G. Software environment: the operation system is Linux Redhat 5.5, and the database is Oracle 11g, the system software is CIN-SCF platform. The logic modules of the pork anti-counterfeiting and traceability IoT system are tested, and the corresponding testing results are listed in Table 1.

Table 1. Testing results of logic modules of system

Logic module	Number of testing samples	Testing result
Cultivation management	103	100 % pass
Inspection and quarantine	46	100 % pass
Slaughterhouse	15	100 % pass
Wholesale market	75	100 % pass
Distribution point	55	100 % pass
Consumers	42	100 % pass

As can be seen from Table 1, all logic modules of the pork anti-counterfeiting and traceability IoT system passed the test, and the performance of the system can satisfy the business requirement.

6. Conclusion

Combining RFID technology and NFC technology, the Pork Anti-counterfeiting and Traceability System based on Internet of Things technology proposed in this paper realizes bidirectional traceability pattern of upward anti-counterfeiting and traceability and downward decision-making of traceability from the cultivation, inspection and quarantine, slaughter, wholesale, distribution and other supply chains, which have a certain value in implementing traceability of meat and vegetables.

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Received November 16, 2016