1 Regulations
In China, RF spectrums are controlled by the National Radio Administration Bureau (SRRC; www.srrc.org.cn) under the Ministry of Information Industry (MII; www.mii.gov.cn). RF resources are very scarce, and they are an important strategic resource for China. Just as natural resources, radio frequencies are an important foundation for survival and development of the society. As China takes an active and open attitude toward planning and usage of RFID frequencies, government agencies work with standards and technical organizations to understand and support frequency planning.

At present, China has four widely used frequency ranges for RFID applications. The first is the low frequency range from 105 KHz to 200 KHz. The second frequency range is 13.553 MHz to 13.567 MHz. China's second generation ID cards fall in this frequency range, and this frequency range is used extensively for fare collection in public transport systems. The third frequency range is 915 MHz to 928 MHz UHF at up to 2 W power. The identification of China's high-speed railway carriages uses this range of frequency. The fourth is the range from 2.40 GHz to 2.425 GHz. Internationally, there is also the 433 MHz UHF frequency for RFID technology.

In October 2005, SRRC published regulations on short-range devices covering 433 MHz and allowed this frequency to be used for short-range RFID products. The SRRC Certification Center provides radio-type approval for RFID radio devices where in-country testing is mandatory. The cost of testing is determined by SRRC and charged by the test labs. SRRC radio-type approval on RFID devices are documents submission, in country product testing, review and approval, and product labeling. There are multiple certification systems in China, and other agency approvals may be required in addition to SRRC approval.

2 Standard
With several Chinese government agencies having competing interest in RFID, it is difficult to understand who is in charge. While China's standardization work is centrally managed by the Standardization Administration of China (SAC; www.sac.gov.cn/english/home.asp), specific standardization work is performed by affiliated relevant technical committees. In September 2005, the SAC issued an officially approved document listing ISO/IEC 18000 in the national standard revision plan. The Article Numbering Center of China (ANCC) and Electronic Industry Standardization Research Institute (CESI; www.cesi.cn/www/en/) assumed the responsibility to convert ISO/IEC 18000 into a national standard. The Ministry of Science and Technology (www.most.gov.cn/eng) took the lead in creating an association of 14 ministries and commissions to organize specialists all over China to prepare a white paper for China technical policy on RFID. This white paper has been completed and submitted to the leaders of relevant ministries and commissions for examination. The white paper studies and establishes China's technological strategy for RFID, industrialization promotion strategy, and standards strategy, and it will play an important role in China's RFID development.
3 Major Institutions in Developing and Testing RFID

Many technical and demonstration centers on RFID technology have been established by Chinese research institutes.

The following are some of these centers:

**RFID Research Center**
This is the Chinese Academy of Sciences (CAS; http://english.cas.cn/Eng2003/page/home.asp) Institute of Automation's (www.ia.ac.cn/new/english/info.asp?column_191) department for R&D on radio frequency technology. This center conducts research and development and applies the theories and methods that have potential into the industrial ecosystem. Currently, however, the main focus is on RFID testing technology, Internet based RFID information networks, and RFID applications in typical industrial situations such as production control in the manufacturing industry, supply chain management in the tobacco industry, food safety, forgery prevention, and others.

**Auto-ID Laboratory**
This laboratory is located within Fudan University. It is one of seven Auto-ID laboratories in the world. Relying on Fudan University's National Major Laboratory for Application Specific Integrated Circuits and Systems, it specializes in research and development, and promotion of automatic identification, intelligent object, and EPC systems. The laboratory conducts basic and applied research related to various industries. It develops EPC systems and tools, promotes the EPC concept, and conducts research on core RFID technology. It participates in the establishment of Chinese RFID standards, promotes RFID applications in China, and provides RFID system training.

**EPC/RFID Lab**
This lab belongs to the China EPC Working Group (http://www.chinaepc.org). It is an open RFID experiment platform where extensive RFID application systems may be tested, including tests for software systems and label application schemes. This lab is supported by EPC Solutions International, Oracle, Printronix, VeriSign, and Alien Technology.

**Shanghai RFID Solution Center**
Set up by RFID Research Center of Shanghai Jiaotong University, this center congregates a number of RFID equipments and provides vivid interaction with the public. The center has already implemented several applications that could demonstrate the use of RFID in the entire supply chain, including the manufacturer, distribution center, and retail store.

**Microsoft Technical Center (China) RFID Laboratory**
This laboratory is for the development of RFID-integrated platform software. A beta version system has been completed, and it is being tested as of this writing.

**NEC Academy (China)**
This academy is for applied research of RFID in supply chains for cold storage of perishable food and forgery prevention. 4 Current Status in Adoption of RFID

China is well aware of the potential of RFID technology for improving manufacturing activities and supply chain operations. The following highlights some of the many RFID implementations that have taken place in China.

**China new-generation smart ID card**
Beginning in April 2004, China started a project to change 1 billion traditional paper ID cards for its citizens into smart cards. About 200 million new cards will be issued annually from 2006, and a total issue of 900 million cards will be completed by 2008. This could be the largest RFID card application in history. Potential market demand for card readers compatible with the new ID card will be in the range of 4 to 5 million.
China Railway automatic train identification system
RFID has been successfully applied in the China Railway Automatic Train Identification System since 1999. It has been widely used in many railway bureaus, and more than 30,000 locomotives and 600,000 carriages have been installed with RFID tags. RFID is playing a crucial role in real-time track management and is credited for increasing the on-time rate of the train system.

Fixed assets management
RFID labels are widely used in electric equipment management of a transformer substation in Shenyang City, Liaoning Province, China. Each piece of equipment has an attached RFID label for unique identification. This application solves routine inspection and maintenance problems for a great number of large-scale fixed assets in an effective manner through on-site identification using RFID.

Clothes processing industries
In 2004, a Chinese clothes manufacturer installed an RFID system on its production line. The system enabled automatic control and the tracking of all material used in production. The system includes intelligent clothes hangers, each installed with an RFID label. Each workbench has an RFID reader-writer with two antennas. The readers are networked to form an integrated workshop automation system. This system can acquire material-processing information for each procedure and manage the production line in real time to realize dynamic optimization on the production line schedule and enable visible material tracking management.

RFID on containers
The information system in a container wharf has become a bottleneck restricting the development of container transportation. Since the container does not provide any electronic information during transportation, the routing and identification of the contents in the container are recorded manually. To enhance the management level of container transportation, a Shanghai port operator implemented RFID for container identification in 2002. At that time, this application was on the leading edge of RFID technology. After working on the project for more than a year, the company finally turned the concept into reality. This project was highlighted in the Shanghai program of major science and technology solutions in 2004. Five-thousand containers with RFID labels traveled between Shanghai and the Yantai Port over a four-month test period.

5 Technology Advances
A good foundation has been laid for technical development of RFID in China as described in the following paragraphs: Shanghai Huahong, and others have begun the manufacture of 13.56-MHz HF RFID chip. In September 2004, Shanghai Fudan Microelectronics began production of the first Chinese 915-MHz UHF RFID chip. Tsinghua University and Beijing University also played a leading role in this field. China has the wafer fabrication capability to produce locally designed chips.

RFID reader/writer, antenna design, and middleware
Many companies have carried out the development of LF, HF, and UHF RFID read-write equipment. These companies include Shenzhen Yuanwanggu, Shenzhen Promatic, Beijing Futianda, Beijing Vision, Shanghai Huashen, and others. China has many talented specialists in antenna design, some of which can be found in South China University of Technology, Tsinghua University, and Shanghai Research Institute of Microwave Technology. These locally designed antennas meet the international standard of performance. With respect to middleware, Shanghai Jiaotong University, Fudan University Auto-ID Lab, and SAP developed the first Chinese RFID middleware through a cooperative effort lasting nearly two years. Preliminary field trials have been conducted. This has laid a solid foundation for the development of mature RFID middleware products.

RFID packing equipment technology
At present, most domestic RFID tag converting equipment is imported from abroad. Therefore, development of core manufacturing equipment using independent intellectual property is one of the keys for healthy growth of this industry in China. Packaging equipment is not only used in the RFID technology field but also in packaging of many sophisticated integrated circuits. Some institutions in Shanghai and Shenzhen have already engaged in the development and manufacture of packaging equipment. Their target is to build a fully automatic RFID chip production line that is comparable to the modern lines found around the world.

6 Future Potential for RFID in China

The low-frequency RFID market is relatively mature. Applications include access control, employee attendance monitoring, automobile theft protection, animal identification, parking lot fee determination, and many others. The high-frequency RFID market is developing rapidly. Application areas include all-in-one cards, transportation, bill and note forgery prevention, and others. Thus, there is huge development potential for the high frequency RFID market.

Ultrahigh-frequency RFID application in the supply chain is the largest expected potential application of RFID. As a global manufacturing center, China plays an important role in the global supply chain. In a sense, China is at the beginning of the global supply chain—the manufacturer. Wal-Mart and other international retail enterprises mandate that their suppliers use RFID technology. This requirement will pose direct or indirect pressure on Chinese manufacturing enterprises to comply. The wave of global RFID application has inevitably spread to China and will bring the application of RFID technology to Chinese factories. The UHF RFID market has great development potential and will become the largest RFID application market in the future.

It is anticipated that China will become one of the largest RFID application markets in the world. With China's low manufacturing costs, it is anticipated that production facilities of some leading international RFID labels and read/write equipment manufacturers will be transferred to China. In the future, RFID technical development in China will also contribute substantially to global RFID development.

7 Conclusion

A solid foundation for RFID can be found in China. RFID technology is relatively well-known, and RFID applications are popular. The RFID market has developed steadily and is growing rapidly; thus, huge business opportunities exist for RFID technology. LF products and HF products are relatively mature markets. These are the results of the promotion and education provided by various Chinese government agencies, organizations for standardization, technical enterprises, and application enterprises. Its potential influence on production and everyday life have been widely recognized by government institutions, manufacturers, logistics companies, retail enterprises, and the Department of Defense, who are RFID user groups now and in the future.

RFID application projects have shown good results, with the government projects dominating the large-scale RFID application projects. The Chinese government promotes RFID applications in various fields, including urban traffic, railway vehicle identification, dangerous goods tracking, and national defense. Many system integrators explore RFID applications in different industries; new applications are emerging in coal mining, tobacco processing, electric power generation and distribution, food safety management, production process control, and supply chain management. Thus, one can expect innovative RFID applications to emerge from China. China is not isolated. Thus, frequency allocations, international standards that are developed, public policy of various nations, RFID applications in other regions, and return on investment on RFID projects will influence RFID applications and industrial development in China.

RFID applications have been led by government sectors in the past. However, RFID applications in the Beijing Olympic Games, the Shanghai World's Fair, and some unusual military RFID applications will raise the world's attention toward China's capabilities in the area of RFID applications. Attention
given to these applications will lead to numerous additional RFID applications in China and set the pace for many RFID projects in the years ahead.

Next week we will take a look at Australia and Singapore.

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