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Radio Frequency Identification of Hurricane Katrina Victims

Recently, news.com reported that the U.S. Disaster Mortuary Operational Response Team and health officials in Mississippi's Harrison County have been implanting human cadavers with radio frequency identification (RFID) chips. Their efforts have been aimed at speeding up the identification process of the victims of Hurricane Katrina. Motivated by the interest generated by this news, in what follows we comment on the technology, applications, challenges, performance, and individual and societal implications of RFID.

RFID is a non-line-of-sight (capable of communicating remotely even when obscured) and contactless (without direct contact between the transacting elements) automatic identification technology. The identification data is stored on chips that can be attached or embedded into products, animals, or even humans. The tag can be active (with onboard power source) or passive (with no power source). An RFID chip consists of an integrated circuit of about 0.4×0.4 mm and an antenna. The ID or user data is written/retrieved to/from the tag by a reader using the energy generated by induction or radiation. The block diagram of an RFID system is illustrated in Figure 1.

Several RFID technologies are currently available, with characteristics such as read only, read/write, encryption, passive, active, and semi-active. They are suitable for a variety of applications. The inherent strength of RFID chips is that they can provide spatial and temporal context to the tagged subject in addition to a unique identity. This adds substantial value to the decision making for various applications, most prominent of which include tracking and tracing livestock and wildlife, hospital patients, inmates, pharmaceuticals and drugs, consignments in a supply chain, engineering parts in aerospace, hazardous material, and perishable food. Many new applications are also being explored, such as how to exploit the RFID potential for tracking locations of indoor users for personalized, contextual information delivery and sharing, as well as numerous healthcare tasks (pharmaceutical anticounterfeiting and authenticity testing, accountability and reliability in clinical trials, medical device, and asset and patient tracking). Pilot studies in the United States and Europe have shown that RFID reduced medical procedural errors, improved location and availability of medical equipment and care delivery to invalids, and provided better management of wounded U.S. soldiers in the Iraq war theater. Last but not least, recent disaster aftermath has shown that RFID technology can be useful in improving record acquisition and tracking of casualties.

Carrier frequencies most used in RFID applications are low (125 kHz, 134.2 kHz), high (13.56 MHz), and ultrahigh (860–920 MHz). The majority of low- and high-frequency RFID systems operate on the principle of *inductive coupling*, and they are also known as near-field systems. The reader antenna generates a magnetic field, which couples with the tag antenna and provides energy to the tag to respond through a shared magnetic field by changing the load of the energy field in terms of amplitude and/or phase of the signal. The

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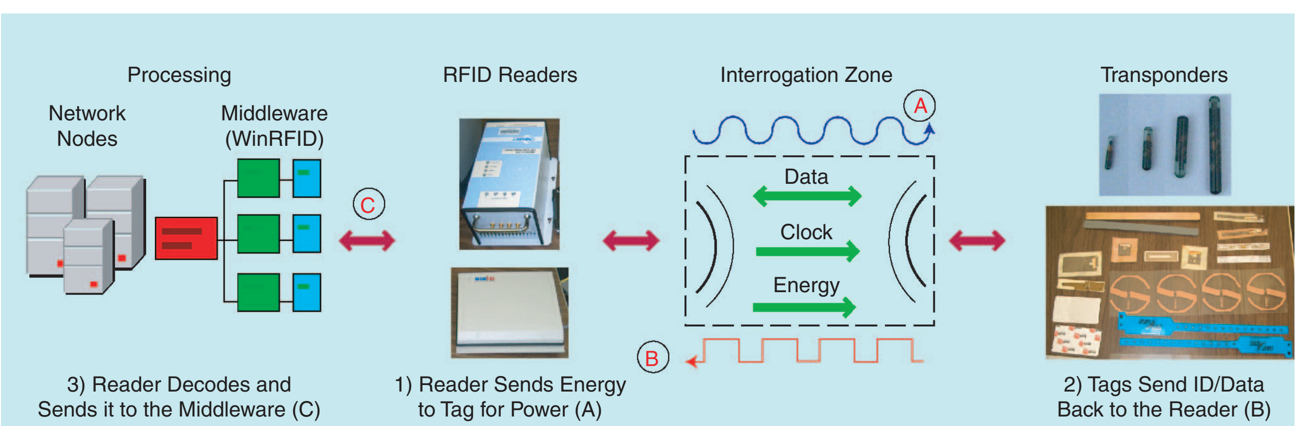

[FIG1] **An RFID system. (Figure courtesy of UCLA-WINMEC.)**

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communication range of this technology is small, from about 1 cm to 1 m. RFID systems that operate above the 30 MHz range use the principle of *backscatter* or *propagation coupling*, and they are also known as far-field systems. Here a portion of the signal transmitted by the reader is reflected back by the tag. The tag sends data back by modulating the load of the received signal in terms of amplitude, frequency, or phase. The communication range of this technology is typically equal to 3–8 m. All of these discrete technologies work on a particular frequency, supporting a distinctive air-interface protocol that governs the communication rules between the tag and reader, anticollision algorithms, modulation and data bit encoding, and commands for reading, writing, and modifying data on the tags.

RFID technology faces numerous challenges. First, it is affected (in general) by the presence of metal, liquids, organic matter, and interference from other radio-frequency (RF) sources. These materials cause RF energy absorption, reflection, multipath, RF signal shading, signal bouncing, and skin effects. Second, the adoption of the technology has been hampered by standards, the evolving aspect of which has made industry wary of committing to any particular technology. This made it very difficult to deploy interoperable solutions. Third, large sections of industry have been waiting for the cost of the RFID technology to come down.

However, industry is working on the latest-generation RFID technology based on software-defined radio, which allows innovations in the physical layer. Control of parameters such as the RF frequency, gain, signal generation and detection, modulation and demodulation algorithms, and data encoding and decoding are realized through a programmable digital circuit in FPGA or DSP. This idea would allow the readers to be reprogrammed on the fly to minimize the effects of most of the interferences listed above.

Current performance of RFID systems is highly application dependent: tag-reader combinations behave differently for different target applications, as well as with variations of the environment for a given application. In general, successful data transaction between tags and a reader with a maximum reading range, and tag read rates (as specified by the existing standards EPC Class 0 and 1, ISO 18000-6A/B, ISO 15693, etc.) with unrestrictive tag orientations are the key aspects that measure performance of an RFID system. Currently, low-frequency and high-frequency technologies perform reliably, but for ultra-high-frequency RFID the deployment needs careful tag, reader, protocol, and environment selection to achieve acceptable tracking reliability.

An important question concerns the health implications of implantable RFID chips. The low-frequency RFID technology is used in implantable tags because it performs better in the presence of flesh and liquids. Studies carried out by various world organizations such as WHO, FCC, IEEE, and NCRP have reported no significant risk to human health at this frequency under noncontact exposure. The Food and Drug Administration (FDA) approved implantable chips for humans on 12 October 2004 but also raised a number of concerns related to adverse tissue reaction, possible migration of the implanted chip, MRI compatibility, and information security.

Many activists and the general public have been skeptical of the RFID technology as a whole. Some of their concerns are related to the cases when 1) the purchaser is not made aware of the presence of the tag, 2) tags cannot be removed or deactivated on demand, 3) the tag is read from a distance surreptitiously, and 4) the ID of a purchased item can be linked to the purchaser through a store transaction. In the case of health applications, there is concern about data mismanagement, data misuse, and identity theft.

Further development of RFID is conditioned by sustained research in technology, engineering use, social issues, and health and privacy issues required by various applications.

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