RFID Technologies and Applications

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INTRODUCTION

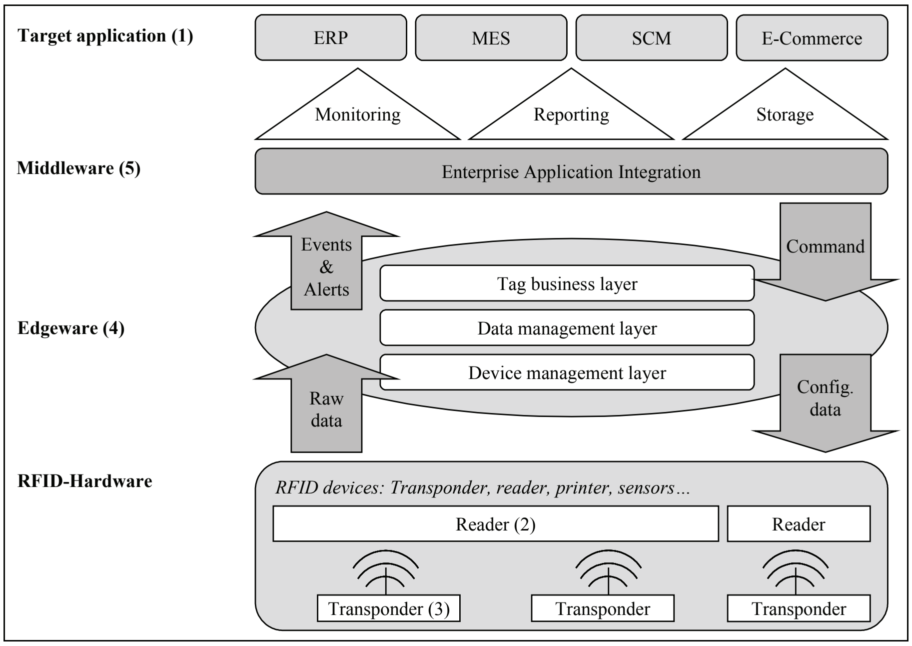
Radio frequency identification (RFID) is a radio-supported identification technology that typically operates by saving a serial number on a radio transponder that contains a microchip for data storage. Via radio waves, the coded information is communicated to a reading device (Jones et al., 2005). RFID does not represent a new development; it was devised by the American military in the 1940s. Since the technology's clearance for civil use in 1977, RFID has been successfully used for the identification of productive livestock, for electronic immobilizer systems in vehicles, or for the surveillance of building entrances (Srivastava, 2005). Due to decreasing unit costs (especially for passive transponders), RFID technologies now seem increasingly applicable for the labeling of goods and semi-finished products. By this, manual or semi-automatic data entry, for instance through the use of barcodes, can be avoided. This closes the technical gap between the real world (characterized by the lack of distribution transparency of its objects) and the digital world (characterized by logically and physically unambiguous and therefore distribution-transparent objects). In addition, RFID facilitates fully automated simultaneous recognition of more than one transponder without direct line of sight between reader and transponders.

CONFIGURATION OF RFID SYSTEMS

A typical RFID system consists of three basic components (Jones et al., 2005): (1) a computer, (2) a reader, and (3) a transponder, as depicted in Figure 1.

1. The computer runs an application that requires real world data (for instance enterprise resource planning [ERP], manufacturing execution system [MES], supply chain management [SCM], or e-commerce applications). The processor sends commands to the reader and receives its replies.
2. The reader is connected to the processor through either a serial interface or a network connection. It contains a so-called "coupling unit," which allows the reader to modulate coded commands onto a magnetic or electromagnetic alternating field. The size and form of this coupling unit may vary, and its dimension determines the design of the reader.
3. The transponder has to be attached to the object to be identified. It is the actual information carrier. All transponders in the reader's field receive commands and send back their response data. A transponder usually consists of a microchip and a coupling unit. There are various transponder designs; most common, however, are small spools attached to adhesive film.

Figure 1. Logical RFID system architecture (Bitkom, 2005; Thiesse, 2005)



An application system that receives real world data through RFID technology has to take into account several factors for the processing of this data (Thiesse, 2005): it must be capable of filtering out erroneous messages; it needs to aggregate received data into complex events; it must support the syntactic and semantic transformation of received data and save it for analytical purposes. In addition to the three basic components, the RFID system's technical architecture consists of two more elements (also see Figure 1):

4. RFID hardware has to contain control software that both transforms the raw data of radio communication into events compatible with the application and that reformats the application commands into data legible for the transponder. This type of software is referred to as "edgeware." It controls the used data's format and its tagging; it also monitors the connected RFID devices.
5. Middleware systems pass on relevant events to the connected applications in the individual syntax and semantics. Middleware is mainly used for the simplification of configuration and for the alignment of RFID systems to the requests of various application fields and target applications.

TECHNICAL STANDARDS FOR RFID SYSTEMS

Efforts to standardize systems on the basis of RFID technologies occur in three fields: standardization of transponder technology, of reader technology, and of RFID middleware. They are discussed consecutively in the following.

First, transponder technologies can be classified using three criteria (Flörkemeier, 2005): according to the individual reading distance, there are close-coupling, remote-coupling, or long-range-coupling systems; according to the energy supply, there are passive, semi-active, and active transponders; with respect to the storage structure there are so-called "write-once/read-multiple" (WORM), read-write, and complex data structures. Unrelated to its reading distance, energy supply, and storage structure, a transponder usually saves at least one 96 bit (max) identification number (Flörkemeier, 2005). This identification number may be formatted according to the widely used number formats, for example, the universal product code (UPC), the European article number (EAN), or the serialized shipping container code (SSCC). The electronic product code (EPC) comprises a new development for RFID technology-based product