Study Defines RFID System Capacity, Sets Performance Metrics for Gen-2 Protocol

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Engineering researchers at the University of Arkansas have developed a novel mathematical model that describes how radio-frequency-identification (RFID) readers capture tag data on a single inquiry. The researchers – Kazem Sohraby, professor of electrical engineering, and Chonggang Wang, post-doctoral fellow in the department of electrical engineering – also developed two critical performance metrics to measure capacity of a single RFID reader environment.

"As far as we know, this is the first quantitative analysis of the performance of the Gen-2 protocol," said Sohraby. "Dr. Wang analyzed the standard Gen-2 protocol and identified a theoretical capacity, or limit, which – given the limits of the technology, as well as interference and collision within the radio signal – identifies the highest possible rate at which a single reader recognizes tags around it."

Radio frequency identification, also referred to as RFID, is a wireless technology that uses radio communication to identify objects with a unique electrical identity. The system includes a reader or multiple readers that emit a radio inquiry, a tag that receives inquiry from the reader and issues a response, and middleware that filters, cleans and organizes raw data. Like bar codes, RFID is used to identify items. Unlike bar codes, which must be brought close to the scanner for reading, RFID tags are read when they are within the proximity of a transmitted radio signal. The technology has applications for business and industry, including retailers, suppliers and transportation providers.

EPCglobal Inc., the organization that sets international RFID standards, recently ratified a new technical protocol, referred to as Gen-2, for RFID passive tags. The new protocol provides advanced features to improve performance and security. Major corporations, including Wal-Mart Stores Inc., have converted to the Gen-2 protocol.

The researchers' mathematical model -- known as Discrete-Time Markov Chain -- helped them discover that the algorithms used to facilitate communication between the individual reader and tags can achieve a reading rate that is very close to the highest possible rate of successful tag identification for a single inquiry. Wang developed two critical performance metrics -- Successful Tag Identification Rate and Tag Identification Speed -- to measure RFID system capacity for a single inquiry. Using the model, researchers found a maximum possible successful tag identification rate of about 36 percent for each query command from a single reader. Based on the algorithm, the researchers achieved an actual successful tag identification rate of 34 percent.

Sohraby emphasized that their study explains how a reader captures tags, and the findings apply only to the speed of a single reader issuing one inquiry. They also give theoretical support for designing advanced protocols to improve RFID system capacity in environments that are prone to radio-signal interference.

In a business environment, the success and robustness of RFID technology relies on the ability to issue not just one but thousands of reader inquiries as a tag passes through a reader field. Success rates identified by Sohraby and Wang answer the probability of a tag being hit by a single reader on a single inquiry. In a distribution center, stockroom or sales floor, thousands of inquiries can be issued in the few seconds it takes for a single product to pass through a reader field. With each inquiry, the probability of successful tag identification increases.

For example, across campus, researchers in the University of Arkansas RFID Research Center, an EPCglobal Inc.-accredited research laboratory in the Sam M. Walton College of Business, produce successful identification rates that are rarely less than 100 percent.

“Readers start firing inquires as soon as a case or pallet enters a read field,” said Bill Hardgrave, director of the RFID Research Center. “In a matter of seconds, you will have thousands of inquiries. The likelihood that a tag will be identified goes up each time a reader sends an inquiry, so chances that a tag will be ‘counted’ are very good. Dr. Sohraby’s theoretical work on inquiry performance complements and reinforces the results of numerous applied tests we have conducted that demonstrate the superior performance of Gen-2 over Gen-1 and the ability to achieve 100-percent read rates on almost any product.”

Sohraby described the Discrete-Time Markov Chain model as a breakthrough in RFID quantitative analysis and predicted that the two performance metrics will become industry standards for measuring RFID system capacity and reliability.

“In the past, these metrics have been talked about in qualitative terms,” he said. “But they needed to be tested, and until now we didn’t have quantitative tools to do that. With the new model, we now have a basis for comparison.”

Sohraby and Wang introduced a novel framework to improve RFID performance of a single reader inquiry through a process called “reading-error prevention” and “reading-error correction.” These processes include methods to protect reader-tag communication through isolation, and tag/reader redundancy.

Wang presented these findings at the AT&T Research 2006 University.

Source: University of Arkansas, Fayetteville