Lesson Title: History of RFID

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Rationale
Why is this lesson important? Why does the student need this lesson? How does this lesson fit in the larger module?

The history of radio frequency identification (RFID) introduces the requirements of different applications and the necessary technologies to meet the requirements. The student needs this lesson to understand the design constraints of low-cost passive RFID tags. This lesson provides a brief history lesson that leads to the UHF passive RFID system.

Objective(s)
What will the student know, be able to do, and value at the end of this lesson? This is smaller amounts of information than the module objectives.

The student will be able to list the requirements of a low-cost tag, describe the requirements of a low-cost tag, identify the major parts of a passive tag, and recall the major institutions involved with EPCglobal, Inc.

Exploration
Explicit concepts related to the Module goal are explored. It is at this point that the student will be provided basic information about the topic and the chance to explore some basic concepts about the topic. This is where the instructor imparts information.

- Define RFID: Radio frequency identification (RFID) is an enabling technology that is an automatic identification method for retrieving and accessing data using devices called RFID tags, sometimes called transponders. The basic RFID system includes tags, readers, and associated interfaces. Its applications include item management, physical access control, travel documents, finance & banking, sensors, animal tracking, human identification, and product counterfeiting countermeasures.
- Identify Friend or Foe (IFF)
  - US and Britain had active beacons 1937-8 (Dobkin, 2008)
  - Aircraft identification system
    - Transponders (tags) on airplanes today
      - When interrogate respond with 12 pulses
      - Unique ID
      - Link ID to other information
      - Location (altitude and distance)
    - Interrogator (reader)
      - Pair of pulses at 1030 MHz in UHF band
      - Transmission of info from interrogator to transponder
    - Expensive but planes are expensive
- Economics of identification
  - The identification system must cost less than the object to which it is attached
  - Large or expensive systems “tagged” first
- Small object constraints
  - Reduce size
  - Reduce complexity
  - Reduce cost
- Low-cost tag requirements
  - No transmitter
  - No battery
  - Simple circuit
  - Being heard in the noise
- No transmitter
  - Backscattering communication: reflect the signal back to the transmitter and modify it to convey information
- No battery
  - Direct current (DC) harvested from the radio signal
- Simple circuit
  - Inductively coupled system like a transformer
  - Lower frequencies (125 kHz – 10 MHz)
- Electronic Article Security (1 bit)
  - Electromagnetic system
  - Acousto-magnetic system
  - Radio frequency (RF) system
- Passive RFID tag block diagram
- Sample applications
  - Rail industry in US
  - Automobile identification
  - Livestock management
  - Pets
  - Dept. of Defense (DoD) identify shipping containers
  - Smart payment cards
- The Rise of UHF Passive RFID (Dobkin, 2008)
  - MIT
    - Robotic vision in 1998
      - Easier to navigate if objects identify themselves
    - Other researchers dream of identifying all objects with RFID (Electronic Product Code)
    - Create Auto-ID Center in 1999 (Sarma, 2006)
      - Proctor and Gamble
      - UCC that administers barcodes for retail products
      - Six major universities
        - Massachusetts Institute of Technology in Cambridge, Massachusetts
        - University of Cambridge in the U.K.
        - University of Adelaide in Australia
        - Keio University in Japan
        - Fugan University in China
        - University of St. Gallen in Switzerland
      - Vision of ubiquitous RFID
      - Requirements
- Simple and inexpensive tags
- Low-cost manufacturing
- Standard infrastructure like DNS to locate information about a particular EPC number
- Savants were names for software agents to consolidate many queries of tags
- 900 MHz chosen as best overall frequency based on cost, read range, and capability

- Wal-Mart joined in 2001
- Two startups in 2000-2002
  - Matrics bought by Symbol Technologies bought by Motorola (Class 0 tree-walking protocol)
    - Alien Technologies
- Class 0
  - Symbol Technologies
  - Impinj
  - Avery
- Class 1 Generation 1 (Class 1)
  - Alien Technologies
  - Avery
  - Rafsec

- EPCglobal Inc. formed in 2003 (Sarma, 2006) and (EPCglobal, 2005)
  - Auto-ID outgrew academic environment
  - Joint venture UCC and EAN (UCC and EAN merged into GS1)
  - EPCglobal Inc. is a nonprofit corporation that leads supply chain standards in RFID
  - Class 0 and Class 1 were incompatible
  - Formed hardware action group (HAG) in 2004
    - UHF Class-1 Generation-2 protocol (Gen2)
    - ISO 18000-6C in 2006
    - Possibly the most important standard for passive RFID tags
  - Standards
    - EPCglobal UHF Class-0 (Class0)
    - EPCglobal UHF Class-1 Generation-1 (Class1)
    - EPCglobal UHF Class-1 Generation-2 (Gen2)
      - ISO 18000-6C

- United States Department of Defense (DOD)
  - Already used RFID in tracking shipping containers
  - Mandated tagging of high-value cases by 2005

- Wal-Mart
  - RFID adds visibility as the items flow through the supply chain from the manufacturer, shippers, distributors, and retailers
  - The added visibility can identify bottlenecks and save money
  - Wal-Mart requested in June 2003 that their top 100 suppliers use RFID at the pallet and case level by January 2005
  - Accelerated the introduction of RFID
Reflection
Several questions are posed to the student to answer and then often discuss as a class. This is an attempt to determine whether the student "gets" the basic concepts delivered above. If they do get it, move on to engagement. If they do not get it, go back to exploration above. It could be as simple as asking a few probing questions or as complex as asking the student to write a paper.

- What distinguishes RFID from barcodes?
- How many planes can be uniquely identified with 12 bits? Does this make sense?
- In an identification system, what is the main rule that should be followed?
- What are the low-cost tag requirements?
- How does a passive tag communicate without a transmitter?
- What are the major parts of a passive RFID tag?
- Can you name three applications before the EPC?
- Where did UHF passive RFID begin and what was its original application?
- What organizations set standards for UHF passive RFID?
- What two major organizations accelerated the use of RFID?

Engagement
Concepts learned in the Exploration are further developed by conducting experiments, designing and building solutions, and solving problems. This is an attempt to cause the student to apply the new knowledge. By applying the new knowledge, the student is much more likely to retain this information. This engagement could be accomplished through a debate, an experiment, a problem solving activity, or anything else that would cause the student to demonstrate understanding and competence.

- Quiz

Expansion
Provide opportunities for students to expand the concepts to more general or global situations including connection to the Module goal. Expand back to the big ideas of the module and prepare for the next lesson.

- Why do you think the UHF frequency range of approximately 900 MHz was chosen over the HF frequency range of 13.56 MHz?
- Do you think RFID would have improved as quickly without the DOD and Wal-Mart mandates?

Lesson Assessment
Assess student understanding of the lesson content. This does not have to be a full-blown examination. It could be a graded homework assignment, a quiz, a performance examination, a graded problem solving activity, or something similar.

- Quiz

Equipment
- None

Software
- None
References

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