FUNDAMENTAL CONCEPTS
AUTOMATIC IDENTIFICATION AND DATA CAPTURE (AIDC) AND RFID
TODAY’S TOPICS

• AIDC Fundamentals
• What is RFID?
• Why Consider RFID?
WHAT IS AIDC?

“Automatic Identification and Data Capture (AIDC) refers to the methods of automatically identifying objects, collecting data about them, and entering that data directly into computer systems (i.e., without human involvement)”

— Wikipedia

• AIDC spans many different technologies
• Anything that captures data to a computer without human intervention can be considered AIDC
• The rise of computers in business made AIDC technologies essential
WHY AIDC?

• Because humans are error-prone and computers are both stupid and unforgiving
• In a perfect world where time and cost were not a factor, the perfect data capture method is human-to-human
• Entering repetitive data is mind-numbing for humans, but computers don’t care
• Machine-to-machine interaction is faster than human-to-machine
• Data entered into a computer system in error takes on a life of its own and becomes costly to correct
TYPES OF AIDC TECHNOLOGIES

- UPC
- EAN-13
- EAN-8
- ITF-14

- GS1-128
- MaxiCode
- Data Matrix
- Active RFID Tag
- Passive RFID Tags

- QR Code
- Microsoft HCCB
- MIT Bokode

- Data Bar
- Optical Memory Card
- Contact Memory Button

- Mag Stripe
- Retinal scan and fingerprint
- Optical Character Recognition
TYPES OF AIDC TECHNOLOGIES

**PRINTED**
- **SCAN-BASED**
  - 1D BARCODES
    - EAN-8
    - UPC-A
    - EAN-13
    - ITF-14
    - GS1-128
  - STACKED LINEAR
    - DataBar
- **IMAGE CAPTURE**
  - 2D BARCODES
    - DataMatrix
    - QR Code
    - MaxiCode
    - Microsoft HCCB
    - MIT Bokode
  - OPTICAL CHARACTER RECOGNITION (OCR)
  - BIOMETRICS
    - Fingerprint
    - Retinal Scan

**ENCODED**
- **ELECTRO-MAGNETIC**
  - MAG STRIPE
  - CONTACT MEMORY BUTTONS
- **RADIO FREQUENCY**
  - PASSIVE RFID
    - Low Frequency
  - High Frequency
    - Ultrahigh Frequency
  - ACTIVE RFID
    - UHF
    - Ultra Wideband
    - WiFi
    - ZigBee
- **SATELLITE**
  - GPS

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CHARACTERISTICS OF COMMON AIDC TECHNOLOGIES

• Scan-based & image capture
  – Relatively inexpensive to “print” the symbols
  – Stable; Cannot be rewritten
  – Serial processing (one at a time)
  – Conveys limited amount of data (ID only or ID, plus nominal descriptive data)
  – Easily damaged: Data recovery is questionable

• Electro-magnetic
  – More expensive than scan/image
  – Serial processing (one at a time)
  – Selectively rewriteable or appendable
  – Can convey more data (larger memory possible with magnetic media)
  – More robust: Data can sometimes be recovered if media is damaged

• RF
  – More expensive than scan/image
  – Group processing (many at one time)
  – Selectively rewriteable or appendable
  – More “hands-off”
  – Can convey more data (larger memory possible with silicon chips)
  – More robust: Data can sometimes be recovered if media is damaged
AIDC COMMONALITIES

• Every AIDC “system” has common components
  – Well-defined “symbols” or data carriers for ID and data
  – Devices for writing to and reading from the symbol/carrier
  – Interface between the read/write device and a host computer
    • Real-time interface
    • “Store and forward” (off-line synchronization)

• Value of all AIDC “systems” depends on well-defined, identification and data capture standards
  – GS1 system of identifiers (GTIN, GLN, SSCC, etc.)
  – GS1 Application Identifiers or ISO Data Identifiers for variable length data fields
ABOUT RFID
Radio Frequency Identification (RFID) is a simple method of using radio energy (inductive coupling or radio waves) to communicate basic information about identity (RF + ID)

- RFID is a group of technologies
- Its primary role is identification of physical goods
- RFID is one of many technologies that are called Automatic Identification and Data Capture (AIDC)
MORE ABOUT RFID

• Equivalent to a very, very simple cell phone conversation
• First use of the technology goes back to the end of WW II
• First RFID patent holder was actress Hedey Lamarr
• We use RFID in various forms in our daily lives already:
  • EZ-PASS/ I-PASS
  • Access badges
  • Automotive ignition systems (Europe – 1990)
  • Payment cards or keyfobs (ex: MOBIL Speedpass)
• First proposed for supply chain applications by GS1 back in 1999 (GTAG project)
• Original work on inexpensive RFID supporting supply chain applications by MIT AutoID Center (funded by GS1, P&G, DoD, Wal-Mart and others; 2000 - 2003)
AN RFID SYSTEM CONSISTS OF FOUR BASIC COMPONENTS

Tags
- Device made up of an electronic circuit and an integrated antenna
- Portable memory
- RF used to transfer data between the tag and the antenna
- Read-only or read/write
- Active or passive
- Usually attached to specific items

Antenna
- Receives and transmits the electromagnetic waves
- Wireless data transfer

Reader
- Communicates with the tag via antenna
- Interprets radio waves into digital information
- Provides power supply to passive tags
- Receives commands from application software

Host Computer
- Reads/writes data from/to the tags through the reader
- Stores and evaluates obtained data
- Links the transceiver to an applications, e.g. ERP
RFID TAG COMPONENTS
PASSIVE, SEMI-PASSIVE AND ACTIVE RFID (1)

• Passive tags
  – Have no power source of their own: Signaling is energy transmitted by a reader, transformed and reflected back to a reader (backscatter)
  – Relatively inexpensive, with simple silicon design
  – Generally small memories (ID only) but can have additional memory to store other information
    • Conditions (temperature, age, batch, origination date)
    • Maintenance history

• Semi-passive (battery-assisted passive) tags
  – Have a small battery
  – Operates like a passive tag, but uses the power source to amplify the reflected signal back to the reader
  – Battery-assist helps to improve the transmission range of the tag
  – More expensive than passive tags
PASSIVE, SEMI-PASSIVE AND ACTIVE RFID (2)

• Active tags
  – Larger battery and a clock
  – Can be “woken up” by a reader or programmed to “ping” (transmit) at regular intervals
  – Much longer transmission range than battery-assisted passive tags
  – Larger memory for storing condition history
  – Can be linked to sensors and to GPS devices
  – More expensive than battery-assisted tags, but often used with large assets, so the tag cost is depreciated over time
PASSIVE, SEMI-PASSIVE & ACTIVE TAGS

Passive

Semi Passive

Active
DIFFERENT TAG TYPES FOR DIFFERENT APPLICATIONS

- Many different tag types use the same RFID “chip” (silicon) and the same air interface protocol
- Communication range of the tag varies with different sizes and shapes of antenna
- Basic tag (silicon, antenna and substrate) can be packaged several ways for different applications
  - Label conversion (adhered to the back of a paper or plastic label)
  - “Sandwiched” into a paper hang tag
  - Rigid plastic casing
- Packaging choice depends on environment
  - Temperature
  - Humidity
  - Vibration/shock
  - Chemical exposure
THE ROLE OF THE RFID READER

Host  Reader module  Antenna  Tag
### Band designation
- **LF** (low frequency)
- **MF** (medium frequency)
- **HF** (high frequency)
- **VHF** (very high frequency)
- **UHF** (ultra high frequency)
- **SHF** (super high frequency)

### Frequency
- **LF** (30–300kHz)
- **MF** (300kHz–3MHz)
- **HF** (3–30MHz)
- **VHF** (30–300MHz)
- **UHF** (300MHz–3GHz)
- **SHF** (3–30GHz)

### Wavelength
- **LF** (10–1km)
- **MF** (1000–100m)
- **HF** (100–10m)
- **VHF** (10m–1m)
- **UHF** (1m–0.1m)
- **SHF** (0.1–0.01m)
LF AND HF BANDS

- **LF:**
  - 125kHz, 134kHz.
  - Relatively expensive.
  - Low range.
  - Robust, but bulky tags
  - Ex: Animal tagging

- **HF:**
  - 13.56MHz.
  - Reasonable cost and performance.
  - Discreet tags, still quite low range
  - Ex: Access badges, payment cards
UHF BANDS

- **860-960MHz:**
  - Better distance for supply chain
  - Ex: UHF “Gen2” case/pallet tags
  - Legislation varies between ITU regions.
- **2.45GHz:**
  - Technically also UHF, also called ‘microwave.’
  - Smaller antennas (and tags).
  - Typically less range.
  - Ex: Real-time location systems (RTLS)
- **433MHz (and others):**
  - Standards still developing
  - Ex: Container “e-seals”
MULTIPLE TAGS AND MULTIPLE READERS

• Need to prevent collisions.
  – When two simultaneous transmissions interfere.
• Singulate tags using anti-collision protocol.
  – Probabilistic approaches.
  – Deterministic, reader querying (tree-walking).
  – Singulated tags become silent.
MAPPING THE SPACE (RANGE)

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<tr>
<td>10,000m</td>
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- Passive UHF
- Passive HF/LF
- Semi-passive (Class III) Gen 2
- Active tags using UWB, Wi-Fi (G2)
- GPS + Satellite
- GPS + Cellular (E911 initiative)

Tracking Levels:
- Vicinity Tracking
- Local Area Tracking
- Wide Area Tracking
WHY CONSIDER RFID?
WHY RFID ROCKS

- No line of sight required
- Little or no human intervention
- "Group" processing
  - Multiple objects can be identified virtually simultaneously
  - Serialized identifiers used to "sort and count" after the actual read event
- Can support both short range and long range read distances
- Memory content on the RFID tag can be modified over time
  - Memory can be locked permanently
  - Memory can be rewritten
  - Separate blocks of tag memory can be written over time
    - Recording transit conditions
    - Maintenance events
- Capture "state" of objects in transit or in storage more often at a lower cost
IF RFID IS WONDERFUL, WHY DO WE STILL HAVE BARCODES?

• Barcodes are ubiquitous and CHEAP
  • More true for 1D than for some 2D (scanner vs. camera)
  • As long as you don’t count the associated labor costs

• RFID requires some initial investment
  • Readers, tags, smart labels
  • Integration with existing systems

• RFID can have some physical challenges
  • Dense environments
  • Liquids absorb RF waves; Metals reflect RF
  • Different frequency regulations for readers in different parts of the world
  • Physical challenges are diminishing with growing use

• Largest changes are in Process and People, not Technology
RFID IS A GOOD CHOICE WHEN…

• I need to identify a lot of objects very quickly
  – RFID can count and identify multiple objects simultaneously
• I need to identify objects that are part of other things
  (ex: airframe parts, medical kits, cases of goods)
  – RFID does not require clear line-of-sight, like barcodes
• I’m operating in a hazardous environment or in open space
  (ex: truck or rail yard)
  – RFID can “read” across long distances
• I can’t afford to devote human labor to the identification task
  – RFID does not require a human to align and scan an object
• I can’t spare cycles for a separate identification step in my process
  – RFID can be incorporated into existing production operation
• I need to add information associated with the ID over time
  – Most RFID tags now are re-writeable, or can be written in segments