INFORMATION SOCIETY TECHNOLOGIES (IST) PROGRAMME

Best Practice Action

D2.2 SIDCOM Training Material Contactless Technologies - Slides Period 1: 01. July 2001 – 31. December 2001

Project acronym:	SIDCOM
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Network on Sensing, Identification and Data Communications with passive Non-Contact Technologies

CONTACTLESS TECHNOLOGIES: WHY NOT?

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Contactless technologies

- **Wireless technologies**
  - 3G, Bluetooth Wireless – Fidelity (WI-FI) IEEE 802.11B
- **Radio Frequency Identification RFID**
- **Contactless smart cards**
- **Contactless sensing**
  - Inductive, Ultrasonic, Photoelectric, Capacitive

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A little bit of RFID history…

- **Developed for defense industry 20+ years for missile tracking and telemetry**
- **Smaller size and lower cost allowed use in 1980s for animal and industrial uses**
- **Large scale in Europe for animal tagging**
- **Large scale use in US for parking/toll roads**

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What Has Changed Over Time

- **Cost has decreased due to improvements in micro-chips and computers**
- **Smaller micro-chip line width size lowers**
- **power needed and size of chip**
- **Computers are faster/smarter: can do more complex signal processing**
- **Better antennas allow smaller tags that can be embedded in labels and products**

What Changed Recently

- Lower cost antenna on labels (printed)
- Higher frequency 125kHz to 2.4GHz means more data transmitted
- Multiple tags can be read in same field
- Demand for real time tracking applications to support e-commerce
- Global standards are in development

First Generation Tags

- Copper wire antenna around ferrite core
- Low frequencies

Square Tag - Gen. 1

Cylinder - Gen. 1

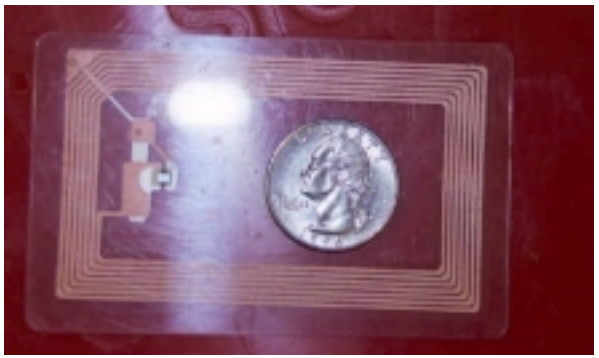
Glass 32mm - Gen. 1

Current Second Generation Tags

- Foil or metal antenna on a label
- Mid range frequencies

Label Tiris - Gen. 2

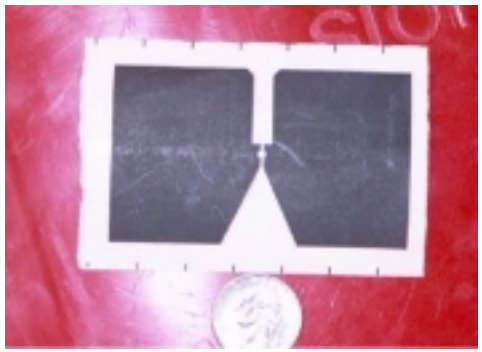
Credit Card - Gen. 2



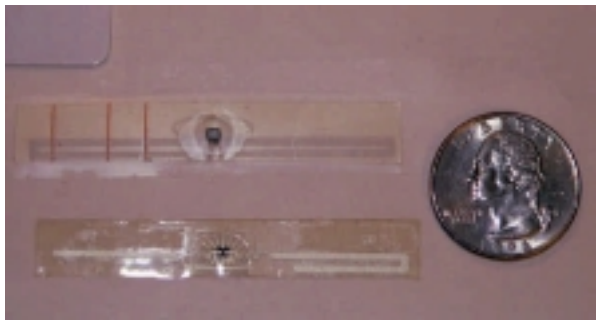
Future Third Generation Tags

- Embedded chip with metallic ink or conductive plastic antenna
- Higher frequencies

Bistatix - Gen. 3

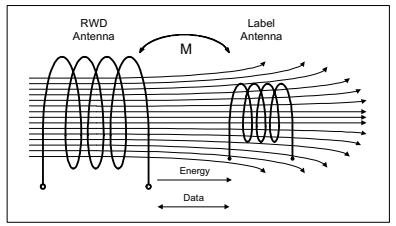


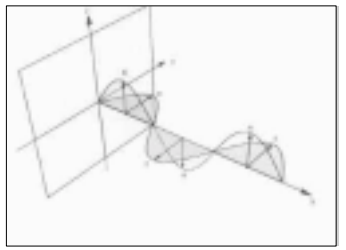
Laundry - Gen. 3



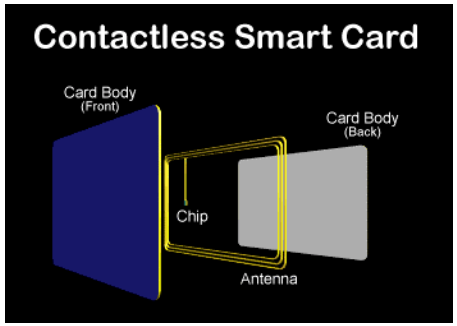
Basics: RFID transmission

- **Inductive coupling**
  - Magnetic field
  - Transmitted signal drops $1/d^3$ and $1/d^4$
- **Propagation**
  - EM waves
  - $1/d^2$
- **"Passivity"**





Contactless SMART CARDS



- **Cross coupled, proximity or vicinity cards**
- **Memory cards** (100-16000 bits)
- **Microprocessor cards**
  - 8, 16 and 32 bits
  - 300 to 32000 bytes
  - JavaCard appls
- **Standards**

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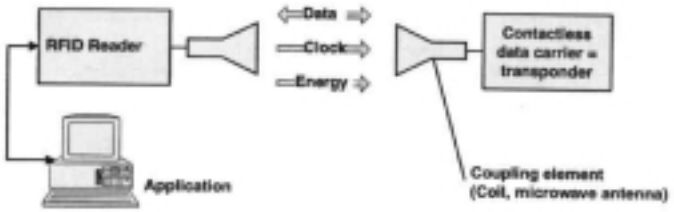
RFID system



Closed loop system
Technology dependent

- ***Transponder*** **or tag**
- **Interrogator or reader,**
  - read or write/read device
- **Transceiver (sender/receiver) antenna**

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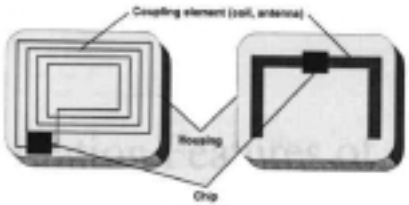
Transponder

- **TRANSmitter/resPONDER**
- **Coupling & energisation**
- **Frequency**
  - Modulation (ASK, FSK)
  - Channel encryption
- **Interrogation zone**



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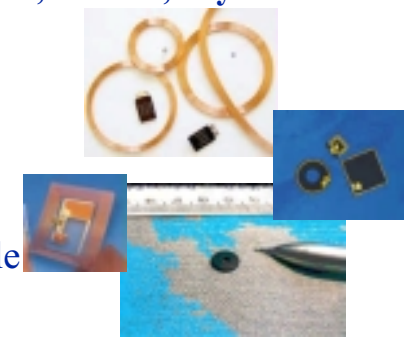
Tags #1

Tags grouped into three basic packaging types

- **Tags – ampoules, coins, pills, "stick", key fob**
- **Cards - credit card size**
- **Smart Labels**

  printed label with an RFID tag embedded
  - thin, flexible, disposable



Tags #2

1. **Data capacitance and structure**
   - 1-bit transponder up to 1 MB
   - *read-only*, *WORM* (write once read many), *read/write*
2. **Writing operation**
   - ID
   - E2PROM (high power consumption during the writing operation - limited number of write cycles)
   - FRAM (100 factor reduction on power consumption, 1000 factor reduction on writing cycles)

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Tags #3

- **Power supply**
  - passive
  - active
- **Operating frequency**
  - 125 KHz
  - 13.56 MHz
  - Higher (2.4 – 2.5 GHz, ISM free band)

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RFID - Key advantages #1

- **Great flexibility**
- **Automatic operation**
- **Growth area of automatic identification and data capture**
- **Non-contact, non-line-of-sight reading**
- **Virtual immunity from obscuring paint, dirt, grease, etc., (depending on frequency)**
- **Robust constructions available, use in reasonably harsh conditions**
- **Read/write capabilities or permanent (non-erasable) ID**
- **Passive/active RFID transponders**
- **New generation, lower cost transponders offering multi-read capabilities**
- **Low to reasonably high (64Kbits) data storage capability**

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RFID - Key advantages #2

- **Wide range of tag options and systems satisfying a range of data storage and data transfer needs**
- **Wide range of data transfer rates**
  - depending on device and carrier frequency used (the higher the carrier frequency the higher the data transfer rates achievable)
- **Close proximity (inductive systems) to tens of meters (radiating systems), without the need for line-of-sight interrogation**
  - depending upon type of transponders and interrogation hardware
- **Extremely high data integrity**
- **Extremely difficult to counterfeit**

RFID – Limitations #1

- **Initial tag cost**
- **Limited interchangeability of tags** (at present, could change in future)
- **Possibility of interference by strong EMI from outside sources** (like in airports and hospitals)
- **Unknown RF sources – welding machines or rotating electrical machinery**

RFID – Limitations #2

- **RFID systems can be hard to debug**

  (and really RF skilled engineers can be hard to find)
- **Electrostatic discharge**
- **Presence of metals can affect RFID system performance**

(can cause shielding or reflections or introduce frequency shift in the system)

challenging the data transmission reliability

RFID: getting started

1. **Basic principles and technologies of RFID**
2. **Scope within company to apply RFID**
3. **Opportunities identification**
4. **Identify needs for open systems development**
5. **Identify relevant standards**
   - necessary or can assist in defining effective solutions
6. **Develop or acquire expertise to prioritise opportunities and determine feasibility and economic justification for using RFID**
7. **Select suppliers**
8. **Develop or acquire expertise to apply and use RFID**

Opportunity for RFID #1

Application Specific

- ***Define the problems to be solved***
- ***Define anticipated benefits of an RFID system***
- ***Define typical data transactions***
- ***Define required throughput and response times***
- ***Identify existing data processing and communications environment***
  - Platforms - Operating systems/programs the terminals will need to run or emulate - Data pathway from the base station/controller to the host (e.g., through a PC or direct) - Network system(s) used - Current and future data handling capacity - RFID system connectivity to current and future data collection and host networks

Opportunity for RFID #2

Application Specific

- ***Identify the physical environment***
  - Number & Location of sites (separate systems). Size and shape (including ceiling heights if indoors) of area to be covered. Building composition. Known sources of RF radiation within or adjacent to the area to be covered (e.g., electrical motors or generators, arc welders, wireless LANs, cordless phones, vehicle location systems, other RFID systems).
- ***Define a Path for Growth***
  - Probable future uses (increased activity). Other possible applications. Probable host platform, software or data communications system upgrades. Any other changes which

Opportunity for RFID

General system parameters

- **Installation cost**
- **Maintenance**
- **Capability for multiple terminals**
- **Number of terminals the system can support**
- **System expandability**
- **System fault tolerance & back up procedure**
- **Effective response time**
- **Battery life for hand-held interrogator units**

Opportunity for RFID

RFID finds suitable application when:

- **The application that can tolerate the tag cost** (tag cost must be in proportion to asset - business value)
- **The application that can't be satisfied with another solution**
  - Barcode
  - Optical Character Recognition
  - Manual system that works
- **There are specific problems that need the capabilities of RFID**
  - Robust, non-line of sight reading/writing,
  - Dynamic data storage on the label, and/or
  - Simultaneous identification
- **The application has a big enough payoff to warrant the change**
  - Good financial return
  - Expanded level of service or efficiency

RFID Typical areas of application

- **Personal identification, security and access control**
- **Safety and personnel tracking**
- **Time and attendance**
- **Document tracking and control**
- **Financial services support**
- **Goods receiving management**
- **Inventory control, pick and place support and warehouse management**
- **Manufacturing work in progress, shop floor data collection and quality assurance**
- **Asset tracking, equipment, components and tool management**
- **Condition monitoring support**
- **Identification, distribution and security of traded goods**
- **Retail product management**
- **Continuous process manufacturing**
- **Library systems**
- **Hotel, Leisure and entertainment management**

Contactless sensing

Contactless sensing includes methods for measuring linear displacement, position, proximity, vibration, gaps and tolerances without making contact with the moving part.

Other physical quantities like speed end acceleration of moving objects, liquid levels, dielectric properties an flow of materials can also be revealed with more recent contactless capacitive technologies.

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Contactless sensing

Inductive sensors

- Radio frequency field using an oscillator and a coil
- Presence of a metal object changes oscillator frequency

Advantages:

- they can detect metal target even through non metallic barriers
- eliminate need for contact
- operate in harsh condition
- rapid response time
- long life

Limitations:

- they can only detect conductive metal,
- short range (less than 1" sensing distance)
- may be affected by metal chips collecting on sensor face

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Contactless sensing

Ultrasonic sensors

- ***Proximity sensor with analogue output stage***
- ***Retroreflective***
- ***Ultrasonic through beam sensor***

Advantages:

- can detect more types of objects
- very good for telling distance; longer operative range than inductive and capacitive sensors

Limitations:

- "dead zone" - cannot detect very close objects nor very small object (depending on the wavelength)
- smooth surfaced objects must be aligned correctly
- very high cost

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Contactless sensing

Photoelectic sensors

Light source and light sensor are housed in the same unit

- ***Thru-Beam***
- ***Reflex***
- ***Diffuse Reflective***
- ***Background Rejection***

Advantages:

- very great sensing range
- very accurate response

Limitations:

- too expensive
- doesn't function in contaminated environment

Contactless sensing

Capacitive sensors

- They works using two plates to form a linear capacitor
- The amount of energy stored between the plates depends on the material between them
- When a material other than air is present the sensor can detect this variation

Contactless capacitive sensing

Why contactless?

- The measure depend only on the capacitive coupling between the electrodes
- The sensing element can be placed anywhere, close the sensing zone, and any object can become as sense element itself
- All the substances have dielectric properties so we can sense through any material

Contactless capacitive sensing
Key advantages and limitations

- **Main beneficial key attributes :**
  - Versatile: can detect just about anything because all materials have a distinct dielectric constant. In addition can detect differences of objects not only presence
  - Robust: can operate in harsh condition, long operation life
  - Low cost, lower than photoelectric and ultrasonic sensor
- **Limitation:**
  - can be affected by varying of temperature and humidity conditions

Contactless capacitive sensing
Applications

The scope for applying capacitive sensing is considerable in every industrial sector where automatic sensing is necessary

- **Conveyors**
- **Robotics**
- **Positioning**
- **Part detection and control**
- **Any material level control**
- **Broken or damaged tool detection**
- **Thickness monitoring**
- **Leak detection**
- **Food processing**