WIRELESS SENSING AND RFID

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RESEARCH EXCELLENCE IN RFID

- Key research area at VTT for more than 10 years
- Extensive interdisciplinary knowledge base and technology platforms support our wide R&D approach to RFID and wireless sensing

  - Silicon technologies
  - Packaging and interconnection technologies
  - Manufacturing techniques
  - Electronics, including printed electronics
  - Radio technology, RF-technology
  - Antenna technology
  - Sensor technology
  - Telecommunication protocols
  - Network topology
  - Embedded programming
Outline of R&D activities in RFID

- **Transponder** development (all-platform tags, harsh environment…)
- **Reader** development (novel low energy adaptive solutions)
- **RFID microchip** development (RF front end, base band, sensor interface…)
- RFID based wireless **sensors** and data loggers, **SAW sensors**
- Novel **smart RFID devices** (mass memory, faster protocols, …)
- **Antenna** design and characterization (tags and readers)
- **Printed RFID** solutions (tags, components, antennas …)
- **Embedded tags** (plastics, wood, …)

Experience in several RFID application areas (logistics, access control, transportation, recycling, forest sector, construction and building, wireless measurements, smart cards …)

- Frequency range from LF to mm-waves, focus areas: HF, NFC (13.56 MHz); UHF (860 – 960 MHz); 2.45 GHz
RESEARCH EXCELLENCE IN RFID

VTT project portfolio covers

- Development and application of RFID solutions for companies (contract research)
- Several large international projects (Indisputable Key, Minami, Adose, RF Platform, Mimosa, Apollo)
- National jointly funded projects
- Self funded research projects

Research results include

- Several commercial follow-up products (Atmel ATA5590 UHF IC, Idesco IR8000 UHF reader, UHF transponders (Wisteq WTUG-132), …)
- Tailored RFID applications (Result Service Finland)
- Numerous patents, patent apps. and publications
- A recognised and eligible status as a research partner and solution provider
RFID TAG DEVELOPMENT

RFID tags are developed at VTT from needs oriented technological innovations to operational prototypes by:

- Electromagnetic simulations
- In-house prototyping
- Measurements

VTT has pioneered platform insensitive tag development:

- All-platform tags (metal, liquid…)
- Application oriented designs
- Enhanced functionality, embedded designs, multiprotocol designs
- Patented antenna structures
RFID TAGS FOR VARIOUS APPLICATIONS

VTT develops RFID tags for different applications and operation environments, aiming at:

- Optimal operation (maximum operation range) in challenging environments
- Possibility for low-cost manufacturing
- New features, e.g. multiband operation, security options, biodegradability etc.
UHF RFID READER DEVELOPMENT

- Several application platforms: fixed readers (for harsh environment, traffic applications), mobile readers
- Several projects from Palomar (EU, 1999-2001), RFID-EAS (Tekes, 2002-2005) to direct industrial development projects
- Novel concepts and solutions:
  - Adaptable and tuneable RF-front end
  - To optimise operational range in reflecting surroundings
  - To optimise power consumption for mobile readers
  - To make compact readers for mobile applications
  - To make robust readers for harsh conditions
  - Cost effective multiple reader situations
RFID IN TRAFFIC APPLICATIONS

- New technology to improve the performance of traffic RFID systems
  - Low-cost tags optimized for windshield attachment, providing maximum reading distance
  - Fast tag response to facilitate high speed applications
  - User-activable tags ('S-Paffa' concept)
  - Novel reader antennas to cover a lane optimally for maximum yield
- Partners: Fenno-ID Ltd, ReadTech (China), Result Service Finland Ltd

http://www.resultservice.fi/
EMBEDDED TAGS FOR VALUE ADDED PRODUCTS

MOTIVATION
- Added value for the (plastic) products by generic RFID transponder solutions
- RFID integral part of the product (design)
- Integration by e.g. injection moulding

BENEFITS
- Cost-effective, covers product lifespan
- Tag protected against water, chemicals, wear, mechanical shocks, …
- Product appearance remains intact

EXPLOITATION
- During the entire life cycle and value chain: product information, logistics, customer service, warranty, recycling …
- Protection against theft
- Certification of product authenticity
TRACKING TECHNOLOGY FOR FOREST INDUSTRY

- Tracking covers the whole wood supply chain from the forest to the end-users
- Improved understanding of wood as a material and of the production processes
  - Improved yield and logistics
  - Reduced waste and environmental impacts
  - Potentially +20% in productivity
  - +10% in the value of the raw material
  - Reduce illegal logging and log theft
  - Environmentally certified timber
  - Improved competitiveness for wood

http://www.indisputablekey.eu
RFID TECHNOLOGY FIELD TESTS

- Identification of displays on a disassembly line
- Identification of containers by a gate reader
- RFID reader integrated on a forklift
- UHF and HF transponders
- Lateral loading of a truck
- Some used equipment
RFID IN CONSTRUCTION INDUSTRY

- **GOAL**: Holistic and detailed control and supervision based on accurate real-time information
- RFID is an enabling technology
SMART SYSTEMS ON TAGS - RFID BASED SENSING

- RFID provides a ubiquitous platform for cheap wireless sensors
  - Wide market penetration will make standard UHF RFID a cheap technology platform
  - Sensor functionalities will drastically widen the scope of RFID
  - Integration with mobile devices will make RFID truly ubiquitous
- RFID provides augmented item and product visibility within supply chains
  - This visibility can be translated into actionable data and predictive changes with additional information attained through sensors
  - Sensors will enhance RFID usability and applications
  - Automated monitoring of transit and environmental conditions through the supply chain (T, P, shocks, moisture…)
- Intelligent sensors can combine sensing, computation and communication into a single, small device
- Smart systems on tags are driving the outgrowth of the ubiquitous information society towards the Internet of Things
MULTI PROTOCOL SENSING TAG

A multi-band passive tag with sensing integration capabilities - fully compatible with ISO 14443A and EPC Gen 2

- Passive tag
- Credit card size
- Operation at HF and at UHF
- Multi-band antenna: a combined coil, PIFA, and fractal antenna

ISO 14443A and EPC C1G2

Fully compatible with standards

Embedded EEPROM memory storage, read and write

Integrated temperature, pressure, humidity, and pH sensors

Mixed signal generic interface
ONGOING MINAmI R&D AT VTT

Usage patterns, proof-of-concepts, user and expert evaluations, ethical assessment

Mass Storage RF tag

RFID tag for shock detection

Ultra light data logger
SAW RFID – IDENTIFICATION & SENSING

- SAW RFID technology can be used for identification and sensing
- SAW reflector response is inherently sensitive for temperature and strain
- Totally passive technology
- Many implementations and read-out possibilities
- Benefits of SAW technology
  - Suits for rugged designs
  - Can withstand high temperatures, high voltages and EM interference
  - Small, light-weight implementations
  - Relatively inexpensive
  - Suitable for mass production
- VTT has demonstrated a wireless strain sensor (proof-of-concept)

Figure: (a) Schematic view of SAW-ID tag with 5 reflectors and two propagation paths illustrated. (b) Illustration of time response for the tag. The pulse spacing depends on measured quantities.
BEYOND RFID – IDENTIFICATION AT MM WAVES

- RFID at all levels will dramatically change how people communicate, acquire services and carry out their purchases
- Present RFID systems are based on technology at 100 kHz to 2.4 GHz. Using millimeter wave frequencies will enable novel features to be included in the identification system
- The novel features include:
  - **Localisation** using a steerable antenna
  - **Miniaturized** tags
  - **High data rate** short range communication

Advantages
- Small wavelength enables small components: Antennas only 1cm²!
- Backscattering communication makes transponder mm wave electronics simple, small and cheap.
- System compatible with mm-wave radars
MMID APPLICATIONS

Radar compatible identification

Fast video download

Localized identification and sensing

MMID Reader and tag

MMID tag with mass memory

MMID reader

MMID tag including sensors
WIRELESS MONITORING OF FOOD QUALITY

Based on EAS tag technology (8 MHz)

Wireless chicken meat spoilage sensor based on hydrogen sulphide detection

Hand held reader
IST International Security Technology

Product: Vivago WristCare™ wristband, a personal safety device to monitor the user's activity and well-being wirelessly

2006 Frost & Sullivan Award for Product Innovation
Award Recipient: International Security Technology

Activities by VTT Sensors:

- Developing a method of monitoring the use of the wristband (whether or not worn by the user)
- Detection of the RF field of the base station to improve the power efficiency of the wristband
- Designing and optimizing antennas for the wristband to enhance the performance of the system
  - Operation distance
  - Power consumption of the wristband
WOODY TAG CONCEPT

- Tailored for log tracking in the harsh forest environment
  - Low temperatures, high moisture in logs, mechanical impacts, rain, mud, snow, oil etc.
- Based on artificial wood material – plastic free
- Compatible with pulping processes – melts in pulping liquor
- Can be manufactured by injection moulding
- Automatic application into logs by harvester machines
- Based on EPC Global C1G2
- Suggestive dimensions: diameter 4 – 6 mm, length 90 mm
- Currently under development
- Can be tailored for use in wooden pallets
  - Size could be reduced
  - Substrate material could be changed for improved performance
  - Application into pallets by a nail gun (as an example)
  - Operational range several meters