From RFID to the Internet of Things: Bridging the gap between Research and Business in the on demand era

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Outline

- Pervasive Revolution
- Enabling On Demand Business
- Technology Challenges
Technology Revolutions

- Mainframe Revolution
- PC Revolution
- Internet Revolution
- Pervasive Revolution

1960's
1970's
1980's
1990's
Today
Any Device over Any Network

All devices can communicate with and understand one another

- Over one trillion devices
- Number of communicating data devices growing from 2.4 billion to 23 billion in 2008 and one trillion by 2012

Source: IDC Research 02/2004
Any Data from Any Location

Seamlessly communicate exploding amount of data on demand, to support people and business processes

- Amount of data accessed will explode to a Zettabyte \((10^{18})\) by 2008
- Variety of Data
- Driving the need for a flexible architecture
- Creating opportunity for business transformation

Amount of data received or transmitted by device (in Petabytes/Day)
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Pervasive Revolution: Enabling the On Demand Era

- Real time sense and response to core applications
- Access to mission critical data from any location
- Connect people, data and processes on demand
- Decision making and communication without human intervention (Autonomic computing)
- New business solutions
Enabling On Demand Business

Sensor & Actuator Endpoints

1. S&A sensors within the enterprise, e.g. instrumentation on manufacturing equipment
2. Remotely connected sensors, e.g. gas pipeline
3. Remote autonomous “smart” sensors with edge controller capability
4. Data feeds from trading partners and suppliers

Sensor Network

Data Analytics

Business Transformation

Event Correlation
Statistical Analysis
Continuous Optimization
Inferencing

Business Choreography

Tooling, Management, Monitoring
The essential part of the vision is a seamless supply chain enabled by the integration of physical objects with the digital world through tagging.

End-to-end real-time visibility and total traceability

- Fundamental changes in every part of a value chain, e.g. retailers no longer own inventory goods as manufacturers take total responsibility in distribution to ensure goods availability
- Businesses will need to respond to market demands in real-time
Shipping - Secure & Intelligent Trade Lane

= accredited entity
= various sensors

signed evidence, documentation, location

Federated Portal
- Carrier
- Customs
- DHS
- other

Manufacturer Distributor
Freight Forwarder
Port Authority “A” Custom
Ocean Carrier
Port Authority “B” Custom
Distribution Centre

(*) TREC= Tamper Resistant Embedded Controller
User-Centric Scenario: ‘Store of the Future’

- **Customer device**
  - Full multimedia capabilities
  - Multiple communication interfaces:
    - cellular, 802.11x, BT, ZigBee, infrared...
  - Geolocation functionality (1m accuracy, indoor)
  - RFID reader
  - Digital camera / video recorder

- **Shopping applications**
  - Downloaded / updated at store entrance
  - Personal shopping list
  - Display advertising
  - Location sensing – direction finding
  - Event processing and correlation
  - Automatic sensor-based check out

- **Tagged merchandise (RFIDs)**
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Challenges

- Scalability
- Networking
- Middleware
- Security & Privacy
Scalability Challenges

- The massive deployment of smart, networked sensors will dramatically affect network volume and traffic patterns.
- Significant architectural changes to global IT infrastructure expected.
- Processing moves to network edge to aggregate and filter:
  - Distributed application processing
  - Code distribution and management

Application “edgification”

Internet

Data, Events, Messages ...

Booster Box

Delivering parts of the application to the edge

Infrastructure to:
1. deploy part of the code at the edge of the network
2. relay processed information to/from the server
Networking Challenges

- Communication and connectivity functionalities for Sensor and Actuator Networks
  - Low-footprint stack for sensor networking
  - Multi-hop communication and relaying
  - Self-configuration, self-healing
  - Power optimization
  - …

- Connecting S&A networks with the enterprise computing infrastructure
  - New messaging protocols: resource reservation, admission control, real-time publish/subscribe engine
  - Real-time operation
Middleware Challenges: Time-Dependent Event Handling

An event-based engine routes, sequences, and filters event data in a time-dependent fashion.

- Sensor / RFID Data
- Surveillance
- Data feeds from trading partners and suppliers
- Other events

Event-based Engine

- Continuously Analyze Event Streams
  Event Analysis
- Identify Patterns of Interest
  Event Action

Selectively Notify Systems & Personnel
Event Notification

DB
TD DB
DBMS DB
Data Warehouse

TD: Time-dependent
Summary

- The real world is being captured (through sensors) and modeled at increasing spatiotemporal resolution.
- On demand businesses need to take advantage of the new sources of data and deal with (monitor, process, store, and respond) the increasingly event-driven world.
- The massive deployment of smart, networked sensors will dramatically affect network volume and traffic patterns, requiring data to be analyzed and acted on locally at the edge of the network.
- The accelerating need to handle large volumes of time-dependent events will give rise to new classes of middleware, programming models, and tools.
- Security and privacy concerns will be strongly amplified and need to be addressed by appropriate policy, legislation, with new software and hardware solutions if there is to be extensive uptake in Europe.
- Open Standards and interoperability are crucial at all levels.