Half a century of renovating
Key Technologies: Reality and Fiction
Creative Science – 26./27.7.2011, Nottingham, UK

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Who we are ...

... is home of the
- first web browser on a PDA
- mediacups
- particle computers

... develops
- new concepts, such as
  - implicit interaction
  - context-awareness
  - context proximity
- new types of hardware
  - extremely low power
  - extremely low cost
Who we are ...

- is home of the
  - first web browser on a PDA
  - mediacups
  - particle computers
- develops
  - new concepts, such as
  - new types of hardware
- applies ideas
  - industrial applications
  - retail applications
  - smart business items
Our Story

An elderly man of around 70 years is renovating an old country house he has inherited.

While removing old remains of technology in the house he is reminded of all the technologies he has witnessed during his life, from electricity cabling to the smart wall paper.
The Future of Computing: Factors

- **Size**: How small is a computer?
- **Cost**: What does a computer cost?
- **Density**: How many computers per square meter (or cubic meter)?
- **Degree of connection**: How many computers need to work together to perform a certain function?

**Example**: Today’s Smart Phone: 7 cm³, 200$, 0.1/m², 1
Activity/Context Recognition on Mobile Phones

- Context Recognition:
  - anytime machine learning and classification
  - activity service ActiServ: an App-Store for activity patterns

- Abstraction: reasoning to generate coarse-grained situation descriptions for situation logging:
  - uncertainty
  - conflicting information

- Context prediction
Stage 1: a Safer Airport (5cm³, 10$, 4m², 2)

Today‘s sensor nodes can already achieve this if

- prices drop somewhat as sensor nodes are deployed throughout large environments
- activity recognition mechanisms become reliable enough to be suitable for safety applications
- sensor nodes can be installed more easily
- applications can be deployed more easily to sensor networks
... please stay tuned
we’ll be back in a minute ...
Stage 1.1: Smart Homes (5cm³, 5$, 4m², 2)

... then these advances can also make it into the mass market
Stage 2: the Smart Grid (5cm³, 10$, 0.1m², 1000)
Smart TecO System

Smart Lab

FS20 system

FS20 system

FHZ1300

FHZ1300

Plugwise system for energy sensing

1. Web interface
2. Connection with WSNs
3. Remote control

WSNs based on µParts

FHT80b system
Prototype

a) uPart

b) Plugwise

c) FHT80b

d) uBox (HTTP Based Sensor Network Manager)
Lightweight Context-Aware Sensing Acting System

- Context recognition for Generator/Consumer
- Example: Open Cast Mining [UbiComp 2010]
- Distributed Collaborative Sensing [Behaviour Monitoring and Interpretation 2010]
Industrial Scenario

Open-cast mining

- Extraction of raw materials without tunneling
- Continuous transport via conveyor belt system
- Expensive to monitor

Source: de.wikipedia.org
Distributed Sensing, Reasoning, and Acting

Crucial: energy consumption and robustness

- Simple reasoning
- Local communication
- Partial order reasoning
- Communication between neighboring nodes

<table>
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<th>$y = z$</th>
<th>$iP(y, z)$</th>
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<th>$iP(y, x)$</th>
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if $msg \vdash R(v_x, v_x)$ and $msg = \emptyset$ then
   LED on
   send($\{v_x = x, R(x, x)\}$)
   timer.start()
end if

if message received then
   $msg \leftarrow \{v_y = y, R(y, z)\} \leftarrow$ received()
   if $msg \vdash R(v_x, v_y)$ then
      send($\{v_x = x, R(x, y)\}$)
   else if $msg \vdash R(v_y, v_x)$ then
      LED off
   end if
end if
Distributed Sensing

Algorithm demonstration

Routing messages along the measurement gradient

Establishing a DAG, i.e. a hierarchical network topology purely by measurement

gradient of the measurement value

sensor node
Experiments

- Experimental implementation
  - JN5139-based sensor node platform
  - Low-cost micro-vibration ballswitch sensor

- Two experiments
  - Realistic scale but with simulated sensor data for showing the general setting of sending and reception of messages in the scenario
  - Smaller scale but with actually measured sensor data, illustrating how the algorithm works on actual sensor data
... please stay tuned
we’ll be back in a minute ...
Stage 3: Smart Labels (8cm², 1¢, 1000/m³, 1-?)

- Printed organic electronics promise to make computing cheaper and more distributed than ever before.

- Enabling
  - novel business processes
  - high degree of automation

- Technological challenges:
  - Can such cheap systems be made autonomous?
  - How can we communicate with 1000 computers?
Storage regulations on storage of chemical goods

- What can be stored with what?
- How much can be stored in one place?

Chemical bins that know about their content
New Project: TIMBUS – Digital Preservation for Timeless Business Processes and Services

![Diagram showing the TIMBUS project with BAT CAD/CAM System, Machine Tool Manufacturer, Material Supplier, and Material Manufacturer nodes. The timeline spans from 2010 to 2041 with phases labeled as Expediency and Execution, and supported by the Seventh Framework Programme logo.]
New Project: TIMBUS – Digital Preservation for Timeless Business Processes and Services

Organisational Business Process Models

Risk Interface

Intelligent ERM

Value Engineering

Service Dependency Monitor

Financial Interface

Information Lifecycle Management Interface

Legalities Lifecycle Management (LLM)

IP Management

Data Protection

Preservation Specific IT Contracting

Preservation Obligations

IP Management

Data Protection

Preservation Specific IT Contracting

Preservation Obligations

Supported by

ESCROW SaaS/PaaS/Cloud SLA
New Hardware: Polytos (BMBF, SAP)
BMBF excellence cluster: Printed Organic Circuits and Chips

Goals

- Infrastructure with reader system for massive amounts deployment of organic Smart Labels e.g. in cold chain management
- Communication protocols for reading from > 1000 Smart Labels per m²
- Development of a silicon based test bed

Testbed

1. Collective transmission of Si-based transponders
2. Signal superposition
3. USRP detects signal pattern
4. Transmission to PC for further analysis
Superimposed Signals

S_1(t) + S_2(t) + S_3(t) = S(t)

Pallet contains perishable goods?

Communication with the pallet as a whole
instead of communication with individual tags

0 1 0 1 1 0 1 0
1 1 0 0 1 0 1 1
1 1 1 0 0 0 1 0
0 1 0 0 0 1 1 0

PC Signal processing

USRP Software Radio

12.08.2011
Superimposed Signals: Addition

![Image of superimposed signals and related hardware setup]

- **Superimposed Signals**: Addition

- **PC Signal processing**

- **USRP Software Radio**

- **Graphs showing signal properties**

12.08.2011
Collective Transmission

<table>
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<tr>
<th>Setting</th>
<th>Number of Trials</th>
<th>Correctly identified Msg.</th>
<th>Average Error Sum</th>
<th>Average Error Mean p. Class</th>
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<td>79.52%</td>
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</table>

**Result:** transmit a set of elements

**Binary Query:** is the element contained in the set?

**Proportion Query:** Which percentage of the pallet sent this element?

**Beyond encoding sets:**
- computation on the channel: average, sum
- advanced data structures: directed acyclic graphs
Summary and Outlook

Where does this go?

- Will products be able to organize their own production process?
- Will they collaborate to support us?

... or will they have other ideas?
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