Linking the Real World to the Virtual World –
Atoms, Bits and Smart Objects

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Smart Objects? Atoms? Bits?

- What if all things were smart?

- What if every object had its Internet home page?

- What if every object had a smart proxy?

but what does „smart“ mean?

atoms

bits
Virtual Worlds - It All Started with Data Processing

- Data processing
- Information processing
- Simulation
- Virtual Reality
How to Bridge the Gap?

Virtual world

Real world
Narrowing the Gap

Virtual world

Real world

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time

files

data bases

manual data entry

bar code labels
Why not attribute every object a unique representation in cyberspace?

- "virtual counterpart"
Virtual Counterparts

Virtual world
(Internet, Cyberspace)

Virtual counterparts
(pure virt. object (e.g. email))

Real world
Making Things Smart with Virtual Counterparts

- **Extend artifacts** by information processing facilities and enable **interaction** between artifacts, e.g. by:
  - embedded processors
  - sensors (e.g., computer vision)
  - tagging (barcode, RFID tags)

- **Virtual counterparts** represent their real-world artifacts in a virtual world
  - coupled to artifact
  - passive ("homepage") or
  - active ("proxy") or
  - service interface ("portal")

*Virtual world*

*Real world*

e.g., HP's Cooltown project
Display Virtual Counterparts of Labeled Artifacts

- **Label** = Internet-URL (pointing to the bag’s „home page“)
  - e.g., *recipe „on“ food for microwave oven*
    (passive parameters or active code)
Artifact Memory

Proxies act as memories for their artifacts

Updates triggered by events

Queries from the real world return memory content

Sensors generate events
Active Proxies Replay
Real-World Manipulations

Context #317: dug “Traxi” bag #5744

create context object

operation “insert”

put dug into bag

new coordinates:
N 39.34.17
E 13.26.43
A New Paradigm?

- Real-world **objects** have *virtual peers*
  - which record a state (sensor data, history, location, ...) and
  - meta-information (type, owner, references, ...)

- **Actions** in one world are *reflected* in the other
  - real transactions manipulate virtual objects
  - virtual actions trigger real-world actors

- **Meta-objects** collect & *process* data
  - infer knowledge, take appropriate actions
An Old Paradigm, But a New View

- Classical paradigm: mapping the real world through thoughts, ideas, data collections, bookkeeping, simulation, factory automatization...

- But provide a new view:
  - everything has a unique virtual counterpart
  - bridges are ubiquitous
  - interactions are immediate

- Required: an adequate model of the real world and techniques for bridging the gap

  e.g., RFIDs
RFID: „Radio Frequency Identification“

- IC with RF-transponder
- Wireless energy supply
  - ~ 1 m
  - magnetic field (induction)
- ROM or EEPROM (writable)
  - ~ 100 Byte
- Price ~ 0.1 $ ... 1 $
  - consumable and disposable

image source: Portolano project
RFIDs as „Smart Labels“

- **Flexible tags**
  - laminated with paper
  - self-adhesive
  - printable (e.g., barcode)

Image source: Portolano project
Smart Labels

- **Chip** (without antenna):
  ~ 2 mm x 2 mm x 10 μm
  - fits into 80 μm thick paper!

- **Antenna**:
  - copper, or
  - printed with conductive ink, or
  - on CMOS wafer (microgalvanic „coil on chip“)
Components of an RFID System

RFID "reader" — antenna — RFID tag

- RFID "reader" and application
- Antenna: ~ 1 m
- RFID tag: ~ 3 cm
- Data transfer: ~ 2 x 2 mm
- Energy transfer
Radio frequency identification tag having a printed antenna and method
Motorola Inc, issued 01/25/2000

„A radio frequency identification tag includes a radio frequency identification tag circuit chip coupled to an antenna including a conductive pattern printed onto a substrate. The substrate may form a portion of an article, a package, a package container, a ticket, a waybill, a label and/or an identification badge...“
Application Domains for RFIDs

- Electronic article surveillance (EAS - anti-theft functionality)
- Inventory control
  - shops or mini bar in hotel rooms
- Libraries, video rental
- Baggage labels
Application Domains for RFIDs

- Ski passes
- Ear clips for animals
- Transport of mail and parcels
- Tracking of goods
- „Radio signature“ of documents
- ...

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A Context Sensitive Cookbook

- Place grocery items on the kitchen counter
- Nearby display shows dishes that can be prepared with available ingredients
A Context Sensitive Cookbook

Groceries are equipped with RFID tags
Context Awareness

- Properties of the ingredients
  - check whether there is enough of an ingredient
  - prefer ingredients with earlier best-before data

- Properties of the kitchen
  - check whether required tools and spices are available

- Preferences and abilities of the cook
  - prefers Asian dishes
  - expert in vegetarian dishes
Commercial Interest in Linking Atoms to Bits

- Connect the **real world** to the **digital world**
  - link between physical objects and **Web pages**
  - e.g., by using barcode readers or RFID readers

- number is transformed to an URL, associated **Web page** is returned
- **identify object instance**, not object type (e.g., UPC)
- but: labels on all objects?
Application Scenarios

- Get **information** about real objects
  *What is contained in this medicine? Listen to music found in an ad.*

- Smart **assistant**
  *What parts need maintenance? What is the layout of this machine?*

- **Services**
  *Who visited this house before?*

- **Context awareness**
  *Is this tool available here?*

- **Smart** home, car, office, ...
  *Adapt to people's preferences*
www.connectthings.com

- Idea: use standard **barcodes** to get information about products (CDs, medicals, ...)
- **Product web site** is provided by manufacturer
- Business: **sell service to companies**, operate servers, promote service
- Customers: Novartis, Siemens, Colgate Palmolive, ...
- Launched **20 Oct 1999**, still operating
The Mobile Phone as an „Internet Remote Control“?

- PDAs, mobile phones, and wireless internet appliances become *request devices for information*
  - displayed on the device or a nearby screen
- „Click“ on a physical object
  - access Internet sites without manually entering URLs
  - find information
  - order products
  - ...

„BarMailer“, a snap-in barcode reader for mobile phones
www.bar-mail.org

- Barcode reader with memory
  - capacity to store 100 codes
- Stand-alone or connected to mobile phones
- Send codes via SMS to bar-mail server
  - server sends back e-mail
- Founded 1997 with help from Ericsson
  - 24 June 00: Motorola investment to form new company
  - 14 August 00: running beta-test in Sweden
  - end of August 00: last updates on web site...?
- Filed for protection for
  “from atoms to bits and back again”
“Cross Convergence” Scanner and Pen

- **Mobile scanner and pen**, $89.90
- Allows to **link** from a printed page directly to the Web
- Scans **barcodes** on printed material and drills down to related web page content
- Up to 100 scans between **downloads**
- **Data well** hooks up to computer for information transfer
- First release shipped **Oct. 30, 2000**
CueCat

- **Barcode scanner** (shape of a cat)
  - LED based; attaches to the computer via the keyboard port
- 10 million free scanners distributed in the US by the end of year 2000
  - 50 millions planned in 2001
  - estimated cost of $ 5 - $ 10 per CueCat
  - someone spends at least $ 500 000 000
- Sends the **Web browser** directly to the „right“ location when scanning the barcode of an ad in a magazine
Mapping of Barcode to Web Page

User has to register to use the software

1. User
2. Web page related to product or document
3. Manufacturer, Advertiser, ...
4. Provider

- Map barcode to URL
- Log user data
- Send targeted advertisements
CueCat Revenue Model

- „Our revenue model is being the gate keeper between codes and their destination online“
  - software in the computers links to Digital Convergence
  - code is encrypted by the scanner
  - scanner adds its serial number
  - DigitalConvergence keeps mapping from barcode to URL as its property
CueCat Reverse Engineering

- **Hackers** know
  - how to **decrypt** the resulting code (base64 + XOR)
  - how to manipulate the hardware so that it doesn’t include the **serial number**
  - ... it **doesn’t encrypt** the bar code number

- **Digital Convergence** doesn’t like
  - reverse engineering
  - open barcode **directories**
  - **free applications** (e.g., download amazon.com information from ISBN numbers on books)
  - **LINUX drivers**
Business Risk Factors

- **“WE ARE DEPENDENT ON INTELLECTUAL PROPERTY RIGHTS AND OTHERS MAY INFRINGE UPON THOSE RIGHTS.”**
  - “We rely on patent, trademark, trade secret and copyright laws, as well as confidentiality procedures and licensing arrangements, to protect the proprietary technology that we have developed, but we can give no assurance that such laws or procedures will provide sufficient protection to us or that others will not develop technologies that are similar or superior to ours.”

- **“OUR RIGHT TO KEEP INFORMATION COLLECTED IN OUR DATABASES MAY BE CHALLENGED IN THE FUTURE.”**
A system and method for using identification codes found on ordinary articles of commerce to access remote computers on a network. In accordance with one embodiment of the invention, a computer is provided having a database that relates Uniform Product Code ("UPC") numbers to Internet network addresses (or "URLs"). To access an Internet resource relating to a particular product, a user enters the product's UPC symbol manually, by swiping a bar code reader over the UPC symbol, or via other suitable input means. The database retrieves the URL corresponding to the UPC code. This location information is then used to access the desired resource.
Patent US6108656

„Automatic access of electronic information through machine-readable codes on printed documents.“

Issued / Filed Dates:
Aug. 22, 2000 / May 11, 1999
NeoMedia Technologies, Inc.

FIG. 3  CLIENT COMPUTER

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Two Worlds that Collide?

- If there is **tight interaction** between the physical and the virtual world – what happens?
  - what is gained?
  - what is lost?

- Can it make a **better world**, or just **better business**?
- Which **techniques** are needed? Which are suitable?
- What are the **limits**?