Instrumented Environments

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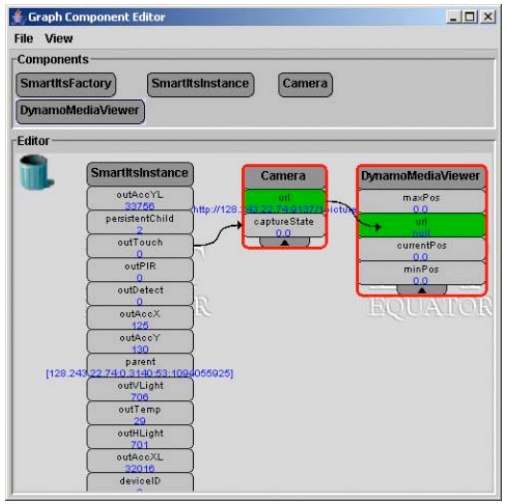
Fri, 12:15-13:45, Theresienstr. 39, Room E 045

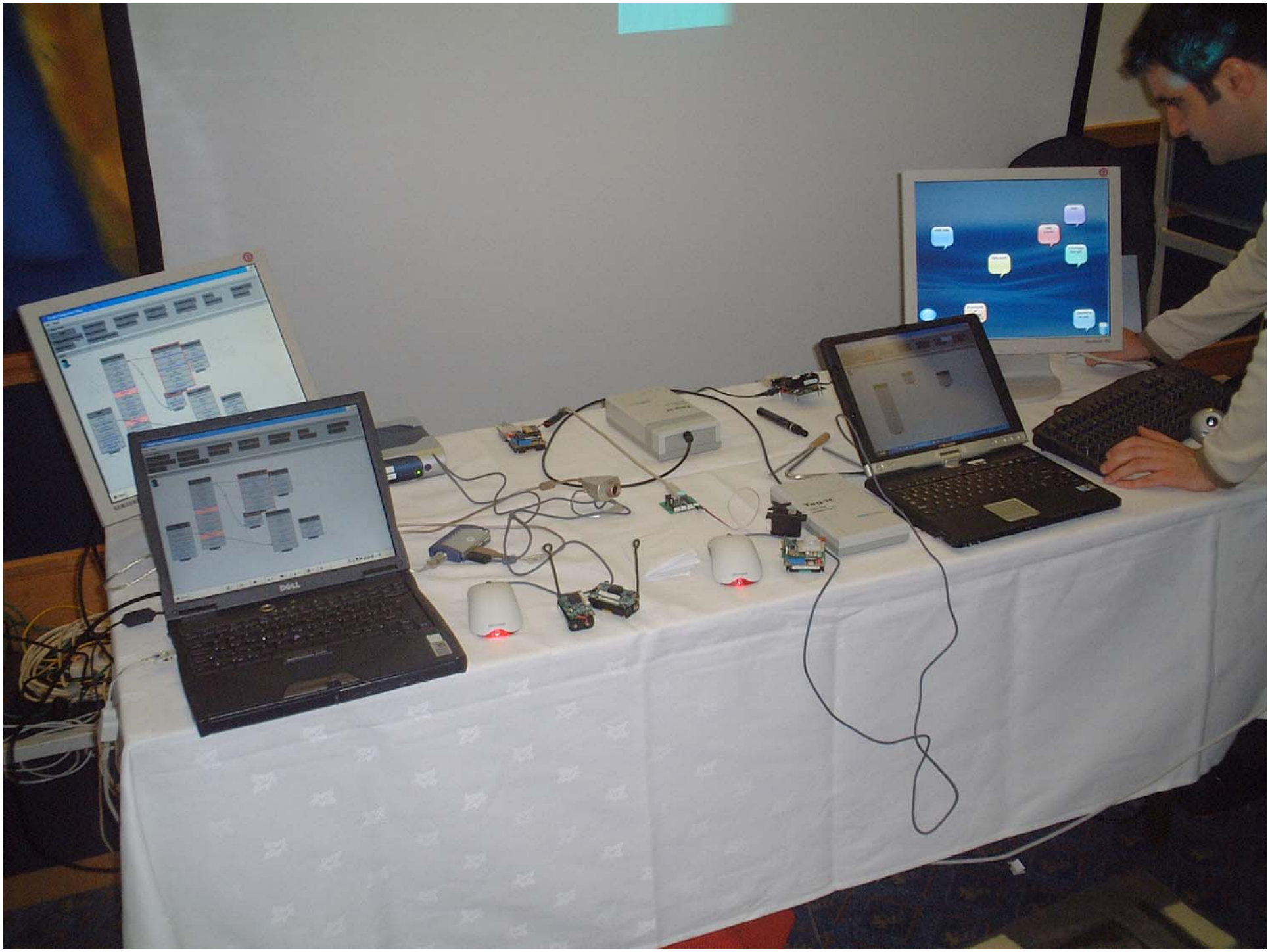
Equip Component Toolkit (Nottingham, RCA)

http://sourceforge.net/projects/equip

http://www.crg.cs.nott.ac.uk/%7Ejym/ect/ect.php



- Collection of I/O hardware components with corresponding software components:
  - TagIt tag readers, using the TagIt component
  - Smart-Its, using the SmartItsFactory and SmartItsInstance components
  - EZIO serial interface, using the EZIO component
  - Video Input (JMF), using the Camera component
  - Audio Input (via JMF), using the AudioCaptureHandler and AudioCaptureDevice component
  - Multimedia Display (via Dynamo), using the DynamoMediaViewer and DynamoSurface components
  - X10 power-line control system, using the X10 component
  - Processing electronic arts language, using the ProcessingHandler component



Example app from RCA: Drift Table

- The Drift Table enables people to slowly float over the British countryside from their own sitting room. The centre of gravity of objects left on this table control the slow scroll of aerial photographs displayed in the table surface. Adding weight to the table causes it to 'descend' zooming in on the landscape below, stacking books on the same side of the table may allow for faster motion. This table suggests a 'hole' in the home connecting physical and virtual space. A display on the side of the table shows the location of the aerial image.

Calder Toolkit (MERL)

http://www.merl.com/publications/TR2004-076/

- Collection of wired and wireless HW components for fast prototyping of physical interfaces
- SW layer:
  - Surrogate objects (SW) represent state of the corresponding HW object
  - Each wired component is a USB HID

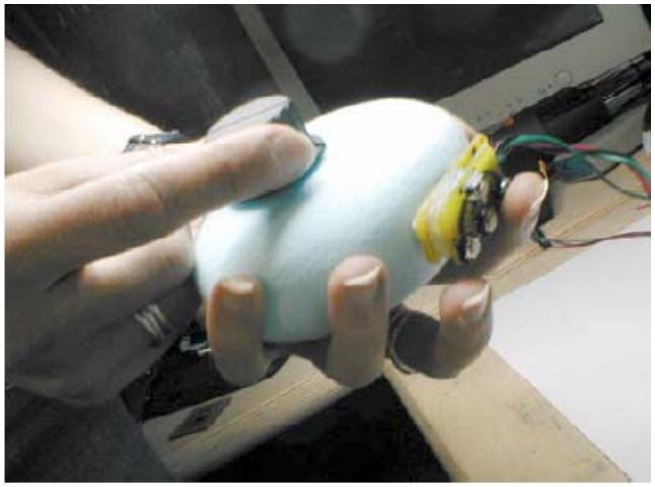


Figure 2. Wireless knob and buttons used within a foam model of a concept game controller.

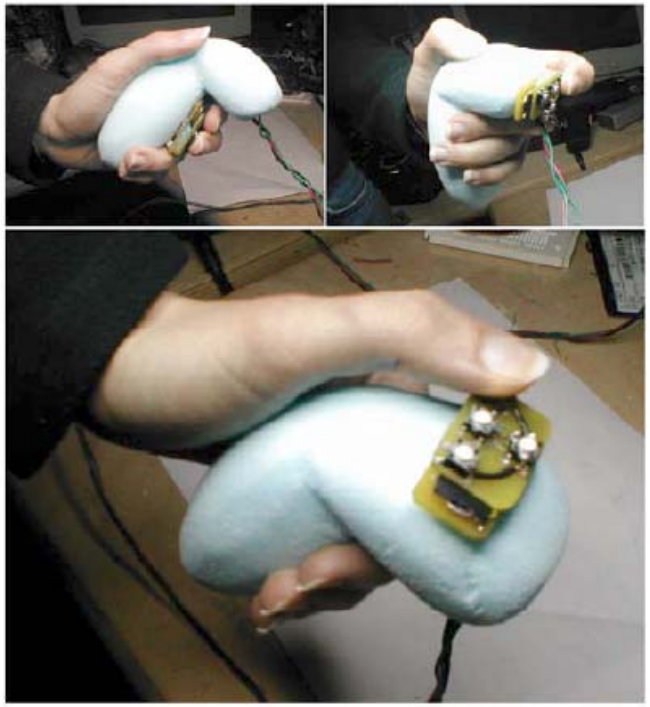


Figure 3. Navigation controller with the wireless buttons placed in a variety of locations around the form.

Figure 6. Wired components. (left to right) I/O Breadboard component, 4-button array, analog joystick, D/A Input Component, single button, and analog knob.

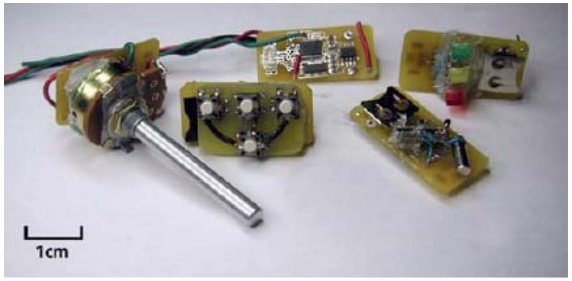
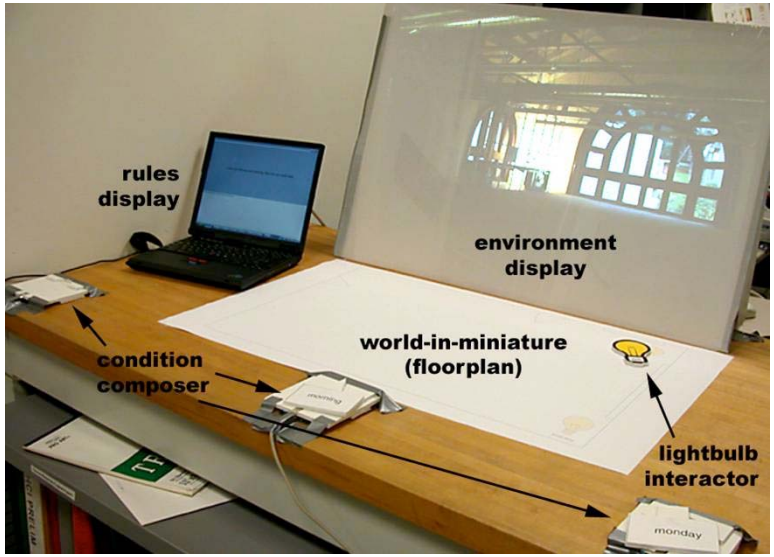


Figure 7. Wireless components: (left to right) analog knob, 4-button array, master uplink transceiver, 2-axis tilt sensor, and 3-LED array.

Papier Mache (UC Berkeley)

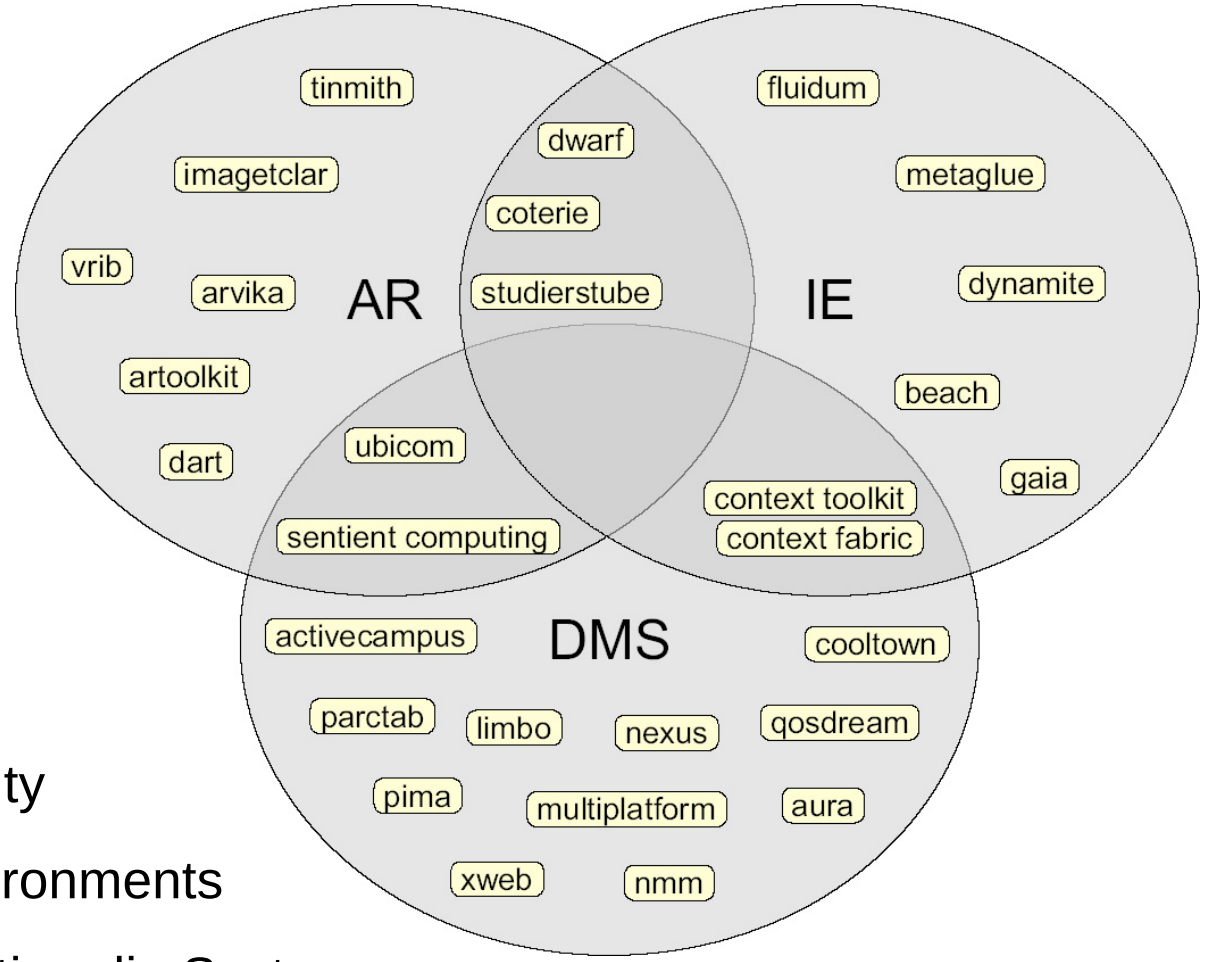
http://guir.berkeley.edu/projects/papier-mache/

- Small library combining:
  - Marker recognition
  - Camera-based object recognition
  - RFID recognition
- Easy association between recognized objects and actions through events
  - Sound
  - graphics



SW Toolkits

Thematic map of SW infrastructures



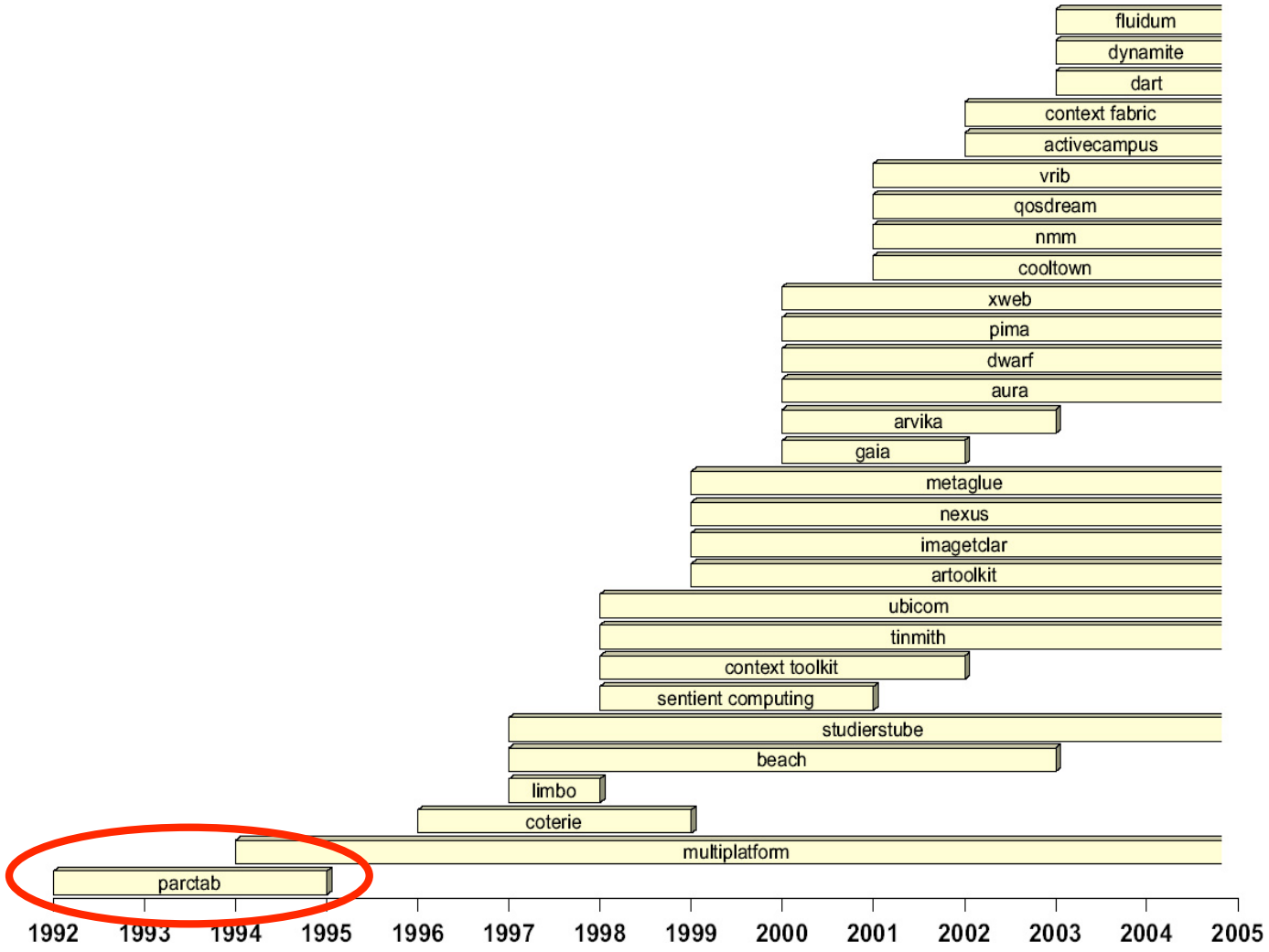
AR = Augmented Reality

IE = Instrumented Environments

DMS = Distributed Multimedia Systems

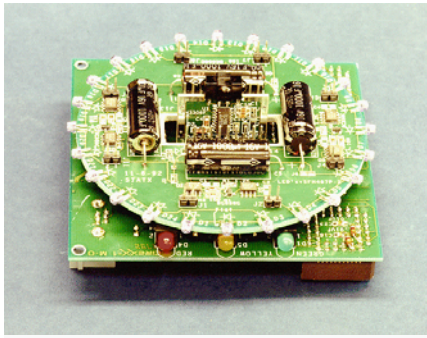
World map of SW infrastructures

Timeline of SW infrastructures

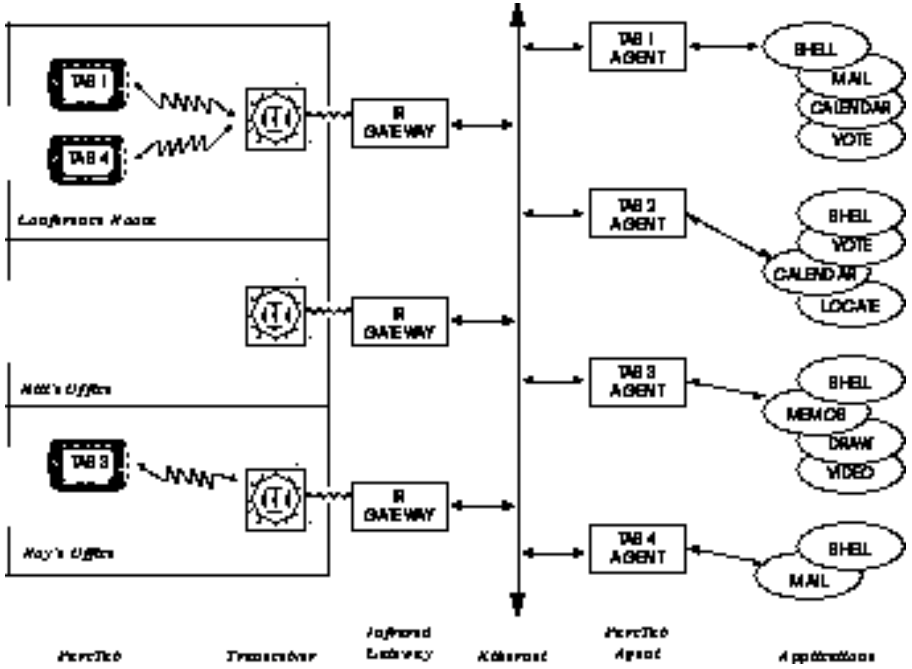


Xerox ParcTab

http://sandbox.parc.xerox.com/parctab/



- Infrared network
  - Base stations in the ceiling
- Each base station was controlled by a IR gateway
- Each tab represented by a SW agent (tab agent)
- Applications written in
  - modula-3
  - Tcl/TK
  - Using MacTabit (~VNC)



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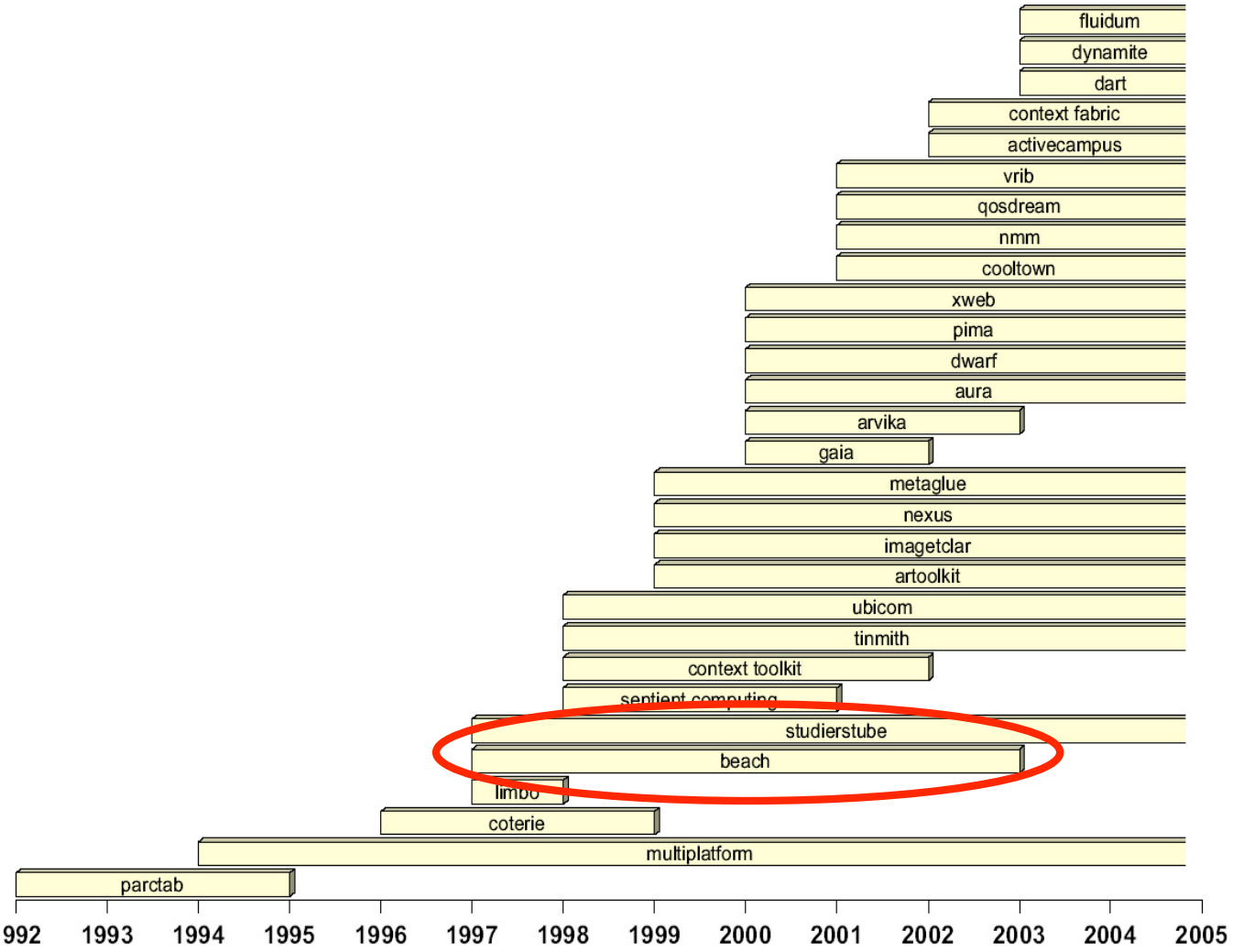
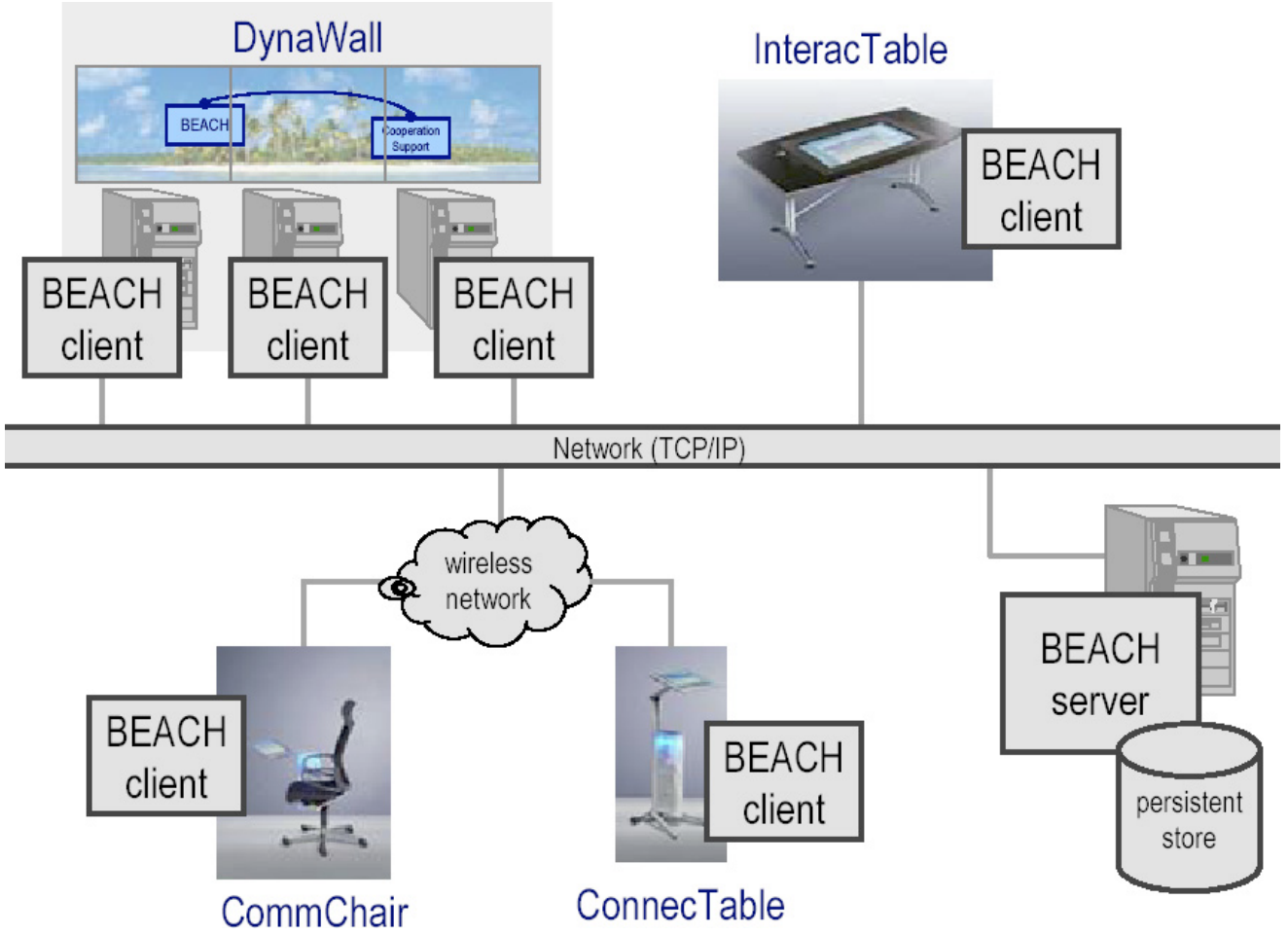


BEACH (FhG IPSI Ambiente)

http://www.ipsi.fraunhofer.de/ambiente/



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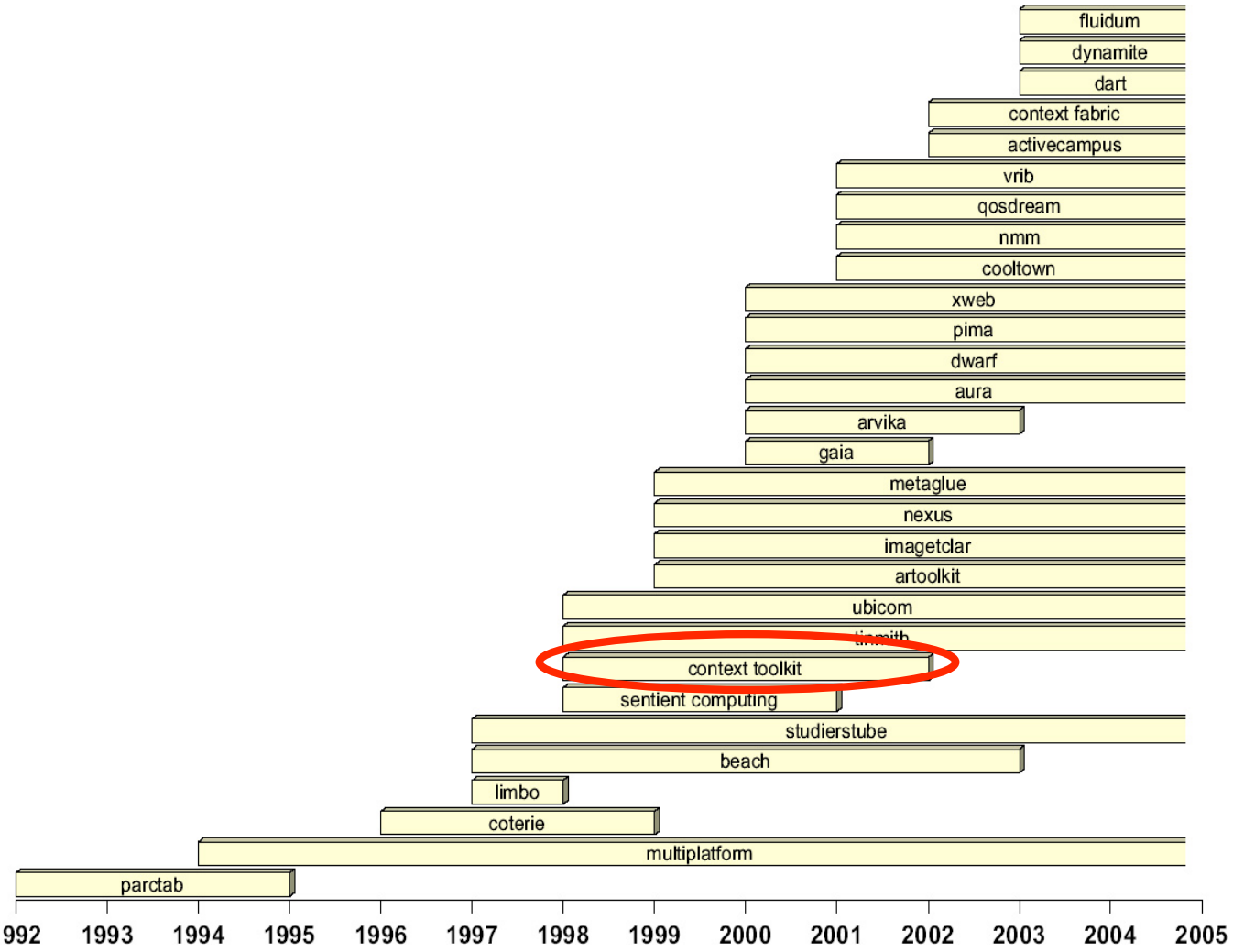
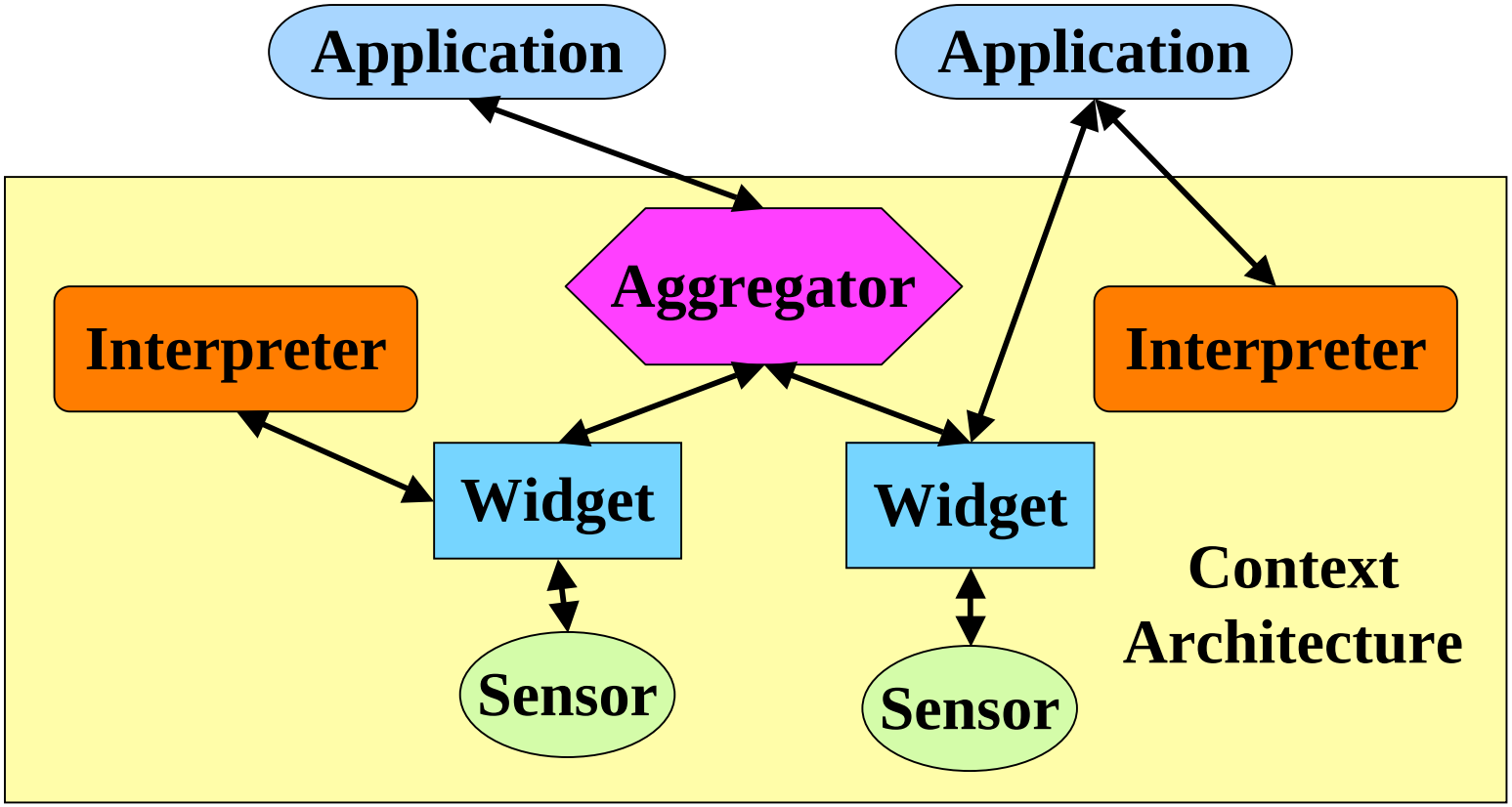
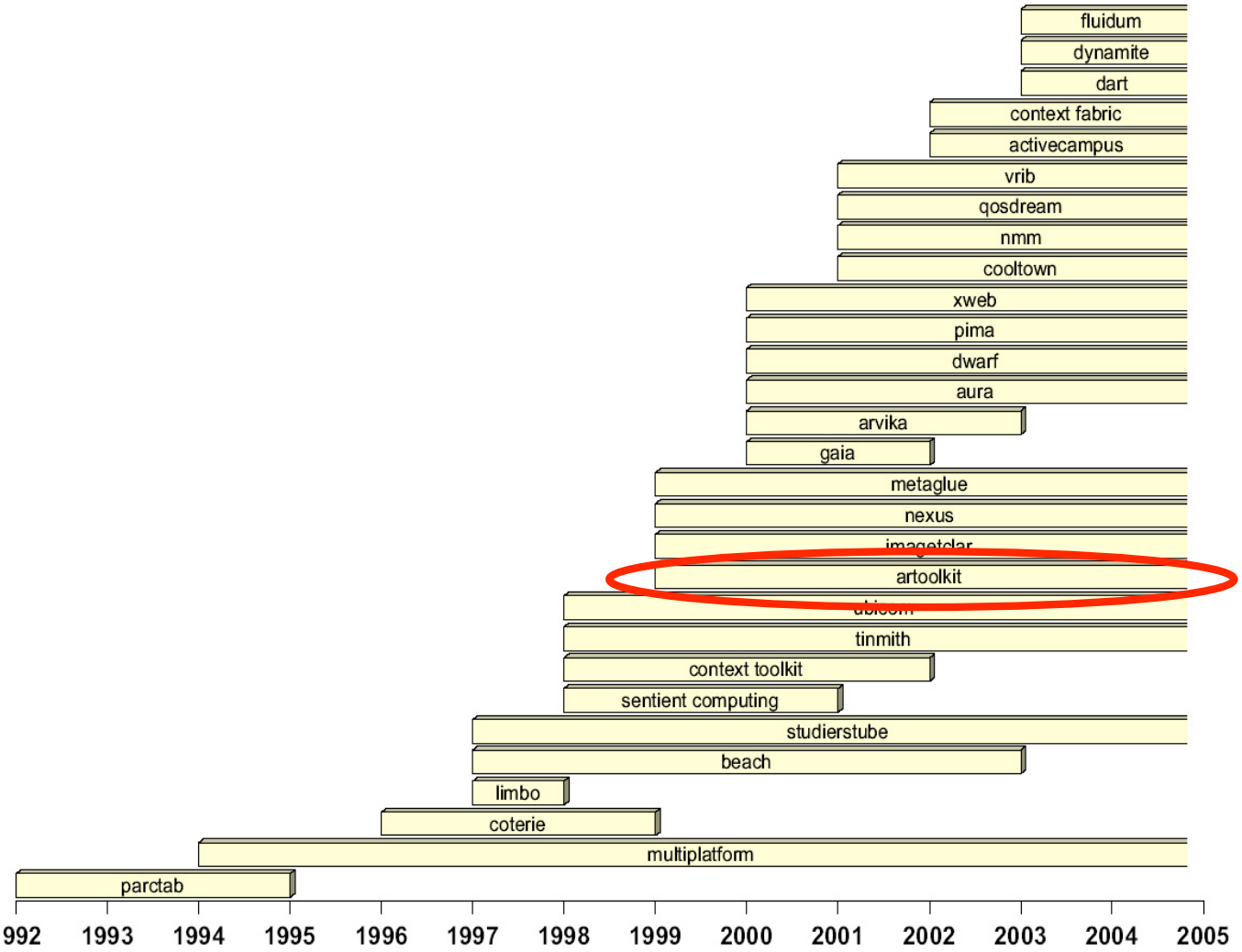


Context Toolkit Framework

- Supports real-world model/methodology and provides library (distributed: XML/HTTP, input-focused)
- Component model: facilitates building of applications in Java

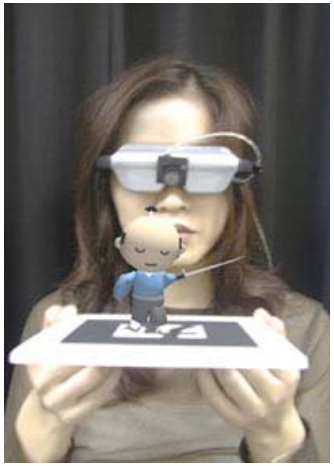


Timeline of SW infrastructures



AR Toolkit

- Library for Marker recognition
- Can be used for camera-based tracking
  - With head-mounted displays
  - With other screens
- C library
- Java wrapper available
- Works on
  - Windows
  - Linux
  - PDAs (WinCE)



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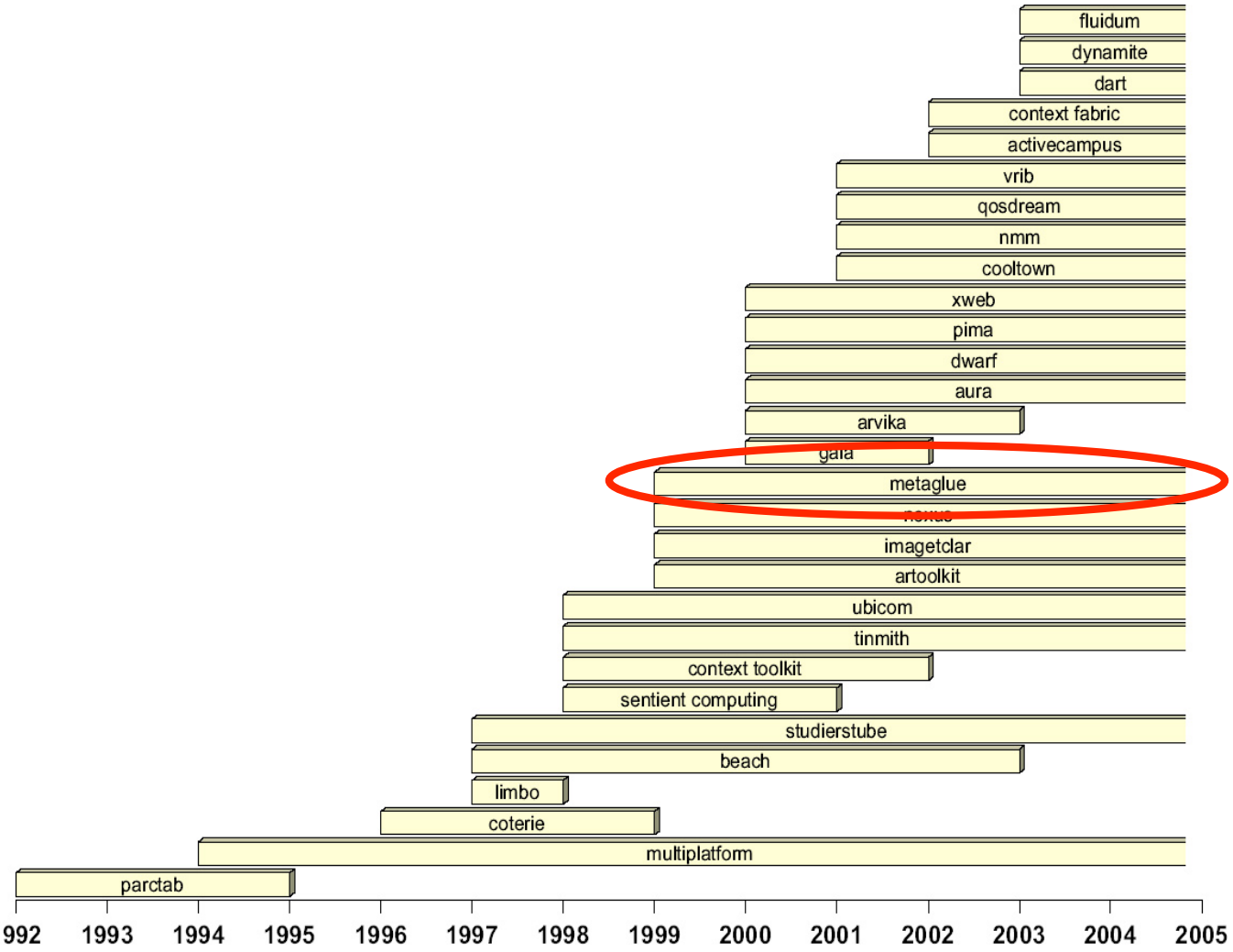
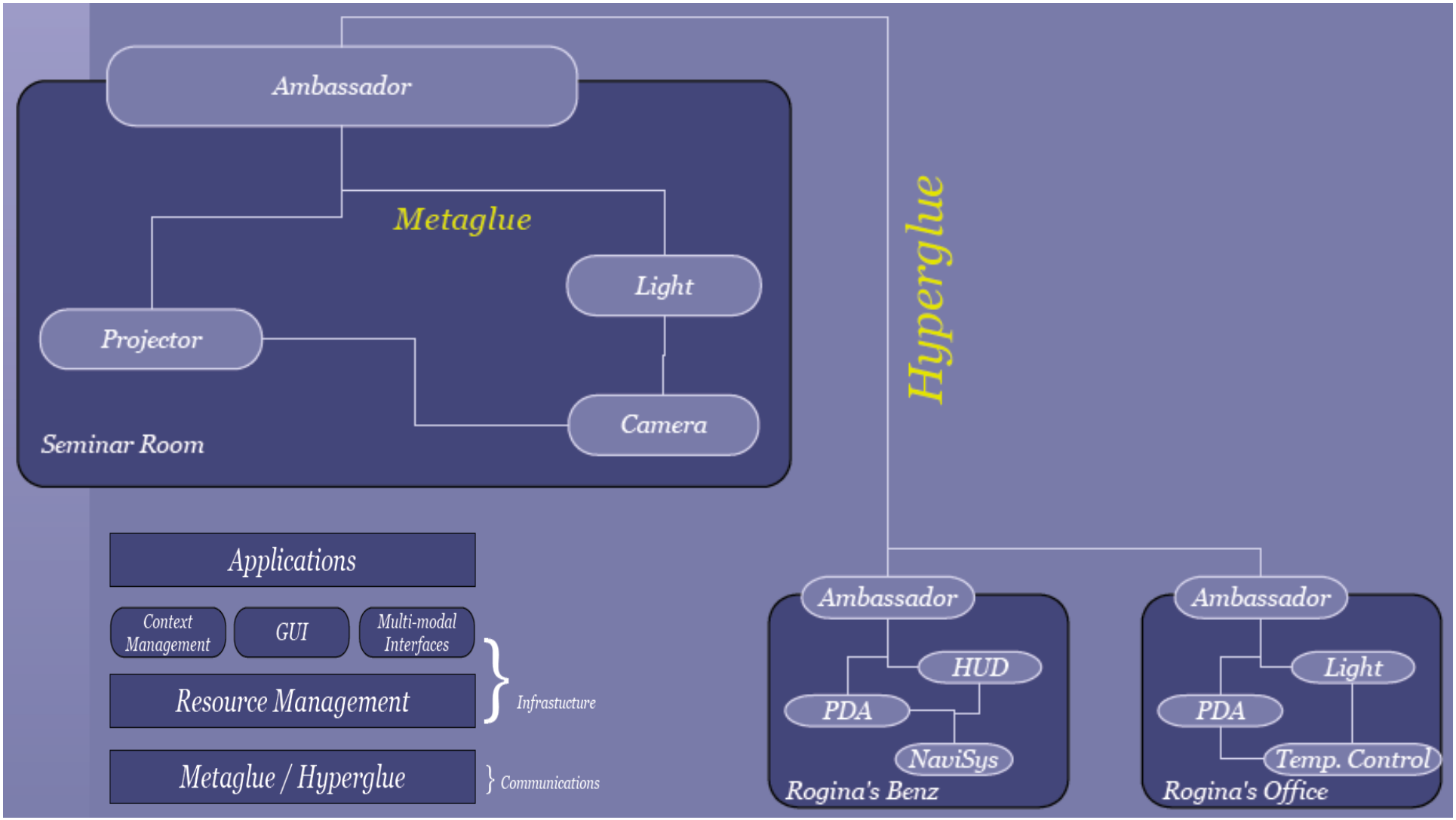


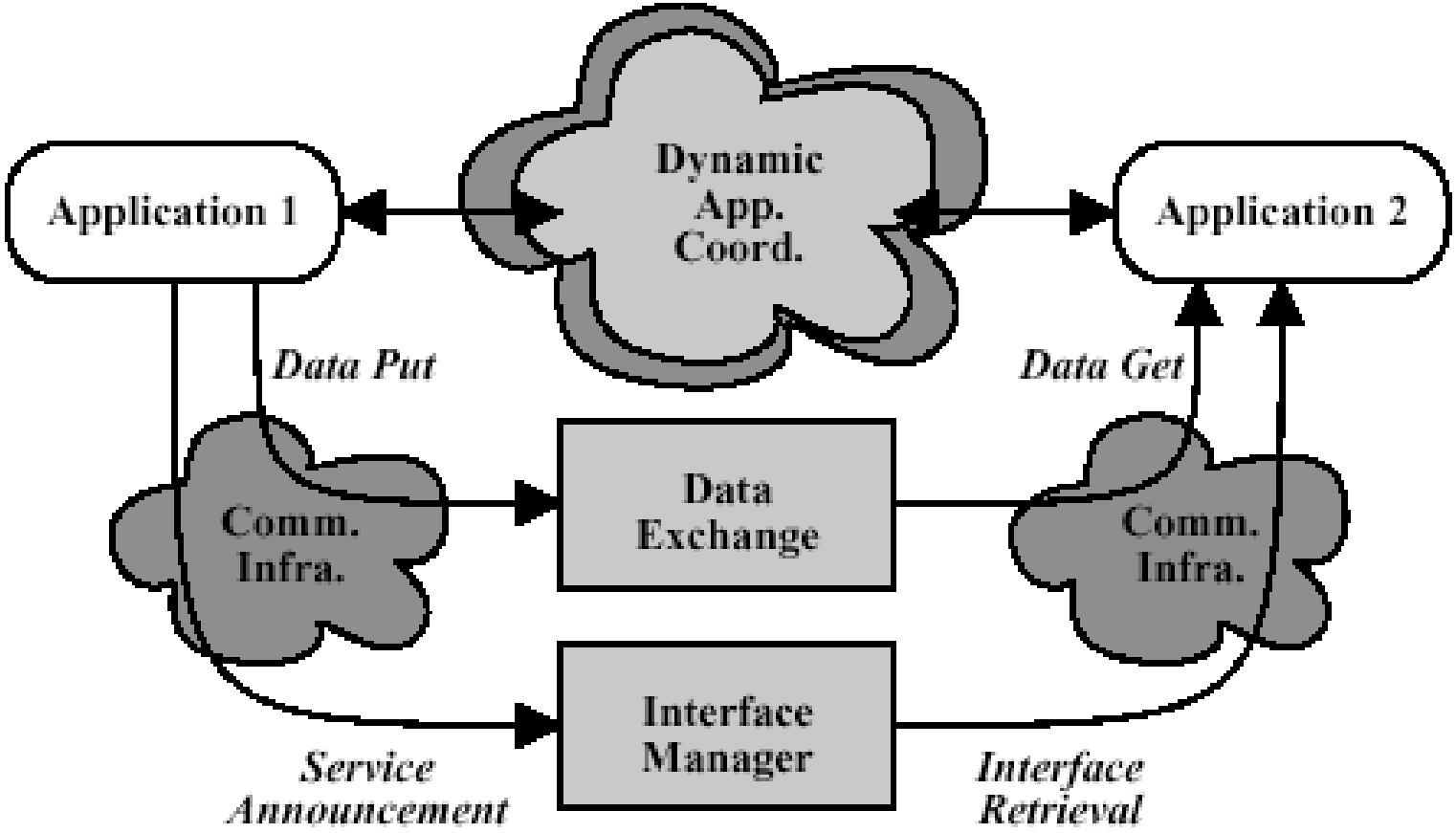
MIT aire + MetaGlue

http://aire.csail.mit.edu/ see video



Stanford Interactive Workspaces

http://iwork.stanford.edu/



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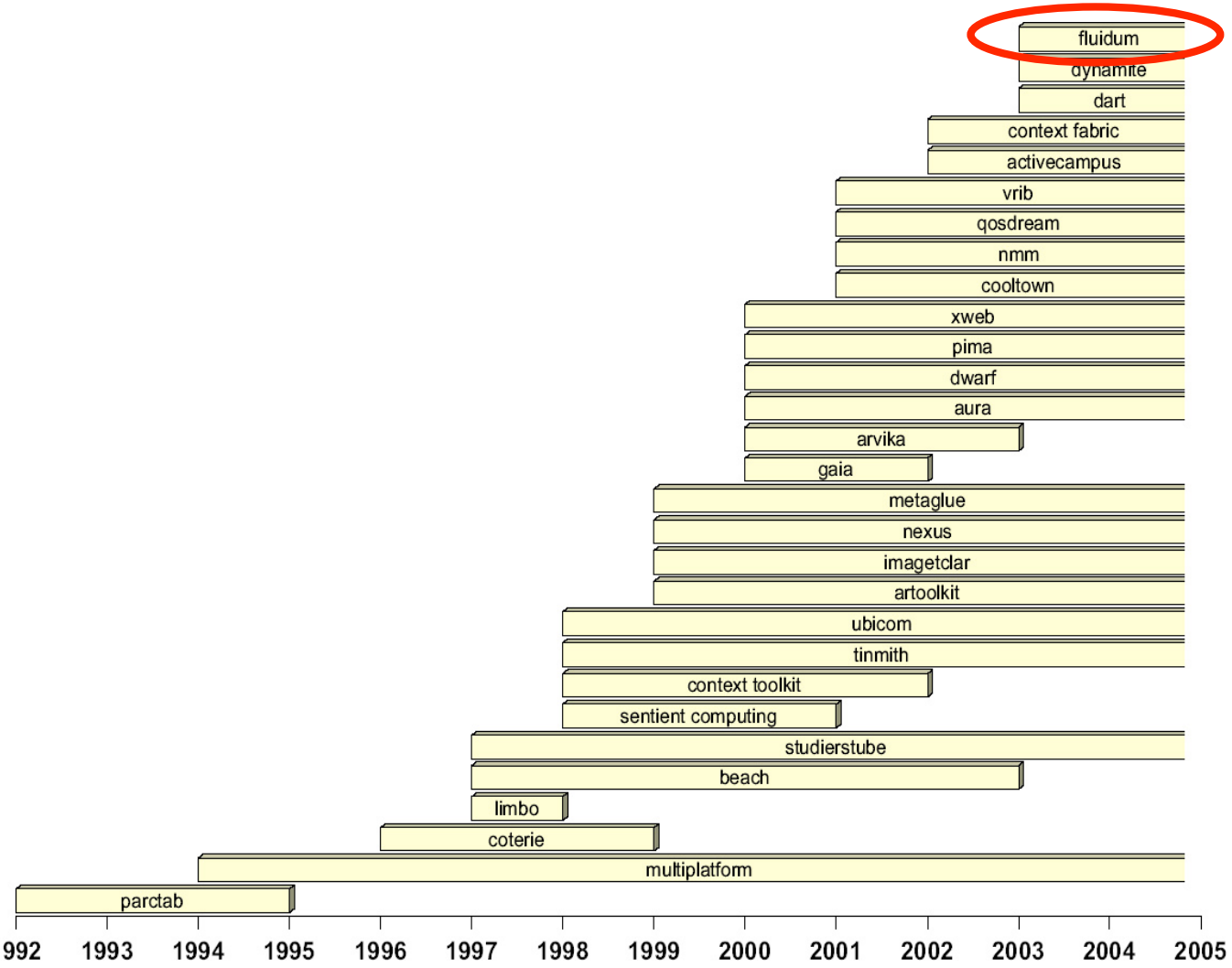
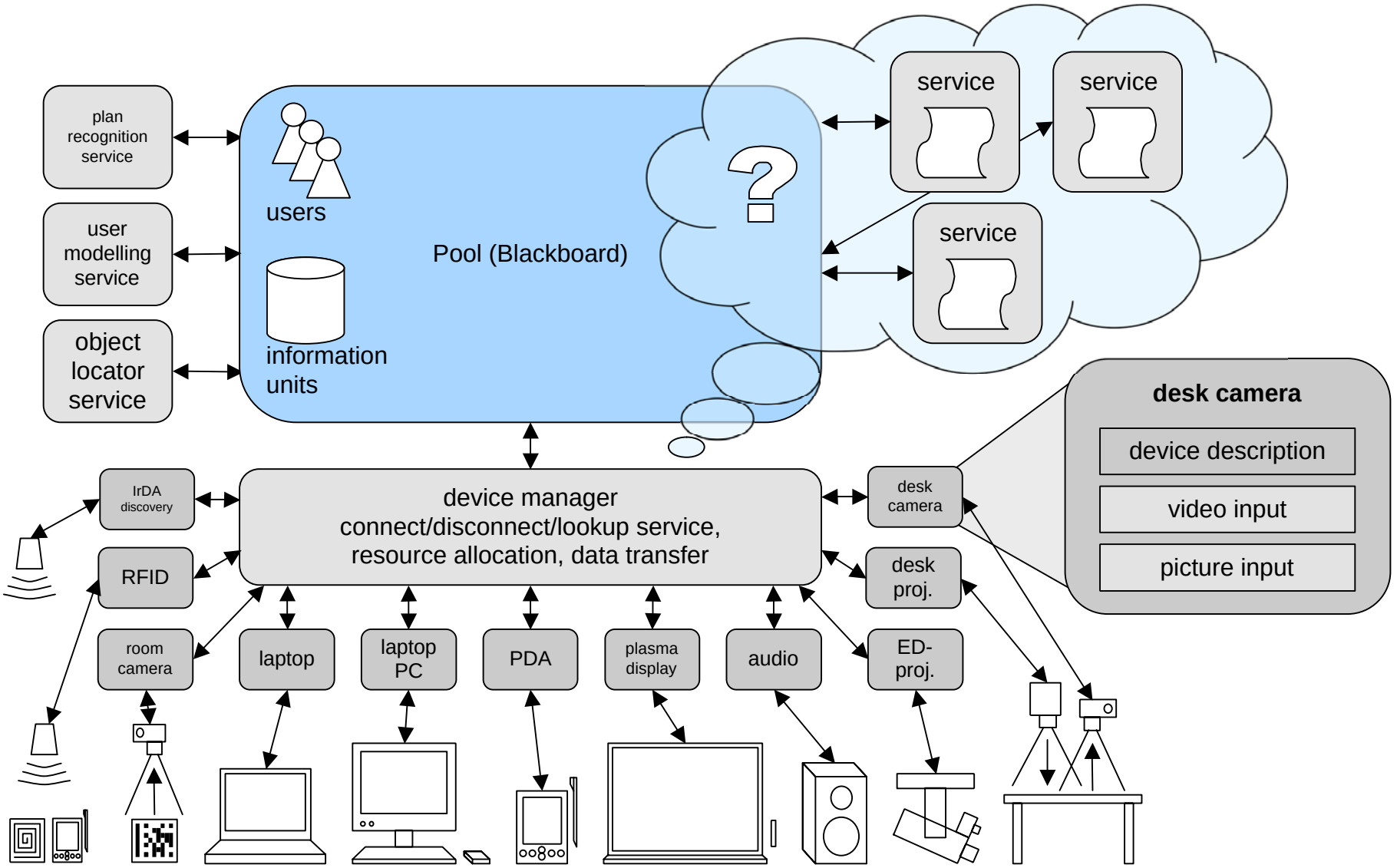


Fluidum SW infrastructure



Comparative discussion

- http://www.soft.uni-linz.ac.at/_wiki/tiki-index.php?page=SmartSpacesiRoom

Device Modeling

Universal Plug and Play (UPnP)

http://www.upnp.org/

Just send data over the network

- (No executables)
- Minimize version issues
- Minimize security issues

Keep implementation private

- Be agnostic re: programming language, OS
- Update implementation w/o affecting interop
  - Improve performance
  - Reduce footprint
  - Improve capabilities

Agree on meaning / format of data

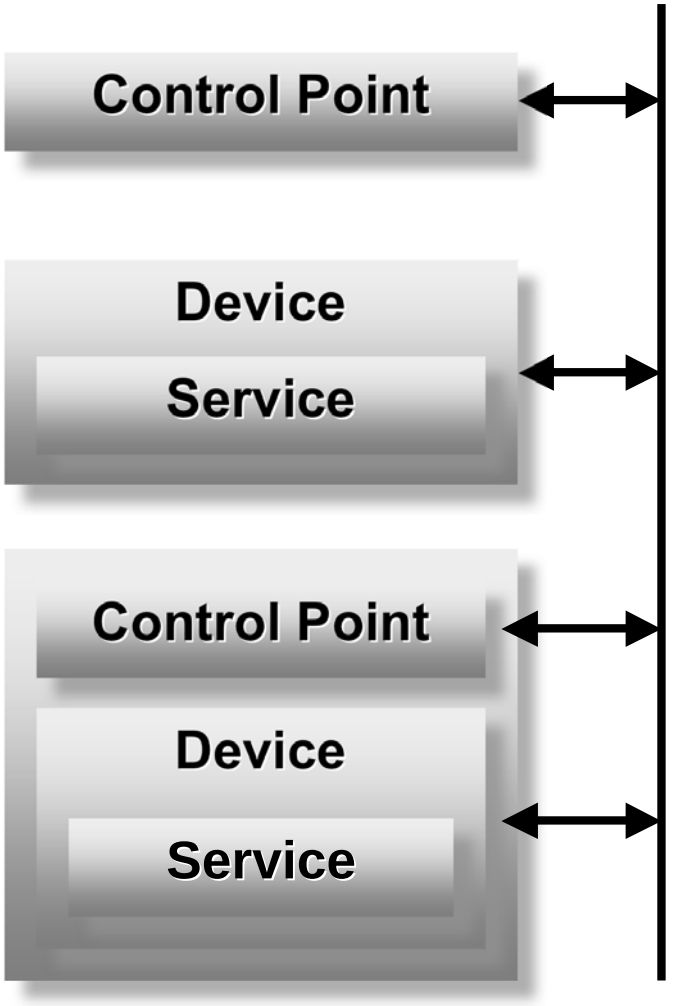
- Choose substrate of proven protocols
- Define device (service) specific protocols in a Forum

UPnP Tactics

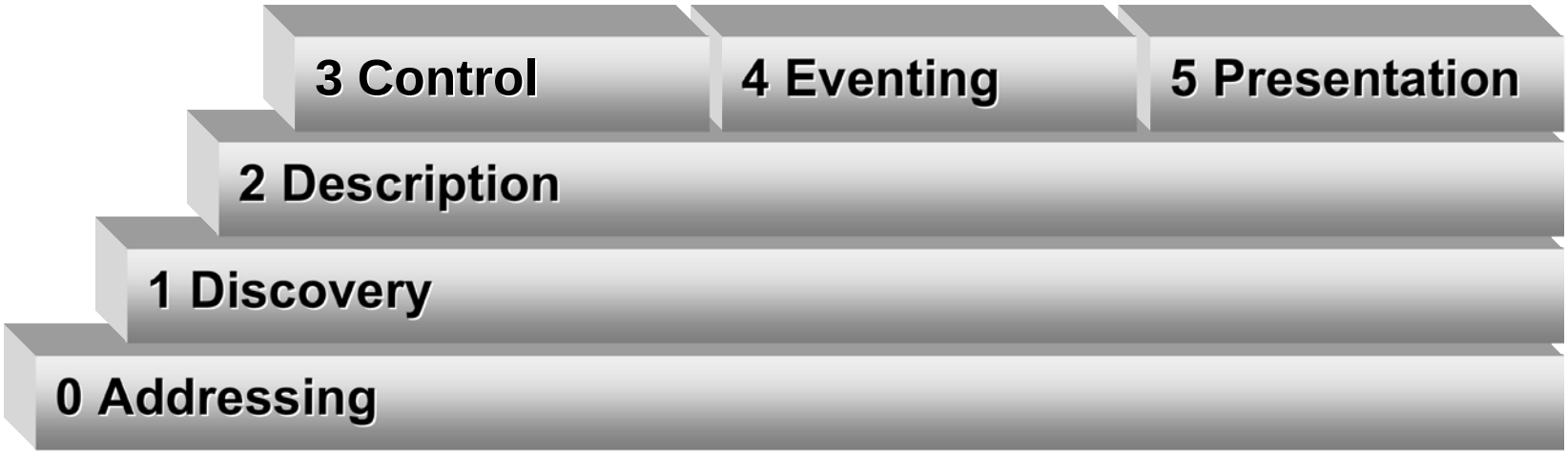
- Start simple
  - Build in only universal things that everybody needs (and can live with)
  - Add as needed
- Minimize requirements
  - Basic IP network connectivity
  - Common HTTP protocol stack
- Leverage existing standards
  - HTTP, XML

Goals

- Describe the protocols for communication between
  - Control points
    - Controller, usually client
  - Device
    - Controlled, usually server
  - *An actual device might contain both functions*



Steps to UPnP Networking



0 Control point and device get addresses

1 Control point finds interesting device

2 Control point learns about device capabilities

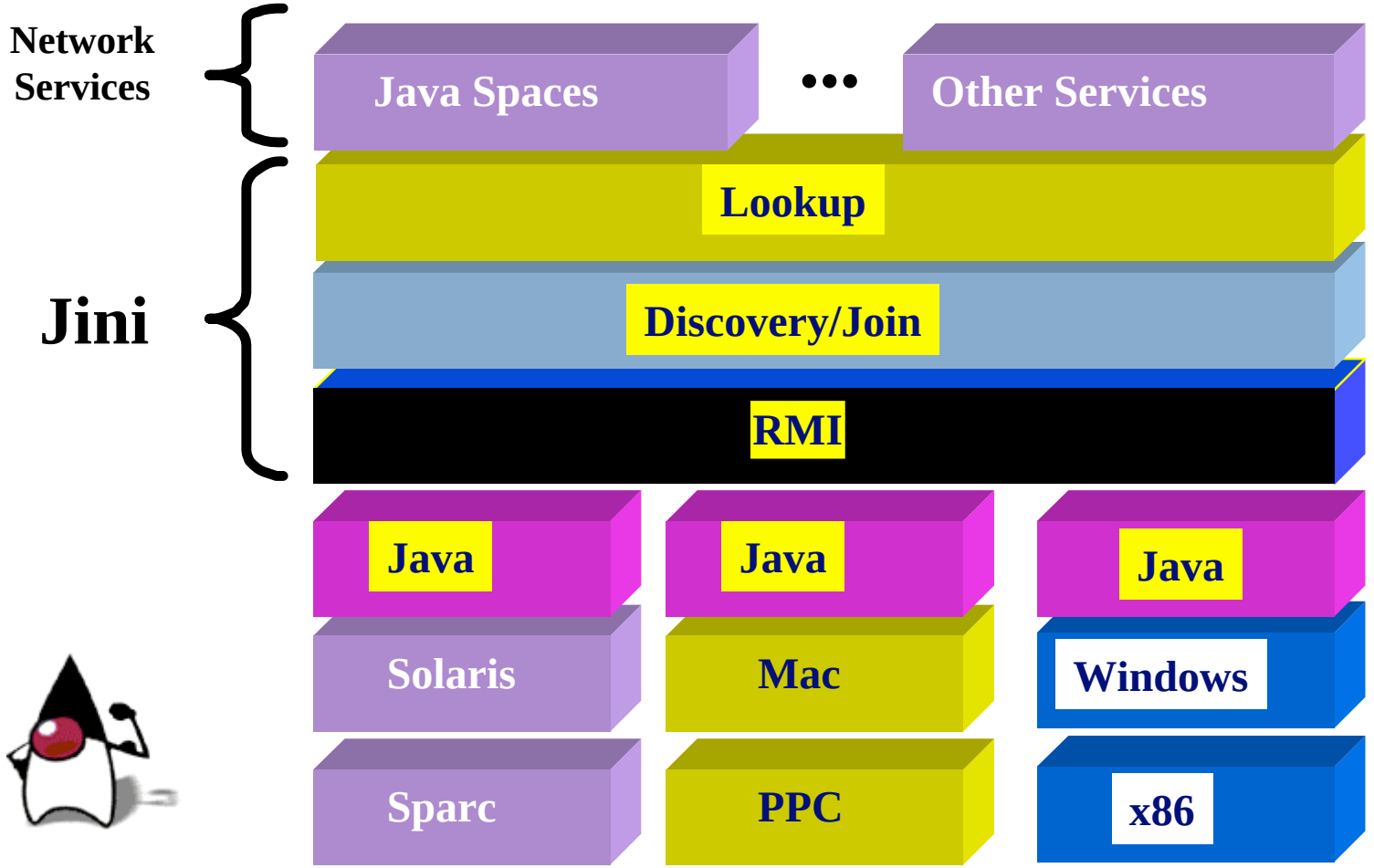
3 Control point invokes actions on device

4 Control point listens to state changes of device

5 Control point controls device and/or views device status using HTML UI

Jini

http://www.jini.org/



Jini, Java, RMI

- Jini is 100% Pure Java
- Write once, run anywhere
- Designed for building robust network apps
- built on the Java standard RMI

“Jini.. a networked federation of Java virtual machines”

- Jini uses RMI for object-object communication
- Full object module support
- Pass any Java object and its code
- Works in any compliant JVM
- Easy to implement (i.e. automatic serialization)
- Provides foundation for addition of
  - multicast, replication and basic security

Jini Architecture

	Infrastructure	**Programming Model**	**Services**
Jini	Discovery Lookup Extended Security	Lease Event Transaction	JavaSpaces TX Manager
Java	Java VM RMI Security	Java API's Beans ...	Enterprise Beans JNDI JTS ...

"Jini can be seen as an extension of the infrastructure, programming model, and services of Java"

Discovery

- Allows Jini services (both HW and SW) to:
  - Find and join a group of Jini devices
  - Advertise its capabilities
  - Provide any required SW and attributes
  - Works with JVM-enabled or non-JVM devices
    - Send out a multicast packet with reference to yourself
    - Receive a RMI reference to the Lookup service

“Discovery solves the problem of finding the place to start in an unknown network”

Discovery in Brief

1. The device advertises and looks for a service

Discovering Entity

2. Lookup Servers run instances of the discovery service which listen for multicast requests from discovering entities

Lookup Server

3. The discovering entity performs a multicast that requests references to the lookup service.

4. **The lookup server calls a remote method on the discovering entity's exported object instance passing a remote reference to its lookup service as the parameter**

Lookup

- Repository of available services
- Stores service as an extensible set of Java objects
  - ID, interface, GUI's, attributes, drivers ...
- Service objects downloaded to user as required
- May be federated with other Lookup services
- Lookup service interface:
  - Registration, Access, Search, Removal

"The lookup service binds the federation together"

Distributed Security

- Extends the Java security model
- Identity carried in remote invocation
- Capabilities
  - Authentication
  - Integrity
  - Confidentiality
  - Delegation

“A simple model that minimizes the impact of security on the developer”

User Modeling

A very brief intro to user modeling

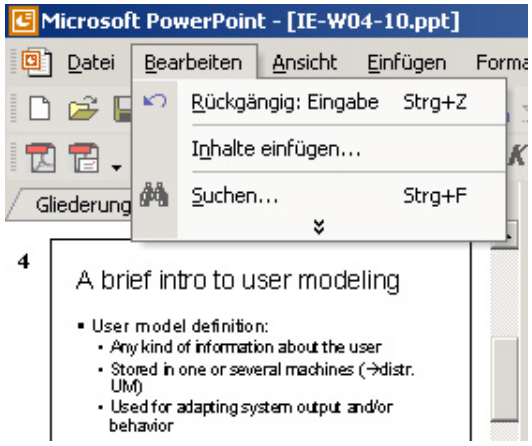
- A user model is:
  - Any kind of information about the user
  - Stored in one or several systems (→distr. UM)
  - Used for adapting system output and/or behavior

- Example:
  - Recommendations by Amazon

A practical example for UM

Acquisition of data for a UM

- Explicit
  - Type in your name, age, address, credit card
  - Adjust your preferences, skills, interests
- Implicit
  - Items purchased in the past
  - Money spent
  - Pages visited / items looked at ?
  - Navigation speed ??
    - Automatic detection of web bots ;-)



Construction of a UM from data

- According to data collected, systems can
  - Store an individual profile of the user
  - Assign the user to a predefined stereotype
  - Find new stereotypes by clustering users
  - Make default assumptions for missing info
    - From global defaults
    - From stereotype

Adapting system behavior from UM

- Greeting customers by name
- Offer customers to sell their used stuff
- Filling in the correct credit card number
  - →security issues, cookies,
  - Try signing on to amazon.co.uk with your account (email address & PW) from amazon.de
  - What parts of the UM do they have?

- Recommendations from domain models
  - Buyers of a DVD Player need DVDs
- Recommendations from „collaborative filtering“
  - Customers who bought X, also bought Y in the past

Ideas for UM in IEs

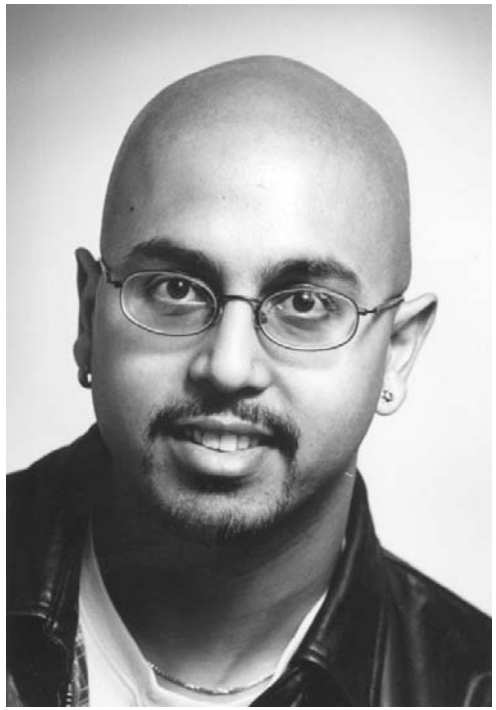
- Idividual UM
  - Identity: detected for example from BT phone
  - Person‘s name for communication
  - Person‘s preferences for the room setup
  - Personal working environment
  - Messages for this person
  - User‘s current plan/task/goal
  - Privacy settings
- Stereotype UM
  - Age group
  - Novice/expert
  - Technical/ untechnical
  - Slow/fast typer
  - Tall/short person
  - ...???

Context Modeling

Context Toolkit

(with slides courtesy of Anind Dey)

- Anind K. Dey (prev. Intel, UCB, now CMU)
- http://www.cs.cmu.edu/~anind/
- Toolkit to support Context-Aware applications
- Strong formalization of “context”
- Implementation in Java.
- Can be distributed on several machines in the environment



Context and Context-Awareness

- Focused on input
- Context: *any information relevant to an interaction that can be used to characterize the situation of an entity*
- Context-Awareness
  - General model of interactive computing
  - Addresses subset of ubicomp problems: input

Value of Context

- Potential for improved usability
  - Very important for mobile users with poor input devices
- “Smarter” applications
- Increased communications bandwidth

Design Space for Context-Aware Applications

- Toolkit allows exploration of design space
- Basic types of context:
  - Location, identity, time, activity
  - Simple/singular → complex/multiple
  - Combinations
- Uses of context:
  - **Present** to user
  - Automatically perform set of **services**
  - **Tag** captured information to ease retrieval

Example

- Tour guides, travel assistants, personalization software

- Reminder to buy milk
  - When to deliver: not time/location specific
  - How to deliver: appropriate modality

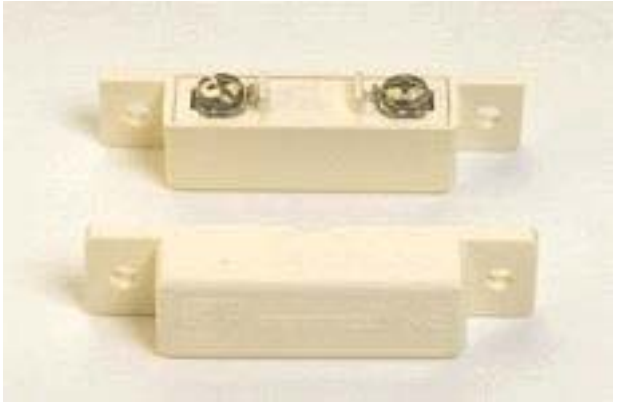
Building Applications

- M. Weiser: The whole point of ubiquitous computing, of course, is the applications.

  - But … what if the applications are hard to build? And, what if this inhibits our ability to build compelling applications?

Why Context is Hard to Use

- Acquired from sensors
  - Not just keyboards and mice – lots of heterogeneous devices
- Need to abstract data
- Distributed
- Dynamic



Results of Difficulties

- *Ad hoc* application building
  - Difficult to build, reuse and evolve
- Small variety of sensors
- Small variety of context: mostly *location*
- Few applications, mostly simple: mostly *presenting context*

- Practical: difficult to prototype, test and evaluate

Context Toolkit: Research Contributions

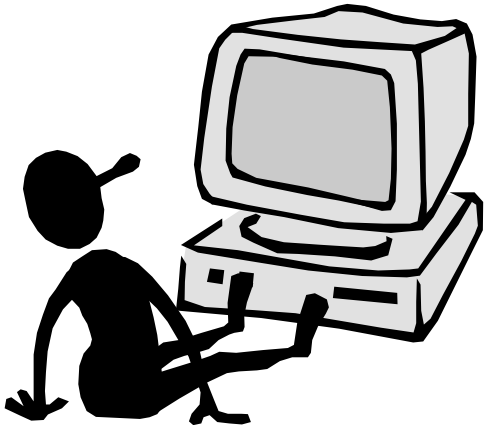
- Conceptual framework requirements
  - Provide framework for designing apps more easily
  - Lower threshold to enable more designers
- Context Toolkit itself
  - Implementation and exploration of design space
- Support investigation of complex problems and more realistic apps
  - Raise ceiling
  - Privacy, uncertainty, security, end-user programming

Toolkit Requirements

- Context specification
- Discovery
- Separation of concerns
- Storage
- Constant availability
- Transparent communications
- Interpretation

Look to input handling

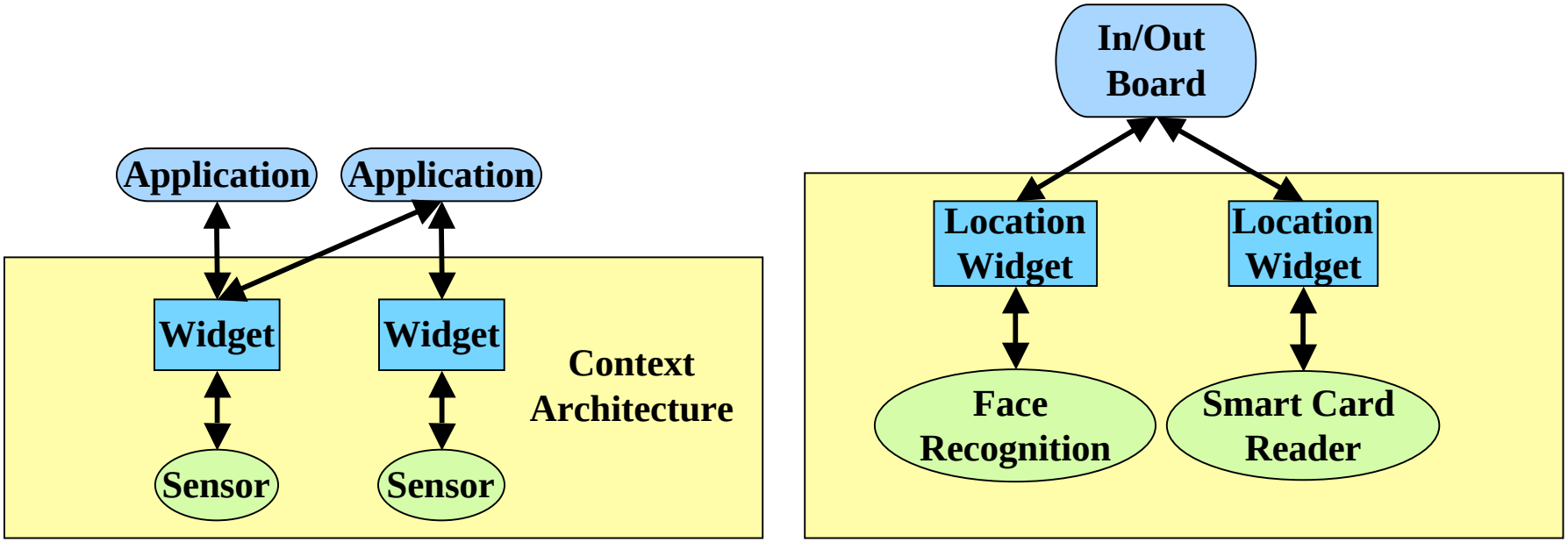
- Graphical User Interface (GUI) widgets
  - separation of concerns
  - callbacks and attributes
  - query/subscribe
  - common interface



  - e.g. button

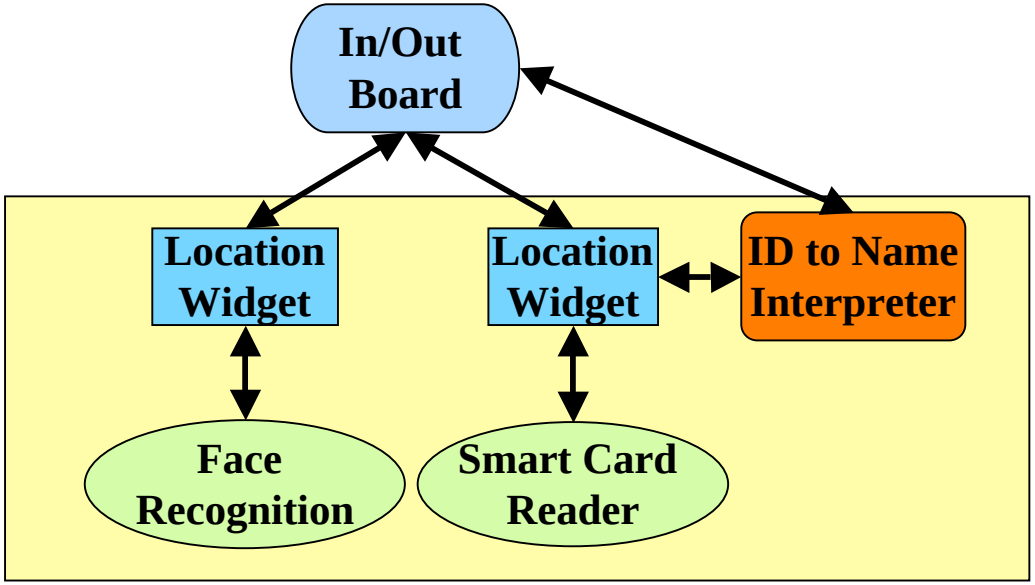
Context Widgets

- Responsible for acquiring and abstracting data from particular sensor, separation of concerns, storage



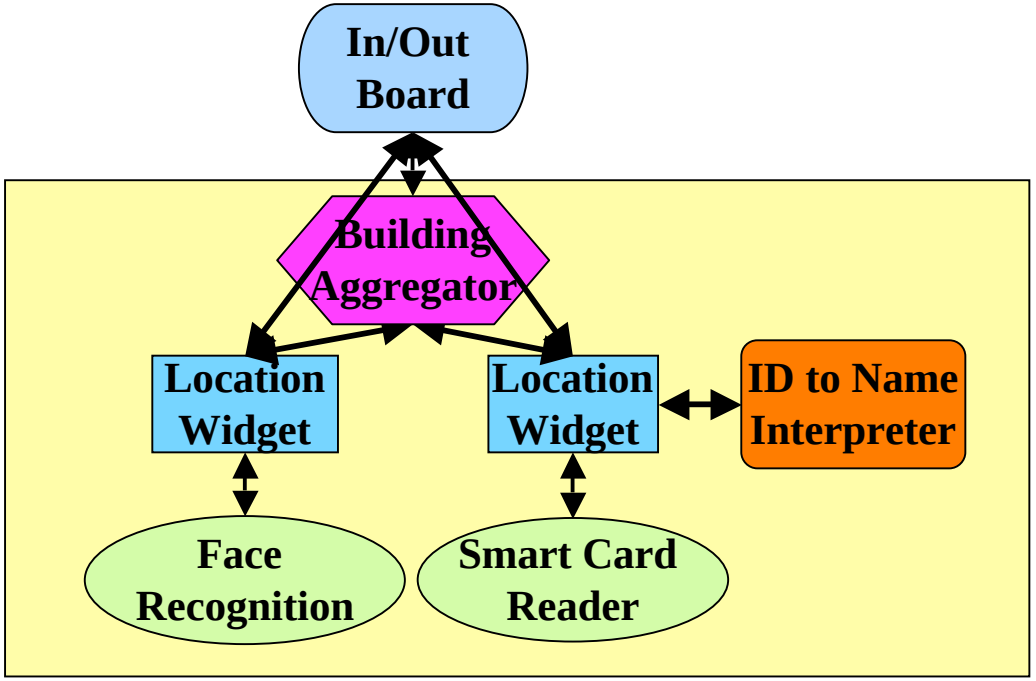
Context Interpreters

- Convert or interpret context to higher level information
- Context not available at appropriate level



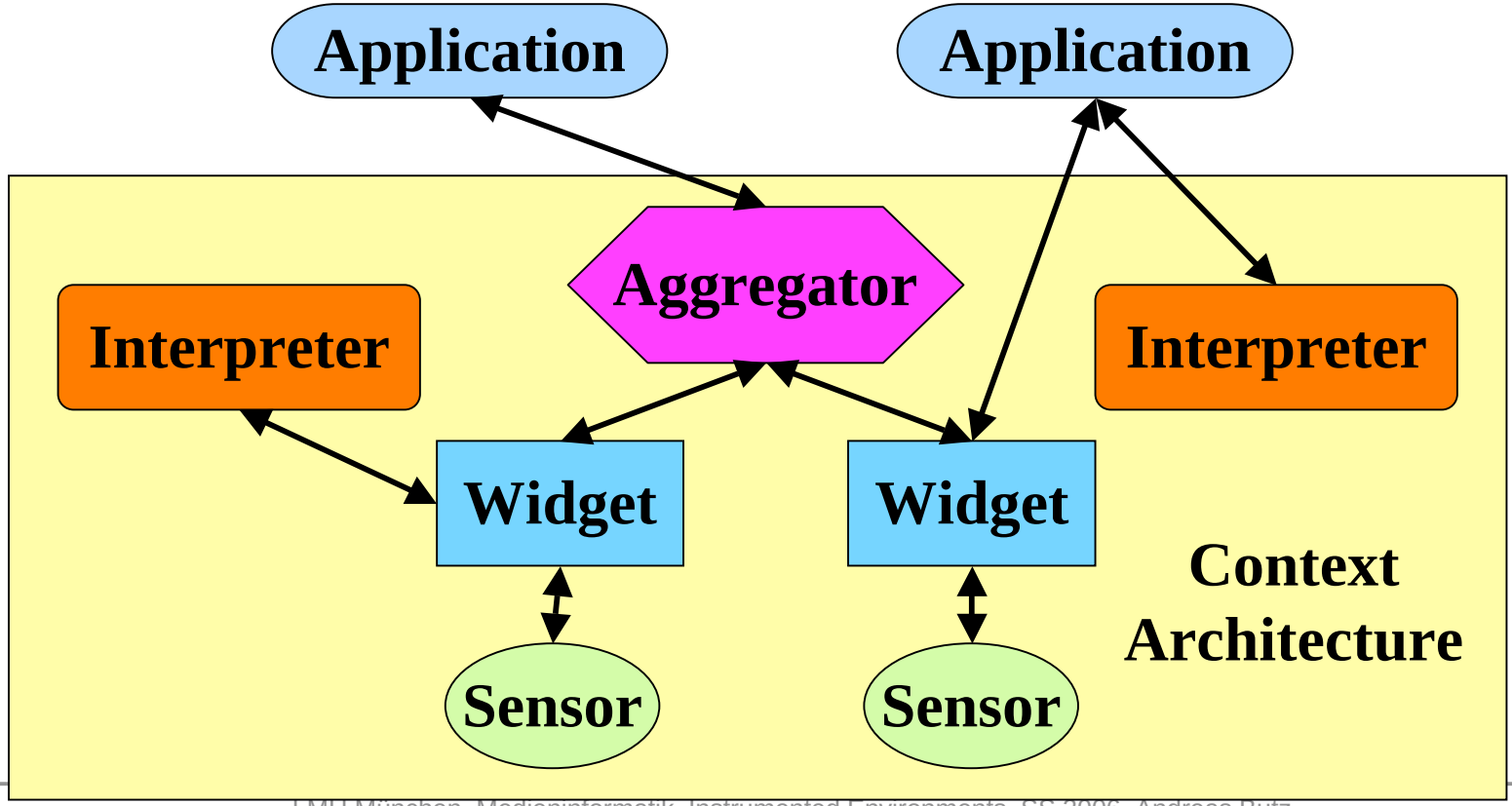
Context Aggregators

- Collect context relevant to particular entities (recall definition)
- Further separation, simplifies design



Context Toolkit Framework

- Supports real-world model/methodology and provides library (distributed: XML/HTTP, input-focused)
- Component model: facilitates building of applications



Experiences: Benefits

- Provides separation of concerns
- Lightweight integration and re-use of components
- Easy to create and evolve apps, allowing exploration of the design space
  - Add context to context-less apps
  - Add more context to context-aware apps

Aware Home (MANSE '99)

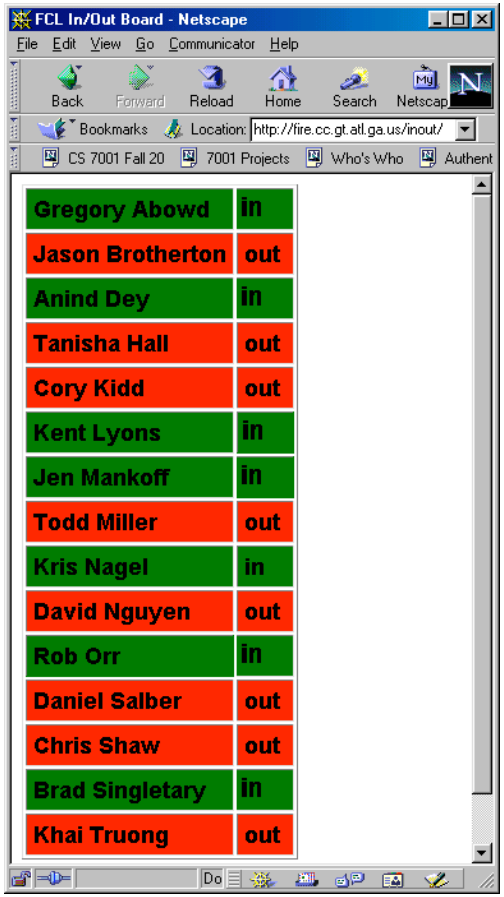
- Great testbed for context-aware computing
- 3 goals: elderly, infants, everyone
- Context Toolkit is the s/w infrastructure in the Aware Home

Applications Built

- Simple use of location:
  - Turn lights on and off (perform service)
- Location and id (perform service)
  - Information Guide: present info about user's group (CHI '99)
  - Context-Aware Mailing List

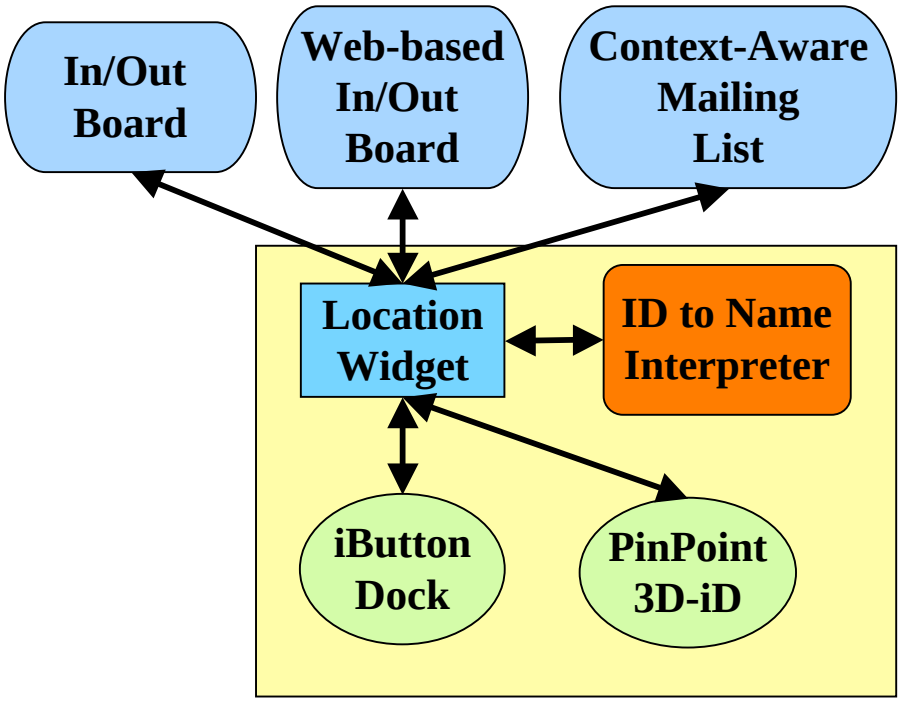
In/Out Board – 3 versions (CHI '99)

- Context used: location, identity, time
- How used: present context



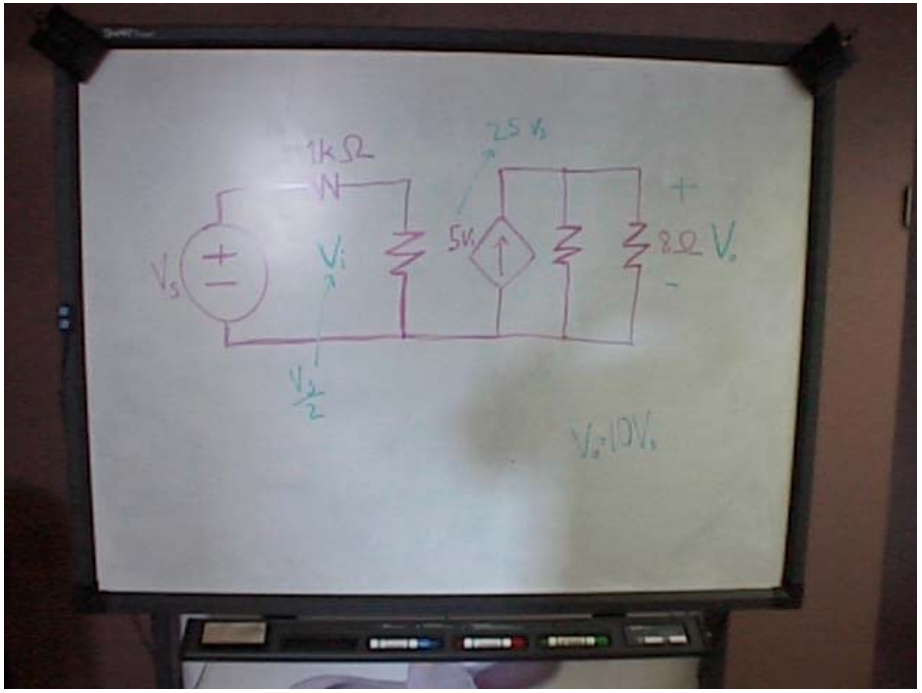
In/Out Board Architecture

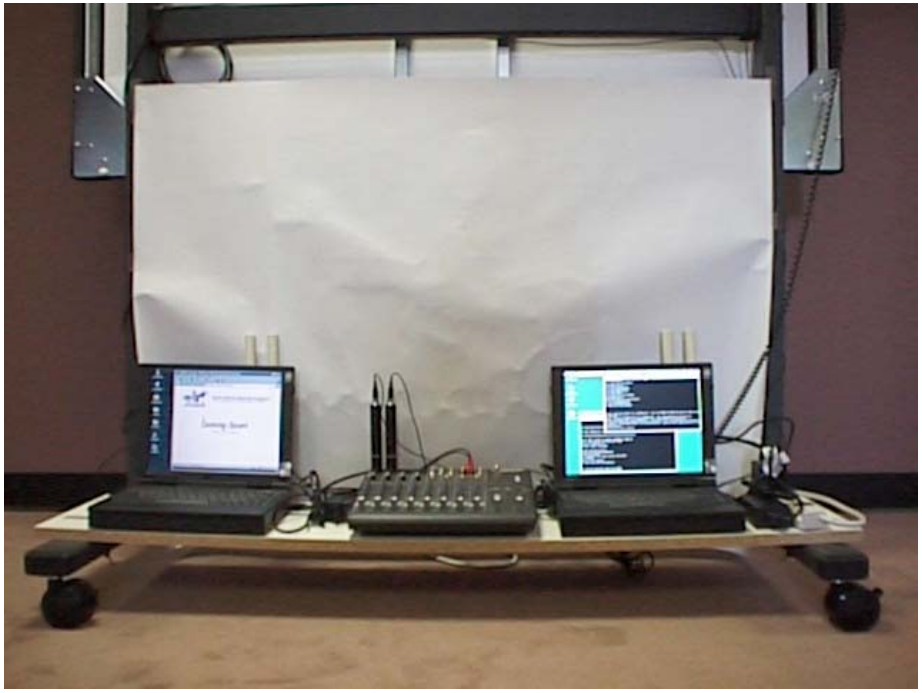
- Simple app demonstrates support for reusability (don't have to re-build infrastructure on per-application basis) and evolving applications

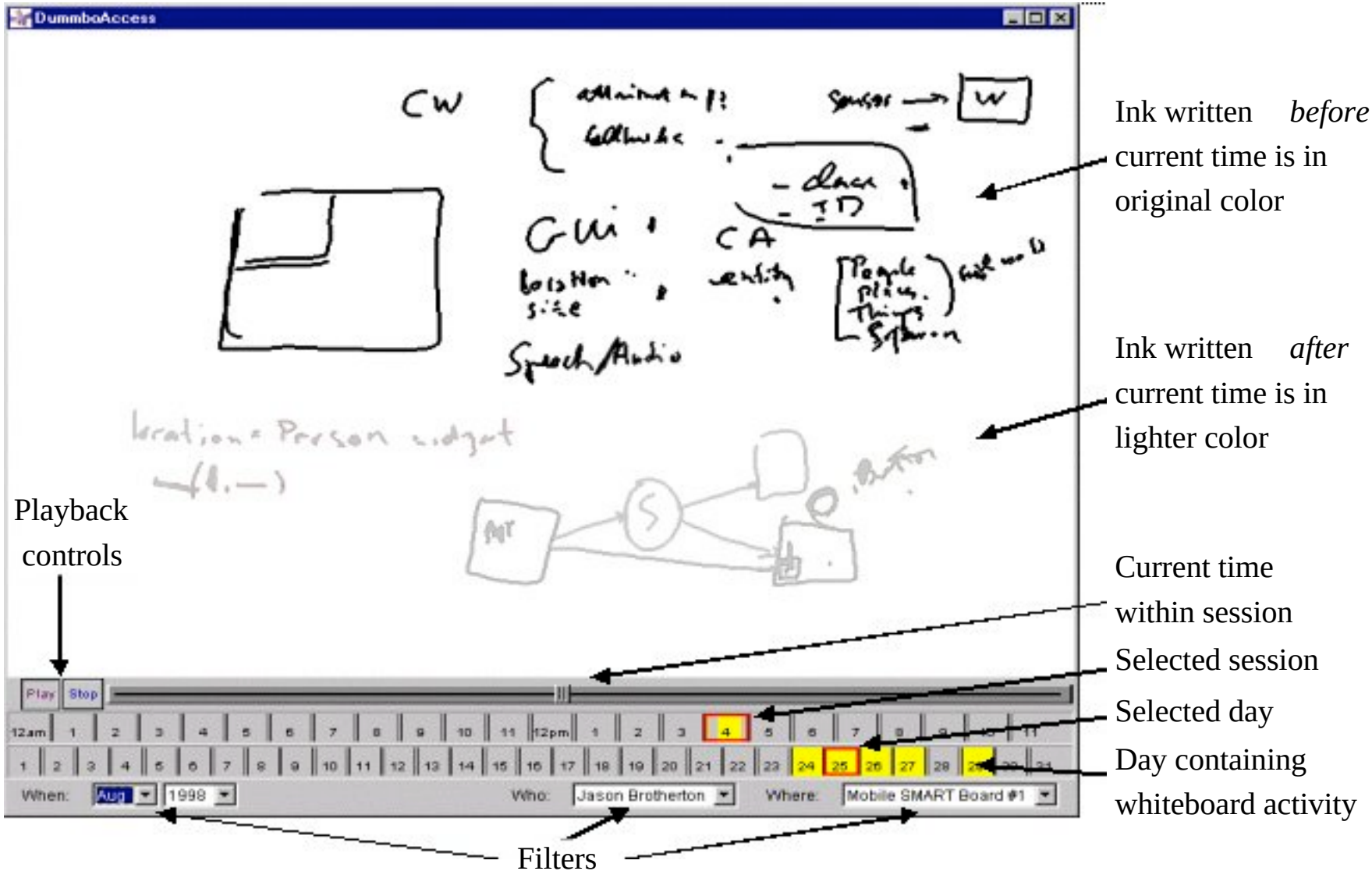


Serendipitous Meetings

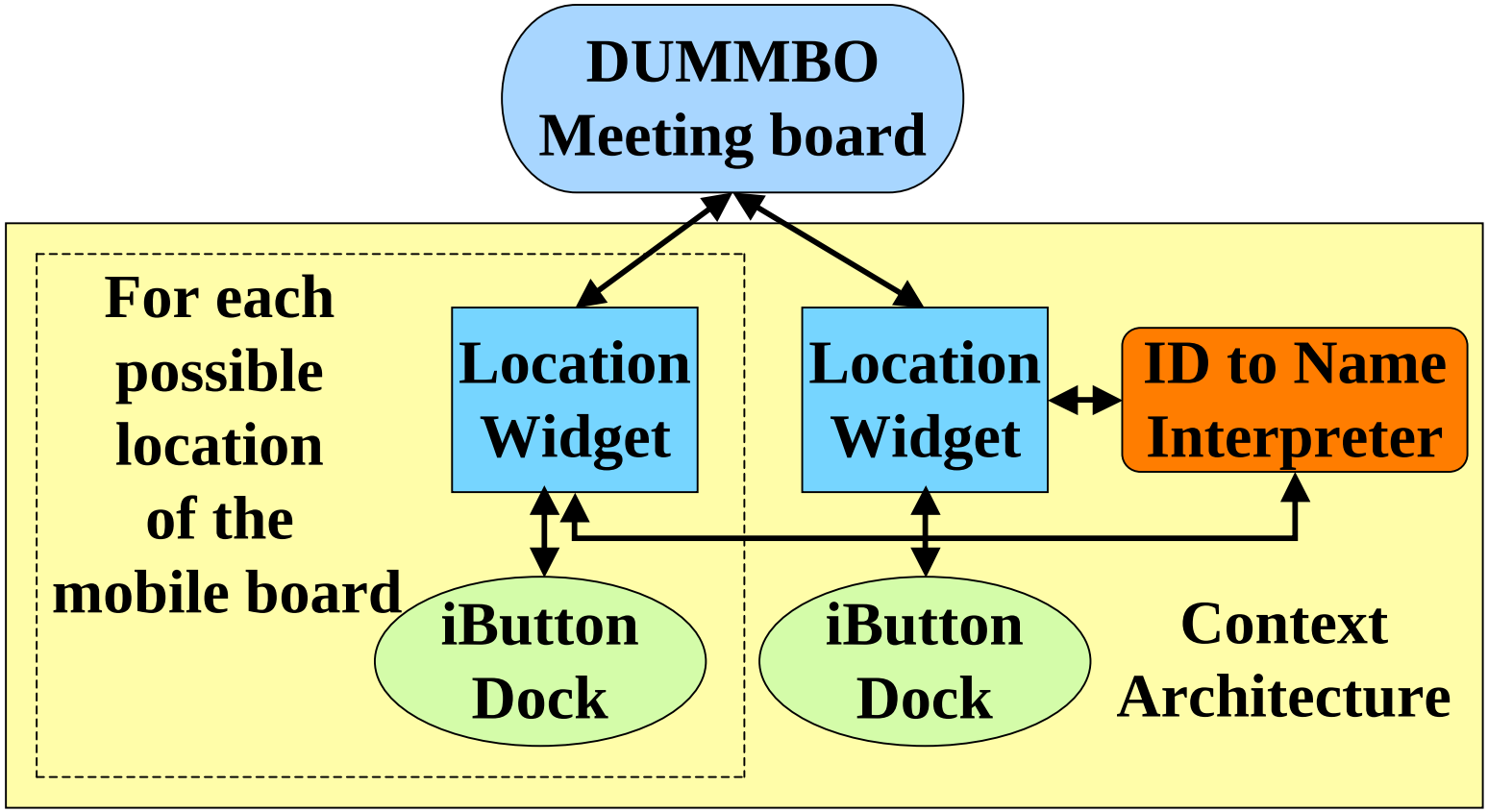
- Context used: location, id, time, activity
- How used: present, perform service, tag
- record and tag drawings and audio for later retrieval

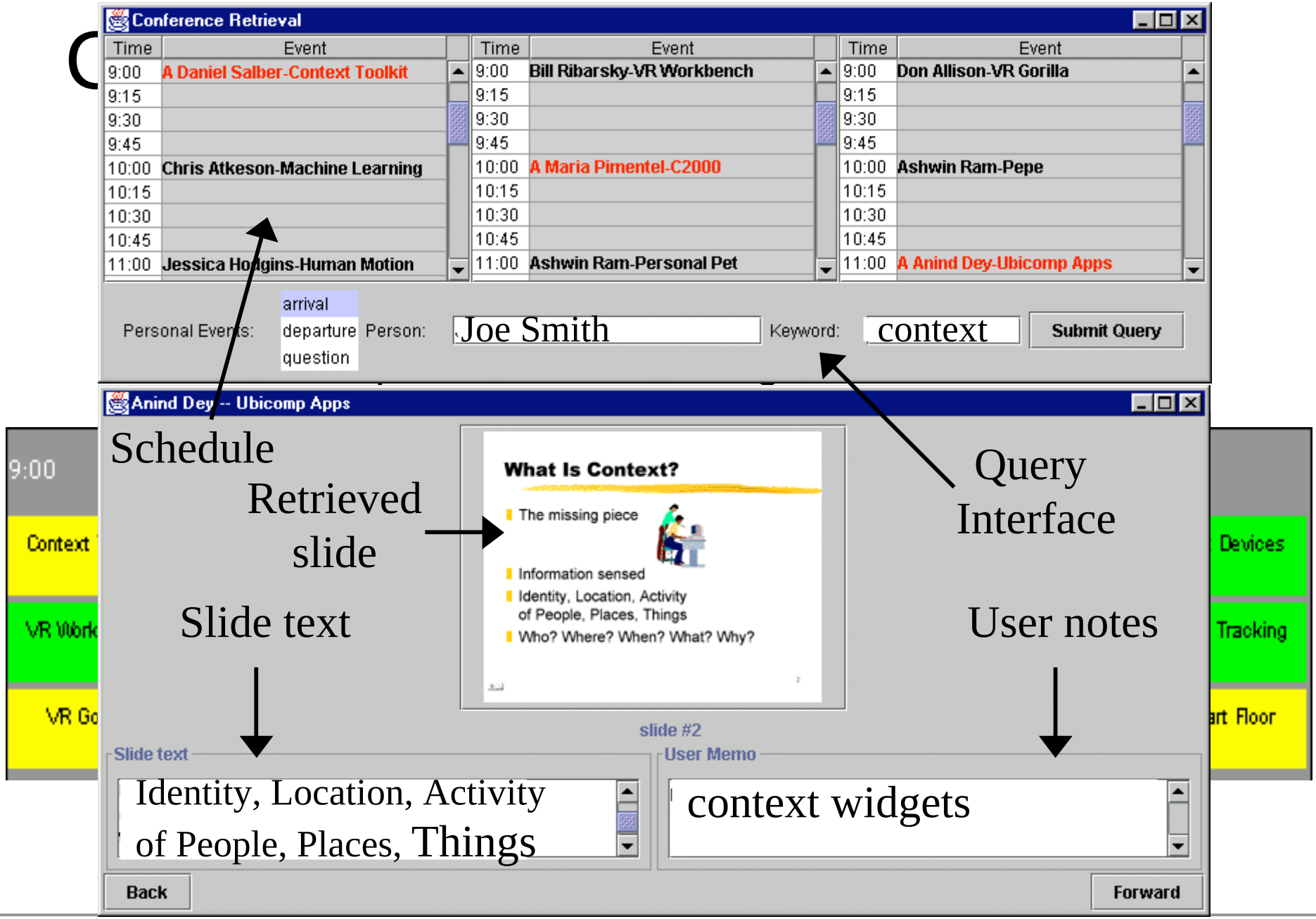
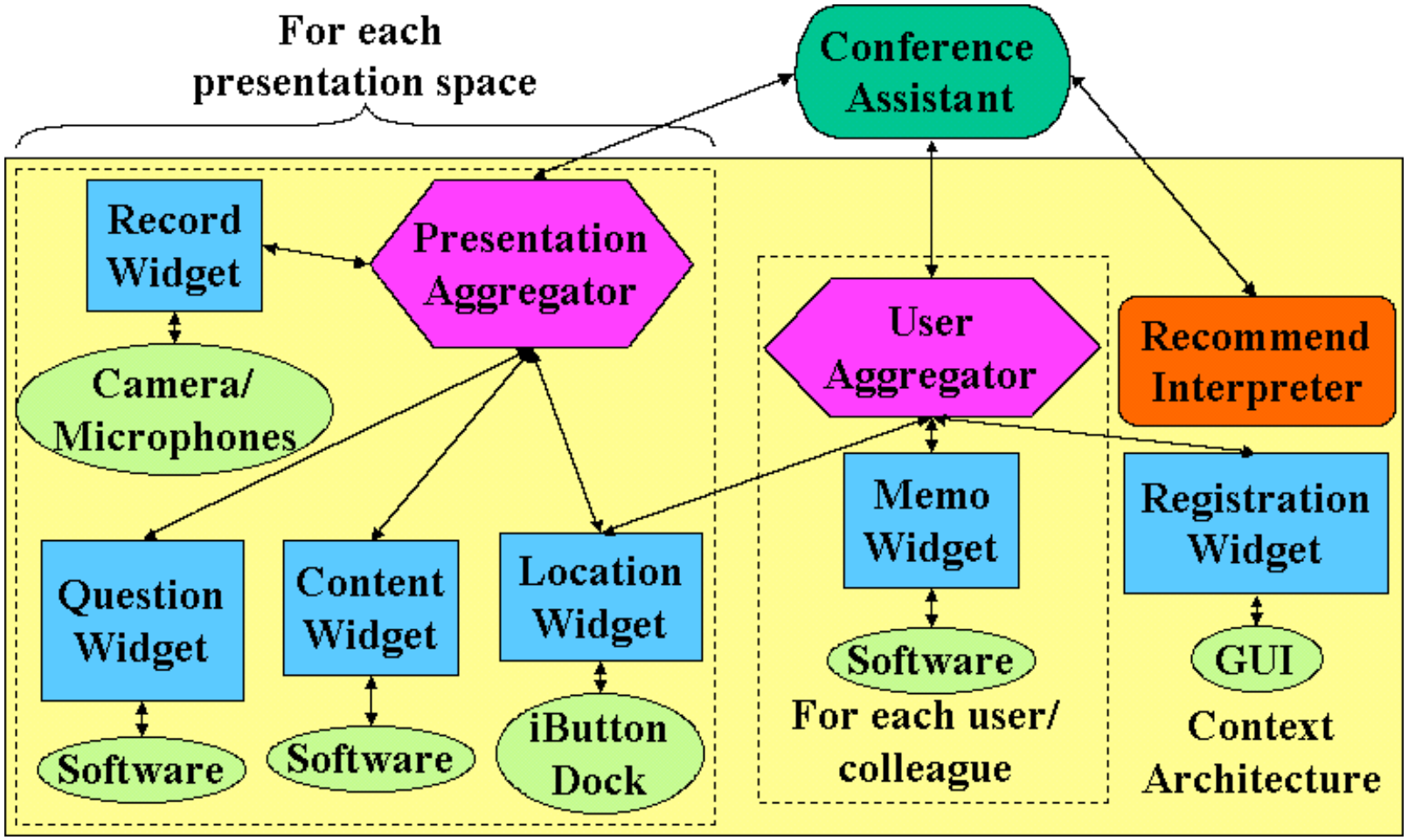





DummboAccess
Play
Stop
When:
Aug
1998
Who:
Jason Brotherton
Where:
Mobile SMART Board #1
Ink written *before* current time is in original color
Ink written *after* current time is in lighter color
Playback controls
Current time within session
Selected session
Selected day
Day containing whiteboard activity
Filters

Meeting Architecture




Conference Retrieval
Time
Event
9:00 A Daniel Salber-Context Toolkit
10:00 Chris Atkeson-Machine Learning
11:00 Jessica Hodgins-Human Motion
9:00 Bill Ribarsky-VR Workbench
10:00 A Maria Pimentel-C2000
11:00 Ashwin Ram-Personal Pet
9:00 Don Allison-VR Gorilla
10:00 Ashwin Ram-Pepe
11:00 A Anind Dey-Ubicomp Apps
Personal Events:
arrival
departure
question
Person:
Joe Smith
Keyword:
context
Submit Query
Anind Dey -- Ubicomp Apps
Schedule
Retrieved slide
Slide text
Query Interface
User notes
What Is Context?
The missing piece
Information sensed
Identity, Location, Activity of People, Places, Things
Who? Where? When? What? Why?
slide #2
Slide text
Identity, Location, Activity of People, Places, Things
User Memo
context widgets
Back
Forward
9:00
Context
VR Work
VR Go
Devices
Tracking
art Floor

Conference Assistant Arch.