DiCPA: Distributed Context Processing Architecture for an Intelligent Environment

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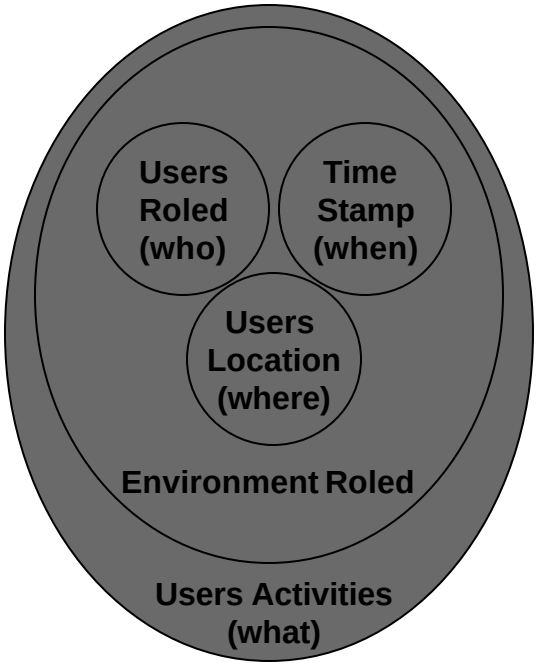
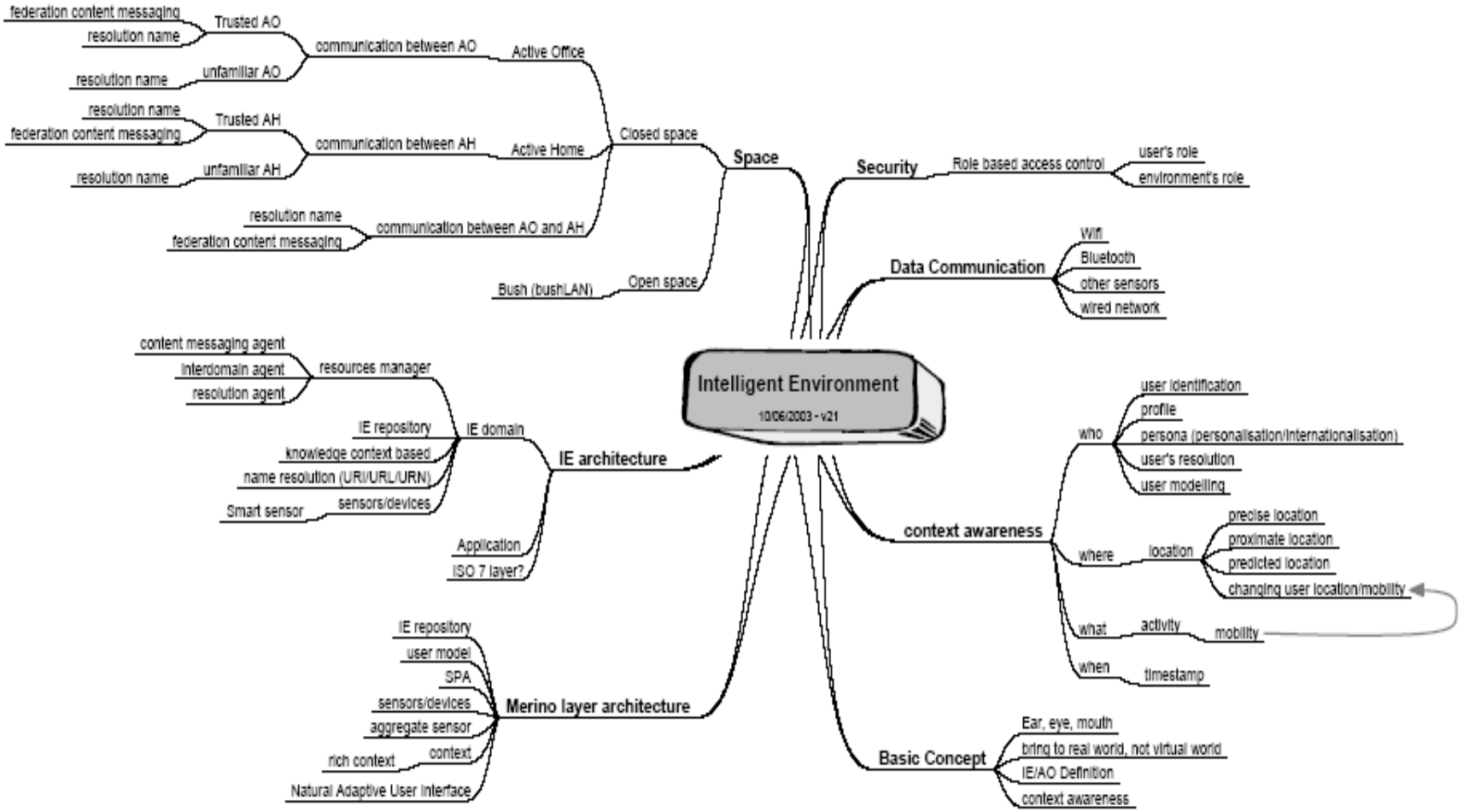
Intelligent Environment

- Interaction: eye, ear and mouth
- Context Awareness Environment: (Who, Where, What, When) -> (Identity, location, activity, timestamp)
- Deployment: low cost, easy/simple and wide acceptance.
- Examples: Adaptive Environment, Aware Home, Intelligent Rooms, Active Office, Smart Home, etc.



Intelligent Environment Mapping



What is an Intelligent Environment?

- A computing environment (open and closed space) with significant processing done by various fix and mobile sensors, which at least contains an IE repository, a resources manager, a knowledge based and a global/local resolution object naming scheme.

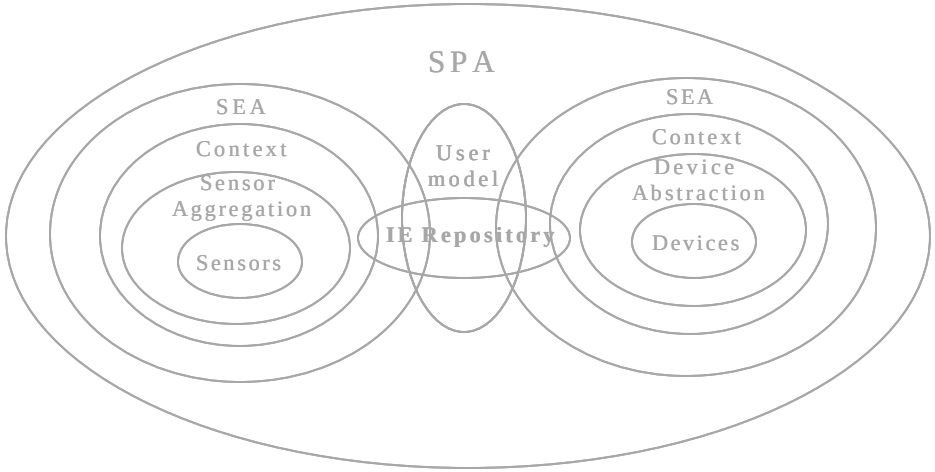
- A computing environment with capability to recoqnise user's location, activities, and the social context defined by the presence of other people.

- An IE can assist and help people with variety of activities by detecting users' current state/context to determine what actions to take based on the context.

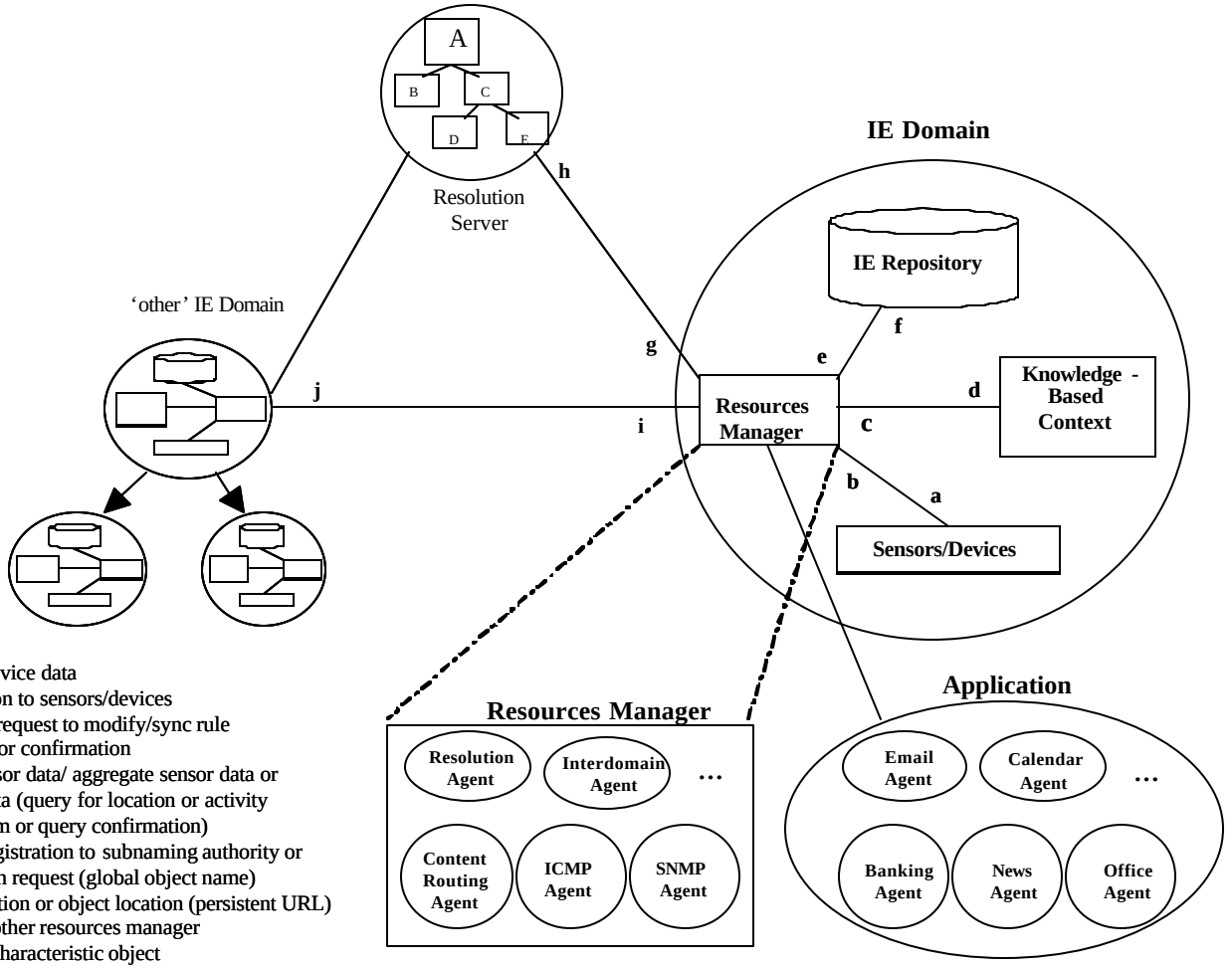
- An IE can use a scalable distribution context processing architecture (*DiCPA architecture*) to manage and respond to rapidly changing aggregation of sensor data. A DiCPA architecture is based on *Merino service layer architecture.*

Merino Service Layers Architecture

(Kummerfeld et.al. Workshop on User Modelling for Ubiquitous Computing, 2003)



DiCPA: A Distributed Context Proceesing Architecture for an Active Environment



a. sensor/device data
b. Instruction to sensors/devices
c. query or request to modify/sync rule
d. decision or confirmation
e. store sensor data/ aggregate sensor data or query data (query for location or activity
f. result from or query confirmation)
g. object registration to subnaming authority or resolution request (global object name)
h. confirmation or object location (persistent URL)
i. query to other resources manager
j. data and characteristic object

IE Repository

- Keeping all objects and their characteristics.
- Every object in IE has an identifier which is registered in the resolution server for resolution purposes.
- Resource Manager manages the communication between IE repositories and sensors/devices using logical multicasting and the communication between IE repository using per to per systems.

IE Resolution

- Every object minimal has a global resolution name.
- Unique Resolution Name (URN) as global unique name and Unique Resolution Locator (URL) as locator which locates any object, anywhere, anytime.
- Purposes: to identify and resolve any object in IE and recording dynamic location due to user mobility in an unfamiliar IE.

Resources Manager

- A network management map.
- Provided information about object status.
- Detects, controls, manages and conclude the functionality of all objects in the IE domain.
- Show failures in the sensors/devices.
- Detects traffic problem and identify what, where, the cause and the time-length of the problem are.
- Ability to control and manage the functionality of IP network and ‘trap’ mechanism so that failsafe mechanism can be implemented.
- Register all existing objects in the IE domain to the IE repository (context repository or user model layer).
- Communicate with other IEs, especially if the object is not belong to the IE domain, the Resources Manager has mechanism to find the object to the resolution server to get the “home server” and continue query to “home server” for the details and characteristics of the object.

Knowledge Based Context

- Advanced and shared knowledge-based based on context.
- Shared knowledge that lead to the growth of services.
- Entities/Objects can exchange knowledge-based and merge with existing knowledge-based.
- Entities use Multiple Classification Ripple Down Rules (MCRDR) and artificial neural network (ANN) component to filter ‘rule’ to produce knowledge maps and capable to extract raw and semantic rule features from sensors/devices (developed by Richard Dazeley – UTas - other SIT-CRC fellow).
- Require a protocol to invoke the services such as JINI, JXTA, UPnP.

User Activity

- User can be identified by his mobile computing devices, image/voice recognition, or by accessing his activities of accessing resources.
- Users can be characterized by: identification and authentification, user profile, user's terminal and user's access network characteristics, and service adaptation to user environment.
- User's location can be located by precise sensors and proximate sensors and user's mobility can be identified from user change location.
- User has a routine activity that can be predicted his location in certain time by query to user's location history then we can have a pattern of user's mobility.

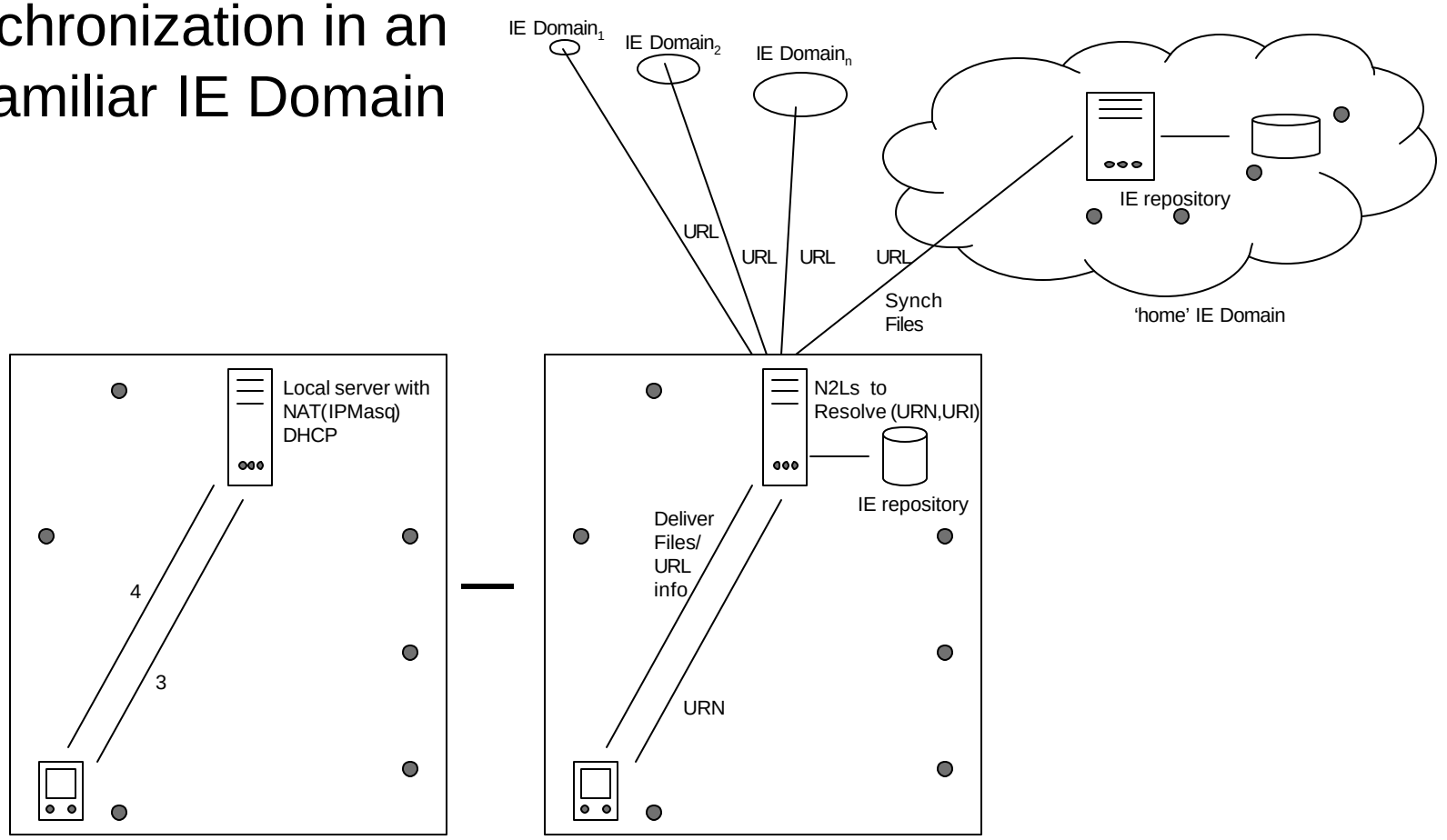
User Mobility in IEs

- User mobility: change user's location in "significant" scale.
- *Not significant change location*: typing in his computer or open his drawer, *significant change location*: moving from a room to other room or moving one side of a room to the centre, to other side.
- Two important variable: speed and location resolution. Approximate significant scale location resolution at 1-3 meter in a room and speed, moving from one place to another at reasonable speed (walking/running less than 20 Km/h)

Application Scenario

- Synchronization in an Unfamiliar IE domain
- An Active Office

Simple scenario: (1/2) synchronization in an unfamiliar IE Domain



1. User login to PDA
2. User come in to unfamiliar IE Domain
3. PDA broadcast MAC address or BDA
4. Server sending local IP address after handshaking
5. PDA establish connection to the local network

● = sensor (Bluetooh AP, WiFi AP, etc.)

PDA getting connection into unfamiliar IE Domain

1. PDA sending User profile (URN) to file server
2. File server resolved the URN become URLs
3. File server connect to relevant external IE domain
4. File server request copy or sync relevant data from external IE repository to local IE repository
5. File Server sending relavant file to PDA, or other equipment based on context

Synch relevant info stored to IE repository based on user profile

Synchronization in an unfamiliar IE domain (2/2)

Query 1: http://resolution.anu.edu.au/1030.52/00-80-BD-08-08

protocol	resolution-server	subnaming-authority	MAC-address/ BDA

Response: john.blog@inul.org

Query 2: GET /usi-res/N2Ls?urn:1030.52:john.blog@inul.org HTTP/1.0

Response based on ‘updated RFC 2168’:

urn: 1030.52:john.blog@inul.org
http://www.inul.org/people/john.blog
http://www.inul.org/pub/presentation.pdf
ftp://ftp.inul.org/pub/presentation.ppt

Other scenario:
an Active Office, what is that?

- A normal office, which consists of several normal rooms with minimal additional decorations (intrusive detectors and sensors, and minimum badging people).

- An implementation model of an Intelligent Environment uses a scalable distribution context processing architecture (Merino Service Layer Architecture) to manage and respond to rapidly changing aggregation of sensor data.

- An Active Office designed to be able to detect current state/context and determine what actions to take based on the context.

User Identity: Teddy Mantoro
U4011906

Date: Friday, 21 February 2003
Time: 11:35:22.01

User Activity: Teddy is in Room 235, sitting in his chair near the main desk, join phone conference with Pelican group.

Office Environment: Room 235

***Registered devices*:**
Workstation 1: fix place, in the main desk, thepenguin (150.203.160.34), Wired LAN, Redhat 9
Workstation 2: fix place, in the window desk, Semeru (192.168.2.119), BlueTooth server, Windows XP
Notebook: mobile, Laptop119 (Dinamic IP Address), WiFi, Wired LAN, BlueTooth client, multiboot, Windows 2000, Redhat 9
Telephone: digital phone, fix place, in the main desk, +61261253878
PDA: mobile, PDA119 (Dinamic IP address), Wifi, BlueTooth client, windows CE

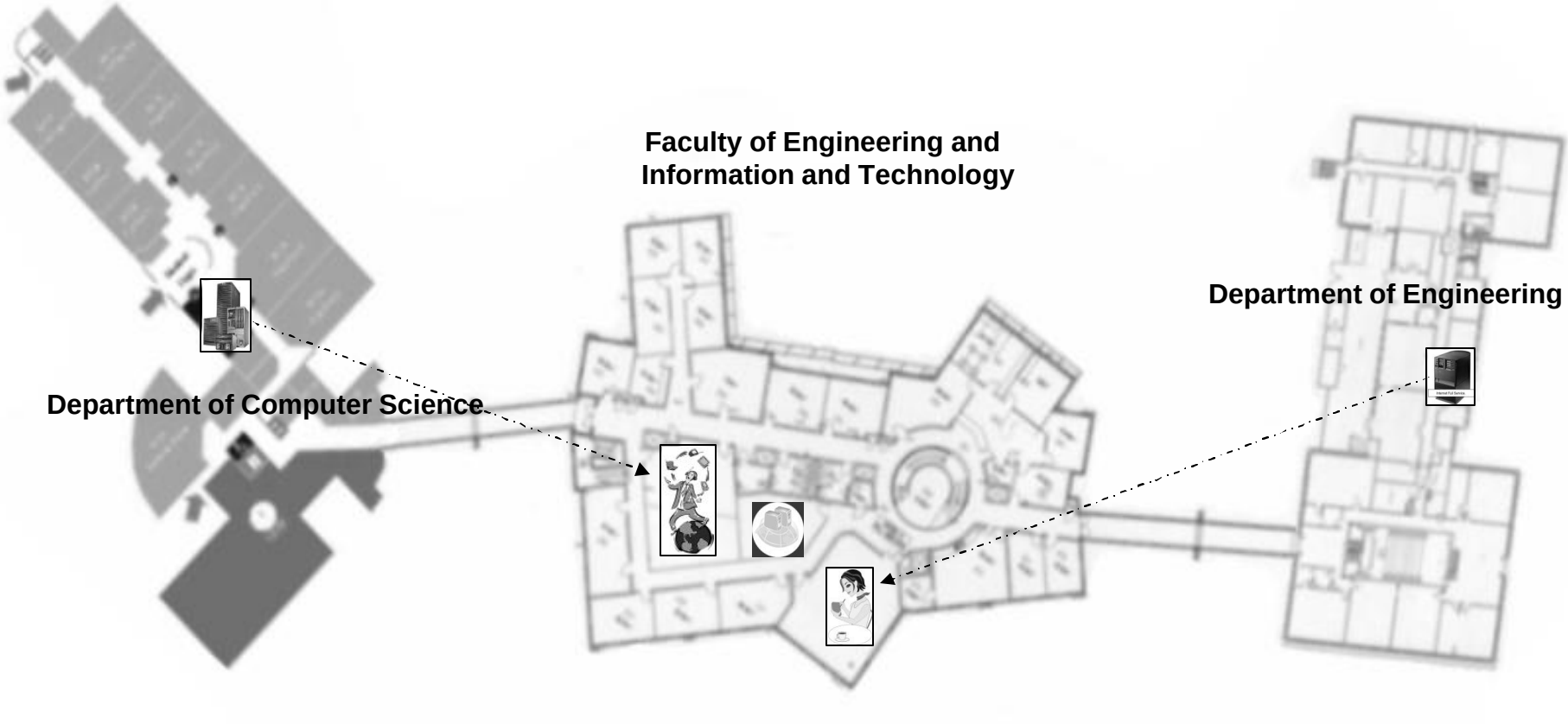
Registered sensors:
Ibutton: fix place, near the door
WebCam: fixplace, in the corner near the window desk, attached to Workstation 2
Temperature: SonyEricsson GM47 with GPRS

Network available in room 235:
Wired LAN: 2 socket, fix IP subnet 150.203.160, dinamic IP, subnet 192.168.2
Wifi: 3 Access Point cover the whole room, SSID: ANUNorth, dinamic IP using VPN (CIPE) with 128 bit encripted link.
BlueTooth: 1 BlueTooth server, 2 BlueTooth clients

Services Status on room 235:

Telephone: active, connect, (phone Conference: running)
Fax: Available on W/S 1, W/S 2
Email: available, IMAP 4, active in W/S 1, W/S 2, Notebook, PDA
Local Printer: Not available
Network Printer: Available from W/S 1, W/S 2, Notebook, PDA, share in resources room, Hplaserjet, Kyoceira 3750
Webcam: active, recording
Ibutton: active, no capture data
Temperature: active, sensing, 26°C
Web server: Apache, not available, last available: 20 February 2003 11:33:33.30 on workstation 1
Meeting maker: active

Example of snapshot of a user activity window



Changing location from a room in a building to other room in other building without lost connection from local IE but changing service delivery in the other local IE.
(We have different O/S for the offices above i.e, W2K server, RedHat, Solaris, and we used Winbind, VPN (poptop/cipe), DHCP, NAT(IPMasq), and LDAP to build WLAN connection among them.
Application in place: User's Location and SpeechCA.

Conclusion

- We proposed a DiCPA architecture – a distributed context processing architecture for an IE - which is simple, efficient, scalable, fault tolerant and applicable to be implemented a cross of heterogeneity computing platforms.

- An DiCPA architecture minimal has an IE repository, a resources manager, a knowledge based and a global/local resolution objectnaming scheme.

- An Active Office as implementation model of an IE is a part "proof of concept" of the distributed IE architecture.

Further Study

- Modelling of share context rules between IE domains in the distributed knowledge based context.

- Define requirements for flexible and efficient communication between resources managers in IE domains to form a society/federation of IE domains.

Recent Publications:

1. **Mantoro, T., Johnson, C. W., "*Location History in a Low-cost Context Awareness Environment*", Workshop on 'Wearable, Invisible, Context-Aware, Ambient, Pervasive and Ubiquitous Computing', Australian Computer Science Communications, Volume 21, Number 6, Adelaide, Australia, February 2003.**
2. **Mantoro, T., "*User Location and Mobility for Distributed Intelligent Environment*" Adjunct Proceedings, The Fifth International Conference on Ubiquitous Computing (UbiComp'03), Seattle, Washington, USA, 12-15 October, 2003.**
3. **Mantoro, T., Johnson, C. W., "*User Mobility Model in an Active Office*", LNCS 2875, European Symposium on Ambient Intelligence (EUSAI'03), Eindhoven, The Netherlands, 3-4 November 2003.**

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BACKUP SLIDE

Context and Context Aware

- Context: any information that can be used to characterize the situation of an entity.

  An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves (Dey & Abowd, 1999).

- Context Aware: A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task (Dey & Abowd, 1999).

URI – URL - URN

- URI: **Uniform Resources Identifiers** (rfc2396)

  A compact string of characters for identifying an abstract or physical resource. URI provide a simple and extensible means for identifying a resources. (rfc2396)

  General syntax: <scheme-specific>:<scheme-specific-part>

- URL: **Uniform Resources Locators** (rfc1738)

  URL is a subset of URI that identify resources via representation of their primary access mechanism such as network 'location' (rfc2396). URL's are used to 'locate' resources, by providing an abstract identification of the resources location.

- URN: Refers to the subset of URI that are required to remain globally unique and persistent even when resources ceases to exist or become unavailable (rfc2396). Uniform Resource Names (URNs) are intended to serve as persistent, location-independent names for network accessible resources, resource identifiers and are designed to make it easy to map other namespaces (which share the properties of URNs) into URN-space (rfc2141, rfc2169).

What is an Intelligent Environment?

The environment of ubiquitous computing and sensing devices with *significant processing done by the sensors*, knowledge of physical detection relationships between separate sensors and devices, using *context-aware mechanism*, resource detection and modeling, and using a scalable distribution context processing architecture (*Merino Service Layer Architecture*) to manage and respond to rapidly changing aggregation of sensor data.

Location Models

Location Models can be categorized into two classes:

- **Hierarchical (topological, descriptive or symbolic)**
  e.g. a room.

- **Cartesian (coordinate, metric or geometric)**
  e.g. GPS (*longitude, latitude, altitude*)

In an Active Office Hierarchical Model is more relevant than Cartesian Model.

User Locations categories:

1. **Precise Location**
2. **Proximate Location**
3. **Predicted Location**

Precise Location sensors $\Rightarrow$ < 1 meter.

Proximate location sensors $\Rightarrow$ > 1 meters (in a room).

Precise Location Sensors

- Swipe card
- Keyboard activity
- Biometric sensor/finger-print
- UWB
- Ibutton
- Etc.

Proximate Location Sensors

- WiFi (802.11b,b+,g)
- Bluetooth
- Active/Passive Badge (depending on the range)
- Voice recognition (microphone)
- Face recognition (digicam)
- Smart Floor, etc.

Sensors Proximate Location by WLAN

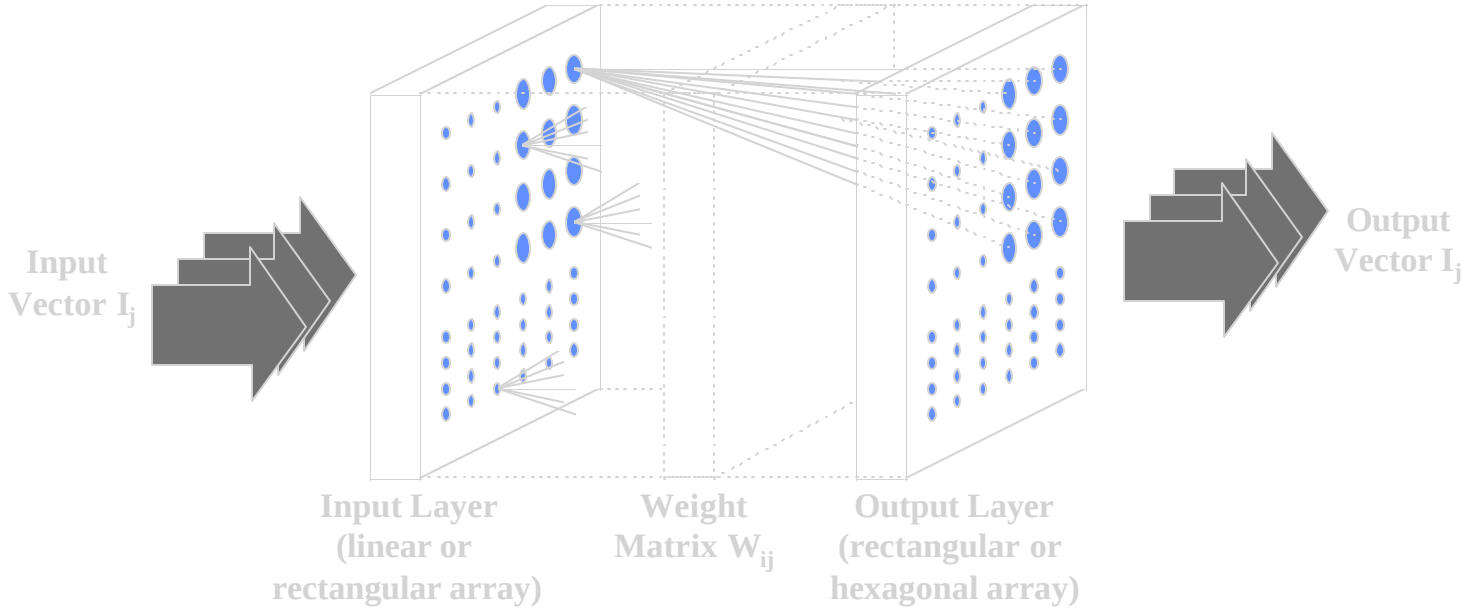
- Scalable for room and office
- Range of Bluetooth (class 1) ~ 3m
- Range of WiFi ~ 25m

Different technique in Wireless LAN to deduce room-scale location.

A self organizing map (Kohonen map) to cluster the signal strength data:

- giving random weight,
- doing normalisation,
- calculating Euclidian distance,
- finding the winner for clustering,
- If alpha = 0, get final weight which leads to output activation and cluster winner allocation.

Once we get the signal strength cluster allocation in the local IE, we directly get current user location.



Self-Organizing (Kohonen) Network Model

Predicted Location

- Aggregate of location history data in IE Repository

UserID	LocationID	Device	Date	Time
TM	125	FR1	13/8/02	04.02
TM	323	VR3	20/8/02	05.01
…	…	…	…	…
TM	125	Sun15	26/8/02	03.02
TM	125	Ibutton1	26/8/02	03.58
TM	125	PC5	27/8/02	04.05
…	…	…	…	…

The example policies for location checkpoints are:

1. **The same day of the week**.
(assume regular work schedules, to find user's location based on the history data of his location in almost the same time and same day of the week).

2. **All the days in a one week range**
(to find user's location based on the history data of his location in almost the same time during a week).

Example:

Chris: Locate Teddy, please …

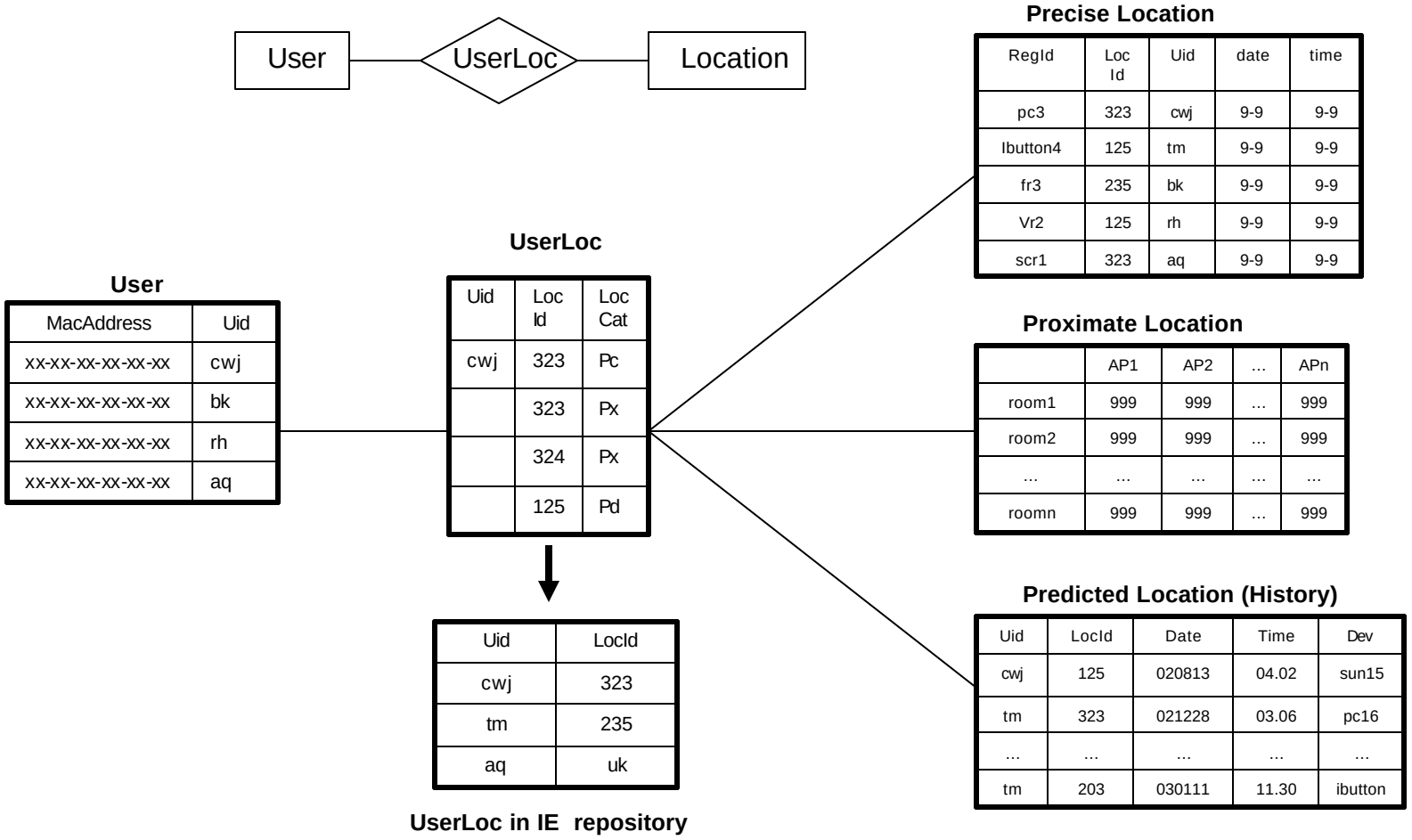
SpeechCA: Teddy is located at room 235 in DCS building, 5 minutes ago.

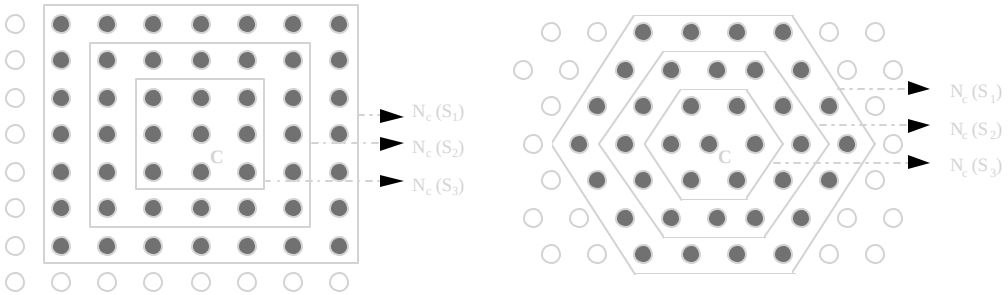
The most probable location of Teddy is in Room 235 in DCS or Room 103 in DE.

/name/ is located at room /r.Room/ in /r.Building/ building, /difftime/ minutes ago.
 # 5 minutes ago ....
Select *r.Room, r.Building, min(time() - h.time) as difftime;*
From *RoomDB r, HistoryDB h ;*
Where *h.userid = 'teddy'* ***and*** *h.date = date()* ***and*** *r.LocationID = h.LocationID ;*
Order by *difftime*

Interoperability Between Sensors for User Location

- **User locations → Aggregation of relationship between user's data and locations**





a) Rectangular b) Hexagonal

Two examples of topological neighborhood Nc(s), where s1 < s2<s3

Motivation (continue)

Understanding the nature of scattering, i.e. reflections