



# A Survey of Context-Aware Mobile Computing Research

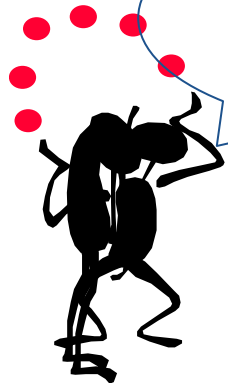
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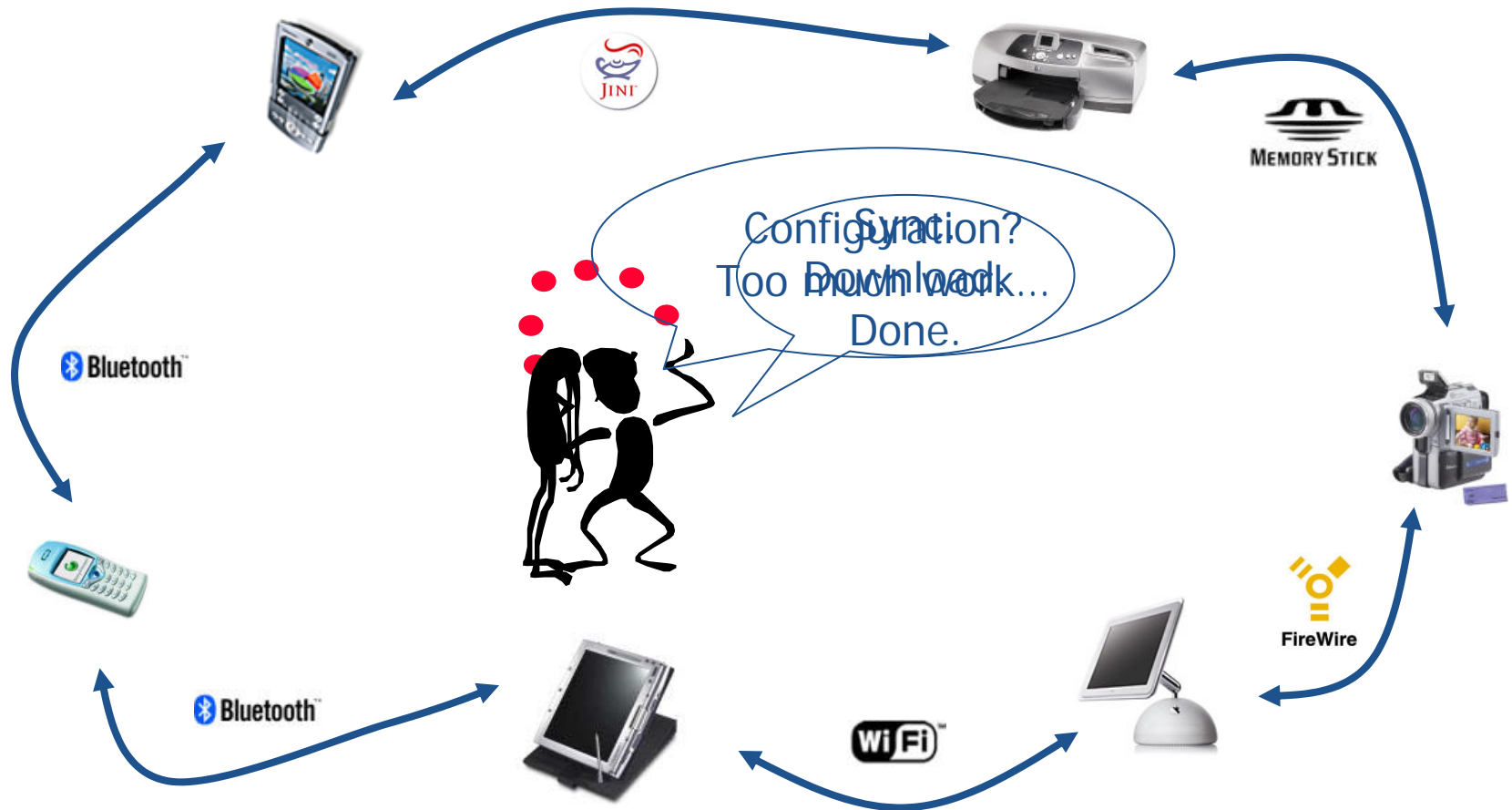
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Too bad they  
couldn't talk to  
each other...



# Introduction (cont')





- ❖ **Context-aware computing is a mobile computing paradigm**
- ❖ **Applications can discover and take advantage of contextual information**
- ❖ **Context-aware Computing**
  - Brings us one step closer to the Pervasive Computing vision
  - Enables computer systems to anticipate users' needs and to act in advance
  - An emerging paradigm to free everyday users from manually configuring and instructing computer systems



# Definition of “Context”

## ❖ In Merriam-Webster Dictionary

- the interrelated condition in which something exists or occurs

## ❖ In context-aware computing

- **No unified definition of context**
- Most of the definitions agree that context has something to do with the interactions between the users and the computing systems

## ❖ Three categories (Schilit) + one

- Computing context
  - network connectivity
  - communication cost, communication bandwidth
  - nearby resource
- User context
  - user profile, location, social situation
- Physical context
  - lighting, noise, traffic condition, temperature
- Time context
  - Time of a day, week, month and season of the year



## ❖ Schmidt et al

- “Knowledge about the user’s and IT device’s state, including surroundings, situation, and to a less extent, location”

## ❖ Dey

- "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“

❖ *Context is the set of environmental states and settings that either determines an application’s behavior or in which an application event occurs and is interesting to the user.*

## ❖ Four Categories (Schilit)

- *Proximate selection*
  - a user-interface technique where the objects located nearby are emphasized or otherwise made easier to choose.
- *Automatic contextual reconfiguration*
  - a process of adding new components, removing existing components, or altering the connections between components due to context changes.
- *Contextual information and commands*
  - which can produce different results according to the context in which they are issued.
- *Context-triggered actions*
  - simple IF-THEN rules used to specify how context-aware systems should adapt.

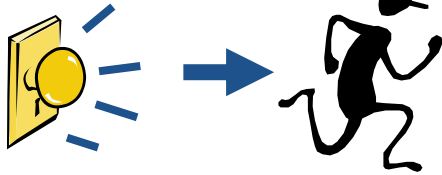
## ❖ Author

- **Active context awareness**
  - an application automatically adapts to discovered context, by changing the application's behavior
- **Passive context awareness**
  - an application presents the new or updated context to an interested user or makes the context persistent for the user to retrieve later
- Active context awareness is more interesting

- ❖ **Call Forwarding**
- ❖ **Teleporting**
- ❖ **Active Map**
- ❖ **Mobisaic Web Browser**
- ❖ **Shopping Assistant**
- ❖ **Cyberguide**
- ❖ **Conference Assistant**
- ❖ .....

## ❖ Call Forwarding System

A user has left  
his office



The phone rings  
in his office



The system detects  
his current location



The system forwards  
the call to a nearby  
phone



The system detects the  
user is in an meeting



Calls are forwarded to  
his voice mailbox



## ❖ Call Forwarding System

- Three types of contexts are used:

The system detects his current location



**Location Context**

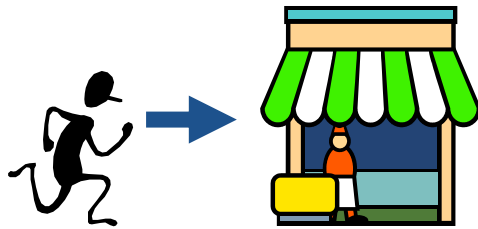
The system detects the user is in an meeting



**Activity Context**

## ❖ Shopping Assistant System

A user enters a store



Turns on his PDA



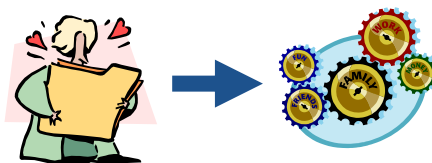
PDA displays the info  
of a store item



As the user wanders  
around in the store



PDA analyzes user's  
personal profile

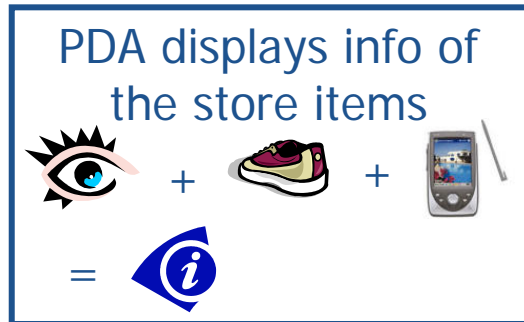


PDA recommends  
store items to the user

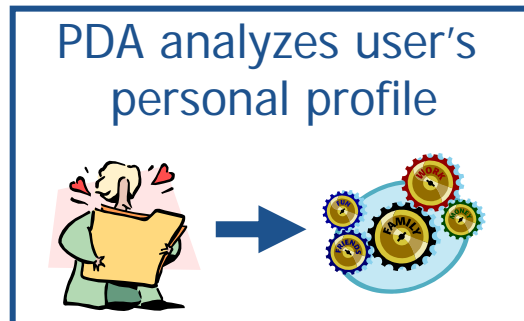


## ❖ Shopping Assistant System

- Three types of contexts are used:



**Location Context**



**Identity Context  
&  
Attribute Context**



- ❖ Sensing the Location
- ❖ Sensing Low-level Contexts Beyond Location
- ❖ Sensing High-level Contexts
- ❖ Sensing Context Changes

## ❖ Sensing Location

- **Outdoors**
  - Global Positioning System (GPS)
  - GPS-less Low Cost Outdoor Localization For Very Small Devices
- **Indoors**
  - Ultrasonic and radio signals “The Cricket”
  - RADAR, Active Floor and Smart Floor
- **Hybrid**
  - based on network domains
  - Mobile-IP protocol
- **Issues**
  - no uniform way to track locations with fine granularity that works both indoors and outdoors
  - context sensed from different sensors may conflict to each other.

## ❖ Sensing Low-level Contexts Beyond Location

- Time
- Nearby objects
- Network bandwidth
- Orientation
- Other low-level contexts:
  - *light level, sound .....*

## ❖ Sensing High-level Contexts

- Such as user's activity



# Modeling Context Information

## ❖ Location Model Purpose

- To handle object mobility
- To facilitate location-related queries

## ❖ Two Location Model

- Symbolic Model
  - representing location as abstract symbols
- Geometric Model
  - representing location as coordinates
- Both model can convert to each other via pre-defined predicates

## ❖ Data Structure

- Key-value pairs
  - Key - Environmental variable, Value - context
- Tagged encoding.
  - SGML – standard generic markup language
  - `<body>` ↔ `<require>`
- Object-oriented model
  - GUIDE system
- Logic-based model
  - expresses the existing contextual information in a domain-centralized database using an entity-relationship data model.
- Others.....

- ❖ It is necessary to decouple the application and the actual context sensing part
- ❖ A middleware layer whose can translate raw sensor information to an application-understandable format
- ❖ **Centralized**
  - Location Information Server at Phillip
  - Centralized maintenance of contexts
  - Scalability problem
- ❖ **Distributed**
  - Rome system at Stanford
  - More privacy
  - Increased computation and communication

- ❖ **There are two key problems in context-aware system security**
  - Ensure the accuracy of location information and identities
  - Establish secret communications
- ❖ **“Perfect” privacy guarantees are in general hard and expensive**
- ❖ **User should be able to have the control over their contextual information and over who may gain access to it**

- ❖ **Research of accurately discovering context, efficiently disseminating contextual information, and making use of the available context, are still at the early stages**
- ❖ **Context awareness is a key factor for new applications in the area of ubiquitous computing**





**Thank You !**