

Programming Ubiquitous Things 2024/25 - Spring 2025 - UiO

Context-Awareness (part 1 of 2)

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Context-Awareness (1/2)

- Definition of Context
- Context-Aware Systems
- Distributed Context-Aware Systems
- Local vs. Distributed Context-Aware Systems
- Collaborative vs . Non-collaborative Distributed Context-Aware Systems
- Examples of Sensors and Types of Context
- Taxonomy (capture, infer, distribute, consume) Addressed in the next lecture

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Examples

Examples that currently show the context-aware behavior on smartphones ?

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Example

https://www.youtube.com/watch?v=KXNNbWg_peM (context aware apps)



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Example

https://www.youtube.com/watch?v=JrRS8qRYXCQ&t=1s (introducting nearables)



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What is Context?

Definition of context

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definitions

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Definition of Context

- The word “context” is subject to multiple interpretations and has been researched in various fields like psychology, philosophy, and computer science
- In the area of (CSCW), context was initially perceived as user location
- In the last years, it has been enriched with other sources of information such as identity, activity, and state of people, groups, and objects

- Context is **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

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Definition of Context (cont.)

- Consider only **relevant information** w.r.t. interaction between user and application
  - thus, application developers can focus on a subset of the user environment data for a given application scenario
- Example:
  - context needed by UbiqMuseum to assist museum visitors is their location and native language
  - other environmental information (e.g., body temperature, marital status) is not relevant
- In mobile and ubiquitous systems, the idea is:
  - context supports systems to be cognizant of its user's state and surroundings and must **modify its behavior based on this information**
- A user's context can be quite rich, consisting of attributes such as:
  - physical location,
  - physiological state (such as body temperature and heart rate),
  - emotional state (such as angry, distraught, or calm),
  - personal history,
  - daily behavioral patterns,
  - etc…

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Definition of Context (cont.)

- Another definition (by enumeration of examples):
  - **computing context**, such as network connectivity, communication costs, and communication bandwidth, and nearby resources such as printers, displays, and workstations
  - **user context**, such as the user's profile, location, people nearby, even the current social situation
  - **physical context**, such as lighting, noise levels, traffic conditions, and temperature
  - **time context**, such as time of a day, week, month, and season of the year
- Possible refinement:
  - there are certain types of context that are, in practice, more important than others for characterizing the situation of a particular entity:
    - ***location*, *identity*, *activity*, and *time***
- These context types not only answer the questions of **who, what, when, and where** but also act as identity indexes into other sources of contextual information

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Context-Aware Systems

- 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.

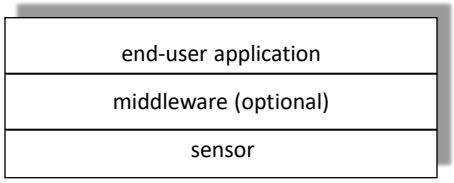
- This results in three main features that context-aware systems may provide:
  - **presentation of information and services to a user**
    - systems that provide information to the user augmented with contextual information (e.g., phone's contact list enhanced with location information) or that provide services based on the current user's context (e.g., show me restaurants nearby, free places in each restaurant)
  - **automatic execution of a service**
    - systems that execute a service automatically based on the current context (e.g., automatically updating my status on a social network based on accelerometer data—sleeping, walking, and running)
  - **tagging of context to information for later retrieval**
    - systems that are able to associate digital data with the user's context (e.g., virtual notes that are attached to certain locations, for others to see)

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Distributed Context-Aware Systems

- These systems can be described as:
  - **distributed system** that uses **context to provide relevant information and/or services to the user**, where relevancy depends on the user's task;
  - including end-user applications that use context information provided by sensors.

- From an architectural point of view:
  - end-user applications layer - consumers of context information
  - middleware layer - communication and coordination issues between distributed components
  - sensors layer - producers

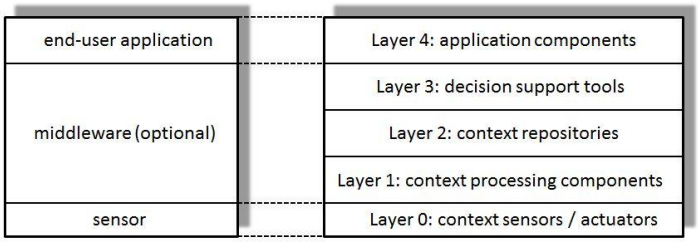


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Distributed Context-Aware Systems (cont.)



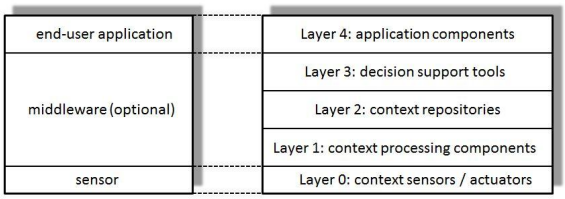
- In simple (local) context-aware systems, the **end-user application communicates directly with the sensor**:
  - e.g., a mobile phone that automatically switches off GPS when battery is below a certain capacity
- Today, it is widely acknowledged that additional infrastructural components are desirable:
  - to **reduce the complexity** of distributed context-aware applications,
  - improve **maintainability**, and
  - promote **reuse**



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Distributed Context-Aware Systems (cont.)





- layer 0 – context sensors and actuators that:
  - provide the interface with the environment, either by capturing it (sensors) or by modifying it (actuators)
- layer 1 – components that:
  - (i) assist with processing sensor outputs to produce context information that can be used by applications, and
  - (ii) map update operations on the higher-order information back down to actions on actuators
- layer 2 - context repositories that:
  - provide persistent storage of context information and advanced query facilities
- layer 3 – decision support tools that:
  - help applications to select appropriate actions and adaptations based on the available context information
- layer 4 – application components that:
  - are integrated in client applications using programming toolkits

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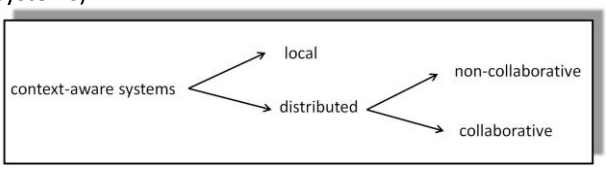
Local vs. Distributed Context-Aware Systems

- Local:
  - **sensors and applications are tightly coupled** (usually through a direct physical connection)
  - e.g., a mobile phone application that sets the mode to silent, while its owner is jogging (the accelerometer that provides the "running" context is directly attached to the mobile phone as well as the application that uses that context to activate the silent mode)
- Distributed:
  - **do not have a direct physical connection between the sensor and the application**
  - thus, it is possible to have multiple:
    - applications receiving information from the same sensor
    - dispersed sensors produce information to be consumed by a single application
  - e.g., a mobile phone may broadcast to a group of friends that its owner is currently walking, to decrease the probability of incoming calls during that period:
    - in this case, the accelerometer is not tightly coupled to the recipient of its information

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Collaborative vs . Non-Collaborative Distributed Context-Aware Systems

- Distributed collaborative systems are systems that **help two or more dispersed humans accomplish a common goal**:
  - e.g., real-time availability information within a group of colleagues, using speech detection, location, computer activity, and calendar entries
  - the common goal is team synchronization (actually, team synchronization is the most common goal of distributed collaborative systems)



- Non-collaborative systems **support only individual goals**:
  - e.g., in a museum, a portable device is provided to the visitors that, based on their current location and individual profile, shows relevant information in their preferred language
  - the goal is individual (the device shows information that is only relevant to its user)
  - the system is distributed since the location is inferred from Bluetooth emitters carefully dispersed throughout the museum

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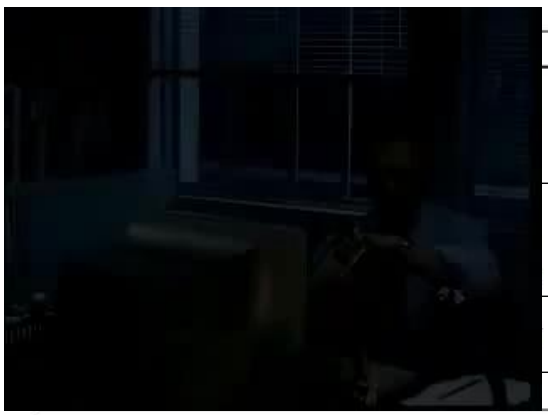
examples

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Examples of Sensors and Types of Context

- the most important types of context are: *location*, *identity*, *activity*, and *time*,
- corresponding roughly to the primal questions: *where*, *who*, *what*, and *when*



Virtual sensors
Networked calendar system, travel-booking system, user's login on location-aware computer, IP subnet
Various authentication schemes at the operating system or application level
Keyboard or mouse activity, application usage
Operating system timer

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Examples of Context-Aware Applications and Sensors

	Description	Sensors used
GUIDE [25]	Information for city visitors	WiFi (location)
Welbourne [97]	Mode of transit: walking, running, riding a vehicle	Clock, GSM/WiFi (location), accelerometer
ContextContacts [62]	Enhanced phone's contact list	GSM, phone activity, Bluetooth (nearby environment)
UbiqMuseum [15]	Assists museum visitors	Bluetooth (location)
AwareMedia [9]	Support coordination at an operation ward	Bluetooth (location), video camera, shared calendar
Stiefmeier [91]	Help workers perform critical and complex assembly tasks in a car production environment	Body-worn, car-mounted, and tool-mounted accelerometers
BikeNet [36]	Cyclist experience mapping	Magnetometer, inclinometer, speedometer, microphone, GPS, GSR stress monitor, CO^2 meter
CenceMe [59]	Social activities (dancing, lunching)	Microphone, GPS, camera, Bluetooth (nearby environment), accelerometer
SoundSense [57]	Music events' sharing	Microphone, camera, GPS
Upcase [82]	Daily activities (working, driving, sleeping, resting, walking outside)	Luminosity, microphone, temperature, accelerometer

Smartphones variablity w.r.t. the sensors available and their accuracy

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Example

https://www.youtube.com/watch?v=SrsHBjzt2E8 (contextual era)



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