

CONTEXT KNOWLEDGE TO IMPROVE ENERGY EFFICIENCY OF SENSING APPLICATIONS RUNNING ON SMARTPHONES.

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Wireless sensor network (WSN) consists of small sensor nodes, which are capable of sensing, processing and wireless communication capabilities. . These sensors continuously generate enormous amounts of data. However, in order to add value to raw sensor data we need to understand it. Energy consumption of wireless data transmission, a significant part of the overall energy consumption on a mobile device, is context-dependent. - Context aware computing (CAC) is a paradigm in which applications make use of contextual information such as time, people, location and activity. The CAC is a rich area of research. WSN is improving the efficiency of resource usage. User's daily context continually changes, the application can dynamically adapt its behavior to the user context to reduce the smartphone energy consumption. The combination of new sensor technology, increasing connectivity, and powerful mobile devices has created significant opportunity to make use of context-aware computing across the enterprise.

Keywords: WSN, CAC, Smartphone, Context- aware

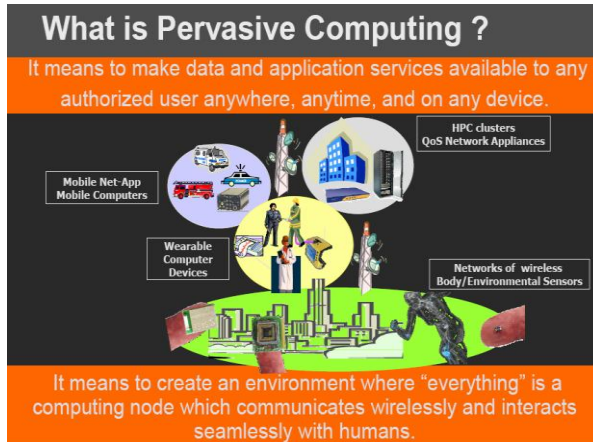
INTRODUCTION

An effective solution for a number of applications that need continuous sensing are Smartphones. A sensing application is continuously running on the smartphone collecting and forwarding data to a backend server. Continuous collect and forward of data from sensors to backend impacts on the smartphone's battery life especially when the samples needs to be geo tagged. Tracking location can reduce smarthphone lifetime to a few hours . wireless interfaces with the body worn sensors, such as Bluetooth, impact the smartphone battery life. However, often data is collected within a context which is not of interest. For example, in an air quality monitoring application, samples collected within a vehicle fail to detect the real pollutant concentration in a certain area due to the filters in the air condition system. A more efficient approach would rely on user context detection to modify the application behavior as a user moves within different situations.

WHAT IS CONTEXT AND PERSVASIVE COMPUTING?

Context is information that can be used to characterize the situation of a person or an object in a Pervasive Computing environment.

pervasive computing creates an environment where “everything” is a computing node which communicate wirelessly and interacts seamlessly with humans.



important aspects of context are

- The **identities** and **attributes** of people and devices.
- The **locations** of people and devices
- The **activities** that people are participating in
- The **roles** and **intentions** of people when participating in the activities

SENSOR EVALUATION

Sensors can provide context to categorizing sensors as either client or environment, sensors can be either hard or soft.

• Hard sensors are either discrete or integrated. Examples of discrete hard sensors include motion sensors, badge

readers, radio-frequency identification scanners, location sensors, and climate sensors, such as temperature, humidity, and atmospheric pressure. Business Ultrabook devices, tablets, and

smartphones are often equipped with integrated hard sensors, such as location awareness, accelerometers, compasses, and gyroscopes.

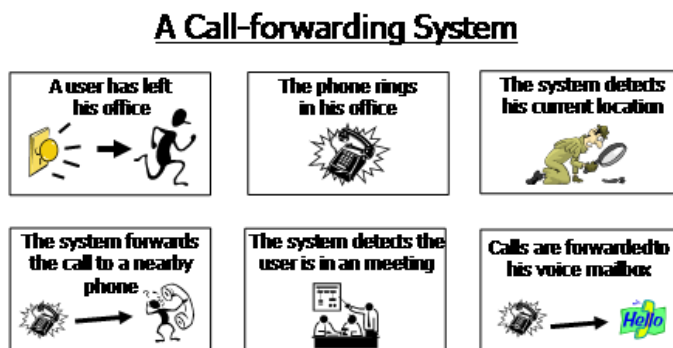
- Soft sensors use applications to create context. Examples include appointment and shift calendars, conference room booking tools, user preferences, and applications that provide load balancing for network activity.

CONTEXT-AWARE SYSTEMS

Context-aware systems are a component of a [ubiquitous computing](#) or [pervasive computing](#) environment.

Context-aware computing refers to a general class of mobile systems that can sense their physical environment, and adapt their behavior accordingly.

A Call-forwarding System



Three types of contexts are used in context aware systems:

1) Location Context

2) Identity Context

3) Attribute Context

- 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 and an emerging paradigm to free everyday users from manually configuring and instructing computer systems.

To develop and prototype a broker-centric agent architecture to support context-aware systems and To demonstrate this architecture can be used to reduce the difficulty and cost of building context-aware systems in an **Intelligent Meeting Room** environment.

The “broker” of this architecture will Sense and reason about contexts on the behalf of capability-limited agents ,Enable agents to share contextual knowledge, Protect the privacy of users and Maintain consistent contextual knowledge.

Agent:

- Study context-aware systems using intelligent agents (context-aware agents)
 - a. Autonomous and Proactive
 - b. Can communicate, not just connect
 - c. Have beliefs about the World
 - d. Have desires and intentions

BROKER

Broker is an overloaded term for agents with a **specialized role**: Mediator, Facilitator, Match-maker.

Mediator is mediate communication messages in a Multi-agent system (MAS).

Facilitator is facilitate task execution between agents to achieve cooperation

Match-maker is match/recommend service advertisements

THE CONTEXT RECOGNITION SERVICE DETECTS

User's mobility and location, if the user is indoor/outdoor and if he/she is resting. we do not focus on which technique is used to detect the user context. In fact, the energy savings are a consequence of how the application adapts to the current context. The context detection is an extra cost that the system has to pay to gain knowledge. By using more energy efficient techniques this extra cost, thus increasing the gain in energy saving. The smart phone accelerometer is used to recognize the following mobility states: walking, riding a bike, going by car or bus and standing. 67 hours of recorded data has been used characterize a J48 tree classifier. We achieved 89% accuracy and execution time is 2.2 sec. Location is provided using

area detection. In our experiments indoor and outdoor location is detected based on the network location provider with an accuracy of 10 m to several hundred meters depending on the number of Wi-Fi access points and cell towers in the connection range. Average execution Indoor/outdoor detection depends on the ability GPS module a location fix. When the phone is outside localization takes 2 sec. on average. When indoor takes 42ms to execute plus a waiting delay of We use the magnitude of the acceleration to detect if the user is at rest or moving. Our assumption is that when the user is resting, he/she doesn't carry the smartphone and leaves it on a still surface (e.g. table). The system assumes that the other context variable remain unchanged when the user is at rest, therefore we stop the context detection. Detection of this context takes our context aware technique is able to dramatically reduce the power consumption of several components. Since the Sensing Application stops when the user is indoors, power consumption of Bluetooth and GPS is 86% lower when using our policy. On the other hand, the cellular and Wi-Fi module power consumption do not change much. The reason is that these components are used also to perform user localization in addition to data transfer, so this affects their energy cost. Finally, note that the accelerometer is used only for the context recognition. This is an extra cost the system has to pay to get context knowledge On the sensor side management modules are introduced which implement the proposed negotiation and association mechanism according to the capabilities of the particular system. On the sensor network edge, each module has a counterpart which establishes the connection to the nodes. Table 1 gives an overview of the requirements and their occurrence in various systems. Since this is a work-in-progress only some of the existing systems are evaluated.

Sensor power.

Decisions about powering sensors (particularly discrete hard sensors) impact both initial installation costs and long-term sensor support costs. Hard-wired AC or DC power can increase initial installation costs but can reduce sustaining costs and improve reliability. Battery power reduces installation costs but requires recurring battery replacement costs (primarily labor) over the long term and can reduce sensor reliability.

Sensor connectivity.

To provide data to cloud-based applications, sensors must be connected to a network. Similar to

power choices, connectivity choices have advantages and disadvantages. Wireless connectivity can be quick and inexpensive to install but may introduce security and wireless channel interference challenges. There are also trade-offs between standard IP-based LAN/WAN connections compared to a low-power mesh network that is either standards-based or proprietary.

SYSTEM CHARACTERISTICS

1. Context-aware agents often run on mobile devices

- For agents to become context-aware, context sensing and context reasoning mechanisms are required
- Context-aware systems often exploit user information (e.g. personal profile, user location & social activity)
- Building context-aware systems can be difficult and costly because
 - (a) limited resources in mobile devices
 - (b) lack of reusable context-aware mechanisms
 - (c) privacy issues in accessing user information

2. Battery Power Constraint

Small devices => limited built-in sensors

Big devices => too many external sensors can be awkward

3. Information Storage Constraint

Historic knowledge saves computation

Limited storage => must intelligently choose what to save and delete (hard problem!)

4. Computing Power Constraint

To process contexts needs CPU power

Limited CPU power => primitive contexts ONLY (limited intelligence)!

5. Communication Constraint

Contexts are “hidden” heterogeneous sources

Not knowing where are the sources and how to communicate => limited context-awareness

6. Essential Mechanisms:

Context Sensing: acquiring information from the physical environment

Context Reasoning: interpreting the information that have been acquired

In the existing systems, both are built from the scratch every time => no reuse!

PRIVACY ISSUES IN ACCESSING USER INFORMATION

- Privacy is about **control of information**
- In context-aware systems, users may not have full control of their information
- Sensors are hidden in the environment
- Information are collected without explicit consent from the users

For sharing of information You tell an agent something about you because you want its service, and later it tells someone else... (you are in trouble!) and The **downstream consequences** of information are unknown or unspecified.

PROPOSED SOLUTION

Context Broker Architecture

- Philosophy: agents can't do “everything” by themselves, let's provide a powerful server entity to help them
- Rationale: the Moore's Law for mobile computing is likely to hold; developing a centralized solution is much easier than any P2P solutions.

The key features:

- Sense and reason about contexts on the behalf of capability-limited agents
- Enable agents to share contextual knowledge
- Protect the privacy of users
- Maintain consistent contextual knowledge

TYPES OF CONTEXT-AWARE RESEARCH

- Enhancing User Interfaces
- Guiding the Adaptation of System Behavior
- Building Pervasive Computing Service

Enhancing User Interfaces

Problem: the user interface of the existing mobile devices **demand too much user attentions** (i.e. cognitive and visual).

Solution: to replace the traditional user interface by enabling devices to become context-aware.

Microsoft research has developed a **Cassiopeia E-105** that can

- Active voice recording application when detects the user is holding the device like a cell phone or microphone
- Automatically reformat the screen display (landscape ↔ portrait) depending how the user holds the device

Guiding the Adaptation of System Behavior

- Problem: Environment changes can **affect the performance of applications** (e.g. using wireless PDA while walking on the street)
- Solution: enabling applications to adapt their behavior in according to condition changes

Guiding the Adaptation of System Behavior



Problem: Complex computer systems are drawing humans into the world of computing

Solution: enabling computers to reason and act in according to the situation of users as they carry out their every activities

Building Pervasive Computing Services

In MIT's Intelligent Room, the open/close of window curtains are automated by detecting the body position of a user in a couch

Building Pervasive Computing Services

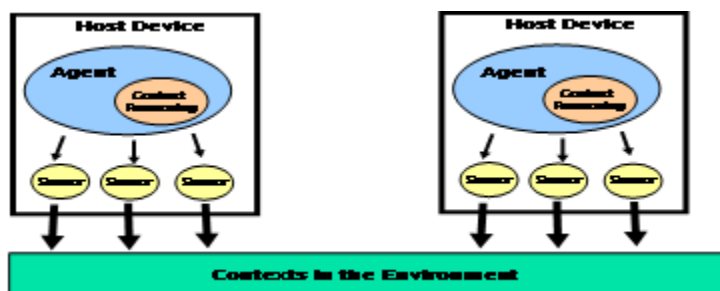
- In HP's Cooltown museum, the visits of Cooltown users are automatically documented based on what they have seen.

Table 1: Building Pervasive Computing Services

| | Enhancing User Interface | Guiding Behavior Adaptation | Building Pervasive Computing Srv. |
|--------------------------------|--------------------------|-----------------------------|-----------------------------------|
| Microsoft Cassiopeia E-105E | X | | |
| Video Streaming App. (Odyssey) | | X | |
| XeroxPARC Active Badge Apps | | X | X |
| Cooltown Museum | | | X |
| MIT Intelligent Room | | | X |
| Context Broker Architecture | | | X |

- Approaches to Support
 - Context-Aware Systems Directly Sensors Access Facilitated by Middle-ware

Acquiring Context Directly from Sensors



Facilitated by a Middle-ware Infrastructure

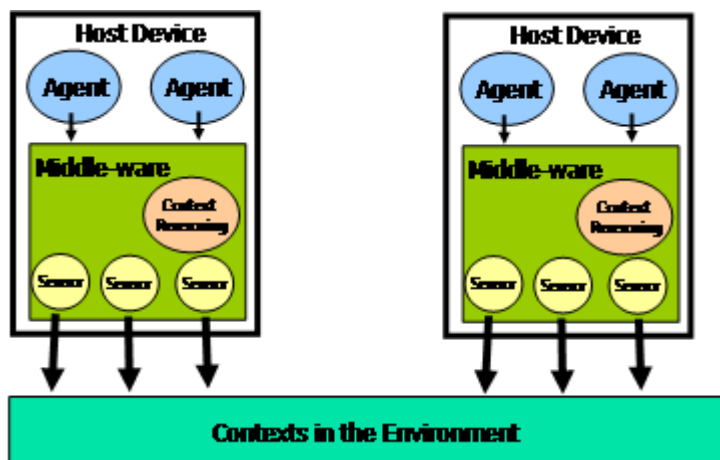


Table 2: Different Approaches to Support Context-Aware Systems

| | Direct Sensors Access | Facilitated by Middle-ware |
|--------------------------------|-----------------------|----------------------------|
| Microsoft Cassiopeia E-105E | X | |
| XeroxPARC Active Badge Apps | X | |
| Video Streaming App. (Odyssey) | | X |
| Context Toolkit | | X |
| MIT Intelligent Room | X | X |
| Context Architecture Broker | | |

CONCLUSION

Building context-aware systems can be difficult and costly using the existing architecture because it has very minimal information sharing , limited reuse of context reasoning and No explicit support for privacy protection.

Context Broker Architecture consist of Limited resources in mobile devices , Lack of reusable context-aware mechanisms and Privacy issues in accessing user information. we propose the use of context knowledge to improve energy efficiency of sensing applications running on smartphones.

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