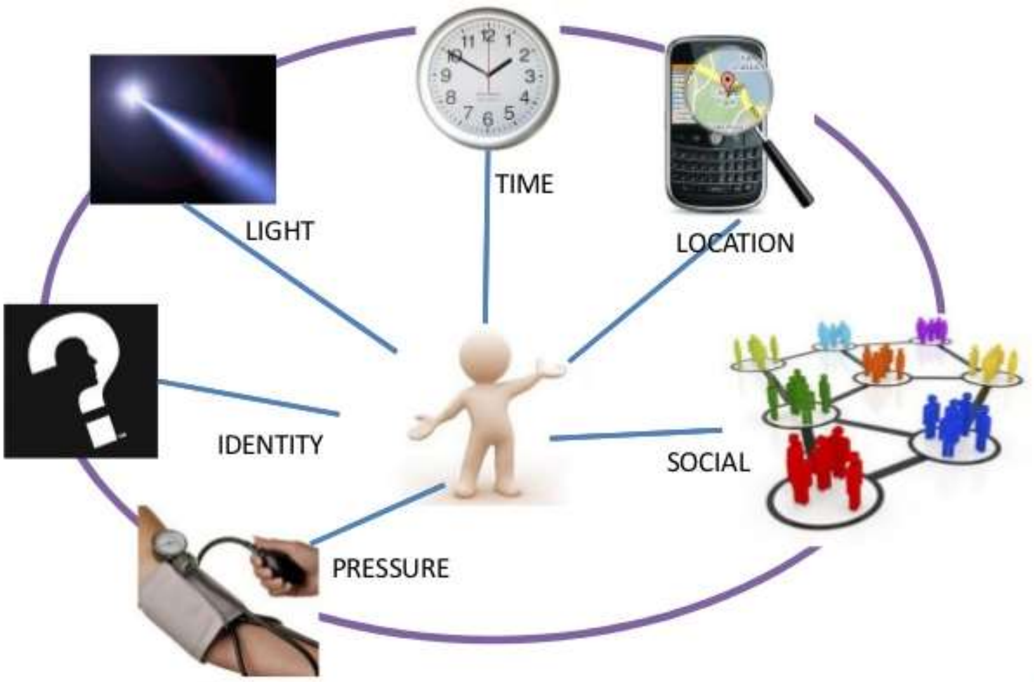
Chapter Eight

LOCATION & CONTEXT AWARENESS



Content of Lecture Eight

Chapter Eight

8.Location and Context Awareness

8.1Introduction

Context-aware services is **a computing technology which incorporates information about the current location of a mobile user to provide more relevant services to the user**[1]. An example of a context-aware service could be a real-time traffic update or even a live video feed of a planned route for a motor vehicle user. Context can refer to real-world characteristics, such as **temperature, time or location**. This information can be updated by the user (manually) or from communication with other devices and applications or sensors .Because of the mobile mobility hence location changing, application should adapt themselves based on the updated information of its actual location .Location is an example of context, that is, information about people or devices that can be used to modify the way system provides its services to the user community [1]. The use of location information to infer user intent based on location and previous user actions can enrich the capabilities of mobile use . **A major problem** in context-based systems is making sure that computers interpret sensor data correctly. Indeed, uncertainty in interpretation cannot be tackled simply by increasing sensor accuracy. It arises when alternative interpretations of sensor readings are possible, each carrying a certain amount of uncertainty. Let us consider a wrist accelerometer telling a software monitoring system that a person's body is rapidly accelerating downward. While the acceleration can be measured very accurately, there is no way to decide with absolute certainty whether the person rearing the accelerometer is falling down, or is simply crashing on her bed or on her favorite sofa. Still, interpretation errors may bring a software system to making the wrong decision.

8.2 Context-Aware Systems Architecture

A general abstract layer architecture of context-aware systems is presented ,consisting in four layers:

1.Network Layer

involves a network supporting context-aware systems and sensor collecting low-level of context information

2.Middleware Layer

manages processes and stores context information

3.Application Layer

provides users with appropriate service

4.User Infrastructure Layer

manages the interface of context-aware systems to offer suitable interface to users.[5]

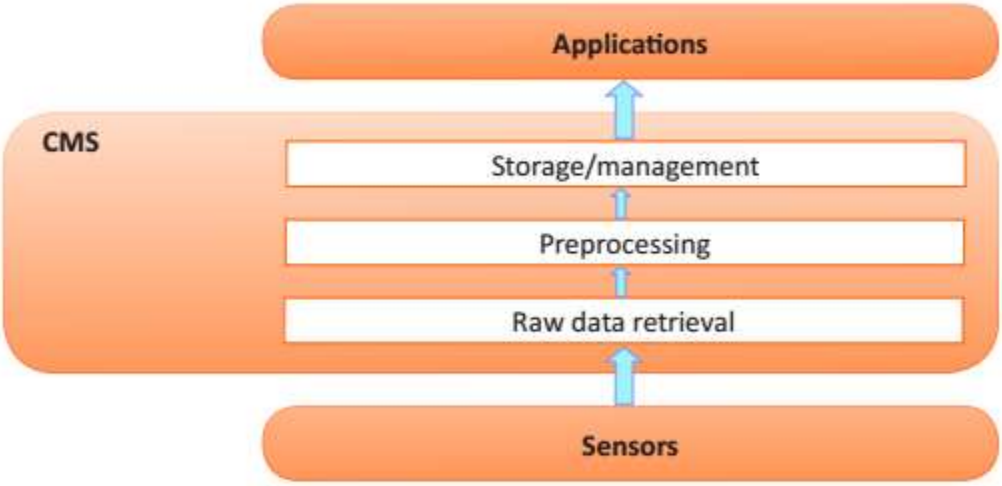


Figure 8.1 Layered framework for context-aware systems

8.3Context-aware Featuresre: identified three features that a context-aware application can support: presentation, execution, and tagging

• Presentation: Context can be used to decide what information and services need to be presented to the user. Let us consider a smart [22] environment scenario. When a user enters a supermarket and takes their smart phone out, what they want to see is their shopping list. Context-aware mobile applications need to connect to kitchen appliances such as a smart refrigerator [90] in the home to retrieve the shopping list and present it to the user. This provides the idea of presenting information based on context such as location, time, etc. By definition , IoT promises to provide any service anytime, anyplace, with anything and anyone, ideally using any path/network

• Execution: Automatic execution of services is also a critical feature in the IoT paradigm. Let us consider a smart home [22] environment. When a user starts driving home from their office , the IoT application employed in the house should switch on the air condition system and switch on the coffee machine to be ready to use by the time the user steps into their house. These actions need to be taken automatically based on the context. Machine-to-machine communication is a significant part of the IoT.

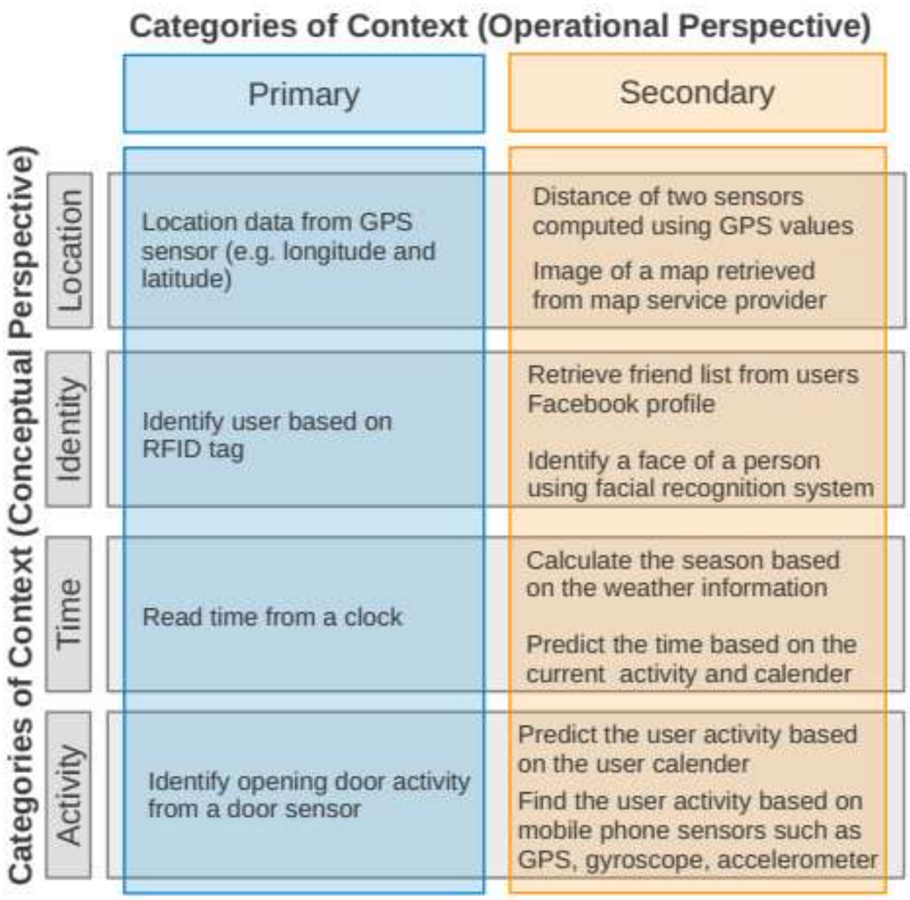
• Tagging: In the IoT paradigm, there will be a large number of sensors attached to everyday objects. These objects will produce large volumes of sensor data that has to be collected, analyses, fused and interpreted [91]. Sensor data produced by a single sensor will not provide the necessary information that can be used to fully understand the situation. Therefore, sensor data collected through multiple sensors needs to be fused together. In order to accomplish the sensor data fusion task, context needs to be collected. Context needs to be tagged together with the sensor data to be processed and understood later. Context annotation plays a significant role in context-aware computing research. We also call this tagging operation as annotation as well.

8.4Context Types and Categorisation Schemes

They identified location, identity, time, and activity as the primary context types. Further, they defined secondary context as the context that can be found using primary context. For example, given primary context such as a person's identity, we can acquire many pieces of related information such as phone numbers, addresses, email addresses, etc. However, using this definition we are unable to identify the type of a given context. Let us consider two GPS sensors located in two different locations. We can retrieve GPS values to identify the position of each sensor. However, we can only find the distance between the two sensors by performing calculations based on the raw values generated by the two sensor. The question is, 'what is the category that distance belongs to?' 'is it primary or secondary?' The distance is not just a value that we sensed. We computed the distance by fusing two pieces of context. The above definition does not represent this accurately. Thus, we define a context categorization scheme (i.e. primary and secondary) that can be used to classify a given data value (e.g. single data item such as current time) of context in terms of an operational perspective (i.e. how the data was acquired). However, the same data value can be considered as primary context in one scenario and secondary context in another. For example, if we collect the blood pressure level of a patient directly from a sensor attached to the patient, it could be identified as primary context. However, if we derive the same information from a patient's health record by connecting to the hospital database, we call it secondary context. Therefore ,the same information can be acquired using different techniques. It is important to understand that the quality, validity, accuracy, cost and effort of acquisition, etc. may varied significantly based on the techniques used. This would be more challenging in the IoT paradigm, because there would be a large amount of data sources that can be used to retrieve the same data value. To decide which source and technique to use would be a difficult task. We will revisit this challenge in Section VI. In addition, a similar type of context information can be classified as both primary and secondary. For example, location can be raw GPS data values or the name of the location (e.g. city, road, restaurant). Therefore, identifying a location as primary context without examining how the data has been collected is fairly inaccurate

- **Primary context:** Any information retrieved without using existing context and without performing any kind of sensor data fusion operations (e.g. GPS sensor readings as location information).

- **Secondary context:** Any information that can be computed using primary context. The secondary context can be computed by using sensor data fusion operations or data retrieval operations such as web service calls (e.g. identify the distance between two sensors by applying sensor data fusion operations on two raw GPS sensor values). Further, retrieved context such as phone numbers, addresses, email addresses, birthdays, list of friends from a contact information provider based on a personal identity as the primary context can also be identified as secondary context.



8.4.1 context is divided in the following four categories

- **Computing context**

includes network connectivity ,communication costs, communication bandwidth, and nearby resources (e.g. printers, displays, and workstations).

- **User context**

includes the user's profile, location, people nearby, the current social situation.

- **Physical context**

includes lighting, noise levels, traffic conditions, and temperature.

- **Time context**

includes time of a day, week, month, and season of the year.

8.5Context-Aware Computing Application

Context-aware applications look at the who's, where's, when's and what's (that is, what the user is doing) of entities and use this information to determine why the situation is occurring. An application doesn't actually determine why a situation is occurring, but the designer of the application does. The designer uses incoming context to determine why a situation is occurring and uses this to encode some action in the application. For example, in a context-aware tour guide, a user carrying a handheld computer approaches some interesting site resulting in information relevant to the site being displayed on the computer[1]. In this situation, the designer has encoded the understanding that when a user approaches a particular site (the 'incoming context'), it means that the user is interested in the site (the 'why') and the application should display some relevant information (the 'action'). There are certain types of context that are, in practice, more important than others. These are location, identity, activity and time.

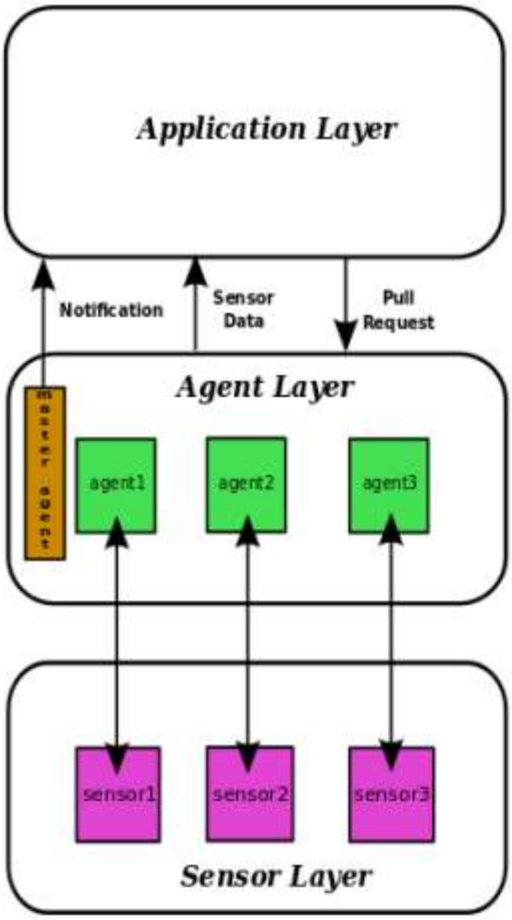


Figure **8.2Context aware mobile application architecture**

- A system is a Context-Aware if it uses a context to provide relevant information and/ or services to the user, where the relevancy depends on the users task.

- E.g. smart phones screen goes brighter when exposed to light (using photo sensors), and goes dimmer on low batter

8.5.1 Structure of a context-aware application

Applications which adapts to the context in which they are used is an interesting concept for improving the experience of one user. Context Aware adaptable applications are introduced. For such applications two different paradigms exist[4] :

- **Self-adaptive application**

refers to applications able to capture the context and modify their behavior . The activity of the application can also participate in the modification of the context, making the whole system working in nested loops. In such a paradigm, there is no separation of concerns between capture of the context and adaptation, which makes maintainability and thee volition of the application more difficult.

- **Supervised adaptation**

relies on a platform inserted between the application and the context. The architecture of the system is the following a platform accesses to the context and allows the application to consult it. In such a system both the platform and the application are adaptable

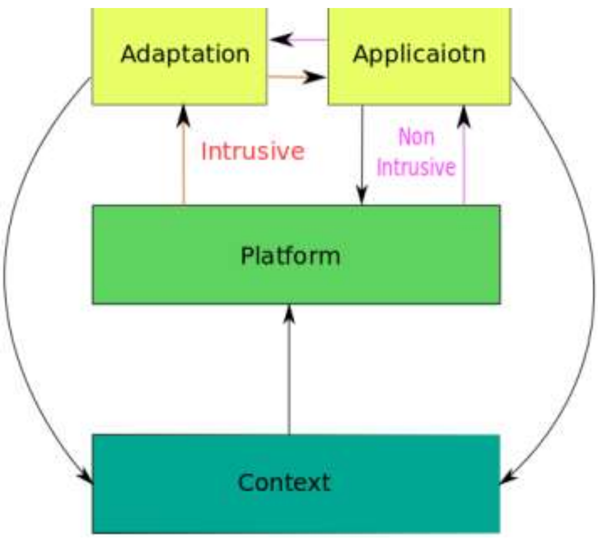


Figure **8.3Supervised adaptation**

The platform can participate to the adaptation process in two different ways

- **A non- intrusive way**

The platform monitors the context and send notifications to the application and the later performs its adaptation itself.

- **An intrusive way**

The platform monitors the context and modifies the application. These modifications are monitored by the application.

8.6Challenges and future trends

Although actual mobile phones have good computational performances and robust sensors, making them an interesting tool for context sensing and context inference ,they are still many challenges which need to be faced. The most important one is the power consumption. Sensing data and making computations in real-time consume a lot of battery.[5]

In order to face with this problem, several approaches are possible :

- Work in [OY] suggest to compress the data, which helps in reducing the amount of data to be processed on the phone or transferred to further location.

- A new trend consists in using mobile cloud this is motivated by the limitation of processing power and data storage in mobiles devices. Computationally expensive and resource demanding tasks are transferred to the cloud ,but this requires an always on connectivity, which is also power consuming. In [OY] the authors also pointed out that with a cloud architecture security

- Another research area is in the framework design [OY], a balance has to be found between accuracy in context-sensing and power consumption during data processing. The framework of the future should decrease the amount of redundant computational operations (via basic signal processing) by not letting go further power consuming processing of data which are not bringing new changes in the context inference.

8.7Context-Aware Recommender Systems

Context-Aware Recommender System (CARS) aim to provide better recommendation by exploiting contextual information (e.g. weather)

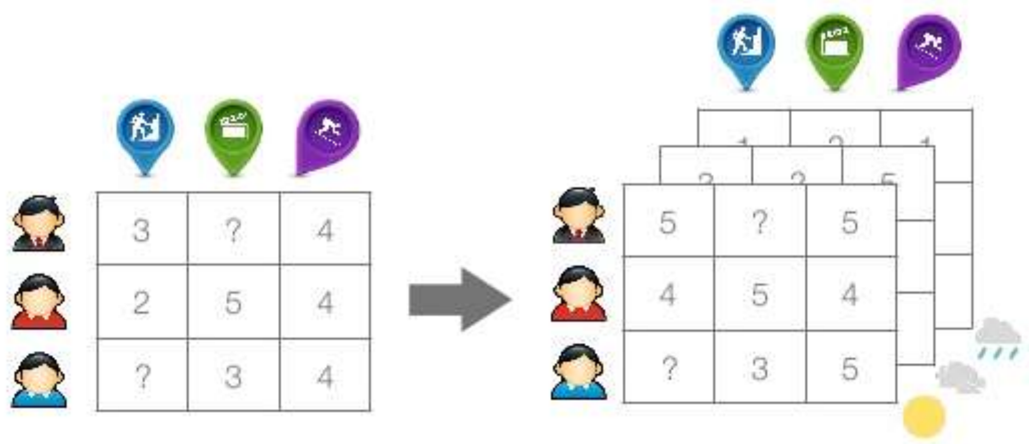


Figure 8.4Context-Aware Recommender Systems (CARS)

8.8Multi-Sensor Based Context-Awareness

The combination of comparatively simple sensors is an interesting alternative to the use of single powerful sensors a sin position- and vision-based systems. The combination of multiple diverse sensors that individually capture just a small aspect of an environment may result in a total picture that better characterizes a situation than location- or vision-based context. The rationale for our approach is to advance beyond location-based systems to achieve awareness of context that cannot be inferred from position, and we see the diversity of sensors as key[2]. Table 1 lists a few examples of how situation sand data from different sensors may relate[4].

Table 2Real world situations related to sensor data

Situation	Sensor data
User sleeps	It is dark, room temperature, silent, type of location is indoors, time is "night-time", user is horizontal, specific motion pattern, absolute position is stable.
User is watching TV	Light level/color is changing, certain audio level (not silent), room temperature, type of location is indoors, user is mainly stationary.
User is cycling	Location type is outdoors, user is sitting, specific motion pattern of legs, absolute position is changing.

There are multiple sensors; they each only have to contribute a part to the whole picture. This means that preprocessing of sensor data will be more focused than for example in vision, where substantially more processing is required to derive information from just a single data source. Figure 1 illustrates the difference between use of one generic sensor and use of multiple simple sensors.

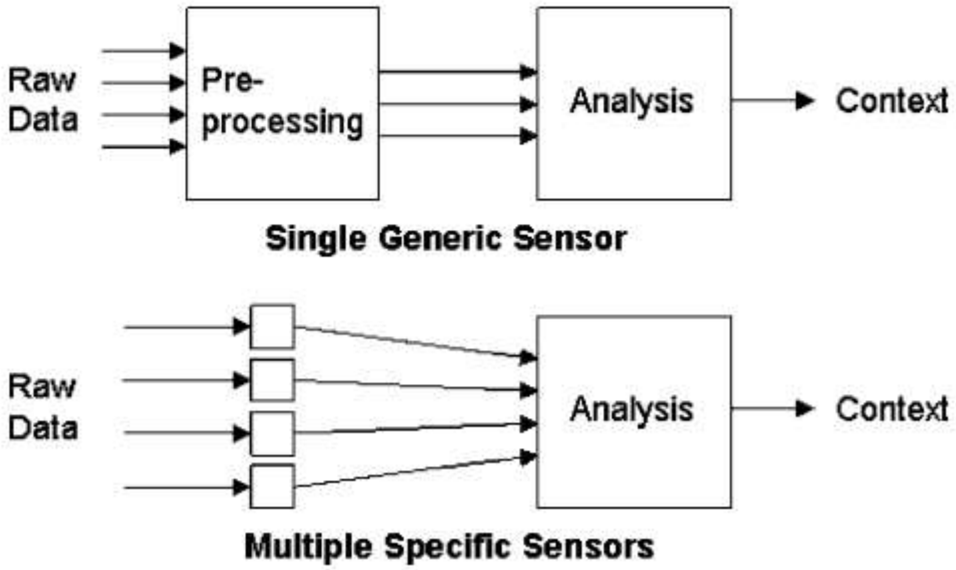


Figure 8.5 Use of a single generic sensor versus multiple specific sensors for context-awareness

The multi-sensor context-awareness may be applied in conjunction with mobile devices and artifacts:

8.9An example of multiple sensing context awareness is :

8.9.1Technology Enabling Awareness (TEA)

The TEA project introduces a three layer approach to abstracting and representing context information. The lowest layer is the sensors itself, captures raw data from a set of heterogeneous sensors[1]. The proceeding layer represents the functionalities of each sensor in terms of functional cues. The third layer, context layer, aggregates the cues from various sensors to suggest the context. context is said to be made up of one or more cues from the various sensors that are capturing the environment[3].

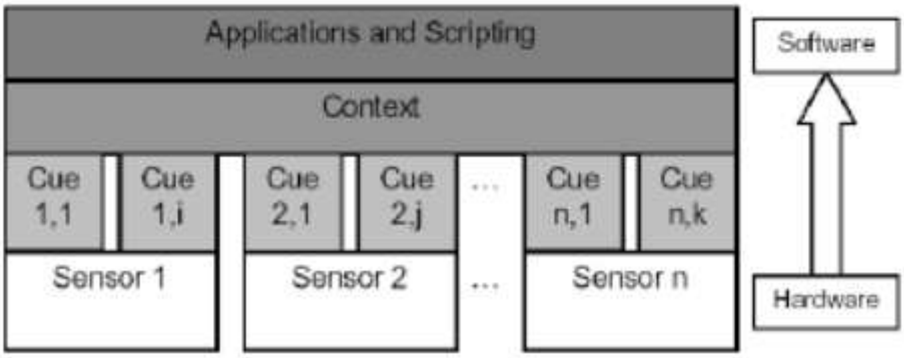


Figure **8.6TEA architecture**

8.9.2 Mediacup

The Media cup is an ordinary coffee mug that is augmented with hardware and software for sensing, processing and sharing context. The Media cup has evolved through several design iterations, resulting in the implementation shown in figure 11.6. The design challenge was to integrate multi-sensor awareness technology and communication without compromising properties and use of the cup, for instance avoiding noticeable changes in shape, size and weight. The Media cup hardware is based on circular board design to be fitted into the base of the cup. The components integrated on the Media cup board are controlled by a PIC16F84 microcontroller with 1 MHz, 15K memory for code, 384 byte RAM for data.[3]

Figure 8.7Mediacup

8.10Location Awareness

One of the unique features of mobile applications is location awareness. Mobile users take their devices with them everywhere, and adding location awareness to your app offers users a more contextual experience. The location APIs available in Google Play services facilitate adding location awareness to your app with automated location tracking, geo fencing, and activity recognition.

Many context-aware technologies give a huge importance to location, but location is just one aspect of context, not the context. Location awareness can improve user experience, but knowing a user's preferences and specific environment makes it all the more personal and all the more powerful. Mobile apps and devices can tap into this information, as can add platforms, to create relevant experiences for consumers. Location is certainly important, but it's just one piece of the puzzle. On the business side, mobile ad platforms can use your location to serve ads, but they can become more targeted through user profiling. Here too, location is just one tool at their disposal. Immobile, a mobile ad network uses context-aware technology to create "SmartAds" which exploit a user's immediate environment to trigger relevant ads. For instance, a user checking the weather on a hot summer day might see an ad for a cold drink or an air conditioner; conversely, on a snowy day, that same user might see an for a hot drink or winter boots.

Location awareness is a component of presence technology that delivers information about a device's physical location to another user or application. The term is most often used in reference to mobile communication devices and cameras but it can also refer to websites that request a user's zip code to deliver targeted information. A device's location is usually determined by one of three methods: by GPS satellite tracking, by cellular tower triangulation, or by the device's media access control (MAC) address on a Wi-Fi network.

Location awareness is a growing trend in hardware and software. **Here are a few of the current applications:**

- ✓ Camera memory cards that automatically tag the location of a picture.
- ✓ Application programs (apps) on smart phones.
- ✓ GPS systems in vehicles.
- ✓ Supply chain management (SCM).
- ✓ Healthcare device management.

As location awareness becomes more prevalent, so do concerns about privacy and security. The IETF has a working group, Geographic Location/Privacy to explore ways to safeguard users while furthering the technology.

Figure 8.8Location Awareness

8.10.1 Location Sensing Techniques

- **Proximity**

  A proximity location sensing technique **determines the object' s location when it is near known location.** The one of the approach is to monitor when a mobile device is in range of one or more access points in a wireless cellular network. COO will be explained as an example.

- **Triangulation**

  Triangulation can be subdivided by **late ration** and **angulation**. late ration uses distance for determining the position, while angulation uses angles .To measuring the distances required by the late ration technique usually uses time off light and attenuation and the attenuation. Time of flight means that with known velocity we can measure the time it takes to travel between the object and point P. For the attenuation, the intensity of an emitted signal decreases as the distance from the emission source increases. In environments with many obstacles such as an indoor office space, attenuation is less accurate than time of flight. Angulation uses angles instead of distances. A constant reference vector like magnetic north is chosen as 0°. TOA and AOA will be explained as the one of the examples.

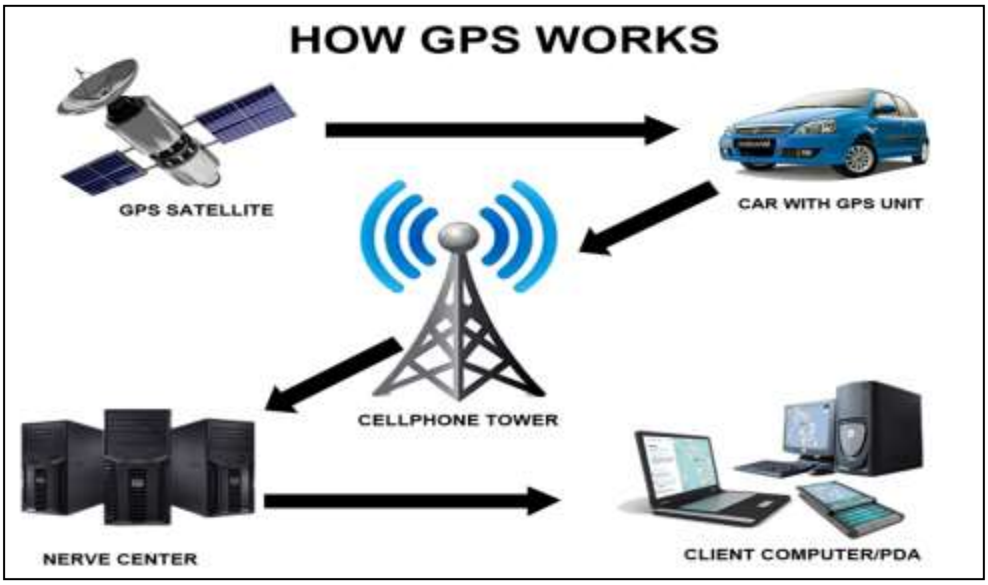
- **Scene Analysis**

  The scene analysis location sensing technique uses features of a scene observed from a particular area to analyze and compare the location of the objects in the scene. The observed scenes are simplified to obtain features that are easy t represent and compare. One way of doing this is to having predefined dataset for the certain area and map the observed scene to it. LPM is the example of the method.

The most well-known location sensing system today is GPS. GPS-enabled devices can obtain latitude and longitude.

➢ Global Positioning System (GPS)

While the methods that we have looked at so far are network based, which is that the location calculation is performed at network, GPS is mobile device based. Here is how .Wireless subscriber must use a device specially equipped with GPS receiver to make a signal of current location. Either continuously or when a signal is placed, the GPS receiver determine the device's latitude and longitude using data such as distance and orbital map received from at least three satellites. The receiver can use this information



8.11 An Awareness Device for Experimentation

For experimentation with multi-sensory context-awareness, we built an Awareness Device with both hard and software components. Basic signal processing is done in hardware, while cue generation, calculation of contexts, and script execution is done in software. The implementation that we describe is a first prototype design, focused on data acquisition, rather than elegant processing. The first hardware platform simply samples sensor data and packages it into a digital signal that can be transferred to a standard portable computer for further processing. The data collection unit was designed to allow experimentation with a greater number of possibly relevant sensors, although it is anticipated that some of the used sensors may not be relevant for awareness of investigated situations. The data traverses the system through four major blocks: the sensors, the analog-to-digital converter, the microcontroller, and the serial line. The sensors measure conditions in the environment and translate them to analog voltage signals on a fixed scale. These analog signals are converted to digital signals and passed to the microcontroller. The microcontroller oversees the timing of the analog-to-digital converter and the sensors, and converts the data from the analog-to-digital converter's bus to the serial line. Finally, the serial line connects to a host computer for further processing, see Fig. 11.4.

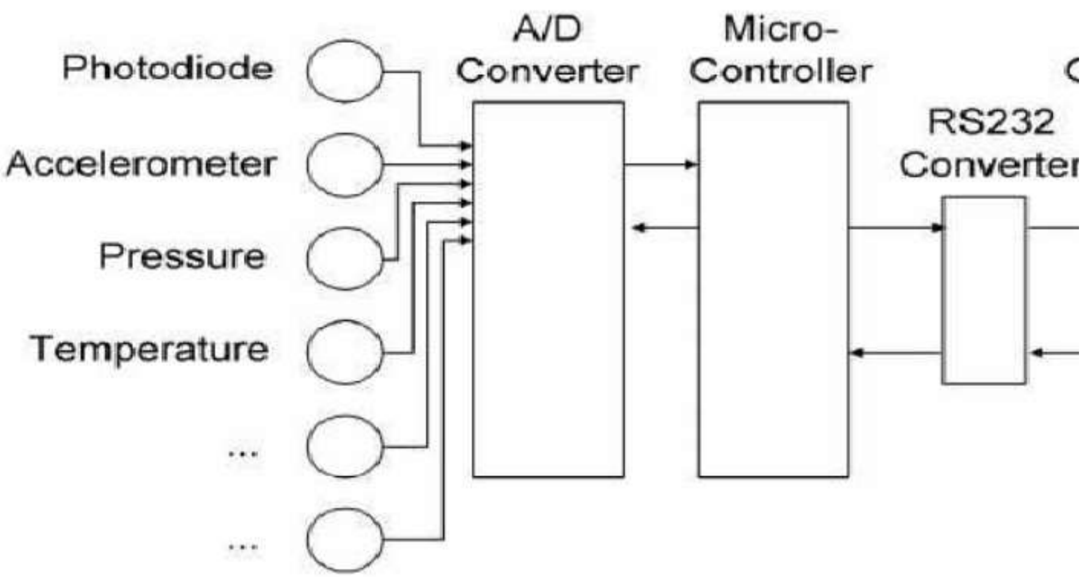


Figure 8.9 Schematic of the Awareness Device

8.12 context-aware applications

8.12.1*Application in health care*

Context-aware mobile agents are a best suited host implementing any context-aware applications. Modern integrated voice and data communications equips the hospital staff with smart phones to communicate vocally with each other, but preferably to look up the next task to be executed and to capture the next report to be noted.

However, all attempts to support staff with such approaches are hampered till failure of acceptance with the need to look up upon a new event for patient identities, order lists and work schedules. Hence a well suited solution has to get rid of such manual interaction with a tiny screen and therefore serves the user with

- automated identifying actual patient and local environment upon approach,
- automated recording the events with coming to and leaving off the actual patient,
- automated presentation of the orders or service due on the current location and with
- supported documentation to provide such qualities for EHR

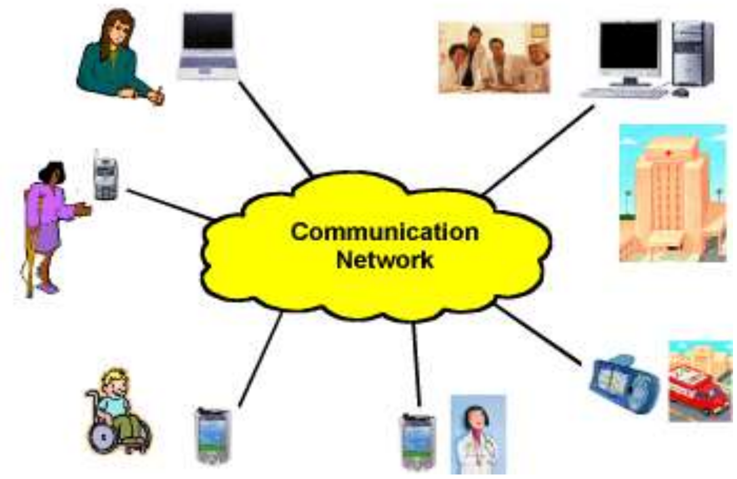


Figure 8.10 Telemedicine scenario

8.12.2 *Applications in pervasive games*

A pervasive game is leveraging the sensed human contexts to adapt game system behaviors. By blending of real and virtual elements and enabling users to physically interact with their surroundings during the play, people can become fully involved in and attain better gaming experience. For example, a pervasive game that uses the contexts of human activity and location in smart homes is reported by an autonomous agent.

References

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