

# An Adaptable Location-Based Service Framework Using Automatic Identification

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## ABSTRACT

This project uses automatic identification (AID) technology to build an adaptable location-based service. The system allows an AID-equipped subject to be tracked within a set area, making him readily accessible to anyone, and giving him access to remote services which will be automatically made available to the access point nearest to his current physical location. This allows for high availability of the service. The system is general-purpose and has a broad-spectrum, making it adjustable for several specific applications. The applicability and practicality of the project will be demonstrated as a localized telephony service which makes use of Voice over IP (VoIP) technology.

## Keywords

Automatic Identification, Location-based Service, Telephony

## 1. INTRODUCTION

### 1.1 Background and Problem

In today's fast-paced world, it has become a necessity to find ways to make even the most common procedures more efficient, especially those related to communication and the transfer of information. [5]

The telephone has become an indispensable instrument in the daily performance of business, allowing one person to communicate with another over large distances. However this technology is limited in that one person can only call another based on their location. The telephone number that one dials indicates a specific location and not an individual person. The caller dials with the assumption that the desired person is at the supposed location. If the target person happens to be at an alternative office, for instance, he cannot be reached.

A visualization of the dilemma is displayed in Figure 1. The caller wishes to contact the male office worker, who usually works in Office A. Accordingly, the caller dials the number for the telephone in Office A. However, the target person happens to be in Office B. The result: The telephone in Office A rings, no one is there to answer it, and the target person cannot be contacted.

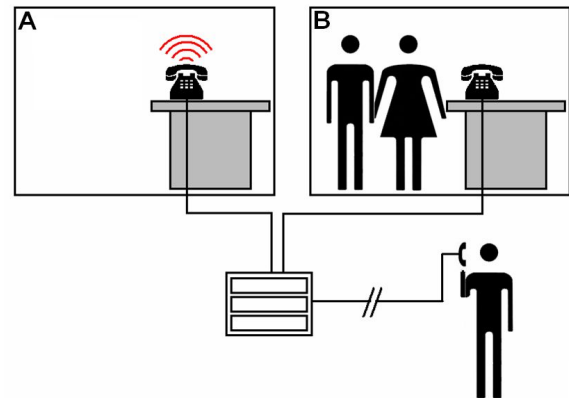


Figure 1. A traditional telephony system. The caller tries to contact the male office worker, who currently happens to be in another office.

In this regard, the recent trend has been towards making devices mobile. [10] The cellular phone provides a partial solution to the problem by maintaining a 1:1 ratio between phone and person, with the phone number identifying the individual. The downside to this, however, is that cellular phone use is significantly more costly than use of a landline telephone. One must also be inconvenienced with the necessity of continuously carrying the phone with them, and this can become a burden. [5] Furthermore, communication through cellular phone is often seen as informal and reserved for personal contacts, not for professional and business use.

The advantages of both landline and mobile phone technology have provided invaluable benefits to communication. [10] Ultimately, the shortcomings of these technologies call for an alternative system that can provide all of their advantages while eliminating their limitations.

### 1.2 Context

In the development of such a system, two technologies in particular that will be utilized are automatic identification (AID) and voice-over IP (VoIP). Several technologies for automatic identification may be used for the system, such as radio frequency identification or the Bluetooth wireless

protocol.

### *1.2.1 Automatic identification*

Automatic identification, or AID, is a generic term for a set of technologies that are used to uniquely identify people or objects automatically. This includes barcode scanning, radio frequency identification (RFID), card scanning, fingerprint and retinal scanning, and voice recognition, among others. [3]

The ideal AID technology for the proposed system is radio frequency identification. RFID is a term that describes technologies that use radio waves to automatically identify people or objects. There are several methods of identification, but the most common is to store a serial number that identifies a person or object, and possibly other information, on a microchip that is attached to an antenna. The chip and the antenna together are called an RFID transponder or simply an RFID tag. This device is a small object, such as an adhesive sticker. The smallest commercially available tags can be thinner than a sheet of paper. The antenna enables the chip to transmit the identification information to a reader. The reader converts the radio waves reflected back from the RFID tag into digital information that can then be passed on to computers that can make use of it. [15]

This technology is the ideal method of identification for the locating system due to its being non-contact and not requiring line-of-sight, thus allowing a user of the system to simply carry an RFID tag and not have to be inconvenienced in making himself identified. The tag may be carried on ID card, or even implanted into the skin. RFID vendors tout the technology as being the only “truly automatic” AID technology. [1]

However, while the prices of RFID equipment have dropped considerably in recent years, the cost may still be too high to implement a system with a small number of users. Although the costs of the RFID tags themselves are affordable, the base station reader is prohibitively expensive, especially for a system that requires several readers.

An alternative technology that may be used is the Bluetooth wireless protocol. Bluetooth provides a way to connect and exchange information between devices like personal digital assistants (PDAs), mobile phones, laptops, PCs, printers and digital cameras via a secure, low-cost, globally available short range frequency. Bluetooth allows these devices to communicate within 10 meters of each other. [11]

USB Bluetooth adapters (commonly called dongles) are commercially available, and as of 2005, far more affordable than RFID readers. Bluetooth-enabled devices are popular, but far more expensive than RFID tags. For a demonstration

system with a small number of users, Bluetooth is still a more practical solution.

### *1.2.2 Voice over IP*

Voice over IP (VoIP), also known as internet telephony or IP telephony, is a technology that makes it possible to have telephone conversations where signals are carried over a network, using Internet Protocol (IP) packets, instead of traditional dedicated voice transmission lines. This system eliminates the need for circuit switching and instead routes calls using packet switching, thereby eliminating the additional costs and the waste of bandwidth associated with circuit switching. When packet switching is used, IP packets with voice data are sent only when data needs to be sent, i.e. when someone is talking.

VoIP technology has several benefits that give it an advantage over traditional telephony. Costs per call are lower, especially for long-distance calls. Infrastructure costs can be kept to a minimum, as little or no telephony equipment is needed once IP infrastructure is installed. Future hardware upgrades can be avoided, as functionality is protocol based and only requires updates of software.

Pure VoIP systems are rare, used particularly in a few office environments. [16] However, telecommunications providers often use VoIP over a dedicated IP network to connect between switching stations. This system converts the dedicated voice signal into IP packets, then back again.

VoIP is another technology to only recently gain popularity. There are still issues, such as latency and possibly data integrity problems for long distances, that continue to hinder it from being accepted for widespread use, but it is nonetheless a very good solution, especially for small, localized networks. [16]

### *1.2.3 Location-based service*

Location-based service (LBS) is an emerging technology, particularly significant to mobile network operators. One of the most powerful ways to personalize mobile services is based on location. [4]

One component behind the workings of LBS is positioning, the most widely recognized system being the Global Positioning System (GPS). Additionally, other means of positioning exist such as network based positioning, which relies on various means of triangulation of signals from various cell sites that serve a mobile phone. Alternatively, the serving cell site may be a broad indicator of the user's location.

Despite its apparent practical uses, development in the field of location based services as of 2004 seems to be driven more by technical ability than actual user need. [4]

### 1.3 Motivation

In large office environments where one person may move from one room to another spontaneously, a traditional telephony system is limiting as it can only identify a location rather than an individual. Traditional telephony may in fact limit the mobility of a person in the environment. An efficient system must be developed that eliminates the need to know a person's location but makes him available over telephone communication in such an environment.

### 1.4 Objectives and Scope

The aim of the project is to make communication in a local area more efficient by allowing each person to be readily accessible wherever that person is, without the cumbersomeness of mobile devices. Localized telephony, as a key service that would benefit much from such a system, will be used as a keystone demonstration of the project. This system will make it possible to call a person without having to know which room he is currently in. A caller would only need to know the contact number of the person he wishes to contact. When that number is dialed, the system will determine the location of the person being contacted, and the base station closest to that person will alert him of the call. This system would be ideal in large workplaces, where people move around freely. The aim of this system is to save time and efforts spent on locating people, and also afford more mobility.

In achieving the fulfillment of these objectives, the locating system will be implemented in a definite area within the Ateneo de Manila University campus. A general framework for the lookup service and for adding extensions for it will be developed. As a demonstration of the applications of the system, the project will also include the IP telephony service.

### 1.5 Limitations

Although radio frequency identification is the ideal automatic identification method for the proposed system, it may be rendered unavailable due to the prohibitively expensive cost of the hardware. In the event that it is not possible to obtain RFID hardware, alternative methods of identification will be explored, such as Bluetooth technology.

## 2. RELATED WORKS

VoIP technology is a rapidly expanding field with several components currently being developed, and existing VoIP technology being deployed at a rapid pace. One application is **Free World Dialup**, a non-commercial VoIP network that allows users to make free telephone calls to other Free World Dialup users. [7] It also allows limited connections to the public-switched telephone network (PSTN). For instance, it is possible to use Free World Dialup to dial toll-free numbers in certain parts of the world, and to receive

calls from the PSTN via gateway numbers.

One limitation of this system, however, is that it requires a constant broadband internet connection in order to operate. Many services will simply not work at lower speeds, such as dial-up internet connections. When a computer is turned off or disconnected from the internet, users cannot make or receive calls from that location.

The proposed VoIP telephony service will be implemented only at locations with high-speed network access, and an assumption must be made that a computer is on with internet access when a user of the system is at a base station.

In one example of AID technology being used to track the location of humans, the school district of Spring, Texas has adopted radio frequency identification as a means for **tracking the arrival and departure of students on school buses**. [12] Upon being scanned, the information of the students' identity and location are transmitted to school administrators and local authorities. This system was implemented in a school district of 28,000 students, and intended as a means for parents to be assured that children were safeguarded against kidnappings. The system initially had errors, however, as the RFID base stations occasionally failed to register some students, or registered those who were not there.

Another possible concern for the system was human error and mischief, such as children forgetting or losing their RFID cards, or even trading cards to virtually swap identities.

In spite of these difficulties, parents and teachers were generally pleased with the system and other school districts expressed interest in implementing similar structures.

One location-based service that has proliferated is **dialing for emergency services on mobile phones**. Dialing 9-1-1 from a mobile phone in the United States activates a location based emergency service application which pinpoints your location and relays the call to the nearest appropriate authorities. The system has been largely successful in the United States, and the Federal Communications Commission (FCC) has made it mandatory that wireless carriers in the country must provide a certain degree of accuracy in locating users who dial 9-1-1.

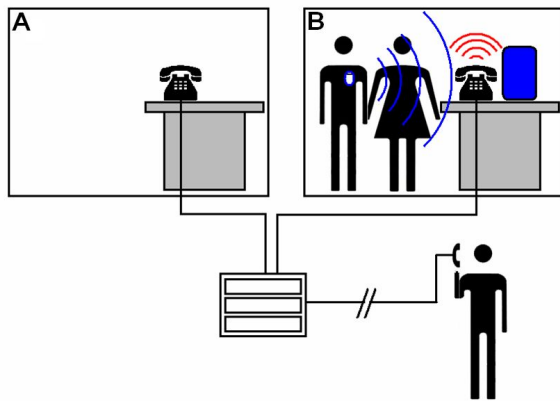
This emergency dialing system is to some extent the reverse of the VoIP location-based telephony service. Instead of basing the target of the call on the location of the caller, the proposed system will base the target of the call on the location of the person desired to be reached.

### 3. METHODOLOGY

#### 3.1 Project Description

The primary deliverable of this project is the **adaptable Locator Service** which actively registers the locations of each of the system's AID-equipped subjects in order to make them readily available to whatever particular service the system is adapted to. Additionally, it includes a lookup service and a general framework for query and for adding extensions.

As a primary demonstration of the system's practicality, the system includes a localized telephony service using VoIP and making use of the Locator Service. This telephony system makes it possible to call a person without necessarily knowing what room he is currently in.



**Figure 2. The location-based telephony service. An AID transponder notifies the system of the person's location, and the appropriate telephone rings.**

A demonstration of the functionality of the localized telephony system can be seen in Figure 2. The caller wishes to contact the male office worker, who can usually be found in Office A. However, the target person currently happens to be in Office B. Instead of dialing the number of the telephone in Office A, the caller dials the number that uniquely identifies the male office worker. The automatic identification system informs the system of the target person's location, and the call is forwarded to the base station in Office B. Clearly, the dilemma found in Figure 1 has been resolved.

The locating system will be implemented in an area within the Ateneo de Manila University campus

#### 3.2 Architecture and Design

The Location Service is made up of two distinct components: the locating system, and the lookup service. The **locating system** keeps a record of the locations of subjects, while the **lookup service** waits for requests for subjects and supplies information regarding the subjects' current location. With these components in place, the system is applied to create a localized **telephony service**

which makes use of Voice over IP technology as a practical demonstration of the system.

##### 3.2.1 The Locating System

The physical setup of the locating system consists of the following components:

- the IP network
- the AID transponder
- the AID reader
- the centralized tracking server

The local area network (LAN) must have a high-speed data transfer rate adequate the service applications to be used (i.e. IP telephony). The computers are assumed to be always-on with consistently active network connection or at least active when the user of the system is within range of these base stations.

The tracking procedure is as follows: AID readers are installed in selected spots (known as "base stations") in the area covered by the system; each uniquely identified and connected to the network. AID transponders, each with a unique identification number, are given to the subjects who will use the system, all of whom are registered with the tracking server. The server keeps and maintains a lookup table that keeps track of the assignments, in order to be able to identify each identification number with its corresponding carrier.

As the subjects move throughout the area covered by the system, the AID readers in the base stations detect which transponders are in its range and relay this information on to the tracking server at regular intervals. More than one transponder may be at each base station. It is also possible that a registered transponder may not be found at any of the connected base stations. Each connected reader in the base stations is identified with its corresponding location. The server acts as the centralized record keeper, maintaining a table of subjects and their current locations.

##### 3.2.2 The Lookup Service

The lookup service waits for requests for subjects, transmitted over the network. For each request received, it queries the locating system for the communications access point corresponding to the subject's current location, and then returns the location of the access point found.

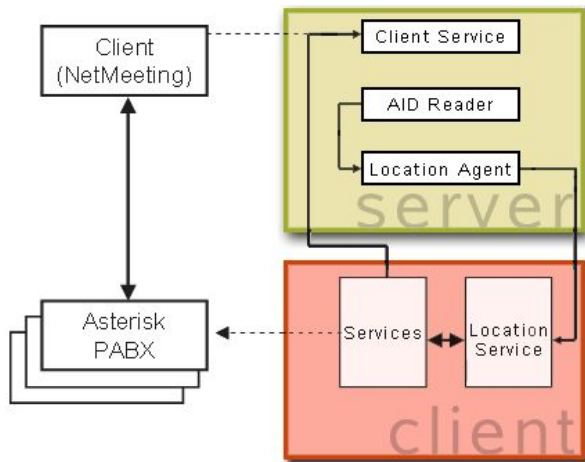
##### 3.2.3 Service Applications

There is a wide variety of applications that can make use of the system. Practical applications would often include some sort of information transfer, such as an important set of documents or a telephone call. These request types or formats must be properly registered with the lookup service beforehand in order for the service to be properly configured to handle them.

The access point can also be any of a number of devices

capable of receiving the corresponding information, from a PDA to a telephone unit. Again, certain access points will work only for certain kinds of applications, so prior configuration must be made and specialized modules must be written.

*The Localized Telephony Service.* The key application of this system is in high-demand telephony, specifically through VoIP. A local VoIP switching system can be integrated with the lookup service to provide instant accessibility over the phone to any subject, wherever they are in the area. A caller would only need to know the subject's personal contact number, dial it in, and the base station nearest to the subject would ring.



**Figure 3. The client-server structure of the localized telephony service**

The interconnection of modules in the localized telephony service can be seen in Figure 3. The yellow box represents the client side component of the system, while the red box represents the server side component.

When a subject with a transponder comes within range of a reader at a base station, it sends a message to the location agent to inform it of its presence. The location agent then passes a message to the centralized tracking server, which then updates its lookup table with the current location of the subject. This makes the subject available to the applied services – in this case, the telephony service. To make the service available to the subject, the server side of the service (i.e. a VoIP H.323 gatekeeper) talks to the client application (Windows NetMeeting or GnomeMeeting) at the nearest base station.

### 3.3 Implementation

The locating system and lookup service are implemented in Java 2 Standard Edition, version 1.4.1.

Java was chosen as the programming language for the implementation because of ease of development for client-

server applications, as well as its portability between operating systems. Although it was written in a Linux environment, the program runs identically on any other operating systems provided that an equivalent Java Virtual Machine is installed and the appropriate equipment is available. Such portability is necessary because the system is meant to be implemented on top of existing computer networks, and operating systems installed on client computers may vary.

A UML class diagram of the Locating System illustrating the classes and the relationships between them can be seen in Figure 7.

#### 3.3.1 The Client Component

The Client Agent class is the main class for the server component, and should be run at each access station in the system. When a Client Agent is run, it connects to a specified server. By default, it connects to TCP port 1800. All communication between the client and the server is done via Object streams. This means that serialized Message objects encapsulating corresponding information are transferred via the socket connection.

On successfully establishing a connection to the server, the Client Agent goes through a registration procedure, sending and receiving identification and other relevant information in a prearranged sequence, until the Client Agent is registered and acknowledged by the server. As part of this sequence, the client receives a collection of registered subjects, along with their identification and credentials, from the server.

When a Client Agent detects a subject within its proximity via a Proximity Agent, it notifies the server, identifying the subject. Depending on how the Proximity Agent is implemented, the client may prompt for information and credentials for detected but unidentified subjects and inform the server of the new registrant.

#### 3.3.2 The Proximity Agents

The Proximity Agent class is a general class that is meant to be extended to create proximity agents – small applications that are run with the Client Agents at each access point. Proximity agents are meant to notify their respective Client Agents when subjects are in proximity. Each implementation has some way of detecting whether a subject is physically within proximity of its corresponding access point.

The AID system interface is an ideal proximity agent application. Using AID detection, this agent can identify subjects in range and notify the corresponding Client Agent accordingly.

### 3.3.2.1 Proximity Control Panel

For preliminary testing, a simple GUI interface was implemented. The interface consists of a list of registered subjects, to which a user can manually add subjects as well as delete existing subjects, and a button to toggle the status of the selected subject. This interface triggers proximity events and notifies the Client Agent. This implementation was used to simulate subject proximity events while the AID proximity agent was not yet in place. A screenshot is provided in Figure 4.

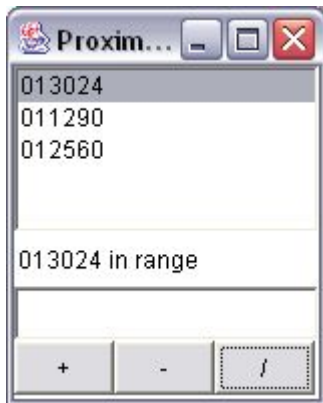


Figure 4. The preliminary Proximity Agent GUI (seen here running with a Client Agent on Windows XP)

### 3.3.2.2 The Bluetooth Proximity Agent

A key component of the project was to develop a functional AID Proximity Agent solution. A Bluetooth implementation is used for the system. The setup requires each access station to be equipped with a Bluetooth adaptor. It uses the BlueZ implementation of the Bluetooth stack, specifically, the Host Controller Interface (HCI) layer functionality, which allows scanning and inquiry of available devices nearby.

Each Bluetooth device has a unique six-octet address. The Location Service can use this address to identify each device as belonging to a subject. Because of this, the system can make use of any device, from headsets to GSM phones. All that needs to be done is to register the device to a holder with the Location Service beforehand.

With the system in place, subjects carrying registered Bluetooth devices are automatically detected when they enter the proximity of an access station. Range depends on the type of equipment used. 10 meters (33 feet) is the standard range for most devices. Only registered devices are used to identify subjects.

As an added feature, when an unregistered Bluetooth device is found in range, the Client Agent displays a graphical prompt for subject credentials and registers the new subject with the server if needed (see Figure 5).



Figure 5. The registration dialog (seen here running on Windows XP)

### 3.3.3 The Server Component

The Location Server class is the main class for the server component. When Location Server is run, it sets up a TCP server socket listening by default to port 1800, then instantiates a ConnectionListener that waits for connections from clients.

The ConnectionListener is a runnable object (meant to be run in a dedicated thread) that continuously waits for socket connections from clients. When it accepts a connection, it notifies the Location Server, which then creates a Client Monitor object to handle the connection. Each registered client is added to a collection on the main Location Server object.

Each Client Monitor is a runnable object that continuously waits for messages from the client it is connected to. Thus, for each client connected to the server, there is one thread on the server side that continuously waits for connections. Each Client Monitor handles the registration sequence with its corresponding client, obtaining identification and other relevant information, and then handles further communication with it.

When notification of subject proximity is received from a client, this information is used to update the lookup table on the Location Server. This table is implemented as a hashtable with the registered aliases of available subjects as indices referring to their corresponding access locations.

Included with the server is a graphical monitor panel that displays registered access stations, as well as subjects, and their current locations (see Figure 6). Subjects may also be registered with the server using this interface.

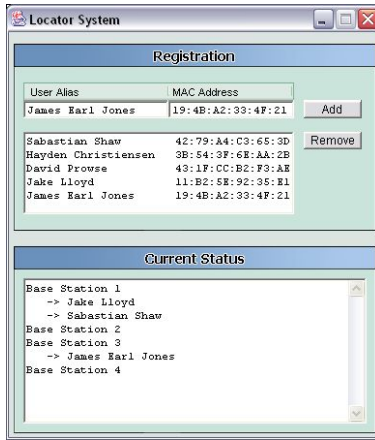


Figure 6. The graphical monitor panel (seen here running on Windows XP)

### 3.3.3.1 Service Interfaces

A key requirement of the lookup service is for it to be able to interface with the service applications, such as VoIP telephony services, as mentioned earlier. Additional interface modules can be easily integrated into the system architecture to coordinate with any services. For VoIP services, as there are different lookup registrar systems for the various protocols, such as gatekeepers for H.323, interface modules will have to be developed for each system.

Currently, lookup interface modules for the GnuGK H.323 Gatekeeper and the SIP Express Router (SER) registrar are in place.

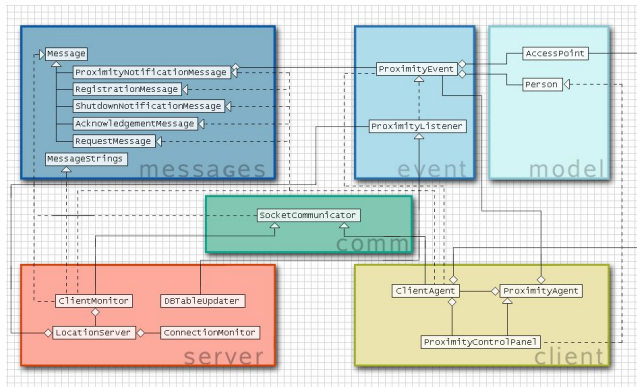


Figure 7. A simple UML class diagram of the Location Service.

## 4. RESULTS

Initial research into the automatic identification component of the project focused primarily on using Radio Frequency Identification equipment. However, as the venture continued, difficulties were encountered in contacting the equipment vendor. As more was discovered about RFID, the technology (specifically the RFID reader) proved to be prohibitively expensive for the small demonstration system that was planned.

One problem encountered with Bluetooth was the apparent inability to modify the reach of the devices and the adaptor. Activated Bluetooth devices could be detected by the adapter from a distance of approximately 10 meters. For the purposes of the demonstration system, this was too large. Base stations needed to be spaced away from each other far enough such that the 10 meter radii around them do not overlap each other. If a Bluetooth device was in range of more than one base station, it would be registered to the station that it came into range of first, not necessarily the station that is closest.

There was a slight delay between the time of activation of a Bluetooth device and the time that it was detected by a base station, despite being immediately in range. This delay lasted 4-6 seconds. While it is noticeable in a demonstration, it should not be a significant problem in a practical setting. However, a more significant delay occurred between the time that the Bluetooth device was switched off to the time the adapter recognized that it was no longer in range. This delay often lasted over 15 seconds, and would be more of a problem in a practical setting.

## 5. CONCLUSION

This solution makes communication in a local area more efficient by making the telephony service follow the user, rather than the user being confined to a limited space to use the service (as with traditional circuit-switched telephony), or being forced to bring the service with him or her (mobile devices).

The project was implemented using Bluetooth equipment, which proved to be far more cost-effective than RFID for a small system. USB Bluetooth adapters were reasonably priced, and common Bluetooth devices such as PDAs may be used as transponders. The implementation is ideal for use in urban office-type settings, with a small number of users carrying Bluetooth devices.

## 6. RECOMMENDATION

Although the solution is efficient for a system with a small number of users, the need for each user to carry a Bluetooth device would be a costly requirement in a system with many users. Additionally, the range of Bluetooth (10 meters) may be too long or too short, depending on the environment.

The modular and extensible nature of the solution makes it easily adaptable to various technologies with minimal overhead effort, allowing it to be used in a wide variety of environments. For instance, the Bluetooth component may be substituted for a fingerprint scanning system for increased security in government buildings. Similarly, the telephony service may be substituted for a paging system in a dormitory.

More development should be done with this and similar systems to adapt to various environments, and to explore the practicality of location-based services.

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