

ESRI User Conference 2006 Technical Report

- Report Title: Ubiquitous GIS Using RFID Tags and ArcPad Mobile GIS

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- Report body (text): See below

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1 Introduction

Remarkable progress has been achieved in recent years in the development and commercialization of various technologies that contribute to the creation of a society based on ubiquitous technology. In fact, as we get closer to realizing an information society in which "anyone, anytime, anywhere" can take part in social activity with ease and convenience, 2005 has even been called "year one of the era of ubiquitous technology".

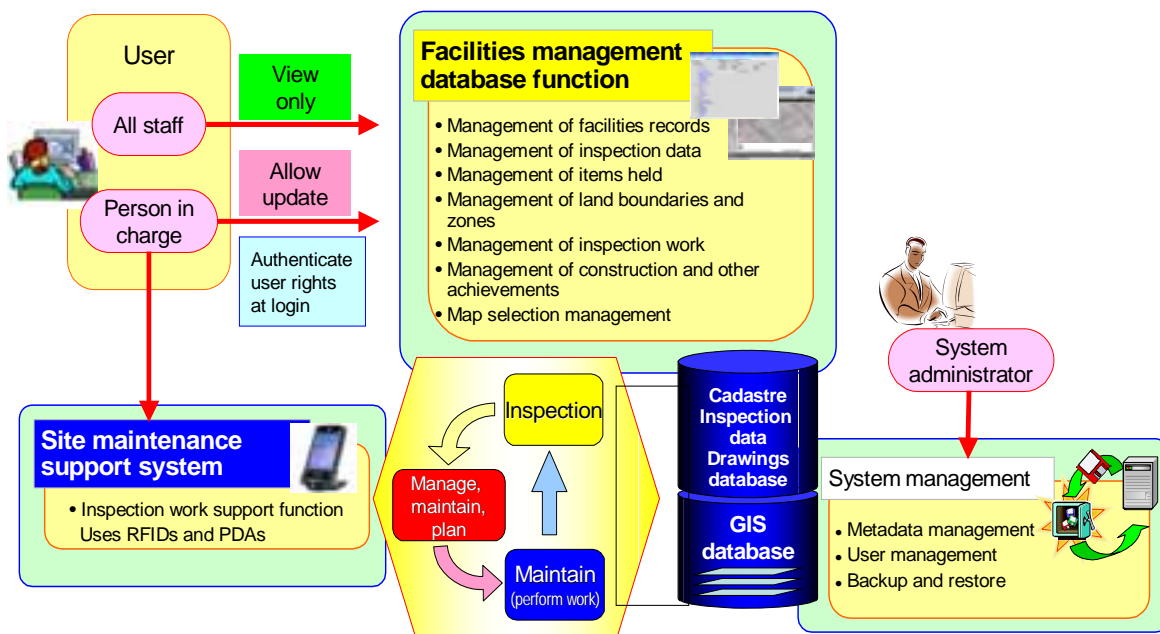
So what sort of society will a society based on ubiquitous technology be? It will be a society in which all things and places are associated with information, linked together by networks that provide natural and unobtrusive support for all of the activities we undertake in that society.

This report describes an example of a project undertaken in the field of facilities management for public infrastructure. The project utilizes "ubiquitous technology," combining technologies such as RFID tags and PDAs with spatial, position and other information, with the aim of improving the efficiency of maintenance inspections and other on-site maintenance work and also of improving the service to the users of the public facilities.

2 Summary of Example Project

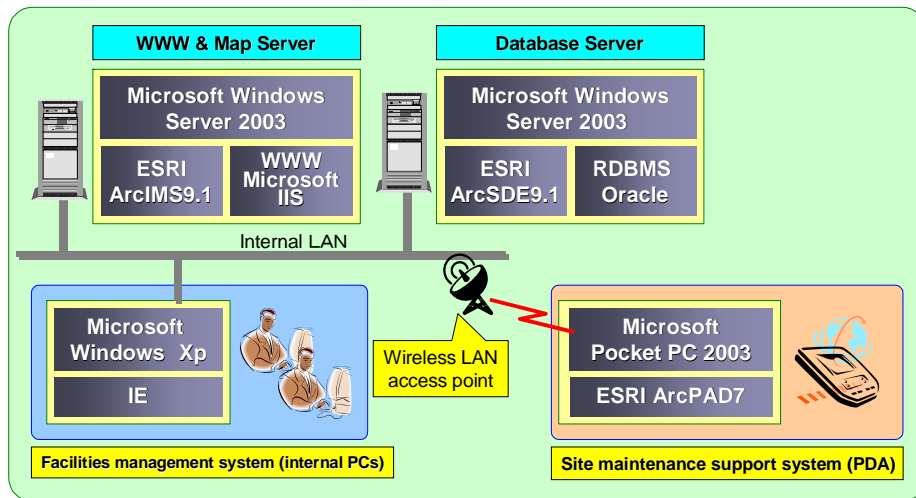
The field of public facilities maintenance has, in recent times, been confronted with the need to improve the service to users while also reducing costs. In order to establish technology that utilizes "ubiquitous GIS" as a way of addressing this issue, an experimental trial was undertaken that involved developing and then evaluating the effectiveness and practicality of a prototype system with aims that included increasing maintenance efficiency and improving the service to the users of the public facilities.

The prototype system developed for the trial consisted of an "integrated facilities management database system" (referred to below as the "facilities management system") and a "site maintenance management support system" (referred to below as the "site support system"). The facilities management system provides centralized management of the data required for managing maintenance of the public facility (each facility, items held by the facilities, inspection records, and finalized drawings, etc.), linked to position information. The site support system supports maintenance management at each site.



The facilities management system incorporates an integrated database of facilities management information based on Web-GIS using ArcSDE9.1 and ArcIMS9.1. The site support system uses ArcPAD7 on PDAs to implement a mobile GIS system to support on-site work.

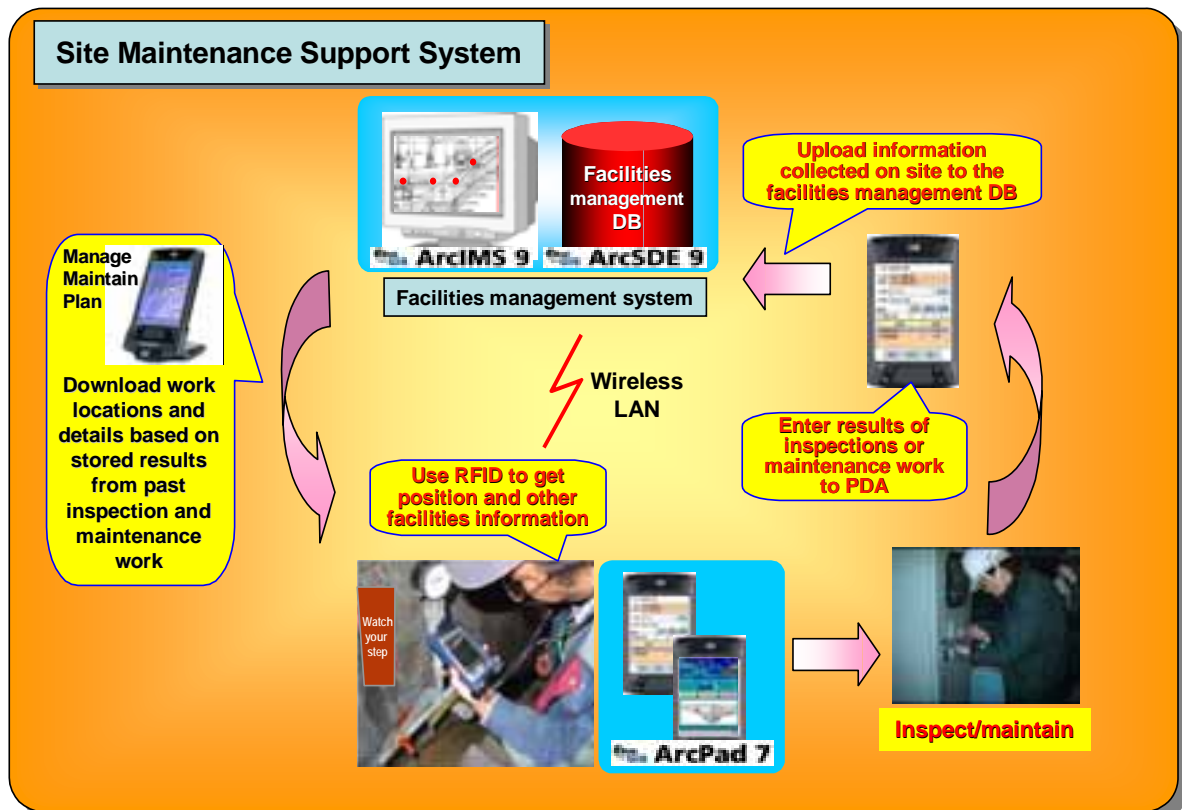
In addition to space savings and avoiding deterioration of records and other paper documents, the system also improves the efficiency of maintenance work by providing a quick and easy way to look up and utilize the information required for day to day work.



The site support system in particular takes advantage of the latest ubiquitous technology in the form of RFID tags.

A function was developed whereby, if a problem is found at a particular item under management, holding a PDA with built-in tag reader close to the RFID tag containing the facilities management number and position information displays the position information for that item in ArcPAD7. The function also allows detailed facility information (type of facility, specifications, past inspection records, etc.) to be accessed easily.

The PDAs have also been equipped with the capability to store site information in the facilities management database efficiently. This makes the overall maintenance management process more efficient and effective.



3 Evaluation of Trial (Issues Identified in Trial)

Applying the prototype system in an actual trial identified the following technical and operational issues.

1) Memory capacity of RFID tags

RFID tags have a very limited memory capacity, typically only several hundred to several thousand bytes. Accordingly, selection of the information to store in the tags based on factors such as the purpose and use of the management data is most important.

2) Reading (detection) of RFID tags

In order to detect an RFID tag, a PDA with a built-in reader needs to be brought to within a few centimeters of the tag. This requirement needs to be taken into account when deciding where and how to attach the tags. There were examples in the trial of equipment that could be inspected visually from a distance but which needed to be approached in order to read the RFID tag.

* The trial used passive RFID tags that cannot generate a radio signal from their own power.

3) Durability of RFID tags

As RFID tags are expected to be used in a wide range of environments ranging from indoor locations to outdoors where they are subject to wind and rain, it is important to select RFID tags which are sufficiently durable (dust proof, waterproof, temperature sensitivity, etc.) for the intended locations.

4) Communication limitations of PDAs

Although the database on the server can be accessed directly when working in locations where it is possible to connect to the wireless LAN, it is essential to incorporate the capability for independent off-line operation as it is impossible to provide wireless LAN coverage over the entire work area.

5) Location detection using the PDA

Although the location information stored on the RFID tags attached to the items under management was the primary mechanism for determining the current location when performing on-site maintenance work, a method is also required to handle cases such as when you cannot get close enough to the item to read its tag, or when the item does not have an attached RFID tag. Consequently, it would be desirable to combine ArcPAD with a GPS function that can easily determine the current location.

6) PDA usability

The normal way of operating the PDA is using the stylus pen (short and thin) provided with the LCD display. The actual users of the PDAs complained that the PDA was difficult to use because the stylus pen was too small and thin making it difficult to pull out for use. They also said that the text on the LCD display was small and difficult to read.

Next, we investigate ways of dealing with the issues identified above, considering not only technical solutions but looking also at operational considerations, so that the next step, the development of a practical commercial system, could proceed efficiently.

4 Potential Ways of Dealing with the Issues Identified

Further work was undertaken based on the following points to improve the functionality and operational performance of the practical commercial system and thereby solve the problems identified in the trial.

- When performing system design, keep in mind the need to consider the system from the user's perspective so that the end product will be suitable for continuous use and also incorporate features that satisfy the specific usage objectives.
- When finalizing the system functions, devote time to understanding and evaluating the latest technology (RFID tags, communications, and similar) and take a proactive approach to incorporating (utilizing) this technology.
- When designing the system's function and operation, give consideration to how maintenance management costs can be reduced through use of the system after it is installed.

Here, we summarize the main potential solutions to the identified problems that we considered in our investigation.

As the issues identified above primarily relate to problems with the RFID tag and PDA technology and how it is used in practice, whether or not efficient use of these two tools (technologies) is possible is the key to the successful implementation of a practical commercial system.

1) Use of RFID tags

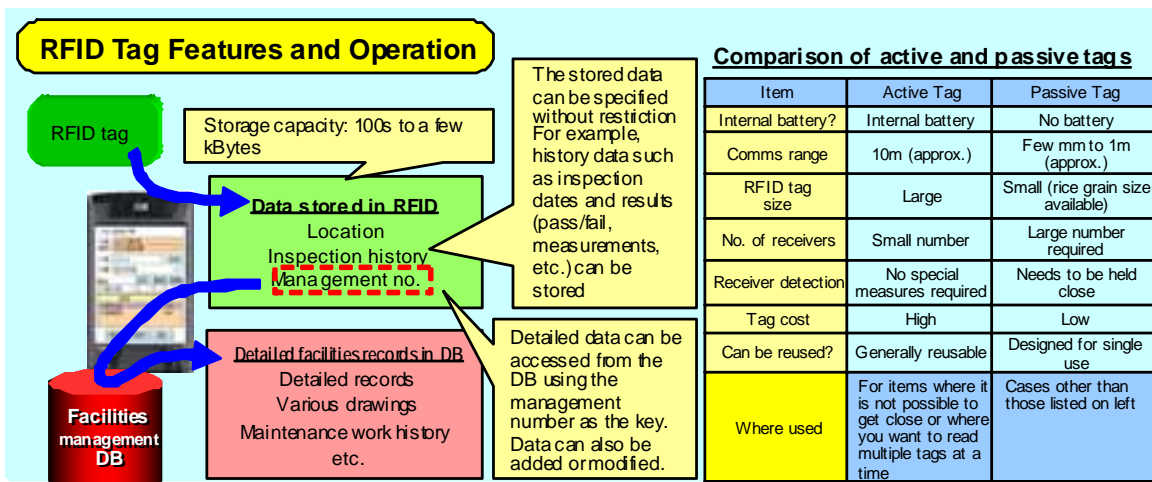
The following strategies were adopted for the design and development of the practical commercial system based on the issues identified with the RFID tags.

(1) Data to be stored in the RFID tag memory

The data to be stored in the RFID tag memory consists mainly of the management number that identifies the item under management and the position information, but can also include the dates and other status information (whether any problems were found, whether problems are being dealt with, whether work has been scheduled, etc.) from past inspections. The management number acts as the key by which more detailed information can be retrieved from the facilities management database.

(2) Use of active RFID tags

Active RFID tags (tags that can generate their own radio signal and which can be read from a distance) are to be used in cases such as when it is not possible to get close to the item under management or when users want to read RFIDs from more than one item at a time.



2) Use of PDAs

The following strategies were adopted for the design and development of the practical commercial system in response to the issues identified with the PDAs.

(1) Support for both on-line and off-line operation

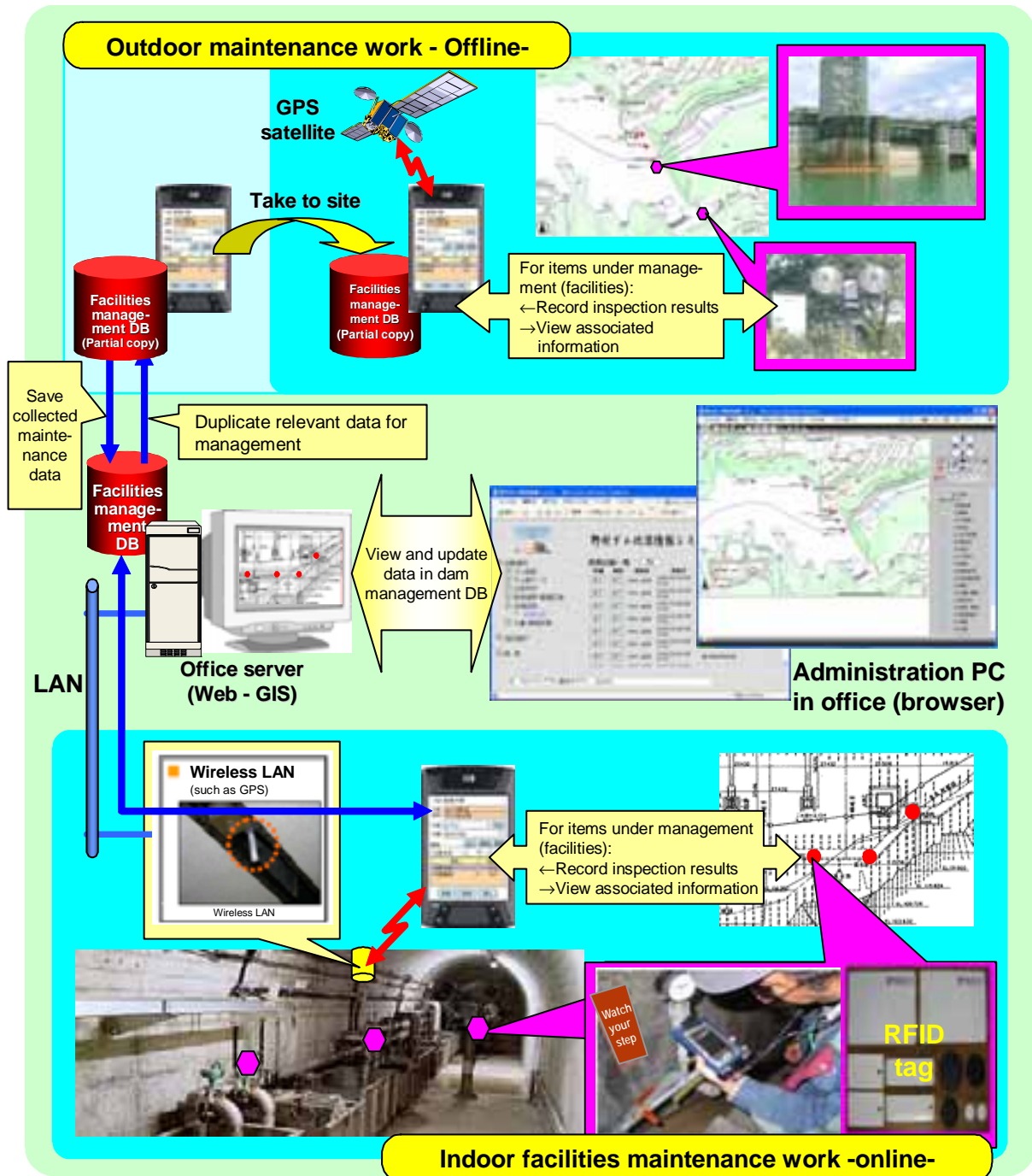
Support both on-line operation using the database when the PDA is within range of the wireless LAN or other communication mechanism, and off-line operation whereby the PDA can store data and access its own facilities summary information independently when out of communications range.

(2) Integration of GPS with PDAs

Consider linking ArcPAD with GPS so that the current position can be determined without reference to an RFID and the position information for the item under management can be obtained easily in ArcPAD.

(3) Fingertip operation of PDA

Make the PDA screen designs larger and simpler to understand so that all operation can be performed using a fingertip.



5 Future Developments

Based on the results of this trial, we plan to start design and development work on a practical commercial system in 2006.

Conducting the trial allowed us to identify the technical issues that need to be resolved in order to implement the system, and the potential solutions to those issues. We believe that this will allow us to undertake the system design and system development work in an efficient and effective manner. Bearing in mind that most ubiquitous technology is still in the process of being developed, it is important to devote time to understanding the latest trends in technology and to incorporate this understanding in the system development process in an appropriate way.

6 Conclusion

Dramatic progress is currently being made in the realization of ubiquitous technology with the development of technologies such as RFID (electronic) tags for storing information and readers for extracting the information from the tags. But where should these technologies be used, what information should they store, and how should they be used? Consideration of these questions is still at the stage of conducting investigations and performing trials. Numerous trials by many different organizations are currently underway to search out the best ways of realizing a society based on ubiquitous technology.

Last year, a trial of a "autonomous mobile support project" was conducted in Kobe, run mainly by the Ministry of Land, Infrastructure and Transportation. The aim of this project was to investigate the creation of an environment in which the information needed to participate in society, work, and other activities, such as "transportation routes," "means of transport," and "destinations," could be accessed by "anyone, anytime, anywhere."

This trial involved the installation of more than 40,000 RFID tags, radio markers, infra-red markers, and Bluetooth and other communication devices at important locations around the town and on induction blocks. These were used to provide tourist and general navigational guidance to overseas visitors. The induction blocks work by giving an audio description of the surroundings when tapped by the cane of a visually impaired person.

Pasco, our employer, was also involved in this trial and was able to gather a high level of technical knowledge. In addition to being actively involved in work aimed at realizing a society based on ubiquitous technology, we hope to offer society many different new but highly effective solutions in the future also.