

SpaceTag: An Overlaid Virtual System and its Applications

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Abstract

SpaceTag is an object system on which each object called SpaceTag can be accessed only from limited locations and limited time period. Its applications include entertainment systems, advertisement services, bulletin board systems, and personal communication systems. For one-way communication, they are broadcasted from the server; for two-way communication, users can cut and paste SpaceTags between their portable PCs and the real space. The SpaceTag system is a location-aware information system, as well as it is like an augmented reality system because it attaches information to the real space. However, we categorize it as an overlaid virtual system, because it has no direct link to real objects. It can be realized as a public service without causing drastic change of this society, and without much cost.

1. Introduction

A SpaceTag is a digital datum that can be accessed only from limited locations and in limited time period. Its data type may be text, image, voice, program, or any other multimedia data type. Intuitively, it is a virtual object like a poster or a memo-pad, stuck on the real 3D space. It can be shown to users through portable terminals that have time and location sensors, e.g., clock and GPS, if and only if the user is within the SpaceTag's effective zone (Figure 1). Users can also stick new SpaceTags onto the space from the terminal.

Since the SpaceTag system can provide location-aware services, it is a mobile information system. It is also like an augmented reality system because it can give augmented information to objects in the real world.

However, its architecture is different from most of known systems. We categorize it as an *overlaid virtual* system. With this architecture, we are free from management of real world objects and work on them. It is also low-cost because it is based on existing digital broadcasting or cellular

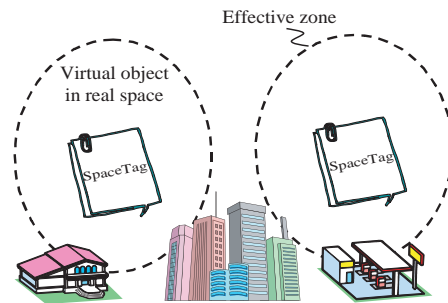


Figure 1. An Intuitive Illustration of SpaceTag

phone systems and can be implemented as a public, general-purpose service.

By these reasons, it is expected that the SpaceTag system contributes to various applications, like bulletin board services, tourist information services, gaming, advertisement, instant communication services, etc. It gives more chances to cyber business because of its simplicity, generality, and relatively low investment risk.

2. The SpaceTag System

2.1. Why Limited Access?

A SpaceTag can only be accessed from limited locations and in limited time period. This seems to be inconvenient and inefficient, but it is an important aspect of SpaceTag's concept.

WWW has enhanced the human ability of accessing data distributed all over the world. It is a very clear benefit of the Internet. No one can deny the advantage of quick information circulation.

However, sometimes information has its *raison d'être* because it is hard to access it. Information is sometimes attractive because it can be accessed limitedly, or because it takes long time and much cost to access it.

For example, consider any festival event you know held only once a year. Many people gather at the festival place and watch the event every year. However, suppose that the festival event were held every day. People would lose interest in the festival.

The second reason for limited access is possible locality of information, e.g., traffic signs. WWW is inappropriate to this kind of information. Location-aware information systems are appropriate. Some cellular phone (micro-cell systems) companies have already begun services to give local information.

The third reason is, of course, that the spatio-temporal coordinates can be used as indices to massive information.

SpaceTag is an information media to support spatio-temporally limited information, in order to satisfy these requirements. In addition to satisfying them, we have designed the SpaceTag system as an open public service to take the following advantages:

1. Users can create SpaceTags with existing multimedia authoring tools.
2. It is easy to give mutual links and to make mutual transformation from/to existing information media like WWW.
3. With existing information filtering technologies, users can get selected SpaceTags based on their preferences.

2.2. Attributes of SpaceTag

A SpaceTag is a digital object that has at least the following attributes: *ID*, *data type*, *effective zone*, *effective time period*, *error range*, *access rights*, and *channel*.

ID is a serial number given by a server, which is not shown to users. Data types may be text, image, audio, program, VRML, URL, etc. Effective zone is defined by a pair of center location and radius.

Error range depends on the type of location sensor. If the SpaceTag is created at a user terminal, the error is doubled because it occurs at the time of creating and displaying.

Channel is like that of TV broadcasting. For example, tourist channel, communication channel, or gaming channel can be given. If a user selects a channel on the terminal, only SpaceTags that have the same channel attribute are shown.

2.3. Broadcasting and Communication Services

The SpaceTag system has two aspects of services: broadcasting and personal communication.

We are supposing an information providing company that broadcasts information with the SpaceTag system. The

information is intended to be received by general public people. Services are, for example, advertisements, navigational guidance, tourist information, and so on. Since SpaceTags may be motion image or other attractive data types, it can be more fascinating and exciting than conventional media like posters or billboards. This suggests a new type of broadcasting category: *object broadcasting*.

SpaceTags can also be used for personal communication. It is like sticking a small memo-pad at the place. The recipient is not specified. It is targeted to unspecified people around the sender. A recipient can select preferable SpaceTag by selecting a channel or using information filtering functions at his/her terminal. Applications of such kind of communication include bulletin boards for local community and guest book at a sightseeing spot.

If the life span of SpaceTag is very short, the communication is more like synchronous or real-time ones, rather than asynchronous examples shown above.

It is possible to introduce a removing operation for SpaceTags. It is like taking off a stuck memo-pad. With this operation, the recipient can receive a SpaceTag exclusively. It is more like a person-to-person communication.

2.4. Applications

Although we have already shown some applications of the SpaceTag system, we introduce more applications in this subsection, in order to show how it can be widely used. The SpaceTag system is intrinsically inefficient because accessibility is limited. Its application is mainly in the entertainment field, rather than the business field.

Real World Adventure Game: SpaceTags can be used for items in adventure games like secret keys, hints for puzzles, instructions, etc. Players carrying terminals walk around a town, getting and putting SpaceTags according to a game scenario. This type of game is better for our health than existing game machines, and realizes multi-player games naturally.

Multimedia Attraction: With SpaceTags, we can implement attractions and entertainment scenes at festivals or events, like fireworks.

Advertising Event: People must move to access attractive SpaceTags. It causes some economic impacts. For example, suppose that a supermarket chain store announces that some SpaceTags will appear at some of the chain stores on a particular day and people who get the SpaceTag will win a prize. This campaign will gather many customers at all chain stores.

Moving Advertisement: In Japan, there were people whose jobs were professional advertising demonstrator called CHINDON-YA. They walked in the streets, playing funky music with clarinets and drums with bright dresses, shouting advertising messages. These kinds of moving advertisements are only displayed to small number of people, but sometimes more effective than common advertisement like banners on Web pages. It is because it gives strong impression and sometimes causes rumors about the time and place to watch it. Moving advertisement is very easily implemented by periodically changing the location attribute.

Communication Applications: As stated before, SpaceTags can be used for instant communication with people around the user. For example ticket exchange at event sites, looking for partners to enjoy themselves, and exchanging information about police speed-traps are examples of such requirements.

3. Design

Figure 2 shows the basic design of the SpaceTag system.

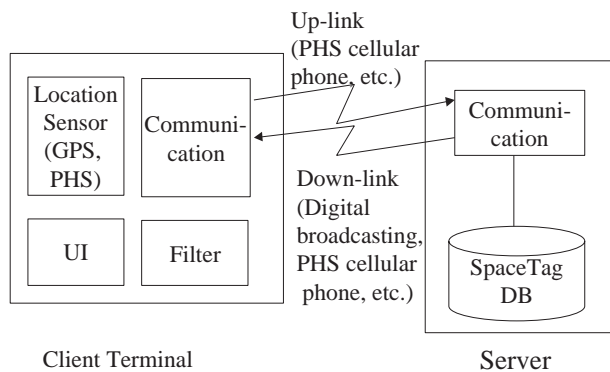


Figure 2. Configuration of the SpaceTag System

3.1. Server

SpaceTags are stored in a database on a server machine, and they are broadcasted from the server to terminals (clients). A server is composed of a database subsystem and a communication subsystem. The server and the database are supposed to be managed by a broadcasting company.

The database is required to manage SpaceTag objects. Since the objects have uniform structure except the multimedia contents, the database can be implemented with standard relational or object-relational database products. Almost all queries are retrievals of SpaceTags that can be accessed from a particular position and time. This fact gives possibilities to tune the database performance for queries.

There are two cases in creating and modifying SpaceTags.

By a broadcasting company: In cases of tourist information and advertisements, etc., information provider (city government or advertising agents) commissions the broadcasting company to manage the SpaceTags. These SpaceTags can be modified or removed only by the broadcasting company.

By end-users: A SpaceTag created by an end-user is transmitted to the server by the up-link communication and stored in the database as a SpaceTag with location attributes of the place where it was created. In this case the SpaceTag can be removed by the creator or some specified people. Appropriate access right management should be applied.

It should be inhibited for end-users to create SpaceTags remotely, in order to avoid SPAM-like SpaceTags. Only the broadcasting company should be allowed.

It should also be inhibited for end-users to access SpaceTags remotely. If it were allowed, remote access would become popular behavior of end-users because remote access is simply convenient; the basic concept of SpaceTag might be crashed and some applications would become nonsense. If remote access is required, the broadcasting company can select remotely accessible SpaceTags and copy them to WWW, or the company can create SpaceTags whose contents are URLs indicating the open data. The SpaceTag system and WWW can be linked and cooperate in this way.

3.2. Communication

The SpaceTag system uses two way communication: up-link (client to server) and down-link (server to client).

For the up-link communication, we adopt popular digital cellular phone system. Required bandwidth is not so wide, because what are transmitted from clients to the server are some control commands, position data, and SpaceTags created at the client terminal.

For the down-link communication we currently have two options: public digital broadcasting and micro-cell type cellular phone (Japanese PHS (Personal Handyphone System)).

In case of adopting digital broadcasting, surface broadcasting is more appropriate than satellite broadcasting, because broadcasting area is smaller. For example, if a 10 Mbps bandwidth channel is reserved, about 60,000 SpaceTags of 1 KB short text can be broadcasted per minute. If large data like image is contained within a SpaceTag, it is possible to broadcast only indexing information to get the real contents from other network in an

on-demand manner, e.g., from the Internet through http or other protocols.

If a micro-cell type cellular phone is adopted, the bandwidth is narrower. In case of Japanese PHS, 64 kbps can be reserved. However, each service area is small enough and SpaceTags that should be really transmitted can be selected.

3.3. Client Terminals

As shown in Figure 2, a client terminal has the following functions.

Location sensor: It senses the position of the terminal itself. We have currently two options for the sensor, GPS and PHS.

Communication: It implements the up-link and down-link communication functions. The manner of connection depends on its implementation. If digital broadcasting is adopted, it receives SpaceTags every time. If PHS is adopted, it should be connected continuously or periodically.

Filter: This function selects SpaceTags that should be shown to the user from all received SpaceTags and stores them. The filtering is based on location, time, channel, keyword, or other attribute values. Location, time, and channel-based filtering functions are mandatory; others are optional. If a wide-area broadcasting is adopted as the down-link communication, many SpaceTags might be filtered out by this function, because most of them are not within the neighborhood. Selected SpaceTags are cached on the terminal as long as it can be accessed.

It should be noted that the filtering function could be modified to show SpaceTags that may not be accessed. Currently we are supposing that this type of cheating does not occur. However, we should design more secure implementation against cheating. Developing one-chip SpaceTag terminal is an example of secure design.

User Interface (UI): It provides the following functions:

- List up all the SpaceTags that can be accessed.
- Sticking newly created SpaceTag in the real space, and removing or copying SpaceTags from the space.
- Channel selection.

3.4. Prototype

We have prototyped the first version of the SpaceTag system. For the communication, we adopt PHS for both up-link and down-link. The server is located in our laboratory;

Oracle 8 is adopted for the database. Terminals are implemented on usual notebook PCs running Windows, with a client software shown in Figure 3, By usual cut-and-paste or drag-and-drop operations, SpaceTags can be moved or stuck in the real world.



Figure 3. User Interface of Our Prototype

4. Discussion

4.1. Overlaid Virtual System

In Figure 4, we categorize location-aware information systems.

Category	Real World	Provided Service
Augmented Reality		
Ubiquitous Computing		
Overlaid Virtual		

Figure 4. Location-aware Information Systems

The first category is *augmented reality*. This concept was originally invented in contrast to *virtual reality*. While virtual reality systems just create realistic 3D computer graphics and give interactive interfaces to the graphical objects, augmented reality is intended to give strong relationship

between virtual objects and real objects. Virtual objects are used to give information about real objects. Examples of typical augmented reality systems are NaviCam[7], UbiquitousLinks[2], and Augment-able Reality[8]. In their cases, special tags are attached to real objects. The systems detect these tags and retrieve related information.

The second category is *ubiquitous computing*¹. In this category, small electronic devices are attached to real objects. The device is enabled to communicate with other devices in a wireless manner like radio waves or infrared. This type of device is also attached to portable computers or human users. They detect each other, sense surrounding situations, and give appropriate services according to the situation. Examples of this category include Cyberguide[1] and Active Badge[9].

The third category, *overlaid virtual* include the SpaceTag system and Touring Machine[4]². In this architecture virtual objects have location attributes and shown at the location.

Overlaid virtual systems may be regarded as a subcategory of augmented reality, because virtual objects can give information of real objects. However, overlaid virtual systems can also be used without real objects, and its implementation is quite different from augmented reality systems. Hence we give a new category.

The most important benefit of this architecture is that it is free from real object management. In case of the first two categories, small tags or devices must be attached to real objects. This fact causes the following four harmful costs proportional to the number of objects. Hence we do not think they are realistic implementation for public and open use.

1. Hardware costs of devices or tags.
2. Labor costs to attach them to real objects.
3. Management costs of real objects; without management, devices or tags might be removed or exchanged by people who are not familiar with the system.
4. Negotiation costs. Before attaching devices or tags, the system administrator should negotiate with the owner of the object.

There is another implementation of augmented reality systems. It does not adopt tags or devices, but recognition of real objects. In this case real world object management is still necessary. System administrators should collect information about shape, color, and material of real objects.

¹It may not be the correct definition of ubiquitous computing, but here we use this name to refer to this type of architecture since many ubiquitous computing systems take this architecture.

²In [4], they categorize Touring Machine as an augmented reality system, but we re-categorize it because it can be used without real objects.

One of the drawbacks of overlaid virtual system is that it cannot give augmented information to moving objects. However, our standpoint is that lower cost is more important than this drawback.

The difference between the overlaid virtual systems and virtual reality systems is that overlaid virtual systems are not intended to represent 3D virtual graphics realistically, for now. This fact strongly affects the system cost and portability.

Then, what is the difference between the SpaceTag system and Touring Machine? In case of Touring Machine, it is intrinsically a Web retrieval system. The SpaceTag system is intrinsically a broadcasting system and realizes two-way communication. It also introduces the time attribute as well as the location attribute. These design factors enable it to realize moving virtual objects like electronic CHINDON-YA and allow lightweight, low-cost terminals.

4.2. Comparison with Situation-aware Systems

Some researchers in this field present the concept of situation-aware information systems, or situated computing. For example, Hull, et al. enumerate personal health, user identity, location, time, etc., as situated information [5].

Our standpoint is to separate time and location information from other situational factors, because they can be obtained easily, more accurate than other factors, and considered to be general purpose. Other situational factors are often difficult to get, inaccurate, or application-oriented. For example personal schedule data is difficult to get and tends to be incorrect, because users are often reluctant to input them and the data often change dynamically.

The SpaceTag system provides low-cost, general-purpose platform to utilize location and time information. Situated computing systems can be built on this platform.

4.3. Business Possibilities

One of the good natures of the SpaceTag system is that it can be started using current communication platform like digital broadcasting or cellular phones, and will be able to be enhanced with the evolution of communication platform.

Our prototype design with PHS and GPS can also be used for practical implementation. In this case available SpaceTags are mainly small data like short text. After digital broadcasting becomes popular and low cost, small antenna will be able to be embedded on a portable terminal and broadband down-link communication will be available for SpaceTags. Even at this stage, old type SpaceTag terminals will be still available for small size SpaceTags. Advanced devices will make it possible for SpaceTag client

terminals to be embedded on cars and provide various functions as car computer applications.

To start with low cost implementation and gradual evolution are very important keys for successful communication platform.

4.4. Other Comments

There are some instant wireless network systems that enable users to communicate with unspecified people around. "Nakayoshi"[6] is one of the instant networking systems, which provides some application like group discussion of portable PCs. The SpaceTag system can be used for instant communication with unspecified people around, but its bandwidth is limited and response is worse than instant wireless network systems. It is because a remotely located server mediates the communication. The SpaceTag system should be used only for short and light communication, e.g., to find a partner to talk to.

Paging service companies and cellular-phone companies sometimes provide information distribution services, like restaurant information, tourist information, traffic information, etc. Of course they are not location-aware and different from SpaceTags. Early SpaceTag systems with narrow bandwidth and wide error range are very much like these services. It means that we can expect that the SpaceTag system is introduced without strong social impact and naturally accepted by many users even now. It is an important point for successful business, and a difference from some augmented reality or virtual reality systems that need such as HMDs or special electronic glasses.

5. Conclusion

In this paper we have described the design and concept of the SpaceTag system. Its special characteristics and our original standpoints are:

1. It is an overlaid virtual system based on broadcast and two-way communication.
2. It can be introduced without strong social impact and gradually improved to future systems.
3. It is low-cost.
4. It has variety of applications, especially in the entertainment and advertisement field.
5. As an antithesis against WWW and the Internet, it preserves what we cannot do in the real world. This principle preserves exciting and enjoyable aspects in the real world.

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References

- [1] G.D. Abowd, et al.; Cyberguide: A mobile context-aware tour guide. *Wireless Networks*, Vol.3, pp. 421–433, 1997
- [2] Y. Ayatsuka, et al.; UbiquitousLinks: Hypermedia Links Embedded in the Real World, IPSJ SIGHI Notes, Information Processing Society of Japan, 96-HI-67, 1996 (in Japanese)
- [3] S. Feiner, et al.; Knowledge-Based Augmented Reality. *Communications of the ACM*, Vol.36, No.7, pp. 53–62, 1993
- [4] S. Feiner, et al.; A Touring Machine: Prototyping 3D Mobile Augmented Reality Systems for Exploring the Urban Environment. *Proceedings of IEEE International Symposium on Wearable Computing '97*, 1997
- [5] R. Hull, P. Neaves, and J. Bedford-Roberts; Towards Situated Computing, *Proceedings of IEEE International Symposium on Wearable Computing '97*, 1997
- [6] A. Kurashima, et al.; Mobile Groupware System "Nakayoshi" Supporting Local Area Collaborations, *Proceedings of DiCoMo'97 Symposium*, Information Processing Society of Japan, pp.233–238, 1997 (in Japanese)
- [7] J. Rekimoto and K. Nagao; The World through the Computer. Computer Augmented Interaction with Real World Environments. *Proceedings of the ACM Symposium on User Interface Software and Technology (UIST'95)*, pp. 29–36, 1995
- [8] J. Rekimoto, et al.; Augment-able Reality: Situated Communication through Physical and Digital Spaces. *Proceedings IEEE International Symposium on Wearable Computing '98*, pp.68–75, 1998
- [9] M. Weiser; The Computer for the 21st Century, *Scientific American*, pp. 66–75, 1991