Ubiquitous Geographic Information (UBGI) and address standards

Sang-Ki Hong

Anyang University, Korea
skong@anyang.ac.kr

Abstract

There can be hardly any doubt that the new generation of geographic information (UBGI) will have a profound impact on every aspect of GIS. Address and address standard would be no exception. This paper reviews the issues regarding address and address standards in UBGI perspective. More specifically, this paper examines the concept of UBGI and the relationship between UBGI and address standard and the possible mechanism to handle various address-related issues in UBGI context.

Address is important because it is one of the major forms of spatial referencing, which in turn is one of the fundamental information for providing context. The challenge is how we extract unambiguous location information from the maze of different address formats.

In UBGI environment, the location information of a feature can be easily discovered through the use of geo-labeling mechanism. Then the location information can be easily exchanged and used without further conversion or transformation through an overarching mechanism for spatial referencing (dynamic position identification scheme, such as u-position). The "free text" address can be correctly interpreted since the geographic context within which the address is used will be always provided in UBGI environment and the meaning of the address will become obvious given the context. These are just a handful of the possibilities that UBGI can benefit address standards. The concepts and standards that are being developed in UBGI field will certainly help to resolve some of the difficult issues in standardizing addresses.

Keywords: UBGI, geographic context awareness, address standards

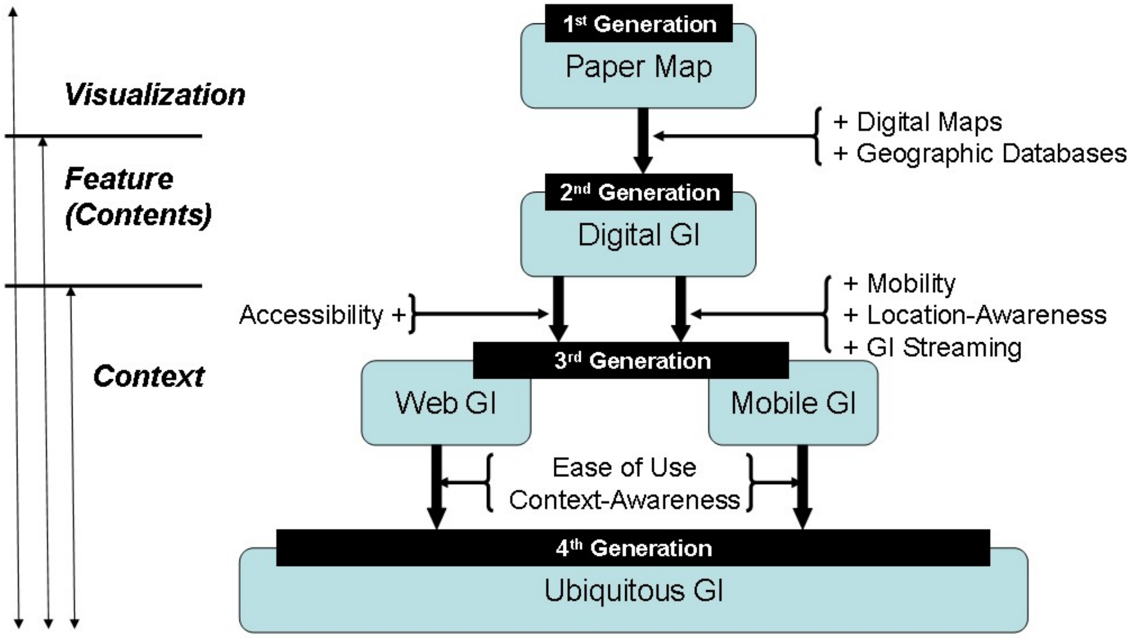
1. Introduction

1.1 The concept of UBGI

UBGI (ubiquitous geographic information) is defined as a set of concepts, practices and standards that helps geographic information and processing (both spatial and temporal) to move into the mainstream computing and create applications aimed at and designed for the average member of the public (AG for UBGI, 2007). In other words, UBGI is geographic information provided to users at anytime, anywhere, and with any device to anything upon his/her contexts. Here, "users" includes not only human beings but also applications and devices with communication. The "context" can be defined as the surroundings, circumstances, environment, background or settings which determine, specify, or clarify the meaning of an event.

To understand the ubiquity of geographic information, we need to examine how the GI has evolved throughout the time. We can divide the representations and use of GI (geographic information) into four evolutionary stages (See Figure 1).

Figure 1. The evolution of Geographic Information (AG for UBGI, 2007)



In the first generation, GI was captured and delivered in the form of paper map, the main function of which is to show what is out there. Visualization of information was the main focus of information handling.

With the advent of digital maps and geographic databases "Digital GI" started to emerge. The main concern of this second generation GI is how to handle the information on the spatial features.

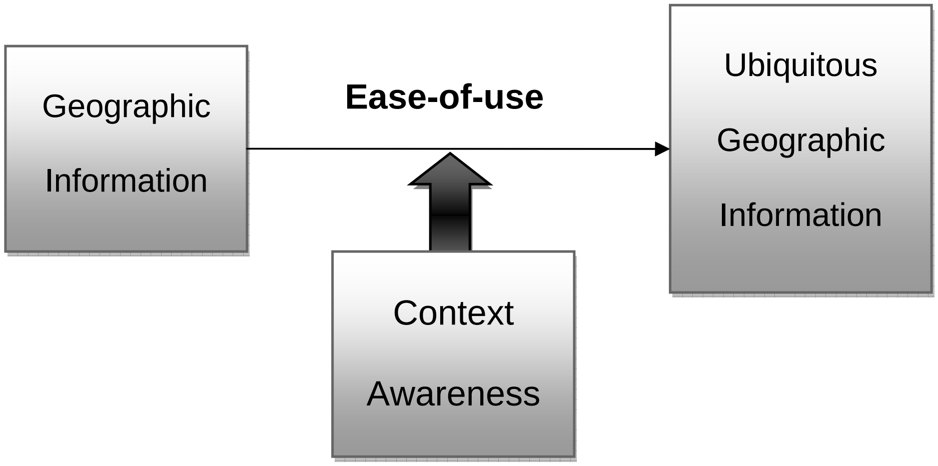
The third generation of GI is characterized as "Web GI" and "Mobile GI," which was brought on by the development in information and communication technology, such as World-Wide-Web and mobile devices such as cell phones and PDA's. The users and information contents of GI have greatly expanded and new type of information services, such as LBS (location based service) became popular.

The next generation GI, so called "Ubiquitous GI" emphasizes the "Context Awareness" and "Ease of Use" in GI as its main characteristics. "Context-Awareness" means that the software not only knows where the user is but also understands the user's environment, capabilities, activities and purpose in any particular situation. By making the devices aware the user's context, we can make the devices use and provide only the relevant information based on the user's current context. With such context-aware software and devices, a true "ease-of-use" in geospatial application and services can be achieved (AG UBGI, 2007).

1.2 Ease-of-use for GI

The "ease-of-use" concept is essential for UBGI services. To make "ease-of-use" possible, two conditions should be met. First, users should be able to access necessary geographic information at anytime and anywhere regardless of the types of hardware or communication methods. In general, users include not only human beings but also applications and machines equipped with communication devices. Second, any user (i.e., anything) should be able to use the necessary geographic information regardless of the user specialty without interpretation or individualization efforts. Therefore the "context-awareness" is the key concept related to the "ease-of-use" for UBGI (see Figure 2).

Figure 2: Relationship between "Ease-of-use" and "Context Awareness"

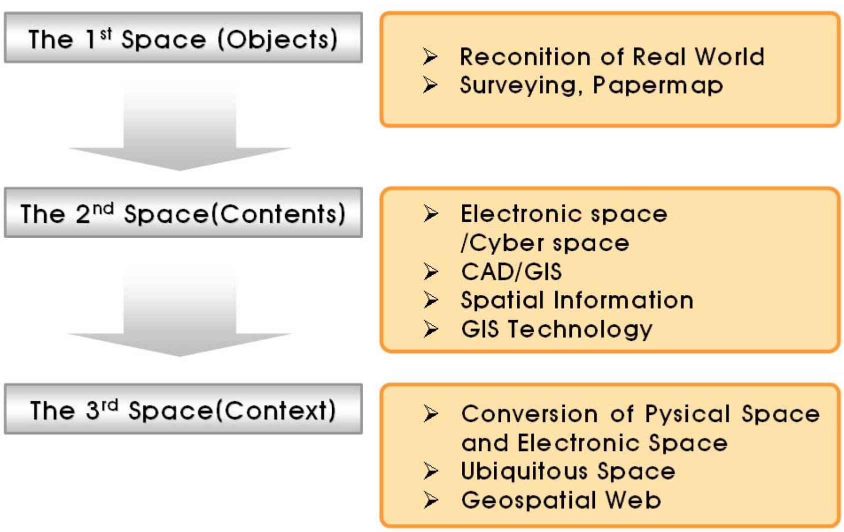


1.3 Address in UBGI context

1.3.1 Space Paradigm Shift

With the rapid development in information and communication technology, a fundamental paradigm shift in the concept of space is taking place. We would call it the "3rd space" as opposed to "1st space" and "2nd space." As shown in the Figure 3, the "1st space" can be characterized as "objects" which is based on the recognition of the real world. The "2nd space" represents the "electronic/cyber space," where there is an overlap between the physical space and electronic space. Current geographic information technology works in this space. The "3rd space" can be referred as "context." In this space, the physical world and electronic world converge, creating a completely new space where the context awareness becomes the most important. UBGI and related technologies will be essential tools to work in this space.

Figure 3. Space Paradigm Shift



1.3.2 Address in the 3rd space

Address, in its various forms, has played an important role as a spatial reference system. The new space, which we could call "ubiquitous space," will undoubtedly require new approaches to many existing spatial problems and spatial referencing would be no exception. There are efforts to make the location information available in ubiquitous way. Projects are underway, for example, in ISO/TC211 to handle location information seamlessly across diverse spaces (ISO PT19151 *Dynamic position identification scheme for ubiquitous space*).

Address and address standard will need to take this space paradigm shift into consideration. Also, the treatment of semantic components in GI can be approached in terms of ontology (ISO PT19150 *Geographic Information – Ontology*), which will have impact on the address standards. There are other relevant developments in UBGI area that can either have impact on address and address standard or help solve the problems in developing address standard. We will look into some of these work areas in UBGI in the latter part of this paper.

1.4 Objectives of this paper

The goal of this paper is to review the issues regarding address and address standards in UBGI perspective. More specifically, the objectives of this paper are as follows:

1. to review the concept of UBGI and the relationship between UBGI and address standard;
2. to explore the potential ways in which UBGI development can benefit address standardization;
3. to explore the possible mechanism to handle various address-related issues in UBGI context.

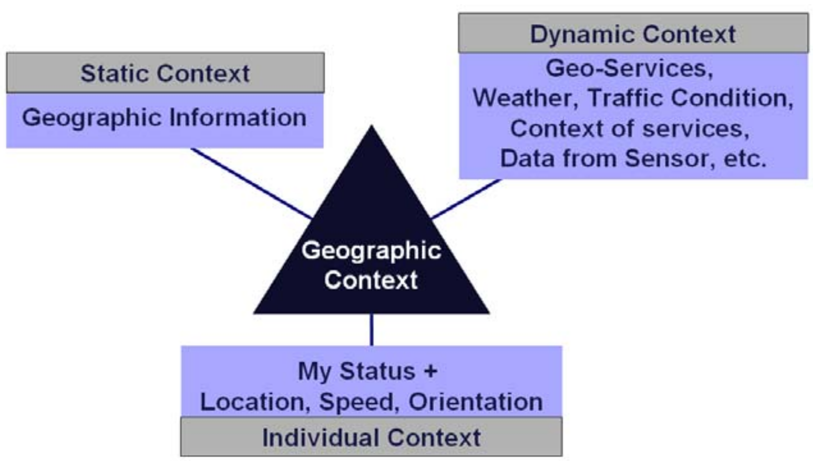
2. Context awareness and address

2.1 Geographic Context awareness

One of the main differences between conventional GI service and UBGI services is that UBGI services delivers GI based on the geographic context of a user. Geographic context can be categorized into static, dynamic, and individual context.

As shown in Figure 4, the individual context information contains specific data about a user such as user preferences, location, speed, orientation, and so forth. Hence it will be used for the individualization of geographic processes. The static context contains geographic information that might affect the user's environment stored as digital data. The dynamic context contains real-time information obtained by sensors or provided by similar information services for weather, traffic, and other changeable aspects of the user's environment. Hence the static context does not change rapidly, but the dynamic context does.

Figure 4: Types of Geographic Contexts (AG for UBGI, 2007)

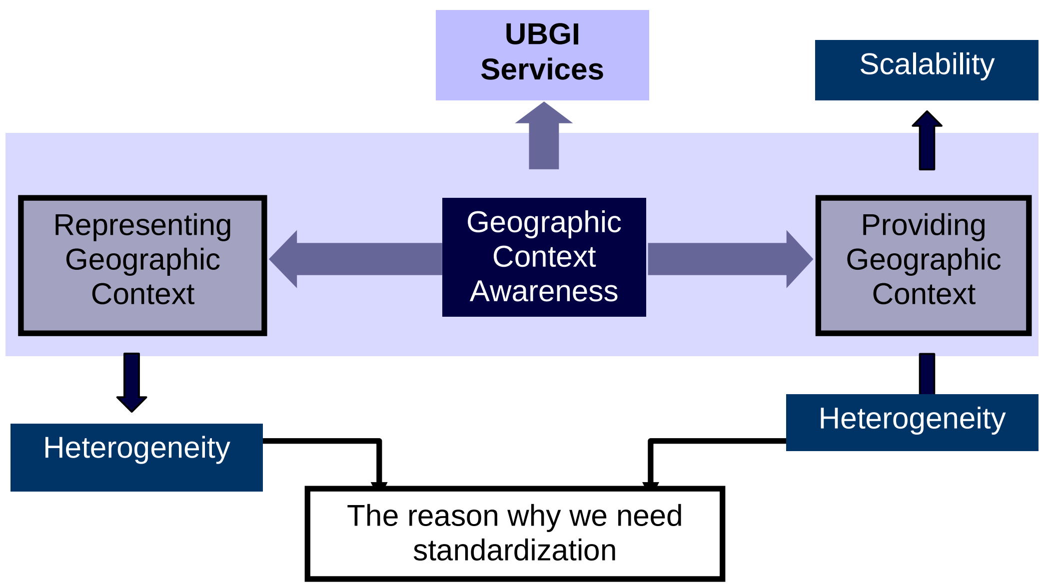


Context-awareness is the integrated process or activity to collect and deliver context specific information, and convert it to tailored data for each user. In order to achieve the context-awareness, following aspects should be considered (see Figure 5):

- ✓ How to represent geographic context;
- ✓ How to provide geographic context;
- ✓ How to interpret geographic context.

As we can see in Figure 5, we need standards in two different aspects. First, we have to deal with the heterogeneity in representing geographic context. Second, we have the similar problem of heterogeneity in providing geographic context. In both cases, address as a geographic identifier reference system is one of the myriad of representations of context. Therefore, address and address standard should be examined in the broad framework of managing heterogeneity of context representation and provision.

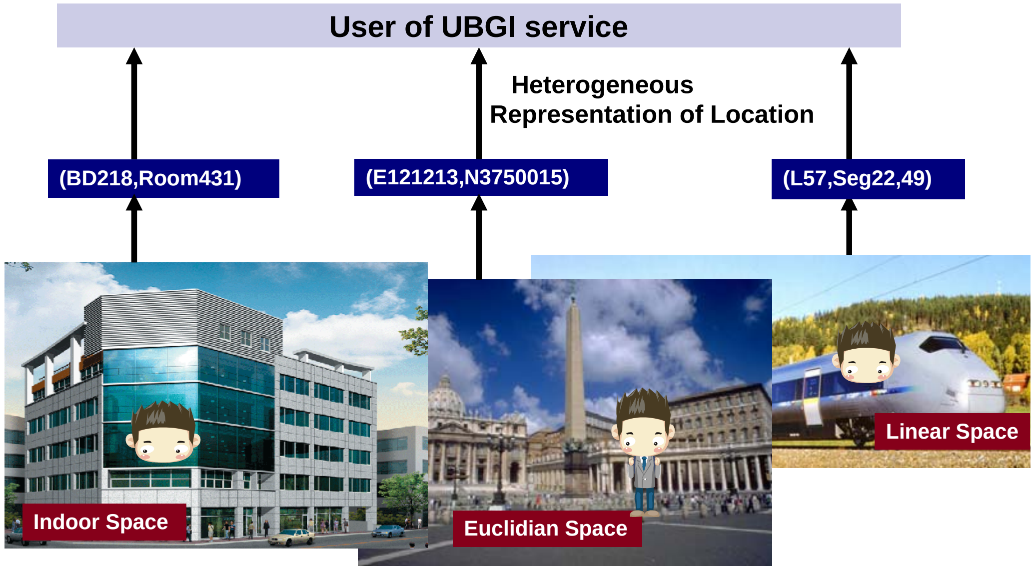
Figure 5: Context awareness (Li, 2008)



2.2 Heterogeneous representation of location

As mentioned above, we need to deal with heterogeneous space and manage the mobility across these spaces in UBGI. In practice, there are several types of spaces, which use different spatial reference systems. For example, CRS are commonly used to specify a position in outdoor space, while a pair of text (Level, Room#) can be used to describe a location in indoor space as shown in Figure 6. When we are dealing with networked space, we will naturally use LRS (Linear Referencing System). In door referencing can be considered as an extension of geographic identifier reference system. Addresses are closely related to all three reference system. To manage the mobility seamlessly across these heterogeneous space, UBGI requires a mechanism to handle the address and other reference systems, hence an overarching structure that can be used to refer to the location information regardless of reference systems (See section 3.2).

Figure 6: Heterogeneous spaces and reference systems



Here is an example (See Figure 6). Mr. Taylor is in the train. His current position is L57, Seg 22,49 in LRS. His is going to meet a friend at the obelisk, the coordinate of which is E121213, N37500015 in CRS. He is to attend the meeting at his buyer's office, the address of which is Room 431, Building 218, New Market Street, SomeCity. To make UBGI services possible, these different representations of location should be handled in a seamless manner. Especially, we need a mechanism to convert address information into other reference systems in a real time. This mechanism should deal with not only outdoor space, but indoor space as well since address can includes indoor space location information as well.

3. Address-related issues in UBGI

3.1 Location and Data Transformation

It is not user's responsibility to find a proper representation model for a particular interface. For a user, a location is a location, regardless of the representation needed for a particular process or service interface. The data transformation should be carried out automatically in UBGI environment, which includes the transformation of location information between different applications. ISO 19133 *Geographic Information-Location based services – Tracking and Navigation* discusses this for location representation, but the scope needs to be expanded to cover all GI data types and properties.

3.2 Dynamic Position Identification Scheme (u-position)

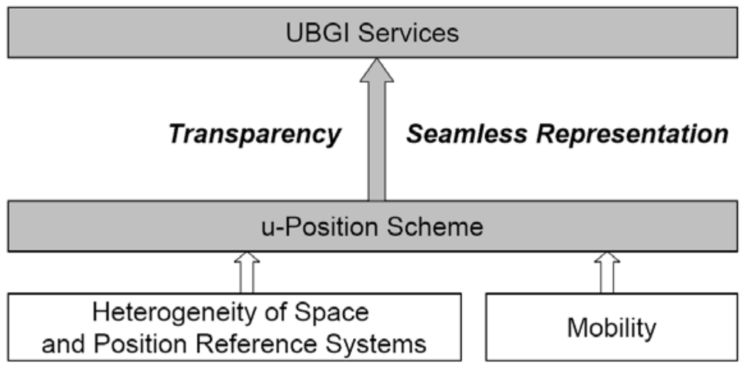
In order to implement UBGI environment, we need to solve two problems: i) mobility, and ii) heterogeneity of space and location representation method. Traditional geographic information systems, which handle only stationary features and provide services to stationary users, can not fully support the mobility required by UBGI. In addition, the representation methods of feature location in UBGI should not be dependent on the type of space and position reference system.

In order to overcome these two problems, a new logical location representation scheme, called u-Position scheme has been proposed. It is an overarching structure that can be used as a universal reference for all types of spatial referencing. The following is a brief summary of the concept of u-Position (ISO/TC211 N2225).

The goal of u-Position

In order to overcome two problems (heterogeneity and mobility), the u-Position scheme provides the transparency of space and location reference system and a seamless representation as shown by Figure 7. The advantages of u-Position scheme are summarized as first *logical representation of location* to achieve the transparency, and second s*eamless representation of location* to support mobility.

Figure 7. U-Position scheme to provide transparency and seamless representation to UBGI services



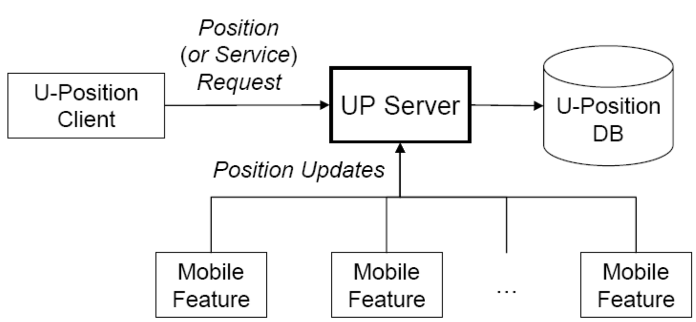
Logical location representation by u-Position scheme

Logical u-Position naming scheme has several advantages over physical location representation as does DNS naming over IP address. The most important advantage is that it provides a high level of transparency, which is a fundamental requirement of UBGI. More precisely, u-Position naming scheme provides two types of transparency, which are 1) transparency to support dynamic aspect, 2) transparency for heterogeneous geographic information.

Mobility and seamless location name

Mobility is an essential requirement of UBGI. By conventional representation methods with physical location, the mobility cannot be fully supported. However, the u-Position server dynamically binds a logical u-Position name and its physical location by u-Position scheme. The physical location of each mobile feature is reported to u-Position server and we can access its physical location at any time as shown by Figure 8.

Figure 8. Updates of physical location on u-Position server



3.3 Mechanism for resolving spatial identifiers

Another way of dealing the heterogeneity of location representation is developing a mechanism to enable the encoding and conformance of different location descriptions between communities, without requiring each community to radically modify or abandon their current practices and methods. The draft new work item proposal for Place Identifier (ISO/TC211 N2413) summarizes the concept of PI as follows:

> …
>
> In reality, multiple identifiers may often refer to a single location, as there are many kinds of location identifiers, such as coordinates, addresses, or facility names, etc. Humans can more easily see the relationship where some identifiers refer to the same location, however this relationship is much more difficult for machines to understand. This difficulty impedes information searches with location identifiers, as shown in Figure 1.
>
> Referred to as Place Identifiers (PIs), this International Standard defines a reference model and introduces a suite of service interfaces for the representation of place information. The structure of a PI consists of a name space, (spatial reference system definition), and a value. The task of creating the PIs lies with each user community. Research and discussions have shown that seeking to enforce a standardized encoding rule on every user community to insure the creation of "globally unique" place identifiers would not be successful.
>
> Therefore the hierarchical design structure of the PI model and service interface architecture mandates unique PI definitions within each user community, while allowing for similar or alike PI definitions between different user communities. The services defined in the specification define a platform to facilitate the sharing and exchange of the PIs between those user communities. (ISO/TC211 N2413)

3.4 LBS and Linear Referencing

Although *ISO 19133:2005, Geographic Information-Location based services – Tracking and Navigation* includes an address model, it will have to be revisited based on the work on the addressing and address standard. Also, the outcome of *ISO 19148, Geographic Information-Location based services – Linear referencing* will have an impact on addressing since street-based addresses are usually linearly referenced.

3.5 Geolabeling

Since address is a geographic identifier reference system which specifies the location by a label or code, address is naturally a part of something called "geolabeling." While some data such as temperature and location can be simply collected from sensors, information about surroundings, such as shops in the vicinity of a feature, are complex and contain large amounts of data and cannot be stored or captured from sensors or a small computing device. It should be provided by a large server storing the entire geographic information in a given area as shown by Figure 9.

Figure9. An example: Providing geographic context by Geo-Labels

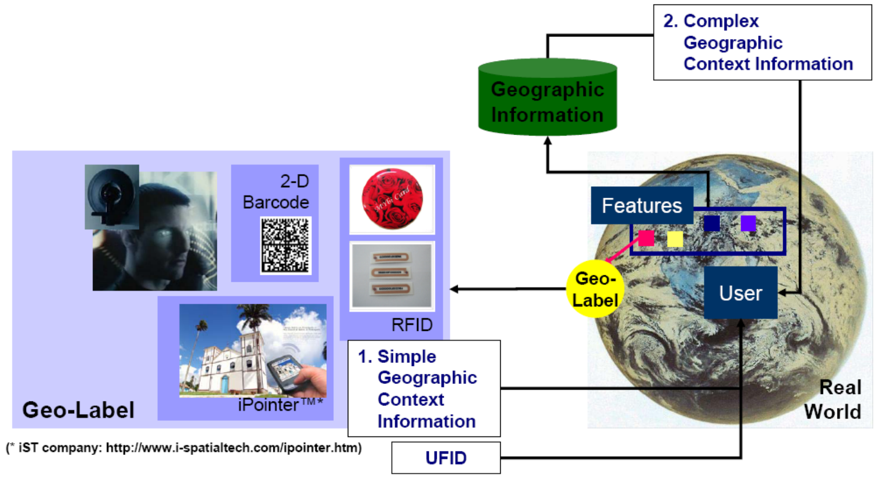


Figure 9 shows an example of a simple mechanism for providing geographic context-awareness from a geographic database server via labels such as RFID or 2-D bar code storing only the identifier of each feature (UFID: Unique Feature Identifier). In order to retrieve and provide geographic context from geographic databases, we need identifiers of features related with the context. They may be recognized either explicitly from RFID or 2-D bar codes attached to the features or implicitly from their locations. This process is called labeling in Figure 9 and can be implemented by physical labels like RFID or by virtual labels using location and spatial databases. iPointer, developed by the iST(intelligent Spatial Technology), is a good example of virtual label.

3.6 Treatment of indoor space

There is a set of emerging spatial theory for indoor space. For example, there are efforts to define primitive types, topology, and operators for Indoor spatial objects. Also, data models for cellular space and R3 space can be constructed (Li, 2008). The treatment of indoor space is important because addresses include indoor component as part of addressing scheme. One of the ways to handle indoor space is using the extension in CityGML to create something called "indoorGML." LOD4 of CityGML provides an "walkable Interior Model" with which we can model interior of a building (Kolbe, 2005). This interior model can be extended to create indoorGML (Li, 2008).

Another interesting approach to indoor space is the concept of space with only qualitative description, such as symbolic space, cellular space etc. Most systems of spatial databases are based on quantitative (e.g. geometric) notation of space (e.g., coordinates, ISO19107, GML, linear reference), but some applications DO NOT require quantitative notion. We can make a statement like "I'm in room 422," or "How many persons are in the lobby?" In this context, space becomes symbolic.

Most practical technologies for indoor spatial referencing is cell-based positioning (cellular space). The motivations for cellular space came from the effort to create a location reference for indoor space. In cellular space, we use cell ID rather than (x,y,z) coordinates for location reference. For example, we can use RFID tags attached in each room and use these IDs for locating a particular room. In this case, no geometry is involved in the referencing, although each cell may have its geometry. Only topology between cells describes the nature of space. (Li, 2008)

The new notion of space in UBGI will certainly have impact on how we deal the location of a feature. With the rapid development of ubiquitous technology and new ways of applying them, new possibilities are emerging. The efforts to develop an international address standard needs to consider these new developments in the field of UBGI.

4. Conclusion

Address is important because it is one of the major forms of spatial referencing, which in turn is one of the fundamental information for providing context. The challenge is how we extract unambiguous location information from the maze of different address formats. The Farm Address and Informal Address found in South Africa have data elements consisting of free text (Coetzee et al., 2008). In this case, it would be very difficult to convert the address into one expressed in one of the existing spatial reference systems, such as CRS.

However, in UBGI environment, the location information of a feature can be easily discovered through the use of geo-labeling mechanism. Then the location information can be easily exchanged and used without further conversion or transformation through an overarching mechanism for spatial referencing (dynamic position identification scheme, such as u-position). The "free text" address will always be correctly interpreted since the geographic context within which the address is used will be always provided in UBGI environment and the meaning of the address will become obvious given the context. These are just a handful of the possibilities that UBGI can benefit address standards. The concepts and standards that are being developed in UBGI field will certainly help to resolve some of the difficult issues in standardizing addresses.

Acknowledgements

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