Digital City Kyoto:
Social Information Infrastructure for Everyday Life

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Abstract. As a platform for community networks, information spaces using the city metaphor are being developed around the world. We see the concept of digital cities as being a social information infrastructure for urban everyday life (including shopping, business, transportation, education, welfare and so on). This article reviews those digital cities to have a better understanding of their current status and future. We are in the middle of a long term project to develop a digital city for Kyoto, the old capital and cultural center of Japan, based on the newest technologies including GIS, 3D, animation, agents and mobile computing. We propose the *three layer architecture* for digital cities: a) the *information layer* integrates both WWW archives and real-time sensory information related to the city, b) the *interface layer* provides 2D and 3D views of the city, and c) the *interaction layer* assists social interaction among people who are living/visiting in/at the city.

1. Introduction

The concept of digital cities is to build an arena in which people in regional communities can interact and share knowledge, experiences, and mutual interests. Digital cities integrate urban information (both achievable and real-time) and create public spaces in the Internet for people living/visiting in/at the cities.

Digital cities are being developed all over the world. Why do regional information spaces attract people given that we are in the era of globalization? We realize that the Internet has triggered global businesses, but at the same time, it enables us to create rich information spaces for everyday life. While the Internet makes research and businesses global, life is inherently local. Business requires homogeneity to allow global competition, while life is heterogeneous reflecting the different cultural backgrounds. Business applications require standard protocols to overcome differences, but we do not need any standard for our life. If there are differences, we need to support cross-cultural communications.

The rapid advance of Internet technologies makes any prediction rather suspect. Digital cities will change together with the computer and communication technologies. No digital city can remain at its current status. Given this qualification, this article visits several digital cities around the world and then reviews their goals, architecture, and technologies to have a better understanding of their current status and future.

2. Visiting Existing Digital Cities

We first turn to digital cities in the US. When we perform a "digital city" search in the US, we find many instances created by America Online (AOL). AOL provides locally focused online network services for several hundred cities and the number is growing. Each AOL digital city (http://www.digitalcity.com/) delivers locally relevant news, community resources, entertainment, and commerce. Unlike general search engines, which aim at retrieving information from the world, digital cities focus on local information. Besides those information services, AOL provides local advertising opportunities for vertical markets including auto, real estate, employment, and health. AOL digital cities are very homogeneous as a result of pursuing economic efficiency. Unlike the US, in Europe, from 1994, more than 100 local authorities started different digital cities. The topics include telematic applications, car-free cities and so on. The European Digital Cities Conference has been held annually from 1994 to discuss a wide variety of topics [9].

An example of the experiments performed is Digital City Amsterdam (http://www.dds.nl/), which started six year ago [2]. This city was built as a platform for various community networks and thus particularly focuses on social interaction among citizens. This digital city was first created for communication between the municipal council and citizens. All communication was presented via text and modems. Terminals were placed at public spaces such as libraries. The success of this experiment increased the interest of the citizens in the Internet. The system continued to grow, and in 1998, 80,000 users were registered with the digital city. Digital City Amsterdam is operated by a non-profit organization called DDS (De Digitale Stad).

Helsinki Arena 2000 Project started in 1996, under the initiative of the Helsinki telephone company (now Elisa Communications) [8]. The goal of the project was building the next generation metropolitan network. This network enables citizens to communicate with each other using live video in both directions: members of a classic car community can cooperate on repairs by using live video transfer. In parallel to the development of high speed networks, an attempt to build the entire 3D city of Helsinki is underway (http://www.hel.fi/infocities/). As the 3D models become more accurate, more computational power and communication bandwidth will be required to view the digital cities at home. Thus, the virtual city can be a face of the project, and will provide a human interface for new broadband services.

(a) Digital City Amsterdam (B) Virtual Helsinki

Figure 1. Digital Cities in Europe

Digital cities commonly provide both profit and non-profit services and face a dilemma in trying to balance the two different types of services. Without profit services, digital cities are seldom attractive and fail to become a portal to the city. Without non-profit services, the city may become too homogeneous as a result of pursuing economic efficiency. In any case, digital cities are forced to face competition with private companies, which provide only profit services. Can digital cities compete with those companies? Technology may also move the border between profit and non-profit services. For example, Digital cities often provide free e-mail and free desk space services, in an attempt to guarantee an equal opportunity to anyone who wants to access the Internet. Since free e-mail services can become commercial, however, it is no longer clear whether this service is profit or non-profit.

3. Digital City Kyoto

3.1 Three Layer Architecture

Kyoto was the capital of Japan for more than a thousand years, and has been a cultural center of Japan for even longer. To begin a digital city project for Kyoto, we started with its design policies. The first policy for designing Digital City Kyoto is to make it *real* by establishing a strong connection to physical Kyoto. Unlike Digital City Amsterdam, our digital city is not an imaginary city existing only in cyberspace. Instead, our digital city complements the corresponding physical city, and provides an information center for everyday life for actual urban communities. Digital activities will become an essential part of the real city in the near future. We think "digital" and "physical" make things "real." We are thus working on a digital part of the real city. The second design policy is to make the digital city *live* by dynamically integrating WEB archives and real-time sensory information created in the city. We will not produce contents nor select them. We will provide a tool for viewing and reorganizing digital activities created by people in the city.

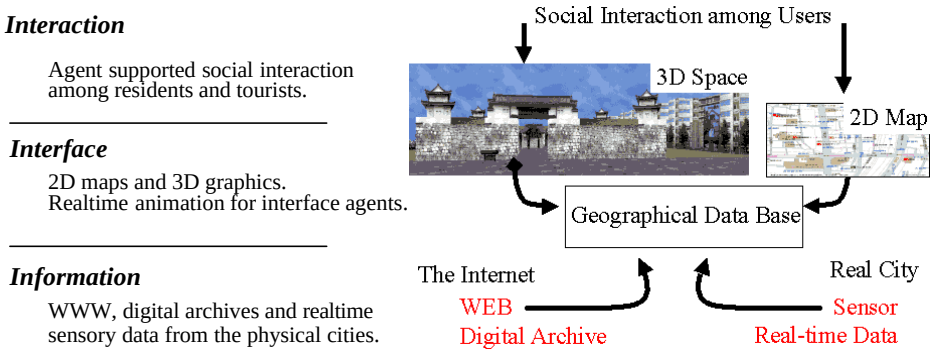

Figure 2: The Three Layer Architecture for Digital City Kyoto

We propose the three layer model as a system architecture suitable for digital cities (see Figure 2) [6]. The first layer is called the *information layer* where WWW archives and realtime sensory data are integrated and reorganized using the city metaphor. The geographical database is used for the integration of different types of information. The second layer is called the *interface layer* where 2D maps and 3D virtual spaces provide an intuitive view of digital cities. The animation of moving objects such as avatars, cars, busses, trains, and helicopters demonstrate some of the dynamic activities in the cities. If an animation reflects a real activity, the moving object can become a tool for social interaction: users may want to click the object to communicate with it. The third layer is called the *interaction layer* where residents and tourists interact with each other. Community computing experiments [5] will be applied to encourage interactions in digital cities.

3.2 Information Layer

To explain Digital City Kyoto, we start with the first layer, the *information layer*. Operations on current WEB sites are mainly by text: users search information by keywords and software robots retrieve information. This search-and-retrieve metaphor works well, especially if the needed information is distributed worldwide. If the Internet is to be used for everyday life, however, the geographical interface will become more important. As shown in Figure 2, GIS is the core of our digital city. The geographical database connects 2D/3D interfaces to WEB/sensory information. From the viewpoint of system architecture, introducing the geographic database allows us to test various interface/information technologies independently.

After digital cities become popular, people will directly register their pages to the geographical databases, but until then, we need some technology to automatically determine the XY coordinates of each WEB page. In Kyoto, however, since the city is 1200 years old, there are various ways to express the same address, and this makes the process very complicated. So far, we have processed 3000 pages that refer to public

spaces including restaurants, shopping centers, hospitals, temples, schools, bus stops. Figure 3(a) shows the results of locating the pages on the map. We can see how WEB pages (restaurants, schools, temples, shopping centers, etc.) are distributed in the city. Various data retrieval methods that involve this map are under development [3].

As the real-time sensory information, we are considering bus schedules, traffic status, weather condition, and live video from the fire department. In Kyoto City, more than three hundred sensors have already been installed and they are gathering the traffic data of more than six hundred city buses. Each bus sends its location and route data in every few minutes. Such dynamic information makes our digital city live. The first trial collects real-time bus data and displays them on the digital city. Real-time city information is more important for people who are doing something in the physical city than for those who are sitting in front of desktop computers. For example, people would like to know when the next bus is coming, where the nearest vacant parking lot is, whether they can reserve a table at a restaurant, and what is on sale at the department store just in front of them. We are now implementing a prototype application that provides live information to mobile users through wireless phones.

(a) GioLink (By Kaoru Hiramatsu) (b) 3D Kyoto (By Stefan Lisowski)

Figure 3: Digital City Kyoto

3.3 Interface Layer

The 3D graphic technology becomes a key component of the *interface layer*, when used in parallel with the 2D maps. The 3D aspect to a digital city allows non-residents to get a good feel for what the city looks like, and to plan actual tours. Residents of the city can use the 3D interface to pinpoint places or stores they would like to visit, and to test walking routes.

Figure 3(b) shows the 3D implementation of Shijo Shopping Street (Kyoto's most popular shopping street). We use 3DML (http://www.flatland.com), which is not well suited to reproducing gardens and grounds, but has no problem with modern

rectilinear buildings. Since 3DML is easy to use, college students in Kyoto have started to join us in cooperatively building the 3D Kyoto. This follows the "bazaar approach" to software development. We hope that have contributors from all over Kyoto will keep the project from being a small handful of stagnant areas, and make this a vast and dynamic city.

At the same time, we started discussing various problems with the shopping street community: since we are using photos, information in the photos becomes old; the advertisements in the photos quickly become out-of-date; and some photos include registered trademarks. It is important for engineers, researchers and shop owners to start thinking of these issues. One solution we are working to implement, is a WEB and FTP interface to allow individual shopkeepers to update the advertisement photos on their 3D buildings by themselves.

3.4 Interaction Layer

Social interaction is an important goal in digital cities. Even if we build a beautiful 3D space, if no one lives in the city, the city cannot be very attractive. We plan to use cutting-edge technologies to encourage social interaction in Digital City Kyoto. One idea we have to encourage cross-cultural interaction in the Digital City is to implement a digital bus tour for foreign visitors to the site. The tour will be a point of entry for foreigners to the digital city, as well as to Kyoto itself. The tour has been implemented within the WEB environment, using I-Chat and Microsoft's agent technology (see Figure 4). The tour guide agent will lead chattering visitors through the Nijo Castle in Kyoto simulated using 3DML. To prepare for creating the tour guide agent, we participated in several guide-led tours of Kyoto. We noticed that the tour guides often told stories to supplement the rich visual environment of Kyoto and provided explanations of what Japanese people, both past and present, did in each place.

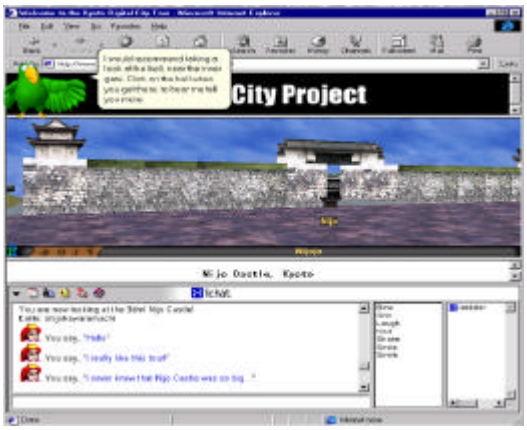

Figure 4: Digital Bus Tour with Agent Guide (By Katherine Isbister)

Another trial for developing social interaction in digital cities uses avatars in the 3D space to bridge residents and visitors. Figure 5 shows the animation of avatars walking in a city with a background image. The technology allows a number of avatars to walk around the city in real-time. By making links between the avatars and the people walking in the corresponding physical city, we can realize communication between digital tourists and physical residents. As the walking motion can be generated by the user's machine via a WEB browser plug-in, only the walking position/velocity and direction need to be downloaded. Thus, a large number of avatars can be created rapidly in real-time. Aside from the "known" avatars, adding a virtual population will activate the digital city and make it more attractive. We have started working on disaster management simulations in digital cities.

Figure 5: Walking in 3D Kyoto (By Ken Tsutsuguchi)

4. Technologies for Digital Cities

The following technologies are unique to digital cities.

Technology for information integration is essential to accumulate and reorganize urban information in a comprehensive manner. Digital cities typically handle WEB pages and realtime sensory data from physical cities. Voluminous high quality digital archives can also be accessed from digital cities. The idea of "using a map" is commonly observed in digital cities. Amsterdam uses an abstract information map, while Kyoto uses a physical map. In the latter case, technologies are needed to integrate different kinds of urban information via geographical information systems (GIS). GIS becomes a key technology for this.

Technology for public participation is unique to digital cities. To allow various individuals and organizations to participate in building digital cities, the entire system should be flexible and adaptive. For designing a human interface that supports both content creation and social interaction, a new technology is required that encourages people with different backgrounds to join in. In Amsterdam, a city metaphor is used

to create a new form of public participation. In designing Kyoto, we recognized the importance of participation.

Technology for social agents is being tested [4]. So far, most digital cities adopt the direct manipulation approach to realize friendly human interfaces. The direct manipulation approach allows users to explicitly operate information objects. Since social agents (human-like dog-like, bird-like and whatever) should have the ability to communicate with a group of users in natural languages, users can enjoy interacting with the agents and access information without explicit operation. This allows a digital city to keep its human interface simple and independent of the volume of stored information [11]. Social agents can easily connect mobile users to the digital city.

Technology for information security becomes more important as more people connect to the digital city. For example, it is not always appropriate to make links from digital cities to individual homepages. We found that most kindergartens declined our request to link them to the digital city. Just as we have social laws in physical cities such as peeping-tom laws, digital cities should introduce social technologies to secure the information spaces. These issues are being discussed, but no implementation has yet to announced.

5. Conclusion

Each digital city has its own goal. America Online's digital cities aim at growing their business in so called vertical markets. Digital City Amsterdam is intended to provide a public communication space to people living in the city. Helsinki is planing the next generation metropolitan network. In Kyoto, a social information infrastructure for urban life is being developed. Urban planning is another motivation behind digital cities. Digital Cities allow community members to directly participate in the urban planning process [10].

The project for Digital City Kyoto was established in October of 1998 [1]. In August 1999, the Digital City Kyoto Experiment Forum was launched. The forum includes several universities, local authorities, leading computer companies, as well as local companies, temples, photographers, volunteers and so on. Researchers and designers from overseas have joined the project. Besides technological problems, we have encountered numerous non-technical research issues such as security, privacy, and intellectual property rights. To gain a better understanding of the big picture of digital cities, we held the International Workshop on Digital Cities. The proceedings include papers from Helsinki, Amsterdam, Antwerp, Shanghai, Turin, Bristol, Oulu, Kyoto and so on [6].

During this project, we found the digital cities have many directions: tourism, commerce, transportation, urban planning, social welfare, health control, education,

disaster protection, politics and so on. Digital cities attract people because different experts can contribute to building a new city, and provide an opportunity to people to create a new information space for their everyday life. All activities in Digital City Kyoto can be found at http://www.digitalcity.gr.jp/.

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