The Advancement of World Digital Cities

Mika Yasuoka, Toru Ishida and Alessandro Aurigi

1 Introduction

Since the early 1990s, and particularly with the popularization of the Internet and the World Wide Web, a wave of experiments and initiatives has emerged, aiming at facilitating city functions such as community activities, local economies and municipal services. This chapter reviews advancements of worldwide activities focused on the creation of regional information spaces. In the US and Canada, a large number of community networks using the city metaphor appeared in the early 1990s. In Europe, more than one hundred similar initiatives have been tried out, often supported by large governmental project funds. Asian countries are rapidly adopting the latest information and communication technologies for actively interacting real-time city information and creating civic communication channels.

All of the above cases are loosely related but independent activities, and thus their goals, services, and organization bodies differ. Wide varieties of names and buzzwords have been employed for labeling localized information and communication networks, depending on the fashion of the moment and their characteristics. 'Cybercities', 'virtual cities', 'community networks' and 'civic networks' are examples of names that have been attached to all sorts of projects. These definitions are very vague and therefore disputed. In this chapter, we will follow the terminology developed in our research community during the past decade and refer to such information spaces as 'Digital Cities'.

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Digital cities have been initiated by three distinct actors: 1) non-profit electronic community forums such as the ‘freenet’ movement in the US, 2) commercial services as local information portals by private companies, and 3) governmental initiatives for city informatization.

The digital cities can be categorized according to their socio-technical and virtual-physical dimensions as illustrated in Figure 1. On the socio-technical di-

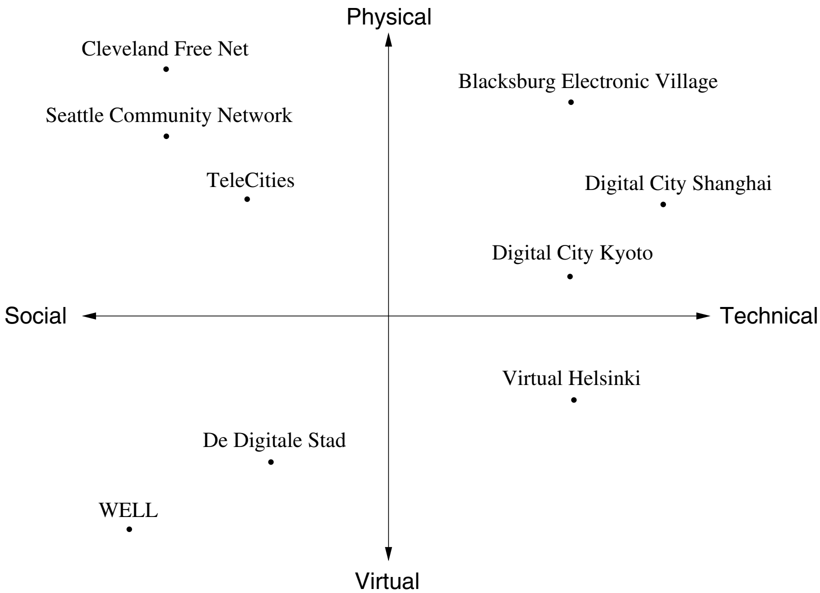

Fig. 1 A classification of digital cities according to their socio-technical and virtual-physical dimension.

mension, one trend is a high-tech direction where computer scientists play a central role and seek for ways of applying advanced cutting-edge technologies to regional information spaces. At the opposite end of the scale, we find a social direction that focuses on how to facilitate citizens’ community life using local information. On the virtual-physical dimension, some digital cities resemble virtual worlds like second life [26] with functions to support community of interests [14], while others have close ties to real cities providing functions to access regional information and activities. To some degree, though, the socio-technical and virtual-physical dimensions of digital cities are inseparable. Although digital cities in the early development stages tended to focus on one of these aspects, they have gradually been interwoven. Digital cities nowadays have become completely heterogeneous, reflecting the cultural background to the corresponding cities. In addition they have become more integrated with citizens’ daily life with the use of advanced technology.

This chapter overviews the history and further advancement of American, European and Asian digital cities from the socio-technical and virtual-physical dimensions. It observes the heterogeneity of models and experiments in the field, and reflects on the wider cross-continental issues of the articulation of community, industries and government within the local information sites.

2 American Community Networks

In the early days of the Internet, somewhat avant-garde attempts were made in many places to explore concepts for the future of the network. It seems that no clear vision had been formed about the structure of the information space for regional communities at that time. President Clinton's administration announced the National Information Infrastructure Initiative (NII) in March 1993, and the NII agenda was proposed six months later. Both efforts contributed to establish the foundations of information networks in the US. NII was proposed as one of the key scientific and technical policies directed towards satisfying the High Performance Computing Act. It specified concrete target values for six items like universal access and scientific and technological research. Targeted research areas included economy, medicine, life-long education, and administrative services. As a consequence, it promoted and catalyzed a wide range of network studies.

However, due to the size of the country it was impractical to depend on the state sponsored information superhighway to construct an information network that could cover all regions. The political tradition of community-centered, privately inspired grass-roots and the ever strong emphasis on freedom of speech made itpossible to spread local information communities across the country. At the dawn of community information network, the leading community activists already recognized the necessity for local and independent networks to support the everyday life of citizens. Such activities quickly gained a high profile in the US and a great deal of worldwide visibility because of their innovative potential.

The Cleveland Free-Net, born in 1986, was the world's first citizen-led community network. It started from a free electronic help line that connected doctors and patients. The Cleveland Free-Net provided a communication channel for everyone with a modem and computer. It promoted the exchange of ideas and opinions between the citizens of the Cleveland region. At the same time, the WELL (Whole Earth 'Lectronic Link), a pioneer 'virtual community' that would become famous worldwide, was born [23]. Stemming from a series of various electronic 'conferences', it formed a great virtual community where people of all generations and occupations could gather from all over the world. They ruled out anonymity and emphasized "exchange with a human face." The WELL was a network-based virtual community but it was not bound to locality. Though some of its 'conferences' extended from the virtual into the physical world and promoted face-to-face meetings and offline exchanges, the WELL was not designed to support regional communities. The early years of networked communities were characterized by a strong emphasis – to the point of being an almost blind faith – towards the myth of the inevitability of the global village and what had been hailed as the 'death of distance' [4]. But a line between globally-oriented 'non-grounded' projects and 'grounded' virtual cities with a clear relationship with geographical communities had to be drawn, because location-based digital spaces were rapidly emerging [1].

Many typical examples of region-oriented community networks started at the beginning of the 1990s [7]. The Blacksburg Electronic Village [5] was born in 1991, and the Seattle Community Network [24, 25] appeared in 1992. They differed in various ways. The former was started by a consortium consisting of regional companies and universities, while the latter emerged from civil activities. In the case of Blacksburg, Virginia Polytechnic Institute and State University worked with Bell Atlantic and local authorities. They built a consortium to create a regional virtual information space. The first two years were spent preparing computers and communication equipment. Dial up services started in 1993. Blacksburg Electronic Village gradually grew large enough to attract regional citizens. In Blacksburg's case, the leading role was taken not by the citizens who would use the network, but by the university, companies and local administration. The network was constructed from the technological viewpoint of companies and universities aiming at transferring research results into telecommunication business. In the same way, many of the early community networks were promoted by 'technical' leaders. The citizens lacked technological knowledge and experience to take the lead. Most community networks required the guidance provided by technical leaders in constructing network infrastructure. However, once the technical infrastructure was in place, the users often rapidly acquired the necessary skills to manage the equipment. Later the development of these local information networks slowed down. For example in 1995 the number of activities of Blacksburg Electronic Village decreased. This was the result of a fundamental disagreement between technology providers and users due to different goals and expectations to the community networks.

The Seattle Community Network (SCN) emerged from civil activities. In 1990, SCN was started as a part of the Computer Professional for Social Responsibility (CPSR) initiative with the goal of creating a cyber space accessible to the public. In 1992, the project was launched in Seattle and started to work on its ideals, vision and strategy. Services started in 1994. Though SCN was faced with financial problems and competition from commercial portals, it grew in size by cooperating with regional libraries that gave an entry platform to the local community by offering a network accessible to everyone. SCN was not led by universities or the city administration, but by the citizens. Its purpose was to provide a sustainable information space for the region's inhabitants. Its services included e-mail provision, homepage creation, and support for regional activities rooted in everyday life. SCN took a leading role for grass-root networking. Just after SCN went in operation, similar initiatives were made in many places across the US. In 1993, the Greater Detroit Free Net started services, and in 1995, Genesee Free Net commenced operation. In 1998, the number of community networks exceeded 300. But not all of them were successful. On the contrary, most were plagued by problems. For example, volunteer-based activities often suffered from chronic fund shortages, highlighting the economic viability of community-driven electronic networking.

After the birth of pioneering community networks like Blacksburg and Seattle, commercial sites like AOL Digital City, and Microsoft Sidewalk came into being. These were profit-oriented portals that provided local information. Their outstanding usability and rapid growth raised the warning that "the pursuit of profit will destroy grass-root community networks." On the other hand, small ventures also started local portals. Even though these sites are run by companies they, unlike the commercial portals offered by global companies, are offering community sites dedicated to specific regions [24]. They act as an intermediate service medium between community networks and commercial portals.

3 European Digital Cities

The European conceptualization of the 'digital city' started with the experience of Amsterdam's De Digitale Stad (DDS) [3, 2] in 1994. The Amsterdam case was the first to use the word 'digital city'. This project quickly got well known and admired for the scope of its aim and openness. Because of it, DDS became a paradigm, and it led a sort of 'digital city' movement within Europe. The Dutch digital city started its activities as a non-profit grass-root organization, but the crucial difference to earlier American experiments was the government's direct support of the project. DDS's functionality ranged from the support of community activities to the encouragement of political discourse, like linking the citizens to the administration. DDS was initially funded by the regional administration, but later it became financially independent. To stand on its own feet, the digital city acquired a company-like character. To cope with the radical technological changes, top-down decisions were often required.

The beginning of DDS was slanted towards the aspects of democracy, administration, politics and economy. Its 'urban' character was also strongly metaphorically emphasized by its interface. It presented and structured the system graphically by employing a city metaphor with thematic squares, cafes and 'residential' sections hosting individuals' websites, hence the 'digital city' idea. Several functions on DDS indicated that it was a nongrounded virtual community that would offer web space, email, and social virtual places where users were not necessarily interested in Amsterdam as a city. Commercial pressure eventually made DDS change into something rather different from its initial 'vision'. It lost its urban metaphorical character and had to compete with a much more varied and articulated offer of free Internet services and connectivity becoming available from many other companies. This has eventually weakened much of its attractiveness and its 'cutting edge' status as a digital city [17].

At the end of 1995, Finland decided to commemorate the 450th anniversary of Helsinki. As one part of its celebrations, Helsinki initiated the construction of a high-speed metropolitan network. The consortium was established by Elisa

Communications (former Helsinki Telecom) and Helsinki city. The members included companies like IBM and Nokia, and universities in Helsinki. They jointly developed virtual tours as well as public services. For example, Helsinki City Museum provided a cultural service for the citizens and visitors interested in the history of Helsinki [16, 15]. A three-dimensional virtual space was set up where the visitors could wander around the Helsinki city hall of 1805. Even though the actual hall did not exist anymore, they built it on the Web and re-created the atmosphere of that age. Helsinki virtual city also offered technically advanced functions. For example, visitors to the city on the three-dimensional virtual city model of Helsinki could make a phone call just by clicking the screen.

The notable point here is that Europe has many digital city initiatives born through the cooperation of public administrations, companies and social activists. Frameworks similar to Helsinki have been introduced in other European cities. In Ireland, for instance, the Eircom telecommunications company constructed the 'Ennis Information Age Town' under public and voluntary partnerships [6].

In Europe, it has been an important theme to integrate and coordinate the efforts of the private, public and voluntary sectors towards better regional and local information systems. TeleCities was an alliance of EU cities that started the European Digital City Project in 1993 [19]. This was originally characterized as a program to support telematics applications and services for urban areas. The TeleCitie's consortium characterizes itself as "an open network of local authorities dedicated to the development of urban areas through the use of information and telecommunications technologies." Its target is to share the ideas and technologies born from various city projects and to strengthen the partnerships among EU cities through this sharing. In this model, each city sets two targets: (1) to utilize information and communication technologies to resolve social, economic and regional development issues, and (2) to improve the quality of social services through the use of information.

The TeleCities support program allows each city to take its own course of actions on facilitating the formation of partnerships and the successful bidding for European Community funds. However, while this approach seemed to have a good potential in bringing together local authorities and the industrial and commercial sectors, grassroot communities and voluntary projects were left out. As a consequence, many initiatives appeared to be 'pushed' to their potential users in a top-down fashion. Especially in the early stages of projects' conceptialization and construction, the top-down management failed to stimulate the citizens' participation, even though it ensured good levels of support. In some cases, management became aware of this operational gap and started to emphasize the need to "base the informatization on society" or the importance of informatization in resolving social issues.

Along with this direction, Vienna city, one of the oldest members of TeleCities, created the informatization plan called 'The Strategy Plan for Vienna 2000'. In Vienna, both the city and the citizens shared the responsibilities for informatization. Under the strategy plan, the city was responsible for the civil services and the citizens were responsible for the projects executed by individual communities. The digital city was run by this cooperative structure. For example, if the city wanted to resolve the issue of digital signatures, the citizens would participate willingly in a trial project and enable its speedy introduction. Such collaboration was realized based on this cooperative structure. Moreover, their plans, processes, results and lessons learned were reported to the EU and used in the other cities, so that effective information sharing was realized. Similarly, in the Italian city of Bologna, the 'Iperbole' – Internet for Bologna and the Emilia Romagna region – initiative was started and run by the local municipality with the intention of being fairly open to grass-root contributions. The city council would provide information and civic services, but would leave an open door to voluntary organizations and citizen groups. This approach allowed the digital city to become an information provider and publisher as well as a plaza for citizens within the official digital city.

About 100 cities from 20 countries have been taking part in TeleCities. EU's support of city informatization has been strengthening, and each city has developed its own digital counterpart taking advantage the sharing of best practices, project plans, and success stories. Although TeleCities acquired members steadily and facilitated projects continuously, it found that their activities still largely lacked the commercial viewpoint. In order to accommodate this need, in 2001, three of the main urban informatization organizations, eris, ELANET and TeleCities, moved towards cooperation. They also supported Global Cities Dialogue in order to construct a worldwide urban network.

4 Asian City Informatization

The most significant trend in Asia was the emergence of city informatization as a governmental national project. Though the momentum generated by American grass-root activities had a great influence, digital cities in Asia were created as a part of governmental initiatives. The first country in Asia to implement an informatization project was Singapore. The administration started the Singapore IT2000 Master Plan in 1992. In 1996, it launched the plan called 'Singapore One: One Network for Everyone' to develop a broadband communication infrastructure and multimedia application service. Korea proposed the KII (Korea Information Infrastructure) in 1995 in response to the American NII. In 1996, the Malaysian administration announced a plan called the Multimedia Super Corridor. Their new high-tech cities, Putrajaya and Cyberjaya, were a part of the Malaysian e-Government and the surrounding regions were designated as multimedia zones. An organization similar to the Western community network was the research project called Malaysian Institute of Microelectronic Systems (MINOS). MINOS, which also acted as an Internet provider, broke away from the Malaysian government in 1996. Three different sectors: public administration, business and citizens cooperated with each other to improve everyday life and promote social interaction. They realized technical innovations with the aim of contributing to the development of the country.

In Japan, the regional network Koala was born with the assistance of a local prefecture. In 1985, it set up an information center, in 1994 it connected to the Web, and in 2000 it was reorganized as a business corporation that promoted community networks. After that, many regional community networks have been developed in Japan with assistance from the administration and telephone companies.

The leader of informatization in Asia was mainly government. It was rare to see leadership exerted by civil activities or grass-root organizations. The reaction from the industrial world was also slow. As for Koala, in spite of its public face, it started as a part of the informatization policy set by the local government. Their policy of "introducing IT proactively and implementing coast-to-coast informatization" was originally proposed by the government. What tended to happen were the emergence of a precise and relatively rigid government-oriented information strategy, rather than the clarification of rules and purposes for community networks in order to prepare the ground for bottom-up initiatives. As a result, the promoters of digital cities often conducted large-scale investments such as laying optical fiber lines or equipping all schools with PCs. The activities of Asian digital cities could be seen as mainly governmental initiatives conducted in the name of city informatization.

An interesting example of rural networking was seen in Yamada village, Japan. This project started in 1996 with the aim of reversing the depopulation trend in rural areas. It can be defined as a regional informatization project to stimulate village life. The community site, which is mainly for village citizens, was developed with the support of the administration. In 1998, the ratio of connected villagers reached 60%, and the interaction both within and outside village increased. The Yamada project greatly contributed to a better understanding of the potential of civil participation in rural areas. However it is worth noting that the Yamada village project was also mainly driven by the administration. So, despite of its success, it was still not a citizen-led activity.

More recently, however, due to a better understanding of the limitations of the topdown approach, many countries have started, since the late 90's, to preach the importance of civil initiative. This movement has been fostered by the American community networks mentioned previously. People who have experienced the grass-root activities in the US played an important role in introducing the concept in Asia. In Japan, organizations like the Community Area Network Forum (CAN) was established. CAN was inspired by American community networks and its goal was to create a rich information space and to promote human communication in actual communities by utilizing the Internet. CAN itself was not a digital city but an organization promoting to build regional networks in Japan.

Apart from the community networking movement, several technology-oriented initiatives were made in Japan. In 1998, Kyoto digital city project [12] initiated by researchers at NTT and Kyoto University developed a social information infrastructure for urban everyday life. Digital City Kyoto covered shopping, business, transportation, education and social welfare as well as tourism. Digital City Kyoto forum was supported by not only local authorities and researchers, but also local citizens, shop owners and students. Being led by computer scientist from telecom companies and universities, Digital City Kyoto had strong advantages in using advanced technologies such as GIS, VR, animation and social agents. Eventually, however, top-down initiatives weakened further developments of vital activities, and the project finalized in 2001 without further development by users. Still, it is noteworthy that experience and knowledge of using advanced technologies such as real-time city sensors, 2D-3D maps, and rich video data was accumulated.

5 Advances in Information and Communication Technologies

As described in the previous sections, the early digital cities had distinct characteristics. Asian digital cities concentrated on using advanced information technology while North American digital cities focused on strong social functions for supporting local community. The level of interaction with the real community also varied. Some digital cities created virtual communities with weak ties to the designated local communities while others created digital versions of physical cities.

Today, digital cities are widespread and have become more mature and diverse. The role of digital cities has transformed over time, reflecting the nature of the existing local cities and rapid advances in technologies. The distinct socio-technical and virtual-physical characteristics of early digital cities have often disappeared in current digital information spaces. It is hard to categorize modern digital cities as either technology test-beds or community spaces. They have evolved according to functional demands of their local communities. For instance, if a real world city attracts tourists, its digital city have to provide functions to support tourists as well as to support local residents with the well-integrated information and online services.

Recently, the integration of the virtual-physical dimension has accelerated due to the advent of wide spread wireless communication networks and mobile devices. Many personal digital assistants (PDAs) and mobile phones are equipped with advanced technology such as digital cameras, videos, personal data storages, GPSs, WiFi and Bluetooth. They have made it possible to create virtual information cities deeply rooted in reality.

In the early development stages of digital cities, several attempts to integrate the virtual and physical world were made, for example Digital City Kyoto and Virtual Helsinki mentioned earlier in this chapter. In the Digital City Kyoto project, several sensors were installed in Kyoto city [12] showing the real-time state of Kyoto bus services such that Kyoto citizens and tourists could find efficient transportation routes. Vision sensors in Kyoto Station were synchronized with the virtual Kyoto Station and made it possible to simulate evacuation systems in Digital City Kyoto [22]. In Finland, the mobile telephone network connected to a 3D model of Virtual Helsinki and provided users route navigation as well as location information [15]. Although these early examples of digital cities never went beyond an experimental level, later digital cities have kept on improving their interactivity with wireless communication networks and devices. In Digital City Kyoto, a city navigation system using existing city information was developed [13]. Originally, Digital City Kyoto was accessed only from desktop computers, but by providing location-based services, users also started to access it from devices with lower computational power such as PDAs and mobile phones. The use of such wireless communication and mobile technology has gradually blurred the border between virtual and physical cities.

Today there exists many other systems apart from digital cities that try to interact with real cities. Some use mobile devices such as PDAs or mobile phones. Some target citizens while others target tourists. Mai and colleagues [18] developed a system that provided positional information in real-time with the help of a digital city model. Their system enabled tourists, who often have difficulty locating themselves on a printed map, to identify their location using images of objects captured by their PDA. With combined location information from GPS and user-captured images, the system gave positional information that was detailed enough to be used by first time visitors.

In addition to local information networks, special service networks such as medical information networks, traffic information networks and smart home networks have been established to actively support citizen's daily life. By connecting local hospitals, libraries and schools with cutting edge digital environment technologies, a foundation for a new generation of digital cities is emerging.

6 Technologies in Digital City Kyoto

In order to grasp a holistic view of information and communication technologies applied to digital cities, we describe some of the information and communication technologies of Digital City Kyoto in more detail. Digital City Kyoto was designed based on the latest technologies of the time including GIS, VR, animation and social agents.

The Digital City Kyoto used the three-layer model illustrated in Figure 2 [10].

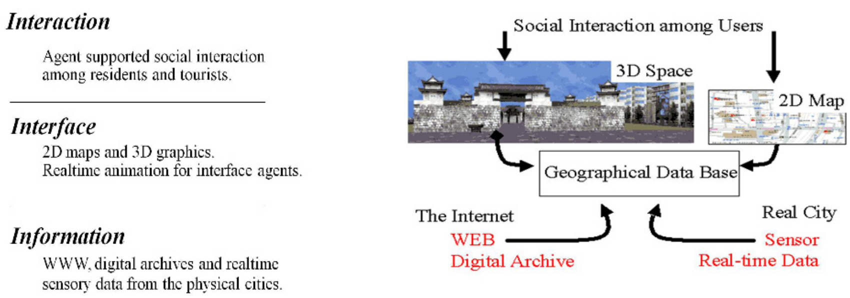

Fig. 2 The three-layer architecture of Digital City Kyoto.

1. The first layer, called the information layer, integrates and reorganizes Web archives and realtime sensory data using the city metaphor. A geographical database was used to integrate different types of information. A tool was created for viewing and reorganizing digital activities made by people in the city.

2. The second layer, called the interface layer, uses 2D maps and 3D virtual spaces to provide intuitive views of digital cities. The animation of moving objects such as avatars, agents, cars, buses, trains, and helicopters demonstrate some of the dynamic activities in the cities. If an animation reflects a real activity, the moving object can become an interesting tool for social interaction: users may want to click on the object to communicate with it.
3. The third layer, called the interaction layer, is where residents and tourists interact with each other. Communityware technologies are applied to encourage interactions in digital cities.

The above three-layer architecture is very effective in integrating various technologies. Only little guidance was required to determine where each technology should be positioned. Some of the technologies developed in Digital City Kyoto are introduced below.

6.1 The Information Layer

When Digital City Kyoto was constructed, operations on the Web sites mainly involved text. Users searched for information by keywords and software robots retrieved the information. This search-and-retrieve metaphor works well even now when a wide variety of search methods have appeared. If the Internet is to be used for everyday life, however, the geographic interface is also important. As shown in Figure 2, the core of our digital city is GIS. The geographic database connects 2D and 3D interfaces to the Web and sensor-sourced information. From a system architecture point of view, introducing the geographic database allows us to test various interface information technologies independently.

GeoLink [8] is a collection of links to public spaces in the map of Digital City Kyoto developed by Kaoru Hiramatsu and holds approximately 5400 pages. These public spaces including restaurants, shopping centers, hospitals, temples, schools and bus stops were collected in a single map. As shown Figure 3, GeoLink can visualize how web pages relate to physical locations distributed throughout the city. People would directly register their pages in geographic databases, but the system would automatically determine the X-Y coordinates of each Web page. The challenge was, however, the unique ways of expressing addresses adopted in Kyoto. As Kyoto has more than 1200 years history, there are various ways to express the same address that makes the automatic process complicated.

GeoLink uses a new data model called augmented WEB space. As shown in Figure 4, the augmented Web space is composed of conventional hyper links and geographic links. A typical example of a geographical generic link is ‘within 100 meters’. The link is called generic, because it is created according to each query issued by users. Suppose that the query “restaurants within 100 meters from the bus stop” is posed. The links are virtually created from a Web page for the bus stop to those restaurants located within 100 meters of the bus stop. Efficient query processing methods for the augmented Web space have been developed.

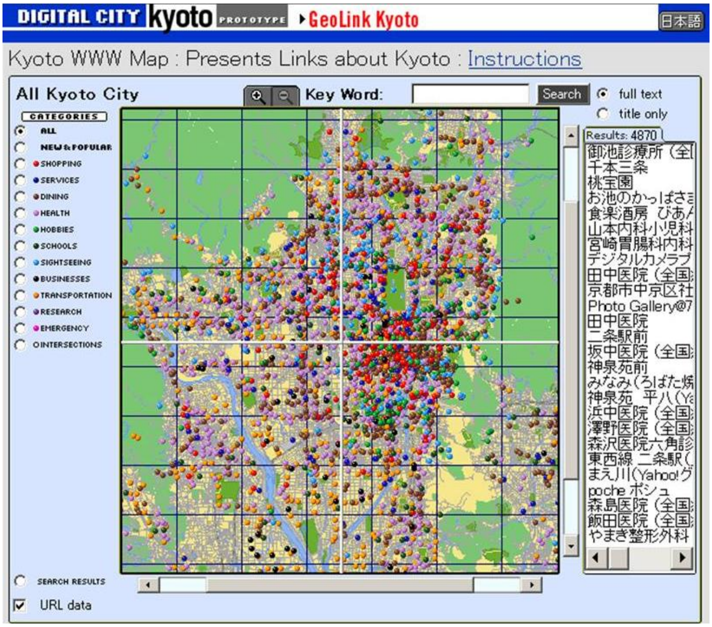

Fig. 3 GeoLink developed by Kaoru Hiramatsu.

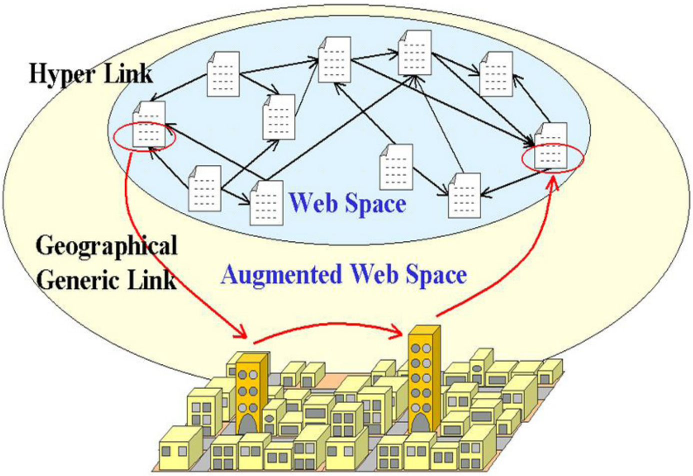

Fig. 4 Information integration using GIS.

Real-time sensory information includes bus schedules, traffic status, weather condition, and live video from the fire department. In Kyoto, more than 300 sensors have already been installed, gathering the traffic data of more than 600 city buses. Each bus sends its location and route data every few minutes. Such dynamic information really makes the digital city live.

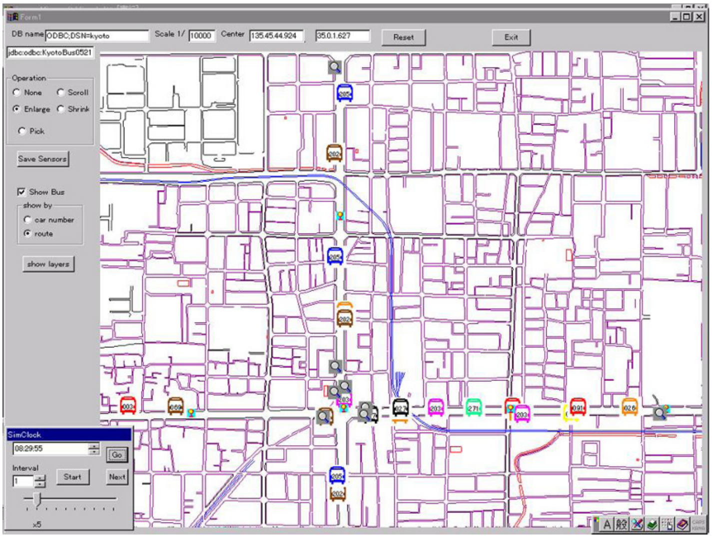

Fig. 5 Bus Monitor by Yasuhiko Miyazaki.

In a first experiment, real-time bus data was collected and displayed on the digital city. Figure 5 shows a bus monitor developed by NTT Cyber Solutions Laboratories. Buses in the city run on the Web in the same manner as in the physical city. Real-time city information is more important for people who are acting in the real 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 in a department store close to them. Digital City Kyoto could provide live information to mobile users through wireless phones.

6.2 The Interface Layer

An enormous amount of information can be accessed through the Internet. Humans have never experienced any similar expansion before in terms of scale and speed. People's various activities are being recorded in the semi-structured database called the Web over time. Consequently, it might be possible to visualize human activities and social interaction, which cannot be directly measured, by investigating the information collected on the Internet.

In GeoLink, the latitude and longitude of a shop are determined from its Web page address, and a link is placed on the map accordingly. As information on the Internet increases, downtown areas would be gradually visualized on the map. We can ‘feel’ the activities in the town from the map showing restaurants, schools, hospitals and shops. Observing this map over several years enables us to understand the growth of the town. It is important that this observation can be carried out by anyone. A map of a digital city is not just a database to measure distances or to check addresses. A map is expected to become a new interface that helps us understand the activities of the city.

Similarly, the three dimensional (3D) graphic technology is a key component of the interface layer, when used in parallel with 2D maps. Providing 3D views of 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 6 shows the 3D implementation of Shijo Shopping Street (Kyoto’s most popular shopping street).

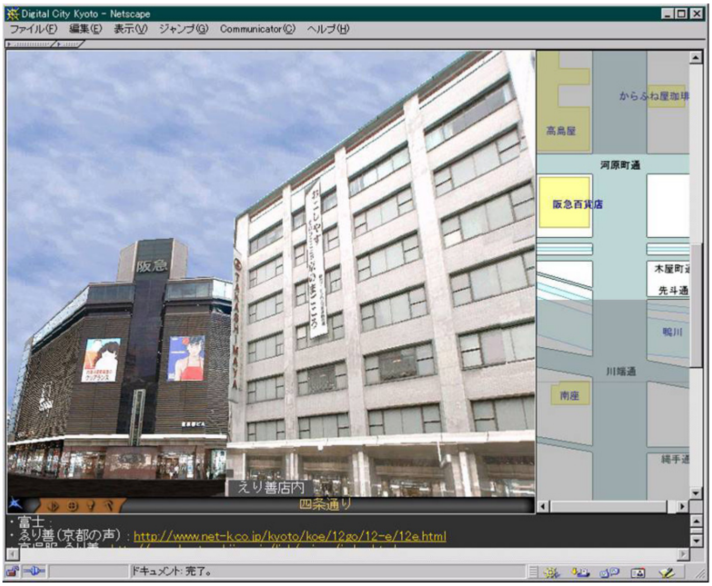

Fig. 6 A 3D implementation of Shijo Shopping Street.

3DML (http://www.flatland.com) is used for this visualization. It is not well suited to reproduce gardens and grounds, but has no problem with modern rectilinear buildings (see Figure 7 as an example). 3DML was originally used to construct games. Since it is also suitable for building a town, this tool was applied to develop 3D cities. A 3DML city can be basically understood as a city made of building blocks. For a start, a digital camera is used to take photos of the city. Some corrections are made in Photoshop, since it is inevitable that the upper parts

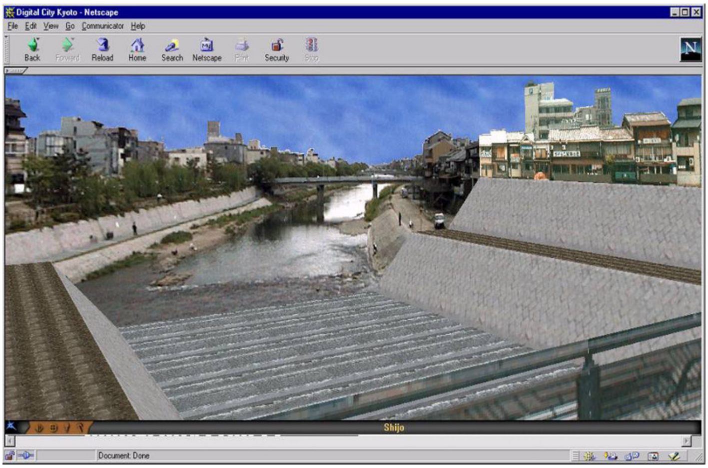

Fig. 7 A 3D implementation of Kamo River in Kyoto by Stefan Lisowski.

of buildings appear smaller due to perspective. The next step is to pile blocks up to create the buildings and paste the corresponding photos. Theyt are not precise 3D space like those produced by virtual reality professionals as it is more a tool for non-professionals. Technical knowledge of virtual reality is not necessary to build a city in this way. Only patience is required.

Fig. 8 Kobe City after the 1995 Earthquake by Stefan Lisowski.

Figure 8 shows a reproduction of Kobe right after the earthquake in 1995 created using existing photos. This work was requested by the Kyoto University Disaster Prevention Research Institute, which has collected 15,000 photos taken in the Kobe area. The organization tried to display the photos on the Web, which was not easy to search through. By rearranging the photos in a 3D space rather than displaying them like a photo album, the data could provide a different angle of the sight. It was not easy to reproduce buildings from the photos, but it was possible to reproduce one part of the city. In performing this, it was realized that reproducing a 3D virtual city from photos or videos is an attractive approach. Two approaches to building a 3D space has been developed: modeling it with CAD and reproducing it from photos or videos. 3DML can be seen as a tool that combines the two approaches while giving the pleasure of personal creation.

6.3 The Interaction Layer

Social interaction is an important goal in digital cities. Even if we build a beautiful 3D virtual space, if no one lives in the city, the city cannot be attractive. Katherine Isbister, a social psychologist from Stanford University, hit on an interesting idea. To encourage intercultural interaction in digital cities, she implemented a digital bus tour for foreign visitors. This idea was implemented in Digital City Kyoto. The tour was designed to be an entry point 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 9). A tour guide agent leads the visitors, who can interact with the system in many ways, through the Nijo Castle in Kyoto simulated using 3DML.

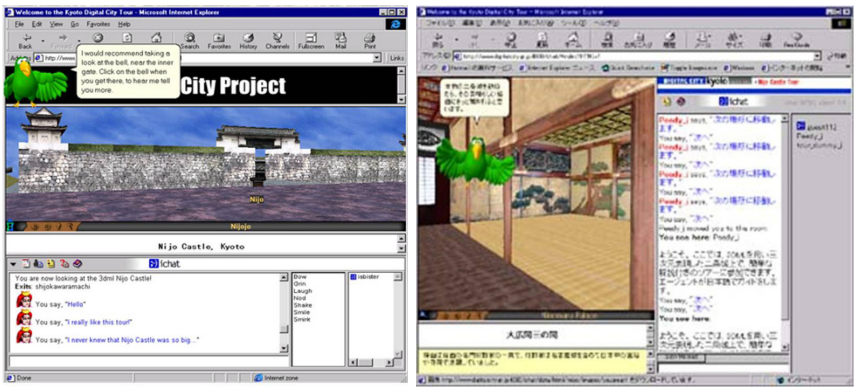

Fig. 9 Digital Bus Tour with Agent Guide (By Katherine Isbister).

Kyoto city, as the owner of Nijo castle, allowed that photos were taken inside the castle. The 3DML world created from those photos is so beautiful that nobody would believe the work was done by non-professional photographers. To prepare for creating the tour guide agent, Isbister participated in several guided tours of

Kyoto. She 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 [9].

This system includes two new ideas. One is a service that integrates information search and social interaction. Unlike Web searches, which are solitary tasks, the digital bus tour creates an opportunity for strangers to meet. Another is to embody social agents that perform tasks for more than one person. Unfortunately, this agent cannot understand the contents of conversations at this stage. After this experience, however, a virtual city platform called FreeWalk [21, 20] and a scenario description language Q [11] has been developed. It was planned that agents should participate in the conversation of tourists on the bus and become famous as bus guides in the Internet world. Guide agents will stimulate various ideas about future digital cities.

6.4 Lessons Learned

We have developed key technologies for digital cities and future research directions from the experience of Digital City Kyoto.

1. Technology for information integration is essential to accumulate and reorganize urban information. Digital cities typically handle Web information and real-time sensor-based data from physical cities. Voluminous high quality digital archives can also be accessed through digital cities. The idea of 'using a map' is commonly observed in digital cities. In this case, technologies are needed to integrate different kinds of urban information via geographical information systems (GIS). It is also necessary to introduce a technology to handle photos and videos of the city so as to understand its activities. Great numbers of sensors embedded in the city will collect visual information automatically. These infrastructures will make 'sending and receiving information' in everyday life much easier.
2. 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 content creation and social interaction, a new technology is required that encourages people with different backgrounds to join in. Social agents can be a key to encouraging people to participate in the development and life of digital cities. So far, most digital cities adopt the direct manipulation approach to realize friendly human-computer interactions. Social agents are used to support human-human interaction. The direct manipulation approach allows users to explicitly operate information objects. Since social agents (human-like dog-like, bird-like and whatever) will have the ability to communicate with humans 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.

3. 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 several kindergartens declined our request to link them to the digital city. This differs from the security problem often discussed for business applications, where cryptography, authentication and fire-walls are major technologies. Just as we have social laws in physical cities such as peeping-tom laws, digital cities should introduce social guidelines that provide the security, so that people feel comfortable about joining the information space.

7 Conclusion

The purpose of this chapter has been to elucidate the digital city activities after 1990 and to provide some reflections on geographical characteristics and cutting-edge technologies. We have described how digital cities have been developed by various organizations and how advanced information technology has been applied to provide location based services. After intensive contributions of wide varieties of professionals to digital cities, current digital cities have become deeply rooted in the daily life of citizens and widely accepted. All the more, empowered by information and communication technologies, current digital cities reflect more city activities than ever.

Cities – the physical ones – are complex entities. They have been successful for centuries and have kept their prominence despite all sorts of past predictions about their dissolution, just because of their ability to concentrate and somehow articulate the co-existence of community, voluntary movements, politics, commerce, tourism, culture and so forth. Digital Cities need to deal with the same complex mix of things in order to attract citizens, retain their usage, and function as entities that ‘augment’ their physical counterparts. A city famous for its tourist attractions will not develop its digital city without an eye on tourism, because the commercial aspect is a part of the basic structure of every day life for them. Popular squares in a city would not take roles of the center of the city as they normally do without the presence of shops around the squares.The same environment, we expect, should be applied to virtual squares and places.

Digital cities together with already established city information infrastructures could form a foundation for further development of city informatization. Based on wireless and mobile networks and handheld devices, we believe that the future digital cities are moving into a new development phase where the physical and virtual city is merging to a single entity.

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