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Considerations in Providing Ubiquitous Internet Access for China's Metropolitan Areas:

A Blueprint for Integrated Wireless Broadband Information Services (IWBIS)

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Abstract

Urbanization is an important trend in the process of China's modernization. The rapidly advancing adoption of information and communications technology (ICT) in China is enabling this process and may also help in addressing the challenges stemming from the rapid changes, including those related to increasing traffic and environmental issues. This paper is intended to discuss a possible approach for enabling the vision of "Digital City" to become a reality by providing ubiquitous Internet access for China's metropolitan areas. In particular, the paper proposes a blueprint for integrated wireless broadband information services (IWBIS) and identifies a number of outstanding research issues to the implementation of IWBIS.

Introduction

Urbanization is an important trend in the process of China's modernization. The rapidly advancing adoption of information and communications technology (ICT) in China is enabling this process and may also help in addressing the challenges stemming from the rapid changes, including those related to increasing traffic and environmental issues. In this paper we discuss a possible approach for enabling the vision of "Digital City" to become a reality by providing ubiquitous Internet access for China's metropolitan areas. In particular, we propose a blueprint for integrated wireless broadband information services (IWBIS).

With a population of 1.3 billion and forward-thinking economic and regulatory policies, China has made its telecom market the center of the Asia Pacific region. According to recent reports of In-Stat, the high-tech market research firm, (http://www.instat.com/press.asp?ID=1142&sku=IN0402356CHW) and

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(http://www.instat.com/press.asp?ID=1495), the development of wireless communications is an area of significant focus, stimulated by government policy and end-user demand. While government scrutiny of foreign investment in China's wireless market remains tight, joint investment in infrastructure, services, and devices are very active:

- Fixed and wireless telephone subscribers surpassed 600 million in the first half of 2004, with mobile subscribers reaching 310 million (and 400 million by February 2006 according to recent government statistics). The number of mobile subscribers in China will reach nearly 610 million in 2009, with the percentage of 3G users ranging from 23%–58%, depending on various competitive scenarios and operator strategies, according to In-Stat.
- CDMA has been a strong growth area in China, with China Unicom having quickly become the world's second-largest CDMA operator. Interoperability between GSM, CDMA, and 3G is a key area of focus for policy-makers. W-CDMA technology will be the dominating 3G technology in China, while TD-SCDMA will grow gradually over time.
- Government considerations will greatly influence factors such as technology maturity, handset availability, system compatibility, global roaming capability, and construction costs.
- Voice will still be the dominating service for 3G in China, while mobile Internet access service will be the fastest-growing service.

While there will be substantial developments in the coming years in the mobile networks as described above, there has recently been growing interest in China in taking the complementary wireless broadband technologies, such as Wi-Fi and WiMAX, into use and developing services both on the unlicensed and licensed spectrum using these. Actually, many of the Chinese cities, in particular the new ones being developed, are in position to design and build the communication infrastructure with adequate broadband capacity (e.g. fiber networks) to scale for extensive use of wireless broadband services.

The Idea of "Digital City" – Soon to Become Reality in China?

A modern city is characterized by the ubiquitous applications of information technology. Actually, in China, "Digital City" is more likely a reality than a slogan – even though in selected cities first. The two prime examples illustrating this are Beijing preparing for the 2008 Olympics and Shanghai preparing for the 2010 World Expo.

Digital Olympics for *2008 Beijing Olympic Games* has been one of the important infrastructure systems to be constructed before the event (http://www.eurochina2002.com/digital_olympics.html). "One world - one dream" of Olympic Game needs IT/IS to hook up the world (http://en.beijing2008.com/)
The overall objective of Digital Olympics is (People's Government of Beijing, 2005):

> *"… ensuring successful hosting of Beijing 2008 Olympic Games, establishing a comprehensive information service system based on individuality and taking people as a dominant factor, conforming with international norms and demonstrating Chinese characteristic, speeding-up construction of "Digital Beijing", promoting industrial development and showing the standards and achievements of China's informatization. The imagery objective of "Digital Olympics" is: by and large ensuring that anybody at any time and in any place related to the Olympics can enjoy*

in a secure, convenient, swift and efficient manner the information service that is affordable, diversified, multi-linguistically intellectualized and individualized."

World Expo 2010 is becoming another important event in China as Shanghai has won the bid (http://www.chinadaily.com.cn/en/doc/2003-10/31/content_277131.htm). It will be an arena for the participating countries to display the achievements and prospects in their social, economic, cultural and technological sectors. Known as the "economic, technological and cultural Olympic Games," the World Expo is held every five years and it is expected that in Shanghai it will be a more important showcase that in many of the previous locations. The theme of this Expo has been chosen to be "Better City – Better Life".

To service World Expo 2010, Shanghai is to build up a city information management system with 6 subsystems as shown in Figure 1. This is to cope with the estimated traffic of 7,800,000 vehicle-times per day and 72 million visitors for 184 days of the event. While the population of Shanghai is 17 million the event will substantially increase the visitor numbers during the event.

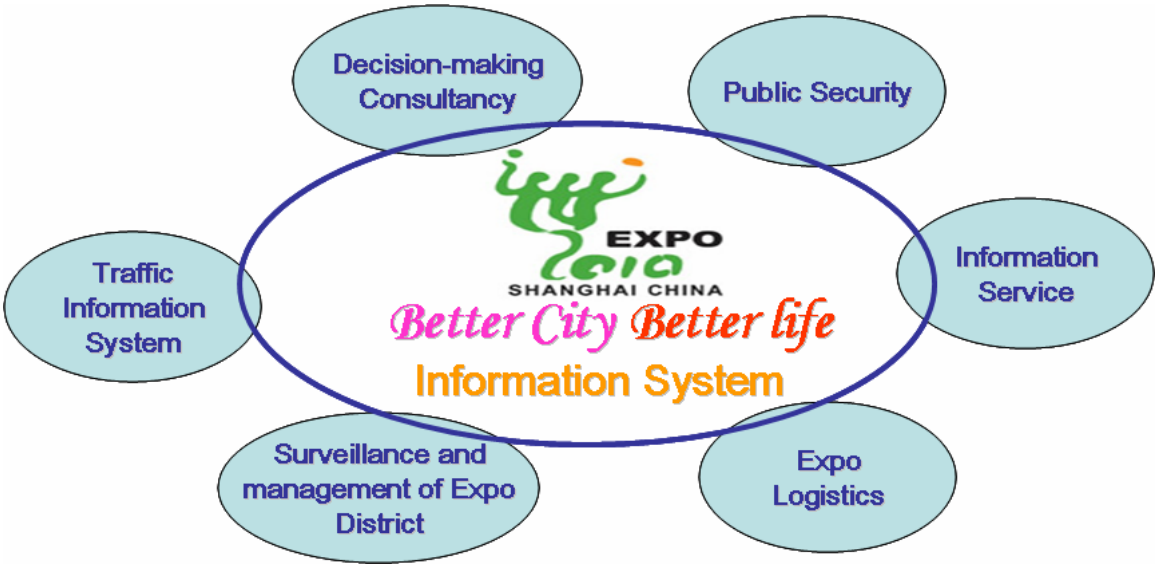

Figure 1: The information system for Shanghai World Expo 2010

(Source: Tongji University, 2005)

To support the event, the Shanghai government is investing over US $10 billion in infrastructure (harbor, airport, city transportation, and cultural facilities). The investment directly of Shanghai's "World Expo projects" is estimated at US$ 3 billion, of which 43% will come from government sources, 36% from companies and 21% from banks. The information services will be one of the major categories to be enhanced.

The demand from the two major cities in China for metropolitan management information system leads a trend in China - many mid-sized and large cities have launched Digital City projects since 2000, with the prevailing adoption of cutting-edge information technology and fast improved data communications facilities (Xinhua News Agency, 2001, http://www.hartford-hwp.com/archives/55/427.html; China.org, 2002,

http://www.china.org.cn/english/BAT/37762.htm; Embassy of PR China in the US, 2004, http://www.china-embassy.org/eng/gyzg/t170487.htm; People's Daily, 2004, http://english.people.com.cn/200411/18/eng20041118_164284.html).

In the recently announced China's science and technology development plan (MST 2006), city information platform has been one of the research focuses, which covers city network information sharing technique, city meta-data acquisition and update, city multi-variable data integration and mining technique, city multi-dimension and simulation modeling, city dynamic surveillance, information sharing standards, and city emergence information service technique. The concept of digital city has been adopted by Chinese government in it's the Eleventh Five-Year Plan. Digital city has been an important project for many Chinese cities during the period (http://news.ccidnet.com/art/1744/20051115/372557_1.html), such as Beijing (http://www.echinagov.com/dzzw/ReadNews.asp?NewsID=13519), Guiyang (http://city.finance.sina.com.cn/city/2006-03-15/67664.html), Yangzhou (http://www.digitalearth.cn/readCont.asp?contID=3912), Tianjin (http://news.enorth.com.cn/system/2006/01/17/001212946.shtml), Wuhan, Guangzhou, Xiamen, Nanjin, Shenyang etc. (http://news.ccidnet.com/art/1744/20051115/372557_1.html).

In a definition by the upcoming China International Conference on Digital City Construction Technology to be held in Suzhou, China, June 10-12, 2006, digital city is a technical system that performs automated city information collection, monitoring, management and decision support by using the techniques of GIS, remote sensing, remote measuring, networking, multimedia, and virtual reality; and it digitizes, networks, and virtualizes city geographic, resource, ecological, demographic, economic, social systems (http://www.ehomecn.com/zhpd/ShowArticle.asp?ArticleID=6044). Based on widely accepted concept of digital city in China, we define a digital city as a set of comprehensively organized information facilities and resources to incorporate a modern city service system, which is extensible to cover its annexed greater area. This definition implies that a digital city is:

1) a part of city system
2) built with computer and communication technologies
3) able to process large amount of information and possesses abundant information resources
4) convenient, effective and efficient in information services

An integrated city information management system in a Digital City is generally composed of various subsystems including those serving the various administrative and service functions of the city but also those enabling the participation of citizens and those providing new business opportunities based on the information service infrastructure. Typical examples include:

- City traffic control information system
- City security and catastrophe monitoring information system (fire extinguishing, medical service, security monitoring, evacuation information services. etc.)
- Ecological environment surveillance information system
- Greater city area utility management information system (water supply, electricity, drainage system, etc.)
- City government public information services (e.g. electronic bulletin board, city legislation information, etc.)

- Commercialized metropolitan area information services (e.g. commercialized news services, advertising services, etc.)
- Tourist information system (shopping, food, map, etc.)

Role of Wireless Technologies in the "Digital City"

Many cities in China have established computer network based information system to support the various functions as described above. However, there are problems in the implemented systems stemming from the architecture and technologies in use:

- They are often isolated systems by different functional divisions of the city, and normally do not share the information properly.
- The infrastructure construction was not well planned and there has been a waste of information facility resources. For example, traffic control system, environment monitoring system, and security system in a city all need to build up a network for both wired and wireless data transmission needs.
- There is a growing demand for the mobile or wireless access to the applications. However, current 2G/2.5G based mobile technology is unable to provide enough bandwidth for the future media rich applications

The above problems have boosted the demand for an integrated information services network that would:

- be able to share information among different services and to create new interoperable services from existing ones
- make best use of the combination of the new fixed and wireless networks to provide ubiquitous and cost-effective access to the city information systems.

Such an integrated service with wireless and mobile access could be implemented by combining the 3G mobile network services, including the rich media but also roaming, charging and subscriber identity services provided by them, with wireless broadband technologies, such as Wi-Fi and WiMAX.

It appears that for WWAN (Wireless Wide Area Network) that are based on cellular technologies and provide high speed mobility the enhanced 3G (e.g. with HSDPA) is a preferred solution, while for the portable/nomadic or indoor/outdoor fixed wireless the WiMAX and Wi-Fi would be appropriate. However, with constant changes in the technology capabilities and business models the case is far from being resolved. For example, with flat monthly rates, unlimited data usage, and faster speeds, the 3G networks become quite competitive with various wireless broadband scenarios.

A Mixture of Mobile and Wireless Broadband

From the evolution course of ICT, the advent of broadband wireless age is natural and its potential impact on the society and economy is tremendous. We can roughly identify three

surges of ICT in the last 25 years: personal computer (early 1980s), the Internet (early 1990s), and wireless network (early 2000s). Each such an evolutionary change has created huge business opportunities. There is a myriad of concepts that illustrate the idea of ever-present, ubiquitous wireless services and u-business (Watson et al 2002; Liang and Wei 2003).

With the capabilities of the various technology solutions improving, and the various camps actively promoting their solution as "the right choice", there are complementary and competing, approaches in moving to the ubiquitous Internet. We summarize some of these below taking into account some of the China specific items.

3G and Beyond – Technologies Based on Cellular Networks

In the mobile telecoms world the 3G has started to gain momentum. Its data transmission rate can be 144 kbps in a fast moving environment and up to 2 Mbps in a still application environment. However, this seems still not enough to meet the increasing requirements from rich multimedia applications.

To address the need for higher data rates a new mobile telephony protocol called High-Speed Downlink Packet Access or HSDPA, also known as 3.5G (or "3½G"), has been developed.,. HSDPA is a packet-based data service with data transmission up to 14.4 Mbit/s (with 4/4 coding) and 20 Mbit/s (for MIMO systems) over a 5MHz bandwidth in W-CDMA downlink. In the 3rd generation partnership project (3GPP) standards, Release 4 specifications provide efficient IP support enabling provision of services through an all-IP core network and Release 5 specifications focus on HSDPA to provide data rates up to approximately 10 Mbit/s to support packet-based multimedia services. The success of this technology as a GSM-replacement, vis-à-vis other contenders like CDMA2000 or 1xEV-DO is to be seen but it has been very widely deployed in the past months by cellular operators around the world and also challenges the promise of WiMAX which still has a way to go to reach wide scale use.

TD-SCDMA (Time Division-Synchronous Code Division Multiple Access) is a 3G mobile telecommunications standard, being pursued in the People's Republic of China by the Chinese Academy of Telecommunications Technology (CATT), Datang and Siemens AG, in an attempt to develop home-grown technology and not be "dependent on Western technology". On January 20, 2006, Ministry of Information Industry of the People's Republic of China formally announced that TD-SCDMA is the country's standard of 3G mobile telecommunication. According to the news by Xinhuanet on March 6, 2006 (http://english.sina.com/business/1/2006/0312/68960.html) China has finally devised its schedule for trials of its homegrown third generation(3G) mobile communication standard TD-SCDMA. The trials will be carried out in the northern city of Baoding, the eastern city of Qingdao and the southern city of Xiamen by China Telecom, China Netcom and China Mobile respectively. However, as 3G does not work as efficiently as HSDPA in supporting the new mobile applications, such as the applications based on European sponsored DVB-H standard, 3G may become a short transition period in China's mobile service market (http://news.xinhuanet.com/newmedia/2006-02/23/content_4215952.htm)

Wireless Broadband – Technologies Stemming from the Internet

The wireless broadband technologies are also advancing rapidly and can be seen either competing or complementing the above described cellular technologies. Since 2000, Wi-Fi (IEEE 802.11x) has been widely deployed and accepted as the wireless solution for local area networks providing broadband access to the Internet. However, its small coverage up to 150 meters (802.11b) or 50 meters (802.11a) has restricted its applications to non-mobile environments and it has not been suited for situations where rapid-mobility is required, such as on a train (Bianchi et al 2003; MORRANE 2005).

Recently WiMAX (IEEE 802.16x), the broadband wireless technology for metropolitan area network, has entered the market (Boslet 2005). WiMAX can reach up to 50 km range with high data transmission speed. WiMAX is now deployed in several countries, such as the US (e.g. movie transmission in Sundance Film Festival), Canada, Egypt (Alkan telecom will establish its network in Cairo using WiMAX-based wireless backhaul and multipoint system), China (e.g. the pilot WiMAX networking project in Chengdu) etc. (Boslet 2005; http://www.redlinecommunications.com/).

Several big Internet and phone companies are moving to provide wireless high-speed access to the Internet, challenging the dominance of those traditional connections to millions of U.S. homes and offices (Drucker and Latour 2005). A UN report (Wireless Internet Institute 2003) suggested that WiMAX+Wi-Fi be a good combination for metropolitan area networking to solve the "last mile" problem and is particularly suitable for developing countries to start with a latest technology with affordable costs for a feasible implementation infrastructure. Seeing the business potential of WiMAX, Intel has been actively involved in the WiMAX research and planning the WiMAX enabled notebook computer to be launched soon (Hachman 2005; Boslet 2005). Another pioneer in the WiMAX business, Proxim, has facilitated Tsunami BWA Platform with an industry mobile roaming capability up to 200 km/h (WiMaxxed 2005), showing the potential of the rapid-mobile applications.

The Relative Merits and Business Considerations

As we compare the above described technologies, we can observe that they have their relative merits and drawbacks. For example, 3G boosted with HSDPA is much more mobile than WiMAX while WiMAX promised data rates of up to 70 Mbps. Eventually, the two technologies will intersect as HSDPA gets faster and WiMAX's mobility improves. As Alan Varghese, ABI's principal analyst puts it: "In the early stages, HSDPA will still be about mobility and data and voice from a cellular kind of platform — and WiMAX will be about broadband data to the enterprise and to underserved areas" .

There is likely to be significant amount of competition between the two technologies in the future. HSDPA won't require new infrastructure as it uses cellular infrastructure which already exists today in 3G networks. Also, the installed base of HSDPA devices may grow very quickly if it becomes widely adopted by the mobile operators and may challenge the adoption of WiMAX.

According to Figure 2, the role of broadband wireless technologies is important in filling up the position at higher data rate end of mobile data communications.

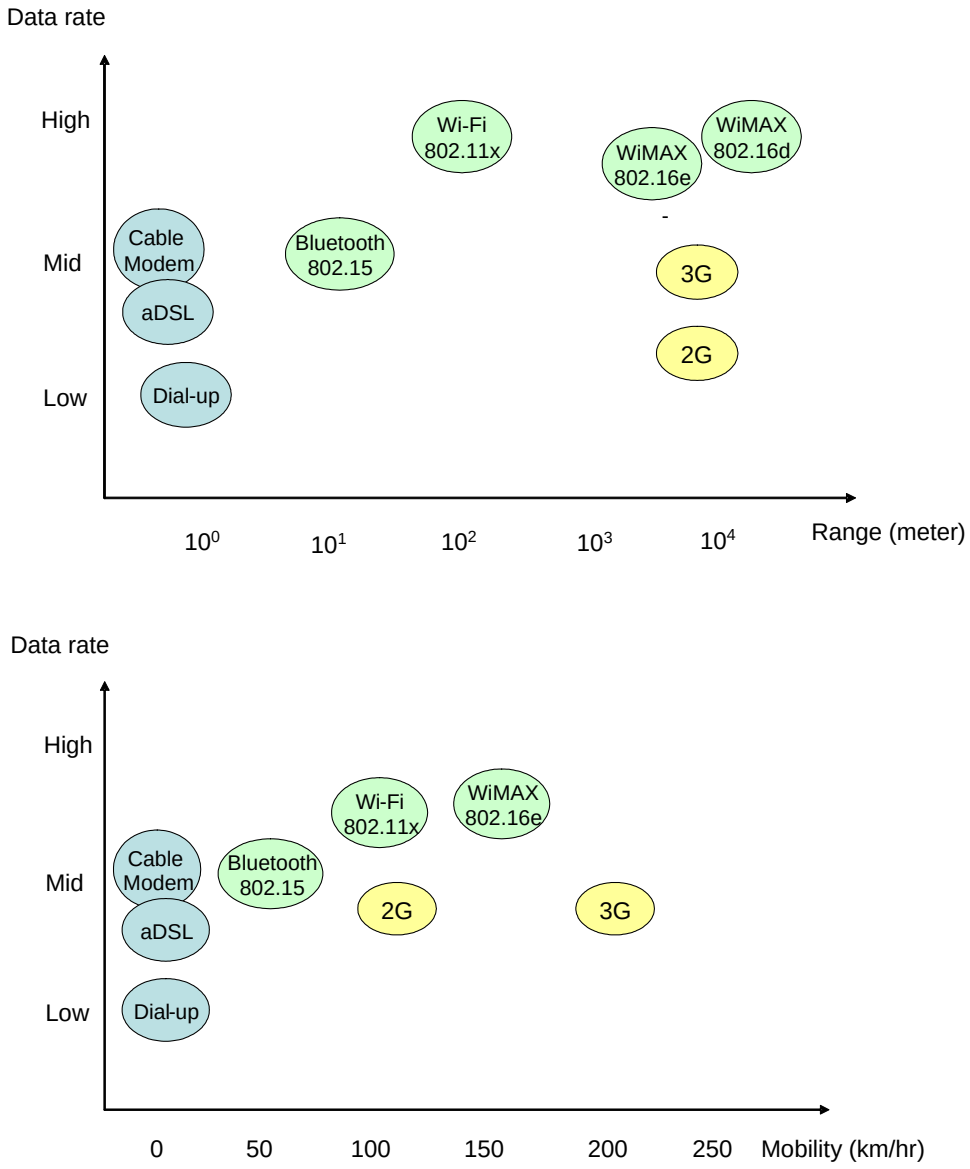

Figure 2: Data rate, range and mobility with various technologies

Currently the case seems to remain open and widely debated: Whether 3G will prove profitable in a large scale remains to be seen, as there is increasing pressure to move towards fixed/flat tariffs in data services, and consumer's willingness to pay for services is still unknown. On the other hand, the business models for the wireless broadband, stemming from the Internet environment, are also unproven. However, we can be confident that an open and low-cost/low-entry barrier service environment will become available to provide the basis for an ecosystem for innovative services in the future.

"Digital City" Applications

Without covering the details of their open architecture and functionality, we present a few application cases in a digital city that will benefit from the deployment of wireless broadband.

To provide some illustrative examples, we have chosen to use WiMAX as the example of a wireless broadband technology. This does not mean to indicate that some other combinations of wireless and cellular technologies would not be equally feasible (for the complementary information about the functions and structure of different city information management systems, see Wang et al. 2005).

Metropolitan Area Intelligent Traffic Information System

The metropolitan area traffic management has been an outstanding issue for decades and is now imposing higher demand with the on-going urban area modernization process in China. A key problem in implementing a metropolitan area traffic information system is that transportation management systems using the existing limited communication infrastructure is unable to support exact, real-time and dynamic information transmissions. Current communications among data collection systems for city traffic, information release system and high-end data processing/service support platform is mainly based on IPv4 network and narrowband cell phone technology. With a WiMAX based wireless metropolitan area network and the IPv6 technology, it becomes possible to construct a metropolitan area intelligent traffic information system that will be featured with:

- Low marginal cost of traffic information sensor deployment,
- Automobile based mobile computing capability,
- Effective data transmission with quality of service,
- Distributed yet powerful data processing capability owing to the better data transmissions, and
- Reliable and secured data transmission services.

Ecological Environment Monitoring System

The environmental protection has long been an important issue in city management and many cities have set up their environment monitoring systems. Previously, as the data communications infrastructure in majority of Chinese cities badly lagged behind, the ecological environment protection division of a city typically implemented the monitoring system of the pollution source through private wireless networks or the telephone network. So it has been difficult to collect the data of environmental pollution instantly or timely. Also, due to the high cost in sensor deployment, mainly cased by the data transmission needs, it is also not viable to monitor the pollution sources on 24/7 basis. WiMAX-based wireless broadband metropolitan area network will obviously satisfy this kind of data communications needs.

Fire-extinguisher Vehicle Location Support

When a residence area is caught by fire, the regular data communications system in the area could be in malfunction. As the fire brigade must reach the site in time with a proper number of fire-distinguishing vehicles and decide which route to take, a mission-critical data communications system is important. Previously, such decisions rely on the experience with little information available. Now with the wireless broadband metropolitan area network, the fire brigade can obtain the needed information in real-time, and coordinate among different teams and fire-extinguishing vehicles via effective wireless network, combined with many

types of science technology such as Global Positioning System (GPS) and Geographic Information System (GIS).

E-Commerce, Information and Entertainment Services

In addition to the "city management" services the same infrastructure will provide opportunities for new e-commerce, information and entertainment services that will become feasible with IWBIS type of system:

- On-demand mobile multimedia entertainment services
- M-commerce with graphically rich interfaces
- On-board vehicle Internet access and high capacity services e.g. IP-based digital TV

A Possible Structure for IWBIS

In general, there are the following common IWBIS underpinned application scenarios enhanced from traditional mobile/wireless applications:

- A cellular phone is accessing the on-demand multimedia programs from a remote repository site.
- A pedestrian is using PDA to talk to someone using a home phone set, while he is able to search a database for the nearest dinning service.
- A multimedia terminal in the moving vehicle is displaying a news program from a digital TV server.
- A police is retrieving a suspect's image and other information when he is chasing a speeding car.
- Sensors distributed city-wide are collecting environmental data periodically and send data to the remote data processing centers.
- Monitors deployed in the streets of a city are sending data to the data processing center, while a mobile surveillance center can access the same data when it is running to a specific location for an emergent event.
- A grid computing network connected by IWBIS allows city-wide computers working together to solve a large problem.

The above scenarios plus other regular application scenarios will be supported by IWBIS that can be seen in the following five layers illustrated in Figure 3.

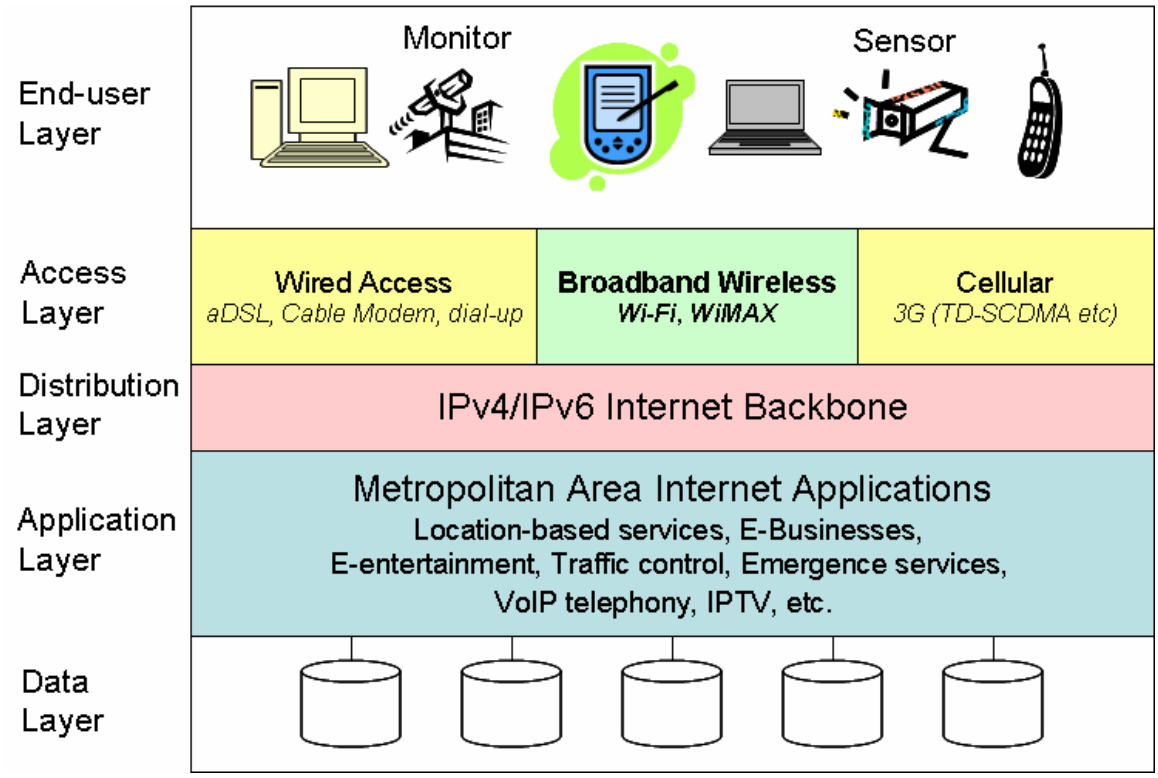

Figure 3: Structure of IWBIS system

To guarantee enough network bandwidth for city information management system, the future network infrastructure will be a hybrid network with wired and wireless network that includes both cellular and broadband wireless technologies. As POTS, xDSL and cable modems can well resolve the wired network access needs and 3G is coming up with solutions for boosting the narrowband network services, we focus on the wireless broadband network access in this section. Figure 4 illustrates the services that could be provided if the combination of WiMAX and Wi-Fi is chosen as a basis. The roles of WiMAX in the infrastructure will be to:

- provide wireless backhauls between WiMAX base stations. Since this is typically within the line of sight, IEEE 802.16 is recommended for the best transmission efficiency
- connect between backbone and Wi-Fi hotspots as the “last mile”. IEEE 802.16a is recommended for Non LOS data transmission services.
- provide direct network access for WiMAX-enabled terminals, such as notebook computers. IEEE 802.16a is also recommended for Non LOS data transmission services.
- allows mobile access to the network from nomadic applications or mid-speed moving environments, such as from a car. For this IEEE 802.16e is the suggested broadband solution.

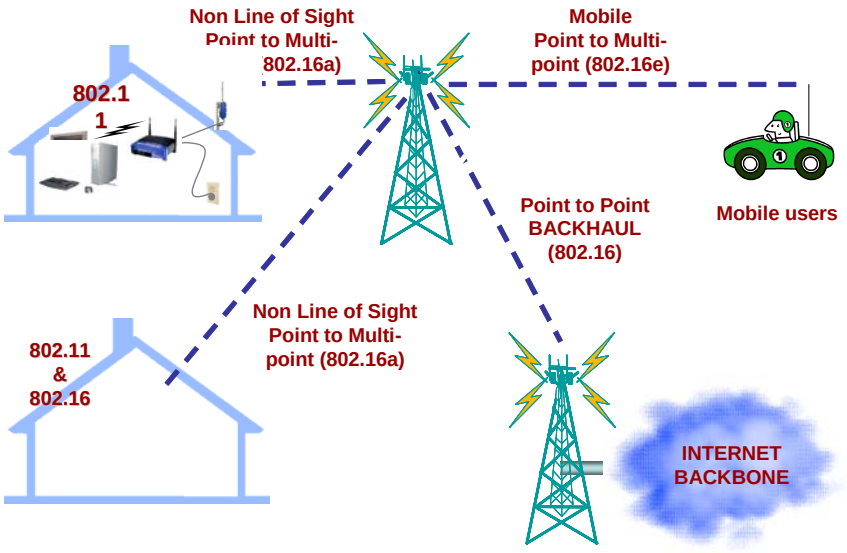

Figure 4: A WiMAX Based Wireless Metropolitan Area Network

The first three types of services by WiMAX have been successfully demonstrated. The mobile access service by WiMAX is still under research and experimentation.

The business activities to establish easy and widely available Wi-Fi access are on-going and wireless ISPs (WISPs) have been actively deploying hotspots in airports, hotels, train depots and other public areas. In addition, there is an interesting approach based on community or cooperative (co-op) model that may have potential to rapidly grow universal Wi-Fi access even worldwide. This model is based on the idea of establishing and maintaining a community of registered users who will make their wireless routers available to other members for free – and to visitors against a small fee. The access points are ordinary wireless broadband routers with specific firmware updates to help manage authentication and billing.

Development Strategies and the Role of the Government

Chinese government plays an important role in adoption of new wireless network technology, like in the adoption of 3G and related standards. In government IT purchasing, according to a circular published on the website of the National Development and Reform Commission, organizations using the State budgets to procure computers, telecommunication equipment, printers, copies and projectors should give preference to the recommended products.

Or example, the new policy again puts the Chinese wireless local area network (WLAN) security standard WAPI (Wired Authentication and Privacy Infrastructure) into spotlight, which is a Chinese National Standard for Wireless LAN (GB 15629.11-2003) proposed by China Broadband Wireless IP Standard Working Group (or ChinaBWIPS), a non-profit organization that is authorized by the Ministry of Information Industry in August 2001. Current WLAN network is known for its lower security control, which can lead to information leakage, so some Chinese researchers decided to start to develop a solution. Then BWIPS became the national compulsory standard in 2003. The Chinese standard required all players in the WLAN industry to make their products comply with the BWIPS standard and co-operate with some Chinese partners. (China Daily 01/07/2006 page5 http://www.chinadaily.com.cn/english/doc/2006-01/07/content_510193.htm)

Similarly, Chinese government's support will be the critical factor in the popularization of IWBIS type of approach. Each city could reserve a special frequency band for IWBIS in the city and its skirmish areas. The frequency band will be further divided into several portions:

- Governmental administration use, such as emergency services, disaster control, etc.
- Public information services, such as location-based city information services, etc.
- Urban area surveillance and control, such as environmental monitoring, traffic condition monitoring, etc., and
- Business services, the use of which will be charged, including advertising, m-commerce, mobile VoIP services, etc.

In this vision, the demand will be mainly promoted by the availability of convenient mobile VoIP and city information services. Consequently, new forms of e-business will be emerging around them. The traffic conditions of the city can be improving with the widely deployed traffic surveillance system enabled by the wireless broadband data transmission services. The environment of the city will be better monitored and controlled.

Items for Research Agenda

We have outlined a possible approach for developing the "Digital City" services infrastructure in China. While some technology choices have been discussed, there is a lot of uncertainty still. Thus, we believe in a technology agnostic approach that does not commit to any particular technology but enables flexibility. In order to implement the vision of the "Digital City" there are a number of open issues to be resolved, including regulatory, commercial, social and political issues in addition to technology and design issues. In this work we focus on the latter research items, like:

- How to plan a good metropolitan area information infrastructure that will be able to adapt to the latest information technologies and will be extensible in next 5-10 years? Many of the Chinese cities, in particular the new ones being developed, are in position to design and build their communication infrastructure with adequate broadband capacity (e.g. fiber networks) to scale for extensive use of wireless broadband services. What should be the roles of public and private players and their partnerships in the construction and maintenance work?
- Among all aspects of information system infrastructure, end user access will be the key point. How this system will adopt constantly developing wireless networking technologies and converging networks to promote the ubiquitous access of the Internet in the metropolitan area?
- As China is seemingly adopting the TD-SCDMA 3G standard, how will this affect the other 3G alternatives and the role of broadband wireless technologies in complementing the services of the 3G network?
- How to create a services ecosystem that enables fast and low cost information services creation and deployment, combined with appropriate business models?

Specific technology issues need to be also resolved to enable mobility of users and appropriate level of security still retaining ease of access and use:

- Rapid IP mobility over a broadband wireless network.
- Mobility management of IPv6 network

- Network security that becomes critical as networks become more open to the public and so also more vulnerable
- Authentication support for ease of roaming among different networks

Consequently, the extended broadband wireless Internet coverage has further stimulated the research on mobile IP technology because of the huge potential of the mobile Internet telephony market. In 2003, China Next Generation Internet (CNGI) was approved by the State Council and organized jointly by eight ministries and commissions including National Development and Reform Commission (http://www.chinadaily.com.cn/english/doc/2004-12/27/content_403512.htm). As the largest core network of IPv6 based CNGI, CERNET2 (http://www.cernet2.edu.cn), started operation in 2004. CNGI-CERNET2 is also so far the world's largest native IPv6 backbone. CNGI-CERNET2 has been growing rapidly in less than two years with the promotions of Chinese government. In February 2006, China's National Development and Reform Commission (http://www.ndrc.gov.cn) advocated that the CNGI to be popularized to most of universities, research institutes, and major enterprises in China during the 11th Five-Year Plan (NDRC 2006).

From the technical angle, IPv6 can provide better QoS for different types of data traffics, but also raises a number of technical challenges to the mobile IP researchers (Jiang et al 2004; Koodli 2005). For example, IPv6 has strict authentication features that will restrict the implementation of IP mobility as well as the billing system implementation. Therefore, how to develop the mobile IPv6 technology support multimedia data flows with required QoS, security, and the support to the features of business applications, remains to be resolved. In this way, IPv6 combined with broadband wireless will be major underpinning network technologies for the proposed IWBIS in the context of metropolitan area Internet applications.

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