

CHINA'S STATE-COORDINATED INTERNET INFRASTRUCTURE

In 1995, as the use of the Internet began to spread through many sectors of Chinese society, the country's leaders had to decide whether to allow this new medium to keep spreading and, if so, how to control it. Even though the technology itself allows decentralized coordination, the leadership chose to implement a hierarchy of responsibility to manage its growth. They hoped the Internet would unleash economic gains without destabilizing the country. Unlike the U.S., where the Internet has blossomed with no central control or central planning, various ministries of the Chinese central government have coordinated decision making while leaving room for private-sector investment and initiatives. This intergovernmental coordination, which

continues to evolve, has given China's Internet its special local character. The government therefore has allowed some competition to develop between domestic ISPs while making sure the infrastructure itself stays securely under its control. The key to this Internet strategy is to restrict the number of organizations that can interconnect with the global Internet. These restrictions have so far not seemed to limit deployment of Internet infrastructure. Instead, China's state-coordinated Internet infrastructure is making possible the rapid integration of the Internet throughout Chinese society.

Besides being geographically vast, China is culturally and ethnically diverse. With 1.2 billion people, it is home to 20% of the world's population, and many of its provinces have more people than most European countries. The number of Internet users in China has more than tripled, from 620,000 in October 1997 to 2.1 million in December 1998 [4]. The Chinese leadership has allowed the Internet to grow

so rapidly because they view it as an essential tool for economic prosperity, the harbinger of a "knowledge economy," in which information flows replace industrial processes as the basis for the economy.

For the past 10 years, China's economy has grown rapidly, with many sectors, such as telecommunications, growing at annual rates of 30%–50%. Each year, about 10 million phone lines are added to the public network. However, China remains an agricultural society with only the eastern provinces heavily industrialized. China's leaders hope to skip some classic intermediate stages of economic development as they encourage the integration of information technology.

Information infrastructure contributes to economic expansion in developing as well as developed countries. There is evidence of a positive correlation between telecommunications infrastructure and economic growth around the world [10]. However, information infrastructure influences social, political, and cultural factors, as well as the economy. These

COORDINATED STRUCTURE

How can the
government use the
Internet to promote
economic development
while maintaining
its political and
economic control?

factors in turn influence Internet infrastructure (see Petrazzini and Kibati's "The Internet in Developing Countries" in this issue). Different countries adopt very different policies regarding their information infrastructures. They reflect "local economic, social, historical, and political circumstances and exhibit remarkable differences in vision, policy design, and implementation strategy" [6]. Recent studies on global Internet diffusion by author Seymour Goodman and others have identified different diffusion models in different countries [5].

The Internet builds on existing information infrastructure. As a socialist state with economic development its primary goal, as stated by the government, China's policy toward Internet infrastructure is governed by the principles of promoting economic development and maintaining the state's political and economic control. Compared to such countries as the U.S., where Internet infrastructure is primarily a private effort (see Mueller's commentary "ICANN and Internet Regulation" in this issue), China's Internet infrastructure is highly coordinated, managed by a combination of public and governmental bodies.

Table 1 outlines the institutional status of the "publicly available" Internet infrastructure in China; the "private" Internet infrastructure is not included. The Ministry of Information Industry, established in March 1998, regulates this infrastructure. China's Internet is built on the physical network facilities owned, built, and operated by the country's dominant telecommunications player—China Telecom—

although some private very-small-aperture-terminal (VSAT) networks, which link cities, are deployed occasionally by competitive carriers and ISPs. Networks built and run by the country's second authorized carrier—China Unicom—are not yet available for Internet services. Internet services are based on four interconnecting networks: two commercial networks—ChinaNet and China Golden Bridge Network (ChinaGBN)—and two academic networks—China Education and Research Network (CERNet) and China Science and Technology Network (CSTNet) (see Table 2). ISPs operate as branches of these

networks or are independent of them. Officially, foreigners are not permitted to operate the services directly, although there are some exceptions.

Carefully Structured Regulation

The Internet in China is under carefully structured regulation [11]. The legal foundation is stated in China's State Council Order 195, called "Interim Regulations on International Interconnection of

Table 1. Institutional status of "public" Internet infrastructure in China.	
Regulator	Ministry of Information Industry
Physical Networks	China Telecom, China Unicom, Private VSATs
Interconnecting Networks	ChinaNET, ChinaGBN, CERNET, CSTNet
ISPs (Access Networks)	Interconnecting networks' local branches, independent ISPs
Users	Academic, government, business, residential

Table 2. China's interconnecting networks.	
Organization	Network
China Telecom	ChinaNET
JiTong Communications Corp.	ChinaGBN
Ministry of Education	CERNET
Chinese Academy of Science	CSTNet

Computer Information Networks in the PRC." These regulations were formally introduced on February 1, 1996 [9] and modified on May 20, 1997 [12]. Under Order 195, the State Council's former Steering Committee on National Information Infrastructure was granted primary regulatory responsibility for China's Internet. Responsibilities include determining and coordinating the important issues of international interconnection. The Committee defined the rights, obligations, and liabilities of international interconnection service providers, interconnecting organizations, accessing organizations, and users. Absorption of the Steering Committee into the newly formed Ministry of Information Industry in March 1998 gave the new Ministry full regulatory control over China's Internet.

In the service provision sector, Order 195 divides China's Internet networks into two categories: interconnecting networks and access networks. The term "interconnecting networks" comes from a literal translation of the Chinese characters *FuLian*, which together stand for "interconnecting" in English. These computer networks are directly linked to the global Internet through international leased lines. So far, only four licenses have been granted: to the two academic networks—CERNET and CSTNet—and to the two commercial networks—ChinaNET and

ChinaGBN. No one else is allowed to operate interconnecting networks without approval from the State Council.

These four interconnecting networks are tied closely to government agencies: The Ministry of Education operates CERNET; CSTNet is being developed by the Chinese Academy of Science; ChinaNET is a service of China Telecom; and ChinaGBN is operated by JiTong Communications Corp., which was part of the former Ministry of Electronic Industries. China Telecom and JiTong Communications both fall under the control of the Ministry of Information Industry. These four networks provide Internet-related services ranging from access and content to global interconnection. Each global interconnection includes an international line from the Chinese side and another international line from the foreign side. All four networks are required to lease international lines on the Chinese side from China Telecom and are not permitted to build their own physical international lines. Lines on the foreign side are often leased from multinational carriers, including AT&T and Sprint.

The Chinese access networks are the equivalent of ISPs in the Western world, providing access and content services, but no direct global interconnection. Any Chinese corporation, after meeting certain safety, legal, technological, and financial requirements, can be licensed as an ISP. Any ISP has to be licensed by and gain global access through one of the four interconnecting networks. They are not permitted to set up their own direct international connections through foreign ISPs.

A large percentage of China's commercial ISPs are not owned by the four interconnecting networks. These ISPs have the option of expanding their services into provincial, regional, and even national operations. Foreign corporations and joint ventures are prohibited from being ISPs, since China still bans foreign participation in its telecommunication services, although the prohibition might be relaxed once China joins the World Trade Organization.

Individual users in most cities can choose their service provider from among the approved ISPs. The competition among them often results in improved service quality and decreased charges.

Physical Networks Supporting Internet Infrastructure

China's public telecommunication system was a China Telecom monopoly until 1994 [8]. The second carrier, China Unicom, was licensed in December 1994 and has successfully launched mobile telephone service in many cities, challenging the China Telecom monopoly. However, China Uni-

INFORMATION INFRASTRUCTURE INFLUENCES SOCIAL, POLITICAL, AND CULTURAL FACTORS, AS WELL AS THE ECONOMY.

com's long-distance network and local wireline networks are still very immature. China's Internet is built mainly on China Telecom's physical networks.

In recent years, China Telecom has significantly upgraded its infrastructure with fiber-optic lines as its backbone. For example, the fiber-optic backbone of

as high as 27% in the cities. Trials on cable modem and digital subscriber line services are ongoing.

Based on these physical transmission facilities, China Telecom developed three value-added data networks designed specifically for data communications: ChinaPAC, ChinaDDN, and China Frame Relay.

ChinaPAC (X.25, 64Kbps), with 2,278 nodes, reaches most counties and some economically advanced towns. ChinaDDN (2Mbps) reaches all the cities and some counties. China Frame Relay (45Mbps) reaches 21 provincial capitals. An asynchronous transfer mode (ATM)-based high-speed network is under consideration.

These three networks provide excellent national coverage. Low-speed links (ChinaPAC) connect them to small towns, medium-speed links (ChinaDDN) to counties, and high-speed links (frame relay) to major cities.

The Four Interconnecting Networks

As of April 1999, China had granted only the four licenses to interconnecting networks—the two academic networks, CERNet and CSTNet, and the two commercial ones, ChinaNet and ChinaGBN. Competition is allowed among interconnecting networks for commercial services, as well as for academic services.

ChinaNet. ChinaNet, a service of China Telecom, is the most extensive commercial internet-working network and the biggest commercial ISP in China. It started by offering services in large cities, including Beijing and Shanghai, in 1995, and has expanded its services to all provinces since then.

ChinaNet was developed under the umbrella of China Telecom, which until 1998 was part of the former Ministry of Posts and Telecommunications. The Ministry's administrative functions have since been transferred to the new Ministry of Information Industry, and China Telecom has been gradually separated from the Ministry. As part of this separation process, China Telecom is being restructured, and ChinaNet's ownership, operation, and organizational structure are still being defined.

The Data Communications Bureau of China Telecom administers ChinaNet, managing its Network

Figure 1. China's national fiber-optic backbone.



Source: China Telecom Annual Report, 1997

the long-distance network completed in 1998 consists of eight horizontal and eight vertical trunk lines. The fiber-optic network has nodes in all the provincial capitals and 70% of all other cities (see Figure 1). All the trunk lines now use either 622Mbps or 2.4Gbps synchronous digital hierarchy (SDH) technology, with potential capacity expansion available by adding wavelength-division multiplexing (WDM) technology. A national satellite network with 38 major earth stations and a microwave network covering remote and difficult-to-reach territories supplements this network [1].

The local access network is dominated by copper-wire local loops. By the end of 1998, the phone penetration rate had reached 10% nationally, though it is

Information Center and ChinaNet Network Operation Center in Beijing. It also manages ChinaNet's international links and national backbones. At the provincial level, ChinaNet includes nodes, networks, and local operations. Provincial and municipal Posts and Telecommunications Bureaus, which are part of the provincial and municipal governments, manage provincial networks and services. The separation of the Bureaus' administrative and operational functions has not yet been implemented at the provincial level, though the separation is expected to be announced soon.

ChinaNet's networks include the national backbone with its provincial nodes, provincial networks,

ChinaGBN. This general information service network is operated by JiTong Communications, which was formed from several major affiliates of the former Ministry of Electronic Industry. ChinaGBN is an outgrowth of the widely publicized Golden Bridge Project, which began in 1993 and is the most significant result of the government's effort (called the Golden Projects) to introduce information technology throughout the country (see Figure 2). ChinaGBN was first assigned to own and operate the Golden Bridge Project, then one of the two commercial interconnecting networks. Its Internet services were first offered to the public in September 1996.

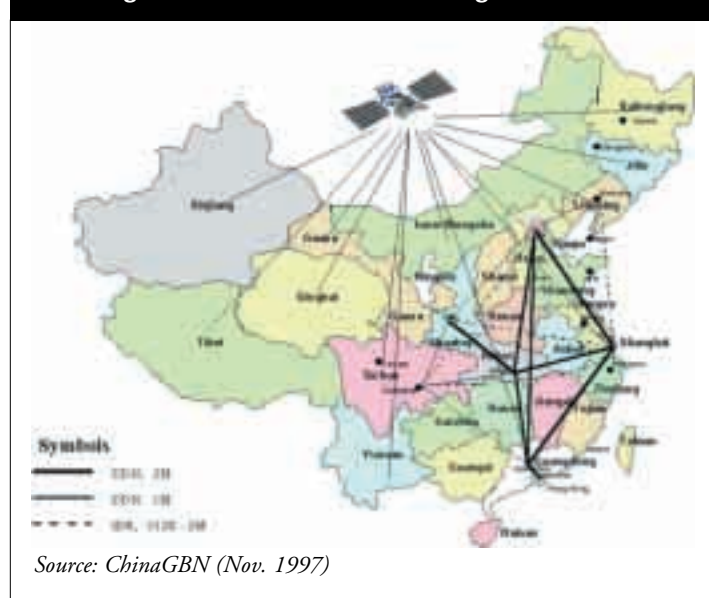
ChinaGBN's network construction was handled in two stages. During the preliminary stage (1993–1996) its Network Operation Center was established in Beijing, incorporating a star network with its own VSAT network to interconnect major Chinese cities. End-user access to its local centers relied on the phone network, ChinaPAC (X.25), and ChinaDDN from China Telecom.

This VSAT-based network is in the process of shifting to a fiber-optic SDH national backbone to interconnect its regional centers. Provincial capitals and other cities will be linked to the regional centers by leased fiber-optic lines from China Telecom or China Unicom. Today, ChinaGBN combines ATM switches with IP routers and plans to switch to broadband ATM networks. The access network will rely primarily on China Telecom's traditional network, though wireless access is being considered.

By the end of 1997, ChinaGBN covered all the Chinese provinces through its local centers in major cities. It now has two international lines from Beijing to the U.S. (256Kbps in 1996, 2Mbps in 1997) and one from Shanghai to the U.S. (2Mbps in 1997). Another 4Mbps was added to each line in 1998, bringing the total to more than 8Mbps. All the international lines are leased from China Telecom, a requirement under China's telecommunication regulations. ChinaGBN competes directly with ChinaNet in offering commercial Internet services.

CERNet. CERNet, launched in 1993 by the State Education Commission (the Ministry of Education since March 1998), is designed to capture the enormous advantages the Internet represents in being able to link universities and research institutions. It was modeled after the mid-1980s U.S. National Science Foundation's backbone project [7]. The Commission created a special task force—the CERNet Administration Committee—to oversee the CERNet project

Figure 2. The China Golden Bridge Network.



Source: ChinaGBN (Nov. 1997)

and international links. The national backbone is built on China Telecom's SDH fiber-optic networks. All the links have the capacity of E1 lines (operating at 2.048Mbps and up). China Telecom has plans to upgrade them to 155Mbps. The local access networks use dial-up modems as well as ChinaPAC (X.25) lines and ChinaDDN lines.

ChinaNet's network management is based on Hewlett-Packard Openview. Cisco Systems CiscoWorks manages the network's routers. On the national backbone, most routers are in the Cisco 7000 and Cisco 4500 series. In October 1998, ChinaNet bought six Cisco 12000 series Gigabit Switch Routers and more than 90 Cisco 7500 series routers to upgrade network performance [2]. By the end of 1998, ChinaNet had about 123Mbps of network bandwidth to Asia, North America, and Europe.

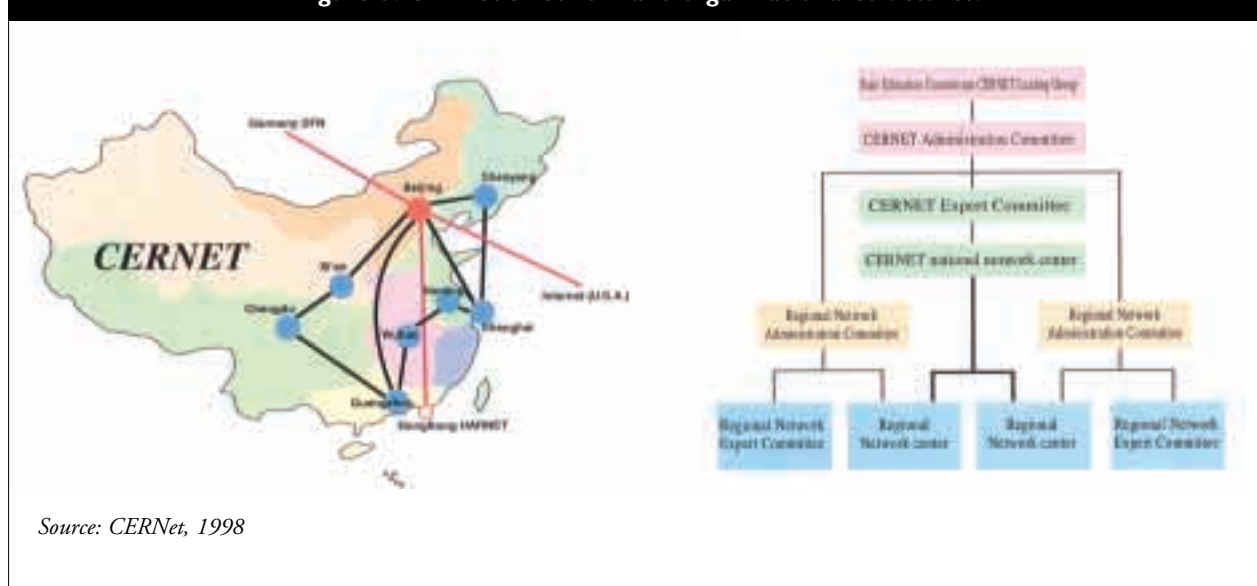
with members from the Ministry of Education and 10 universities making decisions regarding network construction. The CERNET Expert Committee, consisting of network experts from 10 universities, makes all technical decisions. CERNET's National Network Center, headquartered at Tsinghua University in Beijing, maintains daily operation and management of the backbone while providing information and support to users. Regional and local networks are managed through their own administration and technical committees (see Figure 3).

The CERNET network consists of a national backbone interconnecting eight regional centers in other

Catalyst 2900 LAN switches [2], enhancing overall network performance and allowing CERNET to provide new services, such as Layer-3 switching and voice over IP, or Internet telephony.

CERNET's backbone transmission facilities and international connections are funded directly by the Chinese government as well as through charges to end users for outgoing international traffic. In a 1998 interview with author Alex Tan, CERNET's decision makers claimed success for their policy of charging for outgoing international traffic while keeping incoming international traffic cost free. They cited it as a revenue channel that helps maintain and expand

Figure 3. CERNET's network and organizational structures.



cities, more than 300 campus local networks, and international links from Beijing to Hong Kong, the U.S., and Europe, as shown in Figure 3.

CERNET leases transmission facilities, including international links, from China Telecom. In order to promote competition, CERNET has publicly reserved China Unicom, which today lacks long-distance circuits, as its potential supplier. At the end of 1998, CERNET's national backbone bandwidth was upgraded to 2.048Mbps (E1), with regional bandwidth ranging from 64Kbps to 2.048Mbps. Within a year, the national bandwidth is scheduled to be upgraded to 2.048Mbps and more. CERNET has 8Mbps-capacity international leased lines connected to the global Internet.

CERNET's backbone network is connected via various routers. In September 1998, CERNET contracted with Cisco to upgrade its backbone network with Cisco 7500 and 7200 backbone routers, Cisco 3600 voice-enabled access routers, and access servers and

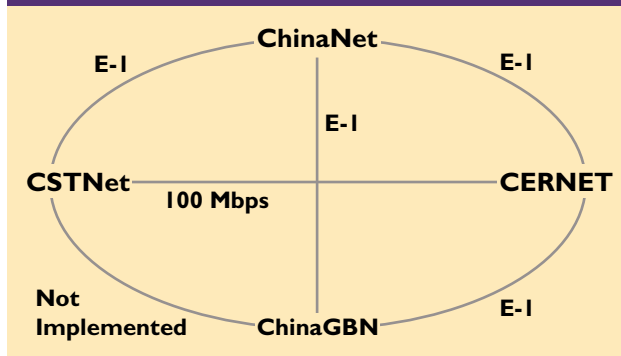
extremely expensive international links while discouraging domestic users from visiting international sites and contributing to the congestion of international circuits.

CERNET's eight regional networks are funded jointly by local governments and universities. The universities are responsible for establishing their own local networks, as well as for connections from their campuses to the nearby regional centers.

CSTNet. CSTNet is administered by the Chinese Academy of Science, whose Computer Network and Information Center runs the network and whose mission is to interconnect all of its research institutes. Other academic institutions are welcome to join CSTNet, to which they can be hooked easily via existing CSTNet routes.

The CSTNet network consists of two major parts: a high-speed wide-area network (WAN) in Beijing, where most of the Academy's institutes are located, and a satellite-based national network that intercon-

Figure 4. Interconnection of the four interconnecting networks in China, June 1998.



nects cities where the Academy's member institutes are located. The Beijing WAN is a 100Mbps fiber distributed data interface (FDDI) fiber-optic network connecting all Academy institutes in Beijing, along with non-Academy research institutes. The national satellite network reaches 23 cities. CSTNet was the first network in China to establish a link to the international Internet. It now has 4Mbps international links to the U.S., Japan, and Europe.

Interconnections and exchanges. As of July 1997, the country's four interconnecting networks had been connected through bilateral peering (see Figure 4) and had upgraded their interconnections to E1 speeds. However, to date, no official Internet exchange center operates in China.

In 1997, the State Council's former Steering Committee on National Information Infrastructure

and the China Financial Network [3]. However, there is a question as to whether this exchange really has central government sponsorship and therefore qualifies as a national exchange. The newly formed regulator—the Ministry of Information Industry—has claimed supervision authority over the national Internet exchange centers. Plans could be announced at any time.

Local ISPs

ISPs in China fall into three categories: the local branches and affiliates of the four interconnecting networks; independents; and those following the America Online model, providing extensive content in addition to access.

Local branches and affiliates. Each of the four interconnecting networks has local branches or affiliates providing access services to subscribers. CERNET goes through its campus networks in universities to serve students, faculty, and staff. CSTNet serves users via campus networks in research institutes. Neither CERNET nor CSTNet is officially allowed to provide commercial services.

ChinaNet and ChinaGBN sell their access services through local branches. ChinaNet relies on the provincial and municipal Posts and Telecommunication Bureaus to build up local access networks, manage local nodes, and market access services. These services are all part of China Telecom, the dominant telecom player and the most successful ISP. The branches have brand names, a pervasive presence, the competitive advantages of cross-subsidization, and technical support.

The local branches of ChinaGBN, which is relatively new to the telecom market, are tied closely to the network's headquarters and are constrained by the fact that they have to lease facilities (such as leased lines) from China Telecom—the parent company of ChinaGBN's

competitor ChinaNet.

Independents. Independent ISPs in China are often entrepreneurial endeavors trying to cash in on the Internet's explosive potential. However, it has been reported in the Chinese business media that most of them are losing money due to the Chinese market's currently limited size and the high fees China Telecom charges for leasing its facilities. (For a list of ISPs in China, visit www.sohu.com.cn/Business_Economy/Company/Domestic/Computer/Internet/ISP/index.html and gbchinese.yahoo.com/Regional/Countries/China/Business_and_Economy/Companies/Internet_Services/Access_Providers/.)

Table 3. Internet subscriber growth in China.

	1994	1995	1996	1997	6/1998	12/1998
Total Internet Subscribers	1,600	6,400	80,000	620,000	1,175,000	2,100,000

Source: CNNIC, ChinaNET, ChinaGBN, CERNET, CSTNet

announced its intention to set up three Internet exchanges, in Beijing, Shanghai, and Guangzhou, in order to facilitate traffic exchange between the four national interconnecting networks. The plan stalled due to technical, financial, and coordination difficulties, as well as the restructuring of the Ministry of Information Industry.

In October 1998, the Beijing City Information Office and the China Information Highway Corp. signed a joint venture agreement with Cisco to construct the Capital Public Information Platform, China's first Internet exchange. The exchange point will connect ChinaNet, ChinaGBN, CERNET, CSTNet,

CONSERVATIVE ESTIMATES PROJECT **SIX MILLION** **INTERNET SUBSCRIBERS** IN CHINA WITHIN A YEAR.

Content providers. The ISPs in China pursuing the America Online model seek two goals: promote Chinese content and avoid the expense of international Web access by keeping all traffic local. A typical example is China Telecom's China Information Network (CNINFO), launched in 1997 and made available nationally a year later. CNINFO is an intranet with a lot of information in Chinese that connects users to a number of in-country Web sites. However, the network also provides global email and Web connectivity. It supports three types of services—access to CNINFO only, without registration on a dial-up basis; access to CNINFO only, with registration and personal accounts; and access to both the CNINFO and the global Internet, with formal registration. All three services include global email access. Prices vary depending on which service the user selects. A detailed network structure was described in China Telecom's 1998 Annual Report [1].

More Subscribers and Domain Name Registrations

Internet subscriptions in China have shown impressive growth since 1994, when there were only about 1,600 users in the entire country of more than a billion people. The number reached 1.17 million in June 1998 and 2.1 million in December 1998 [4],

more than a 100-fold increase in those four years. Conservative estimates project six million Internet subscribers in China within a year (see Table 3). While China's Internet lags behind those of the U.S. and other developed countries by several years, its recent growth rate is as impressive as the rates in many developed countries in the early 1990s.

A large portion of these new subscribers are academic users; the percentage of commercial and government users is increasing gradually. Business analysts in China have identified two especially promising user categories: government employees and parents who want education-related services for their children. As signs of this potential today, ChinaNet launched a program jointly with the central and local governments called "Promote Government Agencies on the Web." Meanwhile, Chinese parents follow an age-old tradition of sacrificing to provide the best educational opportunities for their children; buying a computer with Internet access for children has found its way into that tradition.

E-commerce might represent another driving force in China's Internet growth, but it is experiencing some difficulties due to the country's insufficient laws, poor credit card system, and poor customer protection, as well as to various cultural barriers. ISPs, regulators, and governments are working together to break down

Table 4. Distribution of domain names among second-level names.

	03/97		09/97		12/97		03/98		06/98		09/98		12/98	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
addn.cn	237	14	502	14	561	11	531	8	632	7	791	6	906	5
ac.cn	186	11	251	7	306	6	334	5	363	4	398	3	432	5
com.cn	746	44	1,831	51	3,009	59	4,147	64	6,559	70	9,973	74	13,913	76
edu.cn	254	15	323	9	357	7	365	6	414	4	455	3	531	3
gov.cn	34	2	287	8	357	7	431	7	761	6	749	6	982	5
net.cn	220	13	323	9	408	8	498	8	657	7	873	6	1,223	7
org.cn	17	1	72	2	102	2	153	2	229	2	308	2	409	2
total	1,695		3,590		5,100		6,459		9,415		13,546		18,396	

*Second-level domain names assigned to provinces (for example, bj=Beijing.)

Source: China Network Information Center

BUYING A COMPUTER WITH INTERNET ACCESS HAS FOUND ITS WAY INTO THE TRADITION OF CHINESE PARENTS SACRIFICING FOR THEIR CHILDREN'S EDUCATION.

these barriers in the interests of allowing e-commerce to be a significant factor contributing to the future growth of the country's Internet subscriber base.

A more systematic and accurate indicator of the Internet's growth is the number of registered domain names under the .cn top-level domain. According to the China Internet Network Information Center, which operates domain-name registration at this level, China's Internet domain names increased from 1,003 in January 1997 to 18,396 in December 1998 (see Table 4). While domain names are about evenly distributed among other sectors, commercial domain names, under com.cn, have come to dominate the domain-name registration, with a 76% share in December 1998.

Conclusion

The Chinese government controls the Internet through four organizations, each operating networks that interconnect with the global Internet. All access networks, including ISPs, are required to get their international connectivity and their authorization to operate from one of these interconnecting networks. The Chinese government has implemented a hierarchy of responsibility on the networks making up the Chinese Internet while allowing a certain degree of competition and decentralized decision making.

Competition is allowed not only among the access networks but among the interconnecting networks themselves, particularly ChinaNet and ChinaGBN. But the question remains whether ChinaNet would have developed an effective Internet capability as quickly if there had been no competition with ChinaGBN. Though both networks now fall under the supervision of the newly established Ministry of Information Industry (since March 1998), everyone generally recognizes the value of maintaining a certain degree of competition between the two.

Moreover, China has taken a different path from some other single-party states, such as those in the Middle East, which allow only the government-owned monopoly telephone company to provide Internet service. On the other hand, unlike, say, Indonesia, the Chinese government controls how ISPs interconnect internationally (see Kibati and Krairit's "The Wireless Local Loop in Developing

Regions" in this issue). The Chinese government has found a balance that allows some competition at various levels while making sure the Internet infrastructure itself is never beyond its control. ■

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