CHAPTER 2

Internet Access

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Contents

2.1 Introduction

The number of Internet users worldwide exceeded one billion in 2006, and it was 5.5 billion in 2022 [Internet 2022; Asia 2021; Statista 2024]. The 5.5 billion is 69% of the global population of 7.9 billion. Thus, we still have 2.4 billion people without Internet access today. Since the Internet is one of the critical social infrastructures, we need to work on providing Internet access to more people worldwide. This is the so-called “the last billion users” [Chon 2016]. There are many reasons that the last billion users cannot have Internet access, including physically handicapped, economically handicapped, geographically handicapped, and socially

handicapped, as well as people who do not want to access the Internet.

We have more non-human Internet users, the so-called "Internet of Things" (IoT), than human Internet users [Evans 2011]. The IoT exceeded human users in the twenty-first century's first decade, and we expect far more non-human users than human users in the coming decades.

We would like to address the following issues in this section;

Communication infrastructure
Low Earth Orbit Satellites
Internet Exchange and Peering
Network Usage Charge
Smartphone

Notable developments in the communication infrastructure in the early twenty-first century include low earth orbital satellite (LEO) Internet and mobile telecommunications with 5G and 6G [Chon 2021; Wikipedia 2022]. In section 2.6, we cover smartphones for Internet access.

Communication Infrastructure

We had two remarkable communication infrastructure developments in the early twenty-first century: mobile telecommunication services such as 5G and 6G and low Earth orbit satellite constellations. Mobile telecommunication services are increasingly becoming the communications infrastructure of the twenty-first century, along with wired telecommunication services based on optical fiber. Wi-Fi is still very important as the communications infrastructure, but its role is becoming increasingly complementary to the mobile telecommunications services in Asia. Optical fiber is the primary communications infrastructure for long-distance and high-bandwidth communications. Please refer to these communications infrastructures elsewhere as they are discussed extensively in many documents and conferences [Wikipedia 2022].

Internet services based on low Earth orbital (LEO) satellite constellations are being developed extensively in this decade. The most notable projects include Starlink by SpaceX, Kuiper Project by Amazon, One Web, Galaxy Space, and GW&G60 Projects, among others [Starlink

2021; Amazon 2021; OneWeb 2021; GalaxySpace 2022; Wikipedia 2022b; CNMega 2024]. Starlink is expected to have 43,000 satellites in this decade. GW and G60 in China are expected to have 13,000 and 12,000 satellites, respectively, with lower altitudes than Starlink in this decade.

Additional efforts are being made to provide Internet services based on lower altitudes than the low earth-orbit satellite, such as the High-Altitude Platform Station (HAPS) [HAPS 2021; Wakikawa 2021]. SpaceX decided to work with Starshield of the National Reconnaissance Office of the US Government, with 5,500 low earth orbital satellites in 2024.

See the next section for more information on the low Earth orbit satellites.

Low Earth Orbit Satellites

Internet access would be significantly enhanced by the low Earth orbit satellite constellations in the twenty-first Century [Wikipedia 2022b]. The geographically disadvantaged areas include the sparsely populated deserts, the Arctic, and the Antarctic regions. It also serves disaster-stricken areas as well as war zones and natural disasters. It also serves broadband opportunities worldwide as the satellite constellation could offer dependable broadband service of 100 Mbps or more for download connections.

Starlink offers the leading Internet service based on low Earth orbit satellite constellations. It is based on several thousand satellites deployed for public service, which started in 2020 [Starlink 2021; Branch 2022]. Starlink provided Internet services to more than 500,000 subscribers in forty countries in 2020. 12,000 satellites were approved to be launched by FCC. 42,000 satellites are expected to be launched eventually. You may compare these numbers of satellites with the 10,600 satellites; all other satellites launched from Sputnik, the first satellite in 1957 to today.

Other low Earth orbit satellite Internet projects, including Kuiper Project, One Web, and Galaxy Space, as well as three Chinese organizations, China Satellite Network Group (CSNG), Shanghai Spacecom Satellite Technology, and Hongqing Technology, started to

launch the satellites.

Here are the current plans of Starlink, Amazon Kuiper Project, China Satellite Network Group, Shanghai Spacecom Satellite Technology, and Hongqingd Technology [Hangyung 2024; CNBC];

USA:

Spacelink, SpaceX	42,000 Satellites by 2030
Kuiper Project, Amazon	3,231 Satellites by 2030

China:

China Satellite Network Group	13,000 Satellites by 2030
Shanghai Government Satellite	12,000 Satellites by 2030
Hongqing Technology	10,000 Satellites by 2030

US satellites are low Earth orbit satellites of 550km above the Earth. Chinese satellites are low Earth orbit satellites above 150km the Earth for Internet service, 6G telecommunication, and autonomous driving support [G60 2025; CNBC 2024; Cristina 2025]. Spacelink uses reusable technologies on its launch rockets now. Tech Talkers presented “Why the satellite superfactory in Hainan?” on YouTube [TechTalkers 2024].

These satellite-based Internet services open up new applications, including the following;

- Broadband services with bandwidths of 100 Mbps or more
- Emergency services such as those in disaster-stricken areas and war zones
- Internet services in sparsely populated areas such as deserts, and the Arctic and Antarctic regions

One interesting development is the collaboration between SpaceX and T-Mobile, the 5G mobile telecommunication service provider [Washington 2022].

There are several side effects on low earth orbital satellites, such as

- lights from the satellites which could interfere with nighttime sky observation,

- global coordination on satellite assignment, and
- Collision-avoidance maneuvers [Pultarova 2023].

Internet Exchange and Peering

London Internet Exchange (LINX) offers an up-to-date introductory tutorial on Internet exchanges and peering among its tutorial courses through YouTube [LINX 2020].

When NSFNET and regional networks in the USA and networks in other countries were set up in the late 1980s, we had issues with interconnecting these networks, particularly among commercial networks. Then, we came up with the concept of "Tier": Tier 1, Tier 2, and Tier 3 [Wikipedia, 2022]. 15 Tier 1 networks now connect the Internet with settlement-free peering and transit. Tier 3 networks need to purchase transit and peering from other networks. Tier 2 networks are between the Tier 1 and Tier 3 networks, paying for some of the transit or peering to other networks.

“Internet exchange points (IXPs) began as Network Access Points (NAPs”), and “The primary purpose of an IXP is to allow networks to interconnect directly, via the exchange, rather than going through one or more third-party networks” [IXP 2022]. The first commercial Internet exchange point was Commercial Internet eXchange (CIX) in 1991 [CIX 2022].

We have the following associations of the Internet Exchange Points (IXPs) around the world;

- APIX, the Asia Pacific Internet Exchange Association
- Af-IX, the African IXP Association
- Euro-IX, the European Internet Exchange Association
- LAX-IX, the Latin American Internet Exchange Association

APIX.asia has 36 IXPs among 18 economies in the Asia Pacific region [APIX 2022].

Peering: Two or more autonomous networks connect directly at public or private Internet exchange points. Peering may also be done with a direct

link between the two networks.

Transit: When one autonomous network agrees to carry the traffic that flows between another autonomous network and all other networks as one network carries another network's traffic [Berg 2009]. The transit may be done with or without charging, depending on the agreement between the networks.

Network Usage Charge

Geoff Huston gave a historical overview talk on "Content and Carriage," from the 19th-century postal system to the telephone system, followed by the Internet system recently [Huston 2022]. There have been debates on "Does the sender pay?" for a long time, and it comes up again now. Rudolf van der Berg presented on Big Telco and Big Tech at NLNOG, addressing this issue. BEREC comprehensively assessed the payment issues in his report [Berg 2009; BEREC 2022; ChosunIlbo 2023]. Gahnberg listed the legal matters in South Korea in his 2022 reports, where the sender pay rule was implemented for the domestic case while the international case was pending [Gahnberg 2022].

When the Internet started, the telephone service providers paid for the communications infrastructure. The payment was coordinated through peering and transit [Berg 2009]. Recently, the content providers have also paid for the communication infrastructure. This is especially true for the interconnection of the content providers' data centers. It may take some time before the network usage charge to reach the next stable state.

Smartphones

Smartphones are having a significant impact on Internet access. The smartphones were developed in the early twenty-first Century [Apple 2007; ColdFusion 2020]. The smartphones replaced laptops and personal computers as the primary Internet access device, starting in Asia, followed by other continents in the first decades of the twenty-first century.

LG in Korea developed the LG Prada with a similar hardware design to

Apple's iPhone before the iPhone [Wikipedia 2022c]. NTT Docomo had similar applications to the iPhone before the iPhone's appearance [Wikipedia 2022d]. TinyOS was developed at the University of California, Berkeley, in 2000 [TinyOS 2023]. Then, Apple announced the iPhone in 2007 with the central processing unit, operating system, and user interface. These made the iPhone a general-purpose computer. In addition, Apple put extensive effort into its user interface, as documented on YouTube [ColdFusion 2020]. The initial iPhone came with an analog mobile communication service called 1G. This was promptly replaced by the digital mobile communication services called 2G and subsequent generations, including 3G, 4G, and 5G. The performance of the smartphone also increased significantly.

Keyboards may be problematic in many countries in Asia when computers are accessed. These are especially true in Asian countries such as China, Japan, and South Korea, as elaborated in "Early history of Internet development" [Chon 2022]. Mullaney published "The Chinese Computer" recently [Mullaney 2024]. In his books, he described Chinese keyboards extensively.

Smartphones offer two types of keyboards:

Ten-key in China and South Korea, and twelve-key in Japan, and
Full keyboard.

Users in these countries could avoid using the QWERTY keyboard. In China, artificial intelligence technology could help input characters using character recognition. Please refer to the details in Section 2.2, Users of Computer Communications in the 20th century.

Smartphones with artificial intelligence technology are starting to impact Internet access for the physically handicapped. For example, a smartphone with AI guides blind people on walking streets, and the AI sees the streets and advises the blind [NHK 2024; Microsoft 2024]. AI could assist the voices of people who struggle to produce sound. Dr. Hawking was one of the first people to have AI assist in reading, writing, and talking in the late 20th century. AI and other digital technologies are helping many people read, write, and talk. But, it would take much more effort for the

majority of the physically handicapped to benefit from digital technologies.

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2.2 Users of Computer Communications

Introduction

Computer communications began among mainframe computers and minicomputers in the 1960s [Asia 2013; Computer 2022]. We had the groundbreaking demonstration of the ARPANET at the First International Conference on Computer Communications (ICCC) in Washington, D.C., in 1971 [ICCC 1971]. This was the landmark demonstration of computer communications. The original applications of ARPANET were file transfer and remote execution. One of the additional applications in the 1970s was email, which created "users" of computer communications. When personal computers became popular in the 1980s, we began to see various applications catering to personal computer users' needs, including email, messaging systems, and bulletin board systems, among others.

In this article, we plan to review the history of computer communications users, including their migrations between the three computer communications systems: the Internet, personal computer communications, and mobile phones, which have a microprocessor internally. We primarily cover South Korea, but we also cover other Asian countries and continents, too.

In 1980, the ARPANET had around 5,000 users and over 66 nodes [Asia 2013]. Computer communication networks compatible with ARPANET’s email began to operate in the 1970s and 1980s, such as UUCPNET/Usenet, Bitnet, and CSNET. The Internet consisted of NSFNET with regional networks in the United States, the successor to ARPANET, and other networks in various countries in the 1980s.

PC communication networks, such as bulletin board systems and message systems, including FidoNet worldwide, AOL and CompuServe in the USA, and similar services in many other countries, including South Korea and Japan, became available in the 1970s and 1980s [Asia 2013].

Mobile phone services offered by telecommunication service providers worldwide have been offering messaging services since the 1990s. They were eventually standardized by the Global System for Mobile

Communications (GSM) as Short Message Service (SMS) in 1992 [GSM 2022]. GSM made message services very popular worldwide due to their global compatibility. In South Korea, 2G service based on Code Division Multiple Access (CDMA) technology started in 1997, and SMS over CDMA started in 1997 [Donga 2020].

In this article, we will discuss the developments of computer communication users in the above three areas and the migration of users from each area to other areas. We analyze South Korea as a case study and cover neighboring countries, including China and Japan, as well as North America and Europe.

Timelines – South Korea and the World

The email service was created on the ARPANET in the 1970s [Asia 2013], which is the beginning of "users" of computer communication. Bulletin board systems with messages were also created when the Personal Computer from IBM and other microcomputer systems became available in the 1970s. UUCPNET, along with email service and USENET news, was also created during the same time period. The UUCPNET email service is compatible with ARPANET's email service [Asia 2013]. They were also introduced in South Korea in 1983.

Commercial computer communications services based on the microcomputers including AOL, CompuServe, and Prodigy in the United States were also introduced in the early 1980s.. Similar services started in South Korea such as Chollian in 1984 and Prestel in 1986 [PC 2021; Korea 2021]. In South Korea, these computer communications services were called "PC Tongshin (PC통신)," Personal Computer Communications.

Mobile phone services also began Short Message Service (SMS) through the Global System for Mobile Communications (GSM), whose standards were developed by the European Telecommunications Standards (ETSI) for the second generation (2G) mobile phone networks in 1991[GSM 2022]. South Korea decided to use CDMA technology for 2G, and its service was introduced in 1996, followed by SMS based on CDMA

in 1997 [Donga 2020].

These three tracks—the Internet, PC communications, and mobile phones—accommodated computer communication users from the 1990s. Migrations from some tracks to others evolved to the current status of computer communications, with well over half of the world's population using computer communications. This will be described in the next section, User Migration.

Commercial Internet services began in the late 1980s in the United States, followed by many other countries in the 1980s and 1990s. In South Korea, commercial Internet services started in 1994 by three companies: Korea Telecom, Dacom, and INET.

The introduction of the World Wide Web (WWW) in the early 1990s encouraged many web-based applications, including web-based email services and search services [WWW 2022]. In South Korea, Hanmail, Daum's web-based email service, and Naver's search service were launched in 1997 [Korea 2021].

The next major user service deployments, messaging services, appeared in the late 2000s and early 2010s. WhatsApp started the messaging service in 2009, followed by KakaoTalk and LINE in 2010, and WeChat in 2011 [Asia 2021].

User Migration

There have been significant user migrations from some of the three tracks, especially the PC Communications users track to other user tracks, the Internet, and the Mobile Phone from the 1990s. The migrations are still taking place now.

The first significant migration began with the invention of the World Wide Web (WWW) services based on the Internet in the 1990s. Many web-based services appeared in the 1990s, in particular for end-users, such as search services of Bing and Google in the United States, and Naver in South Korea, and web-based email services such as Hotmail from Microsoft and Gmail from Google in the United States, and Hanmail from Daum in South Korea [Asia 2013; Korea 2021].

The PC communications communities in the United States and South Korea, among others, failed to develop similar services in the 1990s, and encouraged PC communication users to migrate to the Internet with WWW. Eventually, the PC communication services were discontinued in the 2000s in South Korea, and later in the USA and elsewhere.

Some PC Communication users migrated to mobile phone services when Short Message Service (SMS) by GSM was introduced in 1993. When smartphones were introduced in the late 2000s, starting from the iPhone in 2007, the migration to mobile phone services increased substantially. This is especially true as mobile telecommunication services migrated from analog services in 1G to digital services in 2G and beyond. Even Internet users started to migrate to mobile phone services when smartphones became widely available in the early 2010s. Improved keyboards were deployed in the northeast Asia, including China, Japan, and South Korea. They encouraged further migration to mobile phone services. The details of the improved keyboards are described in the next section.

Messaging services like WhatsApp, KakaoTalk, LINE, and WeChat were introduced in the late 2000s and early 2010s. They further accelerated users' migration from the Internet to mobile phone services. Many social networking services, such as Twitter and Facebook, which appeared in the 2000s, also accelerated user migration in addition to messaging services.

Keyboards

Keyboards play several important roles on users, including their migration. We will focus on three cases; South Korea, Japan, and China.

Both the full keyboard and the 10-key keyboard have been popular in South Korea for inputting Korean characters since the advent of personal computers and mobile phones [Korean 2022]. The full keyboard includes both the English alphabet and Korean characters (Hangul) with the conversion key. When smartphones were introduced, their users used the full keyboard or the 10-key keyboard, depending on their preferences. Some people use both. In 2024, Samsung announced that the full keyboard was the default option, with the 10-key as optional [Samsung 2024].

The situation is very different in Japan, where the input method is somewhat complex [Japanese 2022; Nihongo 2024]. First, users must input the Romanized Japanese characters in the English alphabet, called Romaji, followed by a conversion to Japanese characters such as Hiragana. Then, Chinese character conversions are performed. This is mandatory in the Japanese language. Since the Japanese language has many homophones, a Hiragana string (representing the pronunciation) may be mapped to many Chinese character words. Thus, real-time dictation in Japanese is almost impossible, unlike in English or Korean. Then, the remarkable new scheme of Japanese input methods based on the 12-key keyboard was invented in the 2010s [Japanese 2022]. It is called Flick input for smartphones. It made the Japanese input method much easier and more efficient. Keyboard users can input Japanese characters directly without using the alphabet input.

Chinese input methods could be complex because they have to deal with around 10,000 Chinese characters to be inputted [Chinese 2022; Mullaney 2024]. Finally, the pinyin method and other methods were invented. The pinyin method uses the English alphabet for input. Many users started to input Chinese characters using smartphones instead of personal computers because personal computers and smartphones were introduced at similar times. The recent development of handwriting in Chinese is remarkable. This allows handwriting Chinese input methods to be used. This method began to gain popularity. According to a recent publication by Thomas Mullaney [Mullaney 1998; Mullaney 2024], people could type words faster in Chinese than in English now.

Remarks

Korean language support

The Internet did not support the Korean language well in the 1980s until commercial Internet service providers began offering services in the 1990s. USENET news and UUCPNET mail did not support the Korean language either [Korea 2021; Asia 2013]. Its users are in the academic and research

communities, and the local language support is not their primary concern as long as English is adequately supported. On the other hand, PC communications supported the Korean language from the beginning of the 1980s, as the company's interest was in using PC communications for domestic activities in South Korea. In addition, the PC communications service providers have to support the Korean language to keep their customers, i.e., the PC communications users. This is similar to the case of mobile phone services. The Short Message Service (SMS) needed to support the Korean language when they were introduced in the 1990s. This is similar to PC communications.

Need good statistics

We need good statistics on the 20th and 21st centuries in terms of mobile phones, PC communications, and the Internet, including their populations. The population data we could get from the World Bank and the National Information Society Agency (NIA) in South Korea are substantially different [Chon 2022].

User Populations in Korea, Internet and PC Communications

1994

- 140,000: Total Internet Users in South Korea [World Bank 2022]
- 10,000: Commercial Internet Users in South Korea [NIA 2021]

1997

- 1.7 million: Total Internet Users in South Korea [World Bank 2022]
- 1 million: Total Internet Users in South Korea [NIA 2021]
- 3 million: PC Communications Users in South Korea [NIA 2021]

2000

- 19 million: Internet Users in South Korea [Internet 2000]
- 27 million: Mobile Phone Users in South Korea [ITU 2022]

Migration of PC Communications Users

Have PC Communications users migrated more to the Internet or to mobile phones? We don't have good data on this matter. We suspect most PC communications users migrated to the Internet because of the availability of web-based services such as Hanmail by Daum and the search service by Naver. These are not available to PC communications users. Some users of the PC communications migrated to the mobile phone services due to the availability of Short Message Services (SMS). When the popular web-based services became available on smartphones, many PC communications users and many Internet users migrated to mobile phone and smartphone services in the 2010s.

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