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The Direction of mobile evolution examined through the NTT DoCoMo strategy, "Mobile Frontier"

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The direction of mobile evolution
examined through the NTT DoCoMo strategy, "Mobile Frontier"

By
Akihiro Kakimoto

Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Information Technology

Rochester Institute of Technology
B. Thomas Golisano College
of Computing and Information Sciences

May 10, 2003
Rochester Institute of Technology
B. Thomas Golisano College
of
Computing and Information Sciences
Master of Science in Information Technology

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The direction of mobile evolution
examined through the NTT DoCoMo strategy, “Mobile Frontier”

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Abstract

NTT DoCoMo is Japan’s biggest mobile service provider. They added extra value into cellular phone as “telephone”, and contributed to the explosive spread of the mobile phone in Japan. They have still led Japan as a country with the world's largest mobile Internet. The mobile phone now changes our lifestyles or work styles, and has a great influence also on business.

In 1997, NTT DoCoMo created the company vision towards the year 2010, “Mobile Frontier”. It consists of five concepts, named “MAGIC”, and indicates the mobile phone figure in the future as a whole. I regard it as a guideline of this paper, and examine the direction of mobile evolution by researching the following topics: the present situation, the issues needed to realize each concept, and the future.

At first, I state the background of the mobile phone spread in Japan and the cultural aspects peculiar to Japan. After that, I examine the mobile evolution along with the five concepts. The objective of this paper is to refer to and understand the vision of a leading company in the telecommunication field, and consider mobile communications’ influence and applications in the future. The goal is to expand knowledge in the present situation of the mobile phone and the trend towards future mobile, and to examine the direction the Mobile Frontier aims.
1. Introduction 1

2. Mobile Situation in Japan 1
   2-1. Cultural background of mobile phone spread
   2-2. NTT DoCoMo and i-mode
      2-2-1. Change from “phone for talking” to “mobile for using”
      2-2-2. Reasons for i-mode success
      2-2-3. Driving forces for 3G
   2-3. Competitors against NTT DoCoMo
      2-3-1. KDDI
      2-3-2. J-Phone

3. DoCoMo Vision 2010 21
   3-1. Mobile Communications and Society in 2010
      3-1-1. Personal Life: more individualized, diversified lifestyle
      3-1-2. Corporate Activities: deregulation; a more open, global environment
   3-2. Mobile Frontier

4. M (Mobile Multimedia) 24
   4-1. IMT-2000
   4-2. The trend of future applications
   4-3. The factors obstructing the spread of the mobile Internet
5. **A (Anytime, Anywhere, Anyone)**

5-1. Change from mobile to wearable

5-2. Diverse mobile communication usage

   between human and human, human and machine, machine and machine

6. **G (Global Mobility Support)**

6-1. The current situation and issues of global roaming

6-2. The movement of all-IP network

7. **I (Integrated Wireless Solution)**

7-1. Mobile applications with GPS

7-2. Mobile applications with Bluetooth

8. **C (Customized Personal Service)**

8-1. Use of the IC card, named UIM (User Identity Module)

8-2. The social role of mobile

9. **Examination**

10. **Conclusion**
1. Introduction

The Development of the mobile phone in recent years has been tremendous. Until a few years ago, the mobile phone was used mostly for making and receiving voice calls. Today we can browse the Internet, exchange emails, and even play games with the mobile. As further development, the world's first 3G mobile was launched in Oct. 2001 in Japan by NTT DoCoMo; however, the spread is not progressing considerably. When it was launched, the president predicted that the number of subscribers after one and a half years would be 1,300,000. The reality after one year is only 130,000 sets. Some people say that 3G will not spread in the future. However, I believe that it has various attractive possibilities and has been developing certainly. The mobile phone will change our lifestyles, and become not only just a useful device but a necessity of everyday life in the future. This paper focuses on how mobile phones will evolve and the factors obstructing the spread. We will be able to understand why mobile has been in the spotlight.

2. Mobile Situation in Japan

As of November 2002, the entire domestic Japanese market has 78 million mobile phone users. After China (200 million) and the United States (160 million), Japan is the world's third largest mobile phone market. This means that 60% of Japan’s total population is using mobile phone. Compared with that of Western European countries, Japan’s mobile penetration rate is not so surprising. However, with respect to the Internet-enable mobile phones, Japan is remarkable. This is the reason why I have interest in the mobile Internet
and chose this topic. I regard the combination of the mobility and the Internet as a key factor for the possibilities of the mobile phone.

<table>
<thead>
<tr>
<th>Country</th>
<th>Japan</th>
<th>Korea</th>
<th>Europe</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage (%)</td>
<td>81.5</td>
<td>12.5</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 1: World's Wireless Internet Users  
Source: Eurotechnology (November 2000)

2-1. Cultural background of mobile phone spread

While the spread of the personal computer has been delayed, mobile phone use has been sharply spreading instead in Japan. Here I would like to examine the history behind mobile phones' popularity. The reasons for the spread of mobile phones in Japan are related to the following national characteristics unique to Japan. Compared with the U.S., Japan lagged behind in the computer age.

First, against the background of high economic growth and the development of the communication industry, telephones quickly became a household item as a communication tool.

In addition to the telephone as a means of communication, pager rapidly spread among students around 1994. During this time, means of virtual communication by group-oriented youths came into existence. As the popularity of the pager spread, the price came down due to improvement in cost performance. This in turn enabled students to afford buying them on their own. [6]
Because of the characteristic of the Japanese language which can tell information with few characters, the pager was used among students as a kind of entertainment tool. Japanese people have been good at expressing their feelings with few words from ancient times. There are plays on words, such as a haiku poem and a 31-syllable Japanese poem, and also the Chinese characters used in the Japanese language can tell much information with few characters. Therefore, in addition to the telephone, the letter communication by pagers rapidly spread, and finally it shifted to the mobile phone. Mobile phones were more useful than pagers because “there is voice communication on top of word communication.”[6] Thus, mobile phones fit the needs of young Japanese people better than pagers.

Another determining factor for the growth is the substantial price reduction. Price had been reduced to the point that it was easily accessible for ordinary students. When you look at figure 2 and 3 that show the number of mobile phone subscribers and the basic rate per month, you will notice that the mobile phone began to become popular after 1994. Prior to 1994, the mobile phone terminal was not purchased but rented. At the time of subscription, the guarantee fee of over $1000 was required. However, the guarantee system was abolished in 1993, and the system terminals were purchased was introduced in 1994. As a result, the terminal cost went down dramatically. Since then, the increase in subscribers was inversely proportional to the decrease in price. The number of subscribers was 4.3 million in 1994 and increased sharply to 11.7 million in 1995. By the improvement of the cost performance, the mobile phone became inexpensive and indispensable in our lives.
Figure 2: Subscribers of fixed phone and mobile phone
Source: Hiroshi Mochizuki International Laboratory

Figure 3: Basic rate per month of mobile phone
Source: Hiroshi Mochizuki International Laboratory

Looking at figure 4, you will notice that the pager had begun to increase in the number of subscribers around 1990, with subscribers of mobile phones increasing in 1994. After that, only the mobile phone subscribers kept increasing, and finally drawing even in 1995. Then, the decrease in the number of pager subscribers began to set in, as the number of mobile phone subscribers grew. It is the fact that the mobile phone has replaced the pager.
I also estimate that the expansion of the phone call area resulted in the rapid increase in the number of mobile phone users. That attracted those who wanted the convenience it offered.

![The change of pager and mobile phone](image)

**Figure 4:** The change of pager and mobile phone  
Source: Hiroshi Mochizuki International Laboratory

Here I can infer the relationship between personal computers and mobile phones. The mobile phones became the compensation of PCs. It means that a strong demand for the mobile phone reflects the substitution process for the delayed spread of PCs. In fact, the mobile phone began to be regarded as a strong candidate and the driving force for the future network society. Meanwhile, the mobile phone in the U.S. had not experienced the same growth as it did in Japan. That can be considered mainly because the use of PCs had already been spreading very quickly, due to low telephone rates for the Internet access. “As charges for inter-city calls are included in the basic fare, Internet connection fares are very minimal, in line with inter-city calls.” [6] In the U.S., mobile phones were mainly used by business people that were pressed for time and did not mind the high costs. However, for students, using the mobile phone was too costly and quite unnecessary. Using email via the PCs for communication with school and among families and friends had been firmly established in the U.S. Using mobile phones instead was not needed.
In addition, the peculiarity of Japanese communication has affected the mobile phone spread. Japanese young people select mobile phones as major communication tools. While there are a high percentage of mobile phone usages among Japanese students, there are a low percentage of them among American students in their teens and twenties, because of the difference in the nature of their communication. For instance, in case of the U.S., the mobile phone is mostly used for business contacts or private calls of a personal nature. Therefore, mobile phone users in the U.S. are mostly business people, not students. “In Japan, the mobile phone is mostly for group social contacts, or for private social calls mainly in the area of entertainment. Young Japanese like to have a sense of belonging to a group and they find the mobile phone very useful when interacting within the group.” [6] Japanese people tend to want what their friends have. Therefore, “if young Japanese does not have access to a mobile phone, he feels very uneasy for having been left out of the group. He heavily relies on the mobile phone to keep in touch with his group and for social networking.” [6]

As I discussed so far, the mobile phone is widely chosen as a main tool of communication by the younger generation that is responsible for the Japanese future. In conclusion, mobile phones have spread so widely that the mobile phone is better suited for needs of group oriented and virtual communications by young generation than the PC. Another reason is simply delayed spread of PCs in educational process. There was no custom which uses computers before, so many Japanese people including the younger generation still cannot use computers. Thus, such an environment makes computer's penetration into society slow. Therefore, some important roles like email which PCs should take primarily
have been delegated to the mobile phone, because the Japanese people are more familiar with mobile phones.

2-2. NTT DoCoMo and i-mode

2-2-1. Change from “phone for talking” to “mobile for using”

Today’s explosive spread of the mobile phone in Japan is undoubtedly a result of the appearance of i-mode. Japan's biggest mobile service provider, NTT DoCoMo, released the first Internet-enable mobile phone in 1999. i-mode is NTT DoCoMo's mobile Internet access system. It is a packet-based information service, and provides web browsing, e-mail, online shopping and banking, chat, games, and customized news.

i-mode changed not only the existence of the mobile phone, but also our lifestyles and work styles.

Visitors to Japan these days are quick to note a curious phenomenon. Mobile phone users seem to spend more time peering at their handsets than they do speaking into them. Riding the subway, walking along crowded city streets, teenagers and business people alike can be seen with their heads down, scrutinizing their phones’ tiny colored displays. [13]

The i-mode growth rate is much more rapid than the speed of the mobile phone spread before then. The service only started in February 1999, and since then, it has been gaining
25,000 new subscribers a day. As of October 20, 2002, the number of i-mode subscribers exceeded 35 million and overtook that of AOL, the world’s biggest Internet service provider. The subscribers reach no less than 28% of Japan’s 127 million people at present.

The appearance of i-mode had a great influence on the evolution of the mobile phone. The greatest achievement is to set forth the new direction of mobility for the Internet. In fact, many people who had seen news and weather forecasts with the PCs before began to check them with the mobile phone. i-mode changed “phone for talking” to “mobile for using”.

![Figure 5: i-mode subscribers in Japan](source: Eurotechnology)

2-2-2. Reasons for i-mode success

DoCoMo’s success with its i-mode service can be attributed to a number of factors. First, the timing of i-mode’s introduction was significant. Just in those days, data communications increased with the wide spread of email and the Internet in the
computerized world. Since the home PC and Internet market had not taken off in Japan, i-mode offered an attractive alternative, against the background of high mobile phone penetrations. PCs in Japanese homes were not so widespread as in the U.S. and Europe because of the high cost. The local access charges were very expensive and entailed a per-minute charge, not fixed charge like in the U.S. Therefore, Japanese people did not use PCs for the Internet access as much as in the U.S. or Europe. In contrast, i-mode provided the access at unusually low rates, because their charges were based on the volume of data transmitted, not the amount of time spent connecting. The primary difference between the i-mode system and other mobile devices that feature the Internet access is that the connection is constant. In other words, the users are always connected to the Internet. They will see reception of emails instantaneously. In fact, email accounts for nearly 40% of i-mode’s Internet usage time. Approximately $2.50 per month entitles the user to unlimited and continuous Internet connectivity, an i-mode email address, and nationwide coverage. Additional fees are charged for sending and receiving each packet of information (approximately 0.3 cents per 128 bytes). The average data usage was $18 per month in fiscal 2001.

i-mode proved that the wireless Internet connection is so easy. Although a PC takes more than 60 seconds to boot up Windows and connect to the Internet, i-mode needs less than 10 seconds. Before i-mode, Japanese Internet penetration was 13.4% (1998), whereas the U.S. was 37.0%. The latest survey indicates that the penetration is 67.6% and 59.6% in 2002, respectively. In fact, “over 1/3 of i-mode’s subscribers are seeing the Internet for the first time through i-mode.” [1]
Next, the use of cHTML (compact HTML) for the platform is an important factor of its success. European and U.S. mobile phone carriers developed an entirely new technology to provide mobile data services—Wireless Application Protocol (WAP). Four years ago, “WAP was not mature, and there was a lack of rich content and no robust billing system.” [13] Meanwhile, DoCoMo adopted a packet-based system and used Internet technologies, such as a subset of the hypertext markup language (HTML), which is used throughout the World Wide Web. The packet-based system chops data into small units to transmit efficiently. “Because Internet technologies were already well understood, content providers required no steep learning curve to supply data.” [13]

DoCoMo’s approach was highly focused on the content. They expected—as more subscribers sign up for i-mode, more content providers join to provide services, and that
creates further interest and attracts more subscribers. DoCoMo employed a unique business model, and built an attractive win-win-win situation of providing benefits to content providers, consumers, and a network operator in equal measures. i-mode provides content providers with a reliable and systematic billing system. Official i-mode sites approved by DoCoMo are listed on the categorized i-mode menu, which is a portal site for all i-mode users. Some of them are free, whereas others charge monthly fees ranging from $1 to $3. DoCoMo includes the content fees in each customer’s monthly bill according to their access and downloads of the contents, and collect 9% as a commission. That makes it easier for the content providers to charge their own fees. As a result, they can focus on creating quality content to attract more consumers. In return, this generates more usage and results in increased revenue. Meanwhile, approximately 80% of i-mode users subscribe to fee-based services, such as news, mobile banking, ticket reservations, games, and entertainment. Users also can access many unofficial sites by using the i-mode search engine or by typing the URL directly. Thus, for content providers, consumers, and DoCoMo, i-mode is the important point that provides the best platform for cooperation and communication. The 67 certified content providers at launch have grown to almost 3,000, and approximately additional 57,000 i-mode compatible sites are available at the same time.

Finally, i-mode fits in comfortably with the culture. “Life in Japan consists of a lot of waiting, and the Internet-enabled mobile phones are perfectly suited for killing the time.” [2] Friends often wait for each other to arrive in public places, and that provides ample time for them to zip online. People often have to spend long waiting periods on crowded
subway and train platforms, where i-mode fills the time. Besides, daily commutes often take well over an hour. Although there are automobile users, commutes are typically via public transportation—train and bus. Especially in the big cities like Tokyo, everyone is always on the move, and trains and buses are very crowded. Even laptop computers are too big to use in the train, but mobile phones are so small that you can hold them in one hand and even type with the same hand if necessary. There are many people typing mail messages on their phones without even looking at the keypad. “The name DoCoMo means ‘anywhere’ in Japanese, as well as being an acronym for the English ‘DO COmmunications over the MOBILE network’.” [13]

In addition, Japanese people are fascinated by gadgets. They prefer smaller and cleverer. Japanese mobile terminals offer features such as color displays, polyphonic ringers, digital cameras, voicemail/voice note recorders, short messaging, and many others. DoCoMo’s primary audience for i-mode is users in their twenties. Members of this group are among the fastest adopters of new features and innovations to the service. DoCoMo has rolled out its services by observing very closely the usage situations and context of use. Also, one of the most loyal users for i-mode is teenage girls, who use it to keep in touch with friends and to browse interactive content. The reason for having mobile phones for young people is not only to communicate with someone but also for fashion. They put stickers on their phones and also put cute straps on them. Young i-mode users greatly contribute to the data services, such as wallpapers, screen savers, and ringing tones downloads, which comprise a significant portion of the traffic. While the main use of overseas mobile Internet is for business, it is a peculiar tendency of Japan that the
entertainment content is substantial. In fact, approximately 70% of official i-mode sites are for entertainment.

2-2-3. Driving forces for 3G

In October 2001, as the next generation of mobile evolution, NTT DoCoMo launched the world's first 3G mobile phone service in Japan. They named it FOMA (Freedom Of Mobile multimedia Access). FOMA is using Wideband Code Division Multiple Access (W-CDMA) technology, which is one of the global cellular telecommunications standards approved by the International Telecommunications Union (ITU). Three main driving forces are considered behind the introduction of 3G in Japan.

The first is the increasing demand for multimedia services. The Internet has now been dominated by fixed networks, and the similar capability is demanded in mobile environments. The notable success of the mobile Internet services points to the need of advanced mobile applications. At present, the download speed for i-mode data is limited to 9.6Kbps, and the actual data rates are much slower. Meanwhile, 3G has wider bandwidth and much higher transmission speed, which enable larger volumes of data to be transmitted. FOMA operates 144Kbps in a high-speed moving environment, and 384Kbps in a low-speed moving environment, which is 40 times faster than i-mode. By around 2005 when 3G is in general use, the maximum speed will be up to 2Mbps.

"Currently, face-to-face communication is possible with new FOMA handsets incorporating digital cameras, while another service provides video clips of news and
sports highlights.” [13] In addition, since large-size files can be transmitted, corporate users can access their company Intranets; therefore, it will become important for a business tool. DoCoMo has been also developing a variety of remote monitoring applications. FOMA-based monitoring systems will contribute to watch on work progress at construction sites, security systems, and monitoring the weather, etc.

<table>
<thead>
<tr>
<th>Subscribers</th>
<th>2001</th>
<th>2004</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internet users (millions)</td>
<td>533</td>
<td>945</td>
<td>1,460</td>
</tr>
<tr>
<td>Wireless Internet users</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>as % of all Internet users</td>
<td>16</td>
<td>41.5</td>
<td>56.8</td>
</tr>
</tbody>
</table>

Figure 7: Global Internet and Wireless Users
Source: eMarketer (March 2002)

The second force is the demand for global roaming. Although Japan is an island country, a huge number of people travel overseas for business and leisure, and that creates a big market for global services. When the mobile phone developed from analog to digital around 1990, Japan originally designed a digital wireless communications method called Personal Digital Cellular (PDC), which used TDMA technology. Japan wanted to introduce a system which succeeded worldwide. If an excellent system is previously constructed, it often becomes a de facto standard before long. However, the system which spread to the world was Global System for Mobile communication (GSM), which appeared after PDC. GSM is also based on TDMA technology. The big difference between them is that GSM had been developed in Europe where there were originally several operators in many countries while PDC had been developed in one country, Japan. It is impossible to surpass a system originally designed to be used all over Europe. Thus,
only Japan adopted PDC, and GSM was adopted all over the world mainly Europe and Asia. Therefore, Japan had been trying to introduce the third generation in advance of the world.

DoCoMo’s 3G mobile, FOMA, also offers i-mode service. “When 3G i-mode becomes available throughout the world, users will be able to carry their handsets and access i-mode services in the home market and overseas.” [13] However, if enough other wireless operators do not adopt W-CDMA compatible technology, they may not be able to offer global roaming and other services as expected. In addition, since Japan’s domestic mobile phone market began to show signs of maturing, DoCoMo has been working with foreign partners to take i-mode services overseas. In order to increase their corporate value and to promote the wide spread adoption of W-CDMA technology, DoCoMo has invested approximately $15.8 billion in multiple overseas operators during the past several years. Through these alliances, they have established footholds in most of the major wireless markets of the world. In addition, “i-mode’s chances have been boosted by the release of a new version of WAP that is compatible with i-mode.” [13] That means that a browser in a mobile phone makes it possible to view websites created for both i-mode and WAP. It is easy to create websites for i-mode services, so many overseas content providers will be able to enter the market. “There are already many low-priced services in Japan like screen-savers and ringing tones that can easily be exported without any need for software code conversion.” [13] All of these factors will help the market to grow.
DoCoMo invested in | DoCoMo established footholds in  
--- | ---  
North America | AT&T Wireless Services, Inc. | the United States  
Europe | KPN Mobile N.V. | Germany, the Netherlands  
Hutchison 3G UK Holdings Ltd. | Belgium, the United Kingdom  
Asia | KG Telecommunications Co., Ltd. | Taiwan  
Hutchison Telephone Co., Ltd. | Hong Kong  

Figure 8: NTT DoCoMo’s investment in overseas operators

The final and most important issue is the lack of spectrum caused by the unexpected and dramatic rise in the number of mobile subscribers.

Existing second generation frequency bands (800 MHz and 1.5 GHz) appeared insufficient, and services using different frequency bands were, therefore, considered necessary. Responding to this need, the Japanese Government decided to work towards the deployment of IMT-2000 networks. [8]

“One of the principal limitations on a cellular network’s capacity is the amount of radio frequency spectrum it can use.” [12] DoCoMo has only a limited amount of spectrum available for their services. As a result, in certain parts of large metropolitan cities, such as areas near major train stations, their cellular network operates at the current capacity of its available spectrum during peak periods. That can cause congestion, interruptions, and reduced quality of service. DoCoMo has made improvements to their network’s capacity and in the technology they use, including the introduction of dual-band handsets for their 800 MHz and 1.5 GHz networks. They expect that these efforts will enable them to use their existing spectrum more efficiently. However, thanks to the unexpectedly rapid
growth of i-mode subscribers, "there can be no assurance that these efforts will result in reduced levels of congestion or improved service quality." [12] In addition, since their competitors in Japan are not experiencing capacity problems to the same extent, if DoCoMo cannot successfully address the problems in a timely manner, they may suffer constraints on the growth of their services or lose subscribers to their competitors in areas where the problems occur.

For the above reasons, DoCoMo hoped for earlier introduction of 3G mobile. However, eagerness for 3G is different in each country because of each circumstance. In the United States, the telecommunications infrastructure is more developed than many European and Asian countries. As a result, the demand for wireless devices has been lower because consumers have other low-cost options. In other words, there is no necessity for a new system. In Europe, there is no reason why the introduction of a new system has to be sped up. GSM is already there. Thus, only Japan wanted to introduce the new system quickly.

On top of that, different countries will develop 3G at varying speed. The international standard may not be acceptable in some countries. For instance, it is difficult to introduce a new system if the frequency has already been used for another system, even if the system is very new and its performance is so good. Also, it does not make sense to introduce a new system to where the use of the mobile phone is not widespread. That is the reason why it is so difficult to make a mobile phone that can be used all over the world.

FOMA
2-3. Competitors against NTT DoCoMo

There are three main cellular operators in Japan: NTT DoCoMo, the KDDI group, and J-Phone. The competitors of DoCoMo’s i-mode are “EZweb” provided by the KDDI group and “J-Sky” provided by J-Phone. Like i-mode, both EZweb and J-Sky services allow their users to connect to the Internet, send color images, and also utilize navigation programs. These three operators have all received permission and licenses from the government for the establishment of 3G service in Japan.

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Internet-enable</th>
<th>3G</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTT DoCoMo</td>
<td>44.2 million</td>
<td>35.5 million (i-mode)</td>
<td>0.15 million (FOMA)</td>
</tr>
<tr>
<td>KDDI au</td>
<td>13.3 million</td>
<td>11.5 million (EZweb)</td>
<td>3.9 million</td>
</tr>
<tr>
<td>KDDI Tu-Ka</td>
<td>3.8 million</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J-Phone</td>
<td>13.1 million</td>
<td>11.3 million (J-Sky)</td>
<td>(launched in Dec. 2002)</td>
</tr>
<tr>
<td>others</td>
<td>3.9 million</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>78.3 million</td>
<td>58.3 million</td>
<td>4.0 million</td>
</tr>
</tbody>
</table>

Figure 9: Number of mobile phone subscribers in Japan (November 2002)
Source: Telecommunications Carriers Association

<table>
<thead>
<tr>
<th>Service</th>
<th>Provider</th>
<th>Protocol</th>
<th>Download Max Speed</th>
<th>Page Description Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>i-mode</td>
<td>NTT DoCoMo</td>
<td>TDMA (PDC)</td>
<td>9.6 Kbps</td>
<td>compact HTML</td>
</tr>
<tr>
<td>EZweb</td>
<td>au</td>
<td>CDMA (cdmaOne)</td>
<td>64 Kbps</td>
<td>HDML / WML (WAP)</td>
</tr>
<tr>
<td></td>
<td>Tu-Ka</td>
<td>TDMA (PDC)</td>
<td>9.6 Kbps</td>
<td></td>
</tr>
<tr>
<td>J-Sky</td>
<td>J-Phone</td>
<td>TDMA (PDC)</td>
<td>9.6 Kbps</td>
<td>MML</td>
</tr>
</tbody>
</table>

Figure 10: Mobile Internet Services in Japan
Source: Telecommunications Carriers Association
2-3-1. KDDI

The KDDI group is the second largest cellular operator in Japan. "Two fixed-line operators (DDI and KDD) and one mobile phone operator (IDO) merged into KDDI in October 2000." [8] They have branded their mobile services as "au" and "Tu-Ka". They offer nationwide services using cdmaOne technology as well as PDC technology. "Concluding that it could not compete with NTT DoCoMo's own PDC technology, they adopted the cdmaOne system in 1998, banking on its high quality voice service." [8] As a result, approximately 75% of KDDI subscribers are using the cdmaOne system.

In April 2002, the KDDI group launched their 3G service through cdma2000 1x technology in Japan. Although their data transmission speed (up to 144 Kbps) is lower than FOMA (up to 384 Kbps) and they do not offer videophone service, as of December 2002, KDDI has gained over 4 million subscribers compared with around 150,000 for DoCoMo. DoCoMo's 3G service is now a long way behind their cdma2000 1x service.

KDDI's advantage is the existing cdmaOne infrastructure. The cdma2000 network buildout cost for KDDI is greatly lower than DoCoMo's buildout cost, because of the ability to use a greater portion of the current cdmaOne technology in the construction of the network (although the KDDI group incurred additional expense as it converted from PDC to cdmaOne). Therefore, at present cdma2000 1x subscribers can use their handsets in a wider area than FOMA, almost all over Japan. In addition, KDDI has not been advertising their service as "3G". They regard that cdma2000 1x is on extension of the
present services, and try to shift without users’ consciousness. They are planning to abolish PDC service about one year later, and to shift to cdma2000 altogether.

2-3-2. J-Phone

J-Phone is the third largest cellular operator in Japan.

J-Phone was established in 1992 and launched its services in 1994. It is subsidized by Japan Telecom, one of the country’s major fixed-line telecommunication operators. The main stockholder of J-Phone is Vodafone, the largest mobile operator in the world. Since August 2001, Vodafone owns 45% of Japan Telecom stocks and 46% of J-Phone stocks (Japan Telecom owns the other 54%). [8]

J-Phone is known as a pioneer of camera-phone. They launched service named “Sha-mail” in June 2001, and the service greatly contributed to their market share expansion. The users can take pictures with built-in digital cameras, and Sha-mail enables to send and receive them as email attachments. Responding to the needs of customers wishing to send video clips in addition to static pictures, J-Phone then took the next step by introducing “Movie Sha-mail”. It “enables the users to send and receive emails with attachments containing audio/video messages of up to five seconds in length.” [9] The rapid growth of Sha-mail can be attributed to its ease-of-use and a wide variety of handsets, including clam-shell and straight handsets with mobile cameras that offer zooming, frame setting, and other photographic functions.
In December 2002, J-Phone launched their 3G service based on the same standard W-CDMA as NTT DoCoMo. While DoCoMo is aiming at the shift from i-mode users to 3G in Japan by introducing dual mode terminals of W-CDMA and PDC, J-Phone offers international roaming service with GSM networks overseas, taking advantage of its membership in the Vodafone group. J-Phone offers dual mode terminals that work both on W-CDMA and GSM networks. It would enable users to enjoy 3G services when they are in Japan and to use the same handset in Europe, which uses GSM networks and has not been launched 3G service yet.

3. DoCoMo Vision 2010

In 1997, when mobile phone was still used only for telephone, NTT DoCoMo created the company vision towards the year 2010, named “Mobile Frontier”. It had the intention of stimulating further growth of the mobile communications market, and thus improving the quality of life and revitalizing industry.

While the mobile communications market in Japan had grown remarkably, it had started to show signs of slowing down. At the same time, Japan had been facing the major challenge of emerging from the long-lasting effects of a slow economy. With this in mind, DoCoMo began to challenge the Mobile Frontier, in order to reach the second stage of growth. By the year 2010, they projected that the mobile communications market would grow to three times its size of that point.
3-1. Mobile Communications and Society in 2010

3-1-1. Personal Life: more individualized, diversified lifestyle

By the technical innovation and price reduction of computers, computer devices will much more spread into our lives and society widely. A variety of information services will be developed, and a quantity of information individuals consume and send out will be increase. That will bring the expansion of the entertainment services, and the increase of the amount of information-related household expenditures. Furthermore, the change of the lifestyle and the individual needs will result in freeing people from physical constraints such as time, location or distance. This means that personal lifestyles will become much more diverse, and activities will shift from a group base to an individual base. Meanwhile, with an aging society and lower birth rate in Japan, the needs to provide support for activities of senior people, as well as for more efficient government and medical systems, will grow.

3-1-2. Corporate Activities: deregulation; a more open, global environment

"Deregulation and globalization of corporate activities will accelerate the restructuring of industry, the mobility of human resources, as well as the emergence of Small Office Home Office (SOHO) and venture businesses." [19] In such environment, it will be more important for companies to carry out their business activities in a more efficient and open manner. Relationship between diverse networks will become large. That has possibility to
bring the fusion of communication with broadcasting, computers, household appliances, and games, and more new services for individuals will be produced. Meanwhile, by diversification of lifestyles, new work styles, such as a tele-worker and a mobile-worker who make full use of communication technology can appear. As a result, although there are not so many women who continue their work after marriage in Japan, their active advancement on society will be promoted.

3-2. Mobile Frontier

“There are three words that characterize the business of DoCoMo—mobile, wireless, and personal.” [19] Their aim is to make the most of these features and pursue evolution of the mobile communications market. After creating their vision in 1997, DoCoMo launched “i-mode” in Feb. 1999, which was the world’s first Internet-enabled mobile phone service, and launched “FOMA” in Oct. 2001, which was the world's first 3G mobile service. They realized the vision with the available level of technology.

“Mobile Frontier” is based on five key concepts that can be represented by MAGIC.

M - Mobile Multimedia
A - Anytime, Anywhere, Anyone
G - Global Mobility Support
I - Integrated Wireless Solution
C - Customized Personal Service
However, MAGIC cannot be achieved by DoCoMo alone. I believe that “Mobile Frontier” is a vision not only for DoCoMo but also for the whole mobile world. DoCoMo regards these five concepts as indispensable vision for mobile phone spread. Therefore, I examine what each concept aims, these current situations, and how mobile phones evolve in the future along each concept.

![Diagram of DoCoMo Vision 2010 —MAGIC—](image)

Figure 11: DoCoMo Vision 2010 —MAGIC—
Source: NTT DoCoMo

4. M (Mobile Multimedia)

Mobile communications today are mainly for voice, but with the rapid spread of PC usage and the Internet, it is likely that there is an increasing need for multimedia services such as data and images in the mobile environment. To meet the demand and competition in data applications, mobile evolved to the next generation of standards and applications —The Third Generation (3G).
In 1999, the International Telecommunications Union (ITU) established minimum standards for what constitutes 3G services. They called those standards International Mobile Telecommunications 2000 (IMT-2000).

The initiative was to define the goal of accessing the global telecommunication infrastructure through both satellite and terrestrial mobile systems. IMT-2000 has reflected the explosion of mobile usage and the need for future high-speed data communications, with wideband mobile submissions. IMT-2000 is a flexible standard that allows operators around the world the freedom of radio access methods and of core networks so that they can openly implement and evolve their systems. How they do it depends on regulations and market requirements. [24]

IMT-2000’s standards include:

* Compatibility of services within IMT-2000 and with fixed networks
* High quality voice service
* Worldwide roaming capability
* Capability for multimedia applications
* Ability to talk and download at high speed at the same time
* Ability to use video phone

IMT-2000 was initially conceived to enable mobile communication services without changing handsets no matter where the user was. However, due to conflicts of interest
between countries and continents, IMT-2000 recognizes five different advanced technologies as being capable of achieving the 3G standards.

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IMT-MC (multi carrier)</td>
<td>CDMA</td>
<td>FDD</td>
<td>cdma2000 (1x, 1xEV, and 3x)</td>
</tr>
<tr>
<td>IMT-DS (direct spread)</td>
<td>CDMA</td>
<td>FDD</td>
<td>W-CDMA</td>
</tr>
<tr>
<td>IMT-TC (time code)</td>
<td>CDMA</td>
<td>TDD</td>
<td>TD-SCDMA</td>
</tr>
<tr>
<td>IMT-SC (single carrier)</td>
<td>TDMA</td>
<td>FDD</td>
<td>UWC-136, EDGE</td>
</tr>
<tr>
<td>IMT-FT (frequency time)</td>
<td>TDMA</td>
<td>TDD</td>
<td>DECT</td>
</tr>
</tbody>
</table>

Figure 12: Five IMT-2000 standards

In order to sustain the profitability of 2G systems when migrating to 3G, a future-proof solution has to be adopted by the operator. In general, there are two major paths for the evolution towards 3G. First, GSM and TDMA systems will shift to GPRS, and then EDGE. Eventually, they will be replaced by W-CDMA. Second is the evolution for cdmaOne (IS-95) systems towards the cdma2000. The decision for the right path to 3G depends on the specific operator situation.

Figure 13: Migration of standards towards 3G
Source: Siemens
cdma2000 networks are backward compatible to cdmaOne deployments, protecting operator investments in cdmaOne networks and providing simple and cost-effective migration paths to the next generation. cdma2000 becomes available in two phases. Phase one (1xRTT) allows data communications at the speed of 144Kbps. Phase two (3xRTT) will bring the communications up to 384Kbps outdoors and 2Mbps indoors. “The 1x and 3x stand for the number of 1.25MHz radio carrier channels being used.” [28]

W-CDMA also uses the CDMA technology, but is not fully compatible with cdma2000 for both air and network interfaces. “W-CDMA uses a network protocol structure similar to that of GSM; therefore, it will be able to use the existing GSM network as the core network infrastructure.” [24] With respect to economies of scale, the W-CDMA solution has a competitive edge over cdma2000. Already today, more than 67% of the subscribers worldwide are connected to GSM systems. In the future, it is predicted that approximately 85% will belong to the family of UMTS.

![Market share of mobile technologies](source: Siemens)

Figure 14: Market share of mobile technologies
Source: Siemens
<table>
<thead>
<tr>
<th>Carrier</th>
<th>2G</th>
<th>2.5G</th>
<th>3G</th>
<th>Subscribers (million)</th>
<th>Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verizon Wireless</td>
<td>cdmaOne</td>
<td>——</td>
<td>cdma2000 1x</td>
<td>29.4</td>
<td>23.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(01/2002~)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cdmaOne, GSM</td>
<td>(08/2001~)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AT&amp;T Wireless</td>
<td>Digital-AMPS</td>
<td>GPRS</td>
<td>EDGE (2002~)</td>
<td>18.0</td>
<td>14.2</td>
</tr>
<tr>
<td>Sprint PCS</td>
<td>cdmaOne</td>
<td>——</td>
<td>cdma2000 1x</td>
<td>13.5</td>
<td>10.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(08/2002~)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nextel</td>
<td>iDEN</td>
<td>iDEN</td>
<td>——</td>
<td>8.7</td>
<td>6.8</td>
</tr>
<tr>
<td>VoiceStream (T-Mobile)</td>
<td>GSM</td>
<td>GPRS</td>
<td>——</td>
<td>7.0</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(11/2001~)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 15: Six major mobile phone carriers in the United States
Source: Nikkei BP
Note: The number of subscribers and market share are data of the end of 2001.

4-2. The trend of future applications

The promise of mobile multimedia lies in its ability to take mobile communications to the next level by enabling users to combine wireless voice and data services with no restrictions. A mobile phone will become an individual information terminal by IMT-2000. Today, mobile phones are no longer regarded as a tool for only voice transmissions. IMT-2000 has succeeded at steadily increasing the volume of data transmissions, too. Although the present mobile phones can access to the Internet, its technical restrictions are large. They cannot use all protocols used on the Internet standard. However, due to the high-speed transmission and improvement in the
processing ability, we will be able to use the full-scale Internet by mobile phones. First, function to use Web contents will develop. When the resolution of display is improved, Web contents near the usual Internet can be used. As for the description language, although the present mobile phone is using exclusive one, they will be unified into the next version of WAP which is the Europe standard. As a result, Web contents for mobile phones become more substantial, and it will lead to the increase of users.

Although the form-factor limits the mobile phone to a substantially smaller display, there are many applications, or types of applications, that co-exist for both desktops and mobile phones. However, this does not imply that the mobile will support only a subset of the desktop’s functionalities. While a desktop has a substantially larger display and higher communication bandwidth, the phone is always with you, and lets the user be continuously in touch with people and information. Therefore, some applications will be more useful on the phone than on the desktop. Various functions will be integrated into one handset for the owner, such as audio player, digital camera, schedule book, game machine, electronic wallet, and Global Positioning System (GPS). Recently, a number of user applications have been launched for mobile phones, including video, still image support, high-quality audio, and games.

Downloading audio and video files is an excellent example of applications that are not easy in 2.5G. “Audio or video over the Internet is downloaded (transferred, stored and played) or streamed (played as it is being sent but not stored).” [29] 3G and its always-on service is the perfect tool for listening to music on the move. Contents are transferred
using various compression algorithms, such as MP3 for audio and MPEG-4 for video. “With 3G, MP3 files will be downloadable over the air directly to a phone via a dedicated server. There are numerous business models to allow both the network providers as well as the copyright owners of the MP3 material to benefit financially.” [29]

Sending moving images in a mobile environment not only is used for entertainment but also has several practical applications. For example, it can be used for monitoring parking lots or building sites for intruders or thieves, and for sending images of patients from an ambulance to a hospital. Video-conferencing is another attractive application for moving images. It can demonstrate the effects at business. “The transmission of moving images is one of the applications that 3G terminal and infrastructure vendors routinely and repeatedly tout as a compelling application area that will be enabled by greater data rates.” [29] Corporations can easily hold virtual remote meetings between all their regional representatives by using video capable mobile phones. The bandwidth uplift enables high quality image transmission over the mobile network.

In addition, games are often pointed out as one of the most important applications for future phones. Depending on the display size and resolution, advanced graphics will be one key characteristic of the platform. It is likely that we will see three dimensional graphics support in games rather soon. At present, games for mobile phones which linked with game machines, such as PlayStation and GameBoy, have been developing. In the future, the game machine which advances communicability and mobility, and the mobile phone which enriches a game function will approach boundlessly. In fact, Nokia has
announced that they release a mobile game console named “N-Gage” within 2003. N-Gage combines mobile phone functionality with a gaming platform. It also works as a music player and FM radio, and enables Web-browsing, email, and various applications.

To give users seamless access through mobile handsets to functions provided by PCs, Java Virtual Machine is added to recent terminals. The users can download applets (programs that function on their own in terminals) from a network. In addition to high-quality interactive games, applications for Java enabled mobile phones will include: Secure Socket Layer (SSL) security solutions enhancing transactions, improved directory functions, and updating of the software with simple matters. Java enables application/content providers to distribute software (applets) to mobile phones. Instead of a continuous server connection, the user can download his program and use it in times of no reception. Such applications run only on individual phone handsets. If a user downloads an applet called “agent,” customized information from the Internet can be automatically supplied on a regular basis. “Agents are self-contained programs that roam communication networks delivering and receiving messages or looking for information or services.” [29] Electronic agents will play important roles as they are dispatched to carry out searches or tasks on the Internet and report back the results to their owners. That is a very efficient system to get things done on the move.
Until today, most applications for the mobile phone are for entertainment. However, the application for business will increase from now on. As an access way to corporate intranets and databases from the going-out place, the use of the mobile phone will popularize. Laptop PCs take more time to access there and more expensive than mobile phones. “Today, decision makers within global organizations are facing a challenging environment. They are looking for ways to boost the efficiency of their expensive IT investments, like corporate intranets and databases, and achieve the maximum cost effectiveness.” [25] At present, tools and services for building mobile intranet are being fixed quickly. A lot of groupware for the mobile phone has been produced commercially. For example, gateway products for the mobile phone are prepared for major groupware, such as Lotus Notes/Domino and Microsoft Exchange Server. They will enable secure data transmission between mobile terminals and organizational intranets easily. You will be able to browse the contents of your email, scheduling, tasks, and access to the database systems. The key point is change from “use when going-out” to “use anytime and anywhere”. By using mobile phones in intervals of slight time, it will become impossible for the users to part with them.
4-3. The factors obstructing the spread of the mobile Internet

While IMT-2000 has a possibility of developing greatly from now on, it is a risky enterprise. The first factor is the cost. Service providers have to spend huge money to build their 3G network infrastructure. 3G uses smaller cells than 2G, so they need more base stations and transmission towers. NTT DoCoMo seems to make an investment of no less than 10 billion dollars for IMT-2000. Before the investment, "various governments in North America, Europe, and parts of Asia have auctioned off licenses to companies that want to use part of the limited 3G spectrum to provide wireless services. In most cases,
companies paid huge sums of money for the licenses.” [23] After all, the expense concerning that weighs heavily on users as high service charge. In addition, NTT DoCoMo’s i-mode succeeded by the low rates because their charges were based on the volume of data transmitted. However, this system may backfire in 3G. Data transmission of large multimedia files, such as movies and videos, will bring quite high cost. Although consumers will not use if the charge is expensive, companies have to retrieve the expense of investment. Therefore, new services may become comparatively high-priced, and the spread of private use may become dull. Besides, the price of the handset is quite expensive than the present one. Moreover, the service “will be mainly restricted to urban areas for some years at least, because it will not be economical to install them in large rural areas.” [23] Many users will not adopt the systems until they can use them widely.

Second factor is the necessity of outstanding user-interface. To be sure, many people are already browsing the Internet, exchanging emails, conduction banking and stock transactions, making flight reservations and checking news and weather via HTML-based information on their phones. However, if we can use only the small display and the operability in the present state, I believe that the mobile phone will not spread as a full-scale data communication terminal. The display and operability has been improving. We can bookmark websites and copy & paste text, etc. However, people who are familiar with keyboard and mouse of PC will be bewildered by the difference in the operability. Therefore, in order for mobile phone to spread further as a data communication terminal, the user-interface which is easy to use for anyone is indispensable. In Japan, the coverage of mobile phone is about 60% of the population. However, the most is students and
business people, and housewives and elderly people hardly use it. This is because its functions are very complicated and they do not know how to use it well. Even if the issues of cost or technology are overcome and the infrastructure is ready, it does not spread unless a variety of users want to use it.

Furthermore, I strongly believe that the content is important. Success or fail of systems result from not the technology but the desirable content. "The issue is whether content providers will be able to offer compelling material and whether users will want to bother accessing it over wireless, rather than traditional wireline, networks." [23] In other words, even if introductory time is overdue and transmission speed is inferior somewhat, if attractive killer contents are prepared, everybody will come to use them. At this point, the next generation mobile phone seems to be subject precedence and technology precedence. Since NTT DoCoMo hurried the introduction due to the lack of frequency, the development and adoption process were carrier's enterprise oriented. The user's demand and practicality were not considered well. Wireless is being driven by "technology push and market pull". Technology can now take wireless to the next generation, while users and service providers want the applications that new technologies could enable. Additionally enough large capacity of storage in the handset is also required to store a lot of multimedia data. Even if various multimedia contents are provided, it is no use if the handset couldn't store them. Thus, there are several obstructing factors. However, it is the fact that the mobile Internet has the greatest potential. Full-dress spread is from now onward.
5. A (Anytime, Anywhere, Anyone)

Mobiles will provide an environment where people of all ages can utilize mobile communications in diverse aspects of life, anytime, anywhere in a seamless manner, without being restricted by physical location. Furthermore, mobile communication will be used for not only people but also anything that moves, and devices such as vending machines, household appliances, and car navigation units.

5-1. Change from mobile to wearable

The concern of next-generation mobile phone other than various functions and contents is the design of the terminal. Of what form do models really appear as a terminal of the next generation? To take an example of the terminals of NTT DoCoMo’s FOMA, since they are conscious of the TV phone function, that in which a large-sized liquid crystal color display and a video camera are carried is almost the case.

![FOMA terminals](image)

Clamshell-type Handset

Straight-type Handset

Two-part model including Main Terminal with keyboard and Wireless Handset

Figure 18: FOMA terminals
Source: NTT DoCoMo
As evolution of the mobile terminal, research of the devices which are not carried but are put on—wearable—is progressing. Wearable devices will contribute to the seamless integration of technology into everyday life. However, the important issue is the user-interface too. Technologies regarding natural interface, which apply the means of communication between human and computer, have been rapidly developing with improvement in the processing performance of computer.

Technologies such as character recognition, voice recognition, and individual identification have been put into practical use. In addition, some research regarding operation input with arms, legs, and eyes, and detection of brainwaves have been started. However, even advanced technologies such as voice recognition which have been put into practical use are used under ideal conditions. [35]

However, those technologies regard the users who are familiar with the operation of computers. In the future, it will be important that more general technologies which do not depend on a specific environment and require special trainings are developed for more transparent interfaces.

One of the biggest problems when mobile phone is used as an information terminal is smallness of the display. One of the solutions is head-mounted display (HMD). This is an example of Xybernaut's "poma". Instead of the familiar Liquid Crystal Display (LCD) screen, poma has a cable which is connected to a color display mounted on a plastic headband. "The display

Figure 19: Xybernaut's "poma"
projects an image (in a resolution of up to 800 by 600 dots per inch) onto a translucent screen that can be mounted in front of either eye. You see a ghostly image from the virtual world floating between you and the real world.” [37]

More improved prototype display is the MicroOptical’s viewer. This display mounts on the temple of wire-frame glasses. However, the display always has to be positioned just right. If it slides even a few millimeters, the image is out of focus.

As regards the problem of the input interface, virtual keyboard is one solution. The Canesta Keyboard is the world's first projection keyboard capable of being fully integrated into mobile phones, PDAs, or other mobile or wireless devices. “When equipped with the Canesta Keyboard, the device uses a tiny laser “pattern projector” to project the image of a full-sized keyboard onto a convenient flat surface between the device and the user, such as a tabletop or the side of a briefcase. The user can then type on this image and Canesta's electronic perception technology will instantly resolve the user's finger movements into ordinary serial keystroke data that is easily utilized by the wireless or mobile device.” [32] Although current input solutions such as handwriting recognition and thumb keyboards are popular, they are limited in the ability to support type-intensive applications such as document creation and email composition. The integrated projection
keyboard means that the mobile device can support applications which have been practical only with a full-sized, mechanical keyboard previously.

In order for the mobile phone to be wearable, it has to be natural that everyone always puts it on. Therefore, wristwatch-type terminal is an excellent example. “Mobilox” is a prototype of wearable mobile phone with an innovative interface that closes the gap between technology and human body. “The design is developed from using the fingertip as a speaker and the wrist as the microphone. We have always used our hands to communicate with gestures. Mobilox adds to this communication by using the hand as a telephone handset.” [30] This terminal makes mobile phone usage natural to human behavior by using the hand to communicate in the simplest possible way.

In addition, organic electroluminescent (EL) display is regarded as a next-generation display capable of replacing LCD. Organic EL displays consume 50% less power than conventional LCDs with back light. “Not only dose this lower power consumption, and therefore increase battery life, on portable products, but it also means the displays are thinner and lighter, making them ideally suited to mobile devices.” [34] Pioneer developed a prototype of a wearable plastic organic EL film display, and attached it to a
winter coat. “The prototype display has a wide viewing angle, high brightness, and high resolution with a fast response to moving images.” [34] If these are put in practical use, wearable in a true meaning will be realized. For that purpose, not only high efficiency but they must be fashionable. That is because fashion is one of the most important factors to spread new devices.

Figure 23: Organic EL display

5-2. Diverse mobile communication usage

_between human and human, human and machine, machine and machine_

Between now and 2010, NTT DoCoMo would like to create an environment where everyone from children to the elderly can use mobile communications anytime and anywhere. Especially elderly people’s use is important for the further spread. “The world population is advancing in seniority.” [35] In the industrially advanced countries in particular, the population of aged people will reach about 20% by 2025, compared with about 10% in 1950. To achieve the goal, attractive terminals suitable for each generation have to be offered, so that mobile communications can be utilized throughout various stages of life. Mobile terminals will evolve into devices which are currently hard to
imagine. The mobile market will become much more segmented, as consumers rely on their terminals for communications and transactions that relate to who they are, where they are, and what they are doing. “Business applications will evolve so that mobile becomes a channel in all business services, utilizing its advantages of immediacy, timeliness, and personalization.” [31]

Mobile multimedia services include not only traditional human-to-human communications but also human-to-machine as well as machine-to-machine communications. People are just one element in the mobile multimedia world. These wireless services can link people with machines, and even one machine to another, expanding the mobile communications market far beyond the realm of time and population. “NTT DoCoMo expects non-voice traffic to account for 50% of network capacity by 2005, rising to between 70% and 80% of all traffic by 2010.” [33] By then, overall wireless traffic will have increased threefold.

The great growth of non-voice traffic will come from the emerging area of human-to-machine. The Internet and other data services—notably i-mode services—is an obvious example. Subscribers can use wireless networks to access a variety of contents and conduct electronic payments, etc. Another example is a pedestrian navigation service based on the global positioning system (GPS). Machine-to-machine will also create new markets for data communications, such as remote monitoring systems and intelligent transport system (ITS). Vending machines, delivery trucks, parking meters, and utility meters are just a few of the many areas where this technology is at work. For example, a
vending machine can automatically transmit sales data to a monitoring center. The machine's owners will then know how many drinks are left in the machine for refilling purposes. In addition, if an old man with a cane carrying a mobile terminal is going to cross a street, cars around him may catch his existence and stop automatically in the future. These will represent a radical shift in the concept of the telephone from human-to-human to machine-to-machine communications. According to NTT DoCoMo, "an era is dawning in which all kinds of devices, such as cameras, refrigerators, and video machines will become "customers" for wireless networks." [33]

"NTT DoCoMo figures forecast that by 2010, there will be 100 million cars, 60 million bicycles and 20 million pets using mobile multimedia." [31] DoCoMo predicts that "Japan will have a wireless terminal population as great as 570 million by 2010." [33]

*Anytime*  
Elimination of time constraints

*Anywhere*  
Elimination of position constraints

*Anyone*  
Elimination of constraints on users and terminal types that use networks

*With Anyone and With Anything*  
Elimination of constraints on parties on other ends of communications to transmit information through networks
<table>
<thead>
<tr>
<th></th>
<th>(Millions)</th>
<th></th>
<th>(Millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humans</td>
<td>120</td>
<td>TV, Set Top Box</td>
<td>90</td>
</tr>
<tr>
<td>Cars</td>
<td>100</td>
<td>Digital Still Cameras</td>
<td>30</td>
</tr>
<tr>
<td>Bicycles</td>
<td>60</td>
<td>Video Cameras</td>
<td>20</td>
</tr>
<tr>
<td>Portable PCs</td>
<td>50</td>
<td>Refrigerators</td>
<td>40</td>
</tr>
<tr>
<td>Motorcycles, Ships,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vending Machines</td>
<td>10</td>
<td>Others</td>
<td>180</td>
</tr>
<tr>
<td>Pets (Dogs, Cats)</td>
<td>20</td>
<td>Parcels</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>360</td>
<td></td>
<td>210</td>
</tr>
</tbody>
</table>

Could be more than half a billion hosts in Japan!

Figure 24: Possible Hosts in 2010
Source: NTT DoCoMo

6. G (Global Mobility Support)

More and more people will find their domain of activities spreading to overseas, and conversely, there will be more people coming from abroad as well. Mobile communication can provide support for such activities. It will create a worldwide mobile multimedia environment, which makes it possible to use the same device anywhere in the world. To realize this goal, carriers will promote global multimedia through collaboration with overseas operators, corporations and content providers.
6-1. The current situation and issues of global roaming

Some digital mobile phones can be used abroad, and this is called international roaming. “Roaming agreements have been set up with networks in different countries to enable this. The network you are connected to determines the countries where you can use your phone. The number of agreements with different countries is increasing all the time.” [43] “Globalization” signifies enlarging the scope of operations so that people can take their handsets to other countries and receive the same level of services as they do at home. However, the fully global roaming has not been realized yet.

At present, the wireless communication system used most widely all over the world is GSM. It is used in nearly 200 countries with over 680 million subscribers worldwide, from Europe throughout Africa, Asia, and America. Approximately 70% of all wireless subscribers in the world is using GSM. “Originally utilizing the 900 MHz spectrum, GSM providers in parts of Europe, Africa, and Asia later added additional capacity at 1800 MHz. In North America, GSM service is currently available only at 1900 MHz.” [45] However, most mobile phone manufacturers are offering dual-band (900 and 1900 MHz) or tri-band (900, 1800 and 1900 MHz) terminals that work in most places where GSM networks are built.

Although GSM has a large share, the standards are not unified into one. Japan originally developed PDC, and also cdmaOne (IS-95) is widely used in the United States. Therefore, one of the main features of 3G mobile phone was the realization of seamless global
roaming. However, it cannot be attained because various systems, such as W-CDMA and cdma2000, were created and the architecture was not unified into one again. Each carrier has been continuing efforts to extend service areas.

NTT DoCoMo invested about $9 billion in AT&T Wireless to spread W-CDMA network in the United States. AT&T Wireless has announced that they will launch W-CDMA service in four cities (San Francisco, Seattle, Dallas, and San Diego) by the end of 2004. As a result, FOMA subscribers will be able to receive 3G services there. However, W-CDMA network has hardly been built in the world yet since it requires huge investment. Therefore, the international roaming by FOMA will be difficult for the time being.

J-Phone has approached a number of mobile operators outside Japan to provide seamless international connectivity by “Vodafone Global Standard”, which is a W-CDMA roaming service by the Vodafone group. Vodafone Global Standard users can roam internationally with the convenience of using the same J-Phone number as they do at home. J-Phone provides the dual mode handsets which work on both W-CDMA and GSM networks. As a result of these initiatives, the customers can roam in approximately 63 countries and regions, a figure that represents approximately 98% of destinations visited by Japanese people. The move to provide international roaming would give J-Phone a competitive advantage over NTT DoCoMo. However, cost of the dual mode terminal is higher and it is impossible to receive 3G services all over the service areas.
As regards the cdmaOne/cdma2000, there are 135 million subscribers around the world, mainly in Asia and America. According to a November 2002 report from the CDMA Development Group, the total number of cdma2000 1x (3G) subscribers has exceeded 27 million. As of January 2003, cdma2000 1x services are offered in 21 countries including Japan, South Korea, India, Australia, the U.S., Canada, Mexico, Brazil and Russia. Although most cdma2000 handsets can be used in the cdmaOne network too, the international roaming is limited no more than 15 countries, and it can be hardly used in Europe.

It is clear that roaming-enable areas are spreading gradually. However, the progress of the spread differs in each country. Although the number of countries in which international roaming is possible will continue increasing more and more from now on, for several years the service area will be restricted only to the urban areas. As a matter of fact, it is more important for the carriers to expand domestic service areas rather than international roaming. Therefore, it is very hard for roaming to become global literally.

6-2. The movement of all-IP network

To achieve common global network standard for IMT-2000 and beyond, ITU has established a Vision Working Group to develop long term vision and a technology roadmap for IMT-2000 and systems beyond IMT-2000. Today, mobile core networks are based on a circuit-switched architecture. However, with the advent of Internet Protocol (IP) technology and the tremendous growth in data traffic, the mobile industry is evolving
its core networks toward IP-based technology. The ultimate future vision is all-IP network. To realize the vision, two partnership projects have been created and working on the development. One is 3rd Generation Partnership Project (3GPP), which is developing W-CDMA standard based on GSM system, and another is 3rd Generation Partnership Project 2 (3GPP2), which is developing cdma2000 standard based on IS-95 system. 3GPP approach is based on General Packet Radio Service (GPRS), while 3GPP2 created a new packet data architecture building on the Cellular Digital Packet Data (CDPD) platform. Unfortunately, there are significant technical differences between 3GPP and 3GPP2 architectures again, like between W-CDMA and cdma2000. However, the differences must be harmonized for their common long term vision.

All-IP will enable seamless network integration of different access options, such as broadband, fixed wire, wireless LAN, and existing cellular systems, into a single IP packet layer.

This technology allows all communication services to be carried over a single network infrastructure, enabling the integration of voice, data and multimedia services. From the service point-of-view, the network enables fast, flexible and open service development. [42]

The all-IP network will offer operators a number of important benefits including scalability, flexibility, efficient network operations, cost savings, and most importantly new revenue opportunities. “Network resources are used more efficiently, and capacity can be deployed flexibly to meet demand.” [48] As regards cost saving, standard network
equipments such as routers can be used throughout the network. In order to build one base station customized for each carrier today, it costs about 1 million dollars, while that for the IP mobile phone based on routers and the Internet costs about only 1 thousand dollars.

![Figure 25: All-IP network vision](image)

**Single Network Infrastructure**

- Simplify network design
- Share capacity more efficiently
- Significantly lower investment, because off-the-shelf components can be used

**Reduced Risks & Costs**

- Simple and cost-effective network structure & technologies
- Single network supporting all services
- Increased network efficiency
- Future-proof through IP
New revenue from multimedia services

- Richer human-to-human communications
  - All-IP offers a new multimedia communication experience through user reach ability, seamless usage of different communication types and easy-to-use group communications.

- Richer interaction between applications and media streams
  - Easy integration and interworking of different IP-based services will increase the usage of all service types.

- Service mobility
  - Consistent services over various different access networks will increase usage.

- Easier service creation and integration
  - Well-defined open APIs and programming languages enable service creation by 3rd-party developers.

At present, phone calls from laptop to laptop, and from laptop to landline phone have already been possible with the IP network. The voice quality is not so good, though. Therefore, the IP mobile phone must be possible as well, and many manufacturers have been developing it. However, it has not spread due to some obstructing factors, such as technical aspects, regulations, and telecom carriers. If it is realized, the IP mobile phone will have large cost advantages.

However, the technical issue is large. The network may look technically to be in good shape, but the end-user still may experience bad service. There may be long delay or jitter...
when using voice services and streaming services. Perhaps they may suffer from dropped packets while using interactive services. In addition, security management is a big concern and needs to be solved for the wireless networks, as they are becoming more open. At present, Mitsubishi Electric has been working on the IP mobile phone service named "Mobile IP Talk" in Japan. They distributed the terminal for $2,500 by 1000-set limitation experimentally in November 2002. Besides, Intel and Motorola have announced that they tie up and work on development of the dual mode terminal which can be used as both a mobile phone and an IP phone. One of their biggest challenges is the battery which can save enough time. The present "Mobile IP Talk" terminal has only 100 minutes battery life.

Solving these various issues of wireless networks is not a simple task; however, it can be done. The IP management issues have already been solved in the Internet world to some extent and this knowledge must be utilized also in the next movement – all-IP. Putting the IP and wireless technologies together will provide the best from both worlds. The simple and flexible network architecture will enable the proliferation of seamless, mobile services. The increased terminal capabilities allow enhanced services, as terminals support a multitude of new service interactions. Users will have the capability to be permanently connected, regardless of the location, for a variety of wireless usage.
7. I (Integrated Wireless Solution)

Use of wireless technology can be quite diverse, and will present various business challenges. A seamless user environment for mobile networks and corporate networks will be provided. One example is a telemetry system. For checking the meters of utilities like power or gas, for example, with the introduction of wireless technology, it is possible to send the data on fixed time automatically to the utility companies. This can be also used for efficient stock management or goods supply for vending machines. In addition, if wireless communication devices are attached to various things around us, we can remote-control them from anywhere.

7-1. Mobile applications with GPS

One of the most remarkable future mobile applications is Global Positioning System
(GPS) navigation service. Traditionally, GPS had been used solely in the military and automobile market. However, the combination of the mobile phone and the GPS function will create various new applications. At present, the mobile phone equipped with the GPS function has already appeared. It allows users to pinpoint their position and shows the around map on their terminal display. It can be used for transportation and tourist guides. Besides, the GPS function will contribute to improvement in the input operation which is one of the big problems of the mobile phone. By linking the function with search engine, information user has to input can be simplified. For example, when a user wants to check weather forecast or locations of stores, restaurants, banks, and hospitals around there, it will be able to provide information specialized in the user's location automatically.

In addition, development aimed at corporate use is increasing sharply, especially in areas such as vehicle-dispatch systems and systems for tracking dispatched staff. These services are characterized by a number of features, including low set-up cost. Originally, in order to implement these GPS applications, dedicated GPS receivers and communication equipments had to be provided for all company vehicles and employees. This meant that enormous cost and a considerable length of time were required to implement such systems. However, less-expensive and simple services using the GPS function of the mobile phone make it easier for small-size transport companies to introduce these services. Moreover, by using mobile phones, they can also use other services, such as messaging or data transmission, as well as enabling flexible operations in accordance with the needs of the individual companies. GPS applications are thus likely to be used in the future to increase efficiency in a wide range of businesses. As
examples of GPS application services, the followings have been offered in Japan.

- Tr@GPS by Trabox Inc.

This is a vehicle-allocation-and-location system using mobile phones with GPS functions. On the basis of collection and delivery information sent by drivers using mobile phones, it is possible to allocate vehicles in the most efficient manner and to control and issue instructions as appropriate. This is used for efficient allocation of taxies and trucks, etc.

- TIME@NAVI by Toyota Motor Corp.

This is a simple operation control system intended for small and medium-size companies using mobile phones with GPS functions and PCs with Internet access. This can be used for positioning and motion management, schedule management, business liaison, making daily reports and calculating business results, etc.

- CoCo Secom by Secom Co., Ltd.

This service can locate individuals or vehicles under almost any conditions with industry-leading accuracy. Once a subscriber has placed the compact, lightweight handset on a child’s belt or in a backpack, for example — or has it installed on a motorcycle, car or other vehicle — they can quickly locate the position of the device through the Internet or by calling one of the operation centers. Upon the subscriber’s request, CoCo SECOM then informs the subscriber of the location, and sends emergency personnel to the location to search for the individual or vehicle. This is used for emergency situations, such as the theft of vehicles.
Until today, as for location information using GPS, pull-type services were main usage, such as looking for a place, like a map service. However, in the future push-type services will increase with the ability to pinpoint the location. A user specifies beforehand what information is received from which company, and receives only required information. For example, advertisement specialized to your present location is sent automatically; or when some accidents happen, it reports to rescue services and insurance companies automatically. Moreover, not only services to look for a place, but also services to enjoy a place by retrieving information may appear. At present, the information is limited to what there are. However, by adding some event or game elements, it will become possible to offer the value of enjoying a place.

7-2. Mobile applications with Bluetooth

Another promising mobile application is Bluetooth. Bluetooth is a worldwide specification for low-power wireless communication technology. Mobile phones, PCs, peripheral equipments, etc. are connected without using cables, and voice and data can be exchanged. Bluetooth can communicate at the speed of 1Mbps by using the electric wave of 2.45GHz, which can be freely used without the license. When two Bluetooth-equipped devices come within 10 meters range of each other, they can establish a connection together, and since Bluetooth utilizes a radio-based link, it doesn't require a line-of-sight connection in order to communicate. With Bluetooth technology, you can synchronize data, such as address book and schedule, between mobile phones and PCs. You can transmit data received by the mobile phone and pictures taken by the built-in digital
camera to PCs, or can print out them with printers. By using a mobile phone with headset, hands-free communication without wires is possible. Moreover, Bluetooth adopts ad hoc connection, so it can be used only when it is necessary. For example, it is possible that all sale goods’ information appears automatically on your mobile phone when you walk into a store.

However, the reason why Bluetooth attracts attention is not only that. Bluetooth not only makes existing cable connections wireless but also ties new devices, which has not been connected up to now, like TVs, VCRs, and household appliances. “Companies such as Toshiba and Sony are planning to put Bluetooth into all the products they make, including things like toasters, video recorders and microwave ovens.” [49] Once all of the devices can communicate each other, the mobile phone can be converted into a remote that controls various equipments. You will be able to record TV programs from outdoor, and to answer phone calls called to the home land-line phone, by using your mobile phone. In the future, every household electric appliance will have a wireless communication function, and turn into a network appliance connectable also with the Internet. One home server will be placed in each family, and it will be equipped with large hard disk managing all information.

In April 2002, Toshiba has released network appliances. Until that, a lot of manufacturers had been working on network appliances, and there were some products which had network functions. However, it was the first time that appliances which can transmit data between them appeared.
Via the access point, the appliances connect each other, and even to the Internet. They are controlled by the home terminal with touch-panel display. The refrigerator can manage the stock data, such as quantity of materials and their expiration dates. You can check the data in the refrigerator with your mobile phone. Besides, the home server has database of recipe and search engine. It checks both the data in the refrigerator and a recipe you chose, and informs insufficient materials to your mobile phone. Toshiba also released sensor to check open/close of doors and windows, and light switches, which installed Bluetooth. They enable to watch your home security with your mobile phone.

![Figure 28: Toshiba's network appliances](image)

However, integrating Bluetooth functionality into a mobile phone is not an easy task. While Bluetooth and mobile phones operate at different frequencies, costly interference can be encountered in the RF front end. Additionally, implementing Bluetooth in a mobile architecture forces design engineers to make some tough hardware and software choices in the baseband section of a mobile architecture. However, when these problems can be overcome, we will be able to use the functions all over the world, because Bluetooth is a de facto standard which a number of companies around the world are participating. As a result, next-generation multimedia centering on the mobile phone will become a still more familiar communication means.
8. C (Customized Personal Service)

The amount of information available continues to increase, and there will be an urgent need to organize information for personal use. Utilizing its "personal" nature, mobile communication can provide customized services. Besides providing information suitable to individual tastes, preferences, and situations on a timely basis, it can quickly provide on-line processing for sign-up of various network services and financial settlement. Furthermore, a wide range of networks will be linked, so one can use all kinds of services with a single terminal.

8-1. Use of the IC card, named UIM (User Identity Module)

IMT-2000 standards include the definition of the User Identity Module (UIM). The compact integrated circuit (IC) card is mandatory in the 3G mobile communications equipments. Mobile phones built to comply with the GSM standard used in Europe already have the Subscriber Identity Module (SIM), equivalent to the UIM. The UIM is an expansion of the SIM, which carries subscriber information such as telephone number and other information to improve security functions. The card enables users to change mobile terminals by simply removing it from one phone and inserting it into another. The phone number travels with the card, and the user can use them on one service contract. In the future, we may use several mobile terminals appropriately according to scenes: for example, waterproofing terminals for marine sports or shockproof terminals for skiing.
The use of UIM card has possibility to realize international roaming. This card can be inserted into a rented mobile terminal that is compatible with the visited technology, and the user can travel across 3G networks transparently. At present, it is unexchangeable between the 3G terminals of different carriers in Japan. However, J-Phone is planning that the UIM for their W-CDMA network makes compatible with the SIM used in GSM network.

In addition, what an individual contract and a mobile terminal are separable means that a UIM card can be inserted in equipments other than the mobile phone. For example, it is possible to insert a UIM card into television and watch images from the Internet on the television. This also affects the network household appliances stated above. All those appliances are connected to the home server using wireless communication means like Bluetooth. If the UIM card is inserted into the server, they can access to the Internet through the server, or receive remote control from a mobile phone.

Furthermore, the most remarkable usage of the UIM card is a role as a credit card. In the future, the mobile phone will replace the wallet. The card will contain a variety of key information such as credit card number and other personal information, perhaps including
driving license or social security number. In addition, a digital certificate can confirm the identity of the user, and an encryption program will safeguard the communication and validate transactions. This will soften the concerns which many people have about security of transactions over wireless.

In fact, in Finland which has the highest mobile phone penetrate rate in the world, “you can use your mobile phone to pay for a car wash, buy a CD, or get a soft drink from a vending machine. The charge turns up on your phone statement a few weeks later.” [55] Also in Japan, NTT DoCoMo began a partnership with Coca-Cola Japan Co. Ltd., and a coin-less vending machine service, named “c-mode”, appeared. By depositing some money into prepared account in advance, you can get beverages by using your mobile phones. Besides, in May 2002, DoCoMo introduced a new billing system that enables subscribers to pay monthly mobile phone bills at convenience stores. The service uses a two-dimensional bar code on the screens of their mobile phones, and is offered at over 2,000 stores nationwide. There is no fee for this service and users only pay a small transmission charge to download the bar code.

In the future, the mobile phone will be used in every store as a substitute for an actual credit card. At the time, “additional functionality will be provided by short range radio systems like Bluetooth.” [55] When an actual transaction is made, the phone will send credit data to a Bluetooth receiver in cash register. When you are ready to check out, you can simply press “confirm” on your phone and you are all set.
In the meanwhile, as the mobile phone can replace the role of wallet, it holds large risk. What the mobile phone is stolen means that a wallet and a credit card are stolen. Moreover, it may be invaded by hackers or computer viruses. The more financial transaction functions become large, the more it is necessary to perform the measure for protection of privacy and security firmly.

8-2. The social role of mobile

The convergence of a number of technologies is creating the opportunity to provide notable services in the future. The mobile phone will become not only a useful device but a necessity of everyday life. Moreover, it can work as a lifeline. For example, in case of calamity such as fire and earthquake, if you can not only tell the situation with voice but also transmit real images, it must be useful to grasp the disaster correctly in a remote place and to take the suitable measures. If elderly people put on wearable devices which can call with one touch, they can contact to the emergency service whenever something happens. Their position can also be pinpointed immediately by GPS function. In addition, telemedicine and health monitoring become possible. If manometer interlocked with a mobile phone is set to a patient's body, the system will be able to send data to a hospital periodically.

Thus, the mobile phone has unlimited possibilities. However, not every terminal has to be equipped with all of those functions. Each person will have diverse mobile phones with only functions customized for each needs.
9. Examination

Through the success of i-mode, I understand the primary keys for mobile phone spread. I believe that they are the factors of spread also in the next generation.

* Content and its service fee
* Platform
* Timing of introduction

Besides, through the research so far, I understand the main issues the present mobile phone has to overcome.

* User-Interface
* Global Roaming

- Content and its service fee

Content is a factor I believe it to be the most important. In i-mode service, the numerous and diverse contents caused the spread, and contents of entertainment have collected young generation's popularity. For the further spread hereafter, it depends on whether attractive contents utilizing higher transmission speed are provided. I expect peer-to-peer services with moving images. From the popularity of J-Phone’s Sha-mail, I believe that people seem to desire to send out information actively and share it with someone. Probably, such service will be demanded by from children to elderly people. At the same time, their service fees are also important. Carriers have to retrieve the expense of their huge investment to 3G infrastructure. However, if new services become comparatively high-priced, the spread will be greatly dull. Therefore, they prepare for deficit at first, and
have to set up cheap charges and consider the spread of services primarily. 80% of i-mode users subscribe to fee-based services due to the low rate. Users are willing to pay money to attractive contents. This is applied to the category of “M” of the Mobile Frontier.

- Platform

Having adopted the subset of HTML as the platform of i-mode caused entry of many service providers, and it promoted each other competition. In the next generation, anything around us, such as cars and appliances, will be networked, and they will be connected by a huge network globally. Such products are already realized. That will create new services, and the mobile phone will shoulder the central role for controlling them. Therefore, compatibility between diverse networks on the open platform is important. This is applied to the category of “I” of the Mobile Frontier.

- Timing of introduction

In Japan, the delay of the Internet spread and the time of growing demand for information society overlapped well, and i-mode spread remarkably. At present, there is an abundance of information available, and people desire to filter and receive only information which is of interest to them. While various functions are integrated into one terminal, diversification of our lifestyles will demand devices customized for each need. I believe that the killer application of future mobile must be the “personal mobile agent,” which will organize, share, and enhance all of our daily routines and life situations. Along with the personalization, security and user-authentication systems will become more important. A variety of means exist to verify identity, including fingerprints, iris, and voice patterns.
Many manufacturers are already developing biometric recognition technologies, and some have already entered into practical use. These technologies or their combination are essential to build robust systems. This is applied to the category of “C” of the Mobile Frontier.

- User-Interface

User-Interface is the biggest issue to obstruct mobile phone spread. Most users of the mobile Internet are young generations due to the complexity of operation. Therefore, interfaces which anyone can use easily without special training are necessary. The terminal forms will become diverse according to each need. From a variety of effort to improve the interfaces, the development of wearable devices will advance. I have a great interest in organic EL display attached to a winter coat, because it is wearable literally. In addition, when any devices in everyday life are equipped with network functions, the communication will be used naturally by almost the same operation as former. This is applied to the category of “A” of the Mobile Frontier.

- Global Roaming

The service area for international roaming is spreading gradually. Some carriers have already launched 3G services, or are planning the introduction. Those carriers invest in or tie up with others, and try to expand their roaming areas. However, due to differences of each country’s circumstance, need of new system, and huge investment cost, expansion of the areas is difficult. From the present progress of the spread, it is impossible to realize global roaming with 3G systems. Meanwhile, I believe that all-IP network can be realized
by 2010. The IP network has already permeated widely with the spread of the Internet. There is a large stock of resources. Actually, many manufacturers are working on the IP mobile phone and it has already been developed experimentally. In addition, it offers large benefits to both users and operators. Therefore, it will be realized though some issues still remain. This is applied to the category of “G” of the Mobile Frontier.

Thus, the Mobile Frontier of NTT DoCoMo certainly shows the direction where the mobile phone should evolve. Each of the five concepts, MAGIC, is an indispensable vision for realizing it, and is not an independent vision. They are related each other. However, especially I consider the category of “M” to be important since it never spreads without attractive contents.

In reality, the mobile phone has been continuing to follow the way to the achievement of the Mobile Frontier steadily. I give keywords for each concept.

M  — attractive contents utilizing high transmission speed

A  — diverse terminal forms with user-friendly interfaces

G  — realization of all-IP network by 2010

I  — integrated common platform

C  — personal mobile agent as a killer application
10. Conclusion

The primary key of the mobile phone is its mobility. It is always with you. It can be used immediately and easily. That brings large possibility for the further evolution. The expansion of the mobile communications is helping to shape many of the changes in modern living and social mechanisms. When the performance of the terminal improves and it becomes the device which can utilize more diverse information, the mobile phone will evolve to "the personal information terminal" customized by each person.

NTT DoCoMo has already started the development of the next generation. Fourth generation services will feature transmission speeds in excess of 100 Mbps for downlinks and 20 Mbps for uplinks. They will also feature high quality video equivalent to high definition television, and will allow high speed transmission of large data. DoCoMo is actively participating in the international standardization movement for 4G system, and hope to commercially launch the service by 2010. In addition, a variety of companies are working on the development of user-oriented applications.

At present, there may be many people who do not regard the mobile phone as so familiar. However, if indispensable functions for them, such as a wallet and a remote to control various devices, are integrated into a mobile phone, they will surely observe the existence. I expect realization of such convenient society. This is the reason why the mobile phone has been in the spotlight.
DoCoMo has also made up a slogan called DREAM together with MAGIC. When the whole mobile industry realizes the collective DREAM, it will create MAGIC.

D – Dynamics

Change and grow at all times
Challenge the impossible
Make a giant leap toward tomorrow

R – Relationship

Accept each other
Collaborate with many
Create a fulfilled life

E – Ecology

Be aware of nature
Create a better environment
Act with growth of the planet in mind

A – Action

Start something we have not been able to do
Accomplish something nobody has ever done

M – Multi-view

Nurture a wider perspective
Get a birds-eye view and long-term thinking
Stick to them
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AMPS</td>
<td>Advanced Mobile Phone Service</td>
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<td>CDMA</td>
<td>Code Division Multiple Access</td>
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<td>CDPD</td>
<td>Cellular Digital Packet Data</td>
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<td>DECT</td>
<td>Digital Enhanced Cordless Telecommunication</td>
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<td>EDGE</td>
<td>Enhanced Data rates for Global Evolution</td>
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<td>EL</td>
<td>electroluminescent</td>
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<td>Frequency Division Duplex</td>
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<td>Freedom Of Mobile multimedia Access</td>
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<td>General Packet Radio Service</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<td>Global System for Mobile communication</td>
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<td>HDML</td>
<td>Handheld Device Markup Language</td>
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<td>Head-Mounted Display</td>
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<td>High Speed Downlink Packet Access</td>
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<td>International Telecommunications Union</td>
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<td>LCD</td>
<td>Liquid Crystal Display</td>
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<td>Full Form</td>
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<td>Mobile Markup Language</td>
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<td>Personal Digital Cellular</td>
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<td>Subscriber Identity Module</td>
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<td>Small Office Home Office</td>
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<tr>
<td>1xEV-DV</td>
<td>Evolution of cdma2000 with one carrier integrating Data and Voice</td>
</tr>
<tr>
<td>3xRTT</td>
<td>Three Carrier Radio Transmission Technology</td>
</tr>
<tr>
<td>3GPP</td>
<td>3rd Generation Partnership Project</td>
</tr>
<tr>
<td>3GPP2</td>
<td>3rd Generation Partnership Project 2</td>
</tr>
</tbody>
</table>
List of Figures

Figure 1: World's Wireless Internet Users page 5
Figure 2: Subscribers of fixed phone and mobile phone page 7
Figure 3: Basic rate per month of mobile phone page 7
Figure 4: The change of pager and mobile phone page 8
Figure 5: i-mode subscribers in Japan page 11
Figure 6: Subscribers of fixed phone, mobile phone, fixed Internet, and wireless Internet page 13
Figure 7: Global Internet and Wireless Users page 17
Figure 8: NTT DoCoMo’s investment in overseas operators page 19
Figure 9: Number of mobile phone subscribers in Japan (November 2002) page 21
Figure 10: Mobile Internet Services in Japan page 21
Figure 11: DoCoMo Vision 2010 —MAGIC— page 27
Figure 12: Five IMT-2000 standards page 29
Figure 13: Migration of standards towards 3G page 29
Figure 14: Market share of mobile technologies page 30
Figure 15: Six major mobile phone carriers in the United States page 31
Figure 16: Nokia’s “N-Gage” page 34
Figure 17: Vision of future services and applications page 36
Figure 18: FOMA terminals page 39
Figure 19: Xybernaut’s “poma” page 40
Figure 20: MicroOptical’s viewer page 41
Figure 21: Canesta Keyboard page 41
Figure 22: Mobilox page 42
Figure 23: Organic EL display  
Figure 24: Possible Hosts in 2010  
Figure 25: All-IP network vision  
Figure 26: “Mobile IP Talk” terminal  
Figure 27: 4G Mobile Wireless System  
Figure 28: Toshiba’s network appliances  
Figure 29: FOMA card (ULM card)  
Figure 30: c-mode
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