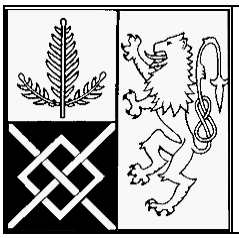

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i-Mode: NTT DoCoMo's Wireless Data Service[1]

Historic Background

In 1992 Nippon Telephone and Telegraph (NTT) (53% owned by the Japanese Government) spun off its wireless phone service division as a separate entity called *NTT DoCoMo*. Then-President Koji Ohboshi built DoCoMo into the world's third-largest wireless phone service provider and a well-recognized leader in wireless *data* service. In addition, it is one of the most valuable companies in the world with its ¥28.2 trillion (roughly $251 billion) market cap as of May 7, 2001.

The road to this prominence is strewn with numerous anecdotes. By 1997, DoCoMo was facing fierce competition in the wireless voice market as the industry was deregulated. Their market share, more than 80% one time, was declining to 60%. In pursuit of "value, not volume," Mr. Ohboshi created a task force to explore other business opportunities including data communications opportunities. The task force, headed by Mr. Keiichi Enoki (then departmental manager, now i-mode's managing director), included some non-traditional members -- a new recruit Mr. Takeshi Natsuno from an Internet startup, McKinsey consultants, NEC engineers, and a female employee Ms. Mari Matsunaga. Ms. Matsunaga was scouted from *Recruit*, a company that publishes various magazines on job recruiting, travel, real estate, and science and technology.

Together with Mr. Natsuno, Mari played a critical role in developing the concept around i-mode and later became in charge of contents, pushing the i-mode strategy along the "analog" line. The team chose as the target market young female phone users. They are to be differentiated from the sophisticated PC users, or the "digital" group, who look at the wireless data service as a mobile extension of their PC access. Given the model, the i-mode phone was designed to be about the same size as the old phones but with a slightly bigger screen (8×6 characters to show a calendar). The team resisted a larger Internet phone that can better emulate PC experience (Matsunaga 2000).

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1 This case was prepared by Professor Jin Whang at the Graduate School of Business, Stanford University. The case was prepared as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation. The author would like to thank Robert Hori, KiHyun Joo, KyungHo Lee, Masa Moroki, Yoshiro Mizuno, Kiyo Oishi, Frank Sanda, Kiyoyuki Tsujimura, Victor Wang and Hyuck Yu. This version was written on June 12, 2001.

Another key decision was regarding the relationship with content providers. For better control (especially in the early stage of adoption), DoCoMo may acquire various contents from content providers or generate internally and resell to subscribers. But the team recognized the core competency of DoCoMo is in network business, and not in direct management of contents. The decision was to create a new department called "Gateway Business Department," serving as a gateway between subscribers and content providers and collect fees for the market maker function – somewhat similar to the Recruit magazine's gateway model.

i-mode was announced to the public on November 19, 1998 at a news conference. They reserved a big press club in expectation of a hundred reporters, but only *seven* reporters showed up. Newspapers covered the story of the allegedly "revolutionary" service in small columns on page 3 and treated it as a non-event.

Figure 1. A typical i-mode Phone with color GUI screen

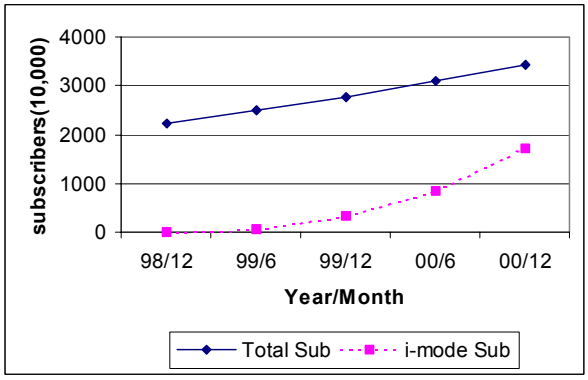
(Courtesy by CNN.com)

As a counter, DoCoMo launched a more aggressive marketing campaign. DoCoMo recruited a then-19-year-old female actress Ryoko Hirosue, an idol to teenagers and younger generation, as the i-mode's CF (commercial film) model to reinforce its market position. To gain credibility, they concentrated their efforts to recruit the revered *Sumitomo Bank* as a content member. By the time they closed the deal, other banks followed. This in turn convinced various retailers to join. On one TV commercial, Ryoko is shown at a hair salon holding a mobile phone. When asked, "Calling your friend?" Ryoko replies, "No, I am transferring money between my bank accounts." On January 25, 1999, another press conference was held just before the launch of i-mode on February 15, 1999. Now it was attended by more than 500 reporters. An insider joked, " Perhaps some came to see Ryoko." Indeed the strategy worked, and i-mode subscription soared attracting more than one million subscribers within six months.

Over time i-mode has matured and reached a diverse user population, and this is not your children's i-mode anymore. The median age of i-mode subscribers is 30 – 7% below 20, 44% in their twenties, 20% in their thirties, and 27% over 40 (April 2001, www.nttdocomo.com). In addition to Ryoko, DoCoMo now hired a new CF model Masahiro Tamura, a male actor in his late 40's, to attract a broader segment of subscribers. To serve the diverse communities, a wide range of applications are available on i-mode. The most popular service is e-mail (representing 40% of overall usage). A user on average reads or writes eight emails per day viewing 10.8 pages, paying a monthly fee ¥300 – the same price as a monthly magazine, on top of the packet charge. Subscribers also trade stocks, check train schedules, play Tamagochi games, receive weather and wind information at major beaches for surfing, participate in digital fishing game, and find dates in real time. Some subscribers use the phone for vertical applications like accessing the corporate ERP system. But mostly, i-mode is used as a companion for killing time. According to a recent survey of i-mode subscribers, 35% replied that they use i-mode to kill time. 23% use it on the subway, 22% at home, and 14% at work. In terms of specific applications, i-mode is mainly for entertainment (40%) such as image and ring-tone download, game and horoscope, as opposed to information retrieval (20%) and transaction (15%) – somewhat different from DoCoMo's original expectation that stock quotes and news would drive the traffic. (See www.anywhereyougo.com.)

In two years of its operation, the i-mode service has 18 million subscribers, and is still growing by 50,000 per day (Figure 2). Note by contrast that NTT (before spinning off DoCoMo) took 13 years to reach one million wireless *voice* subscribers. Also *@Nifty*, the largest wireline ISP in Japan, took ten years to reach 3.6 million subscribers. At its current rate of growth, 3-year-old DoCoMo would become the world's largest ISP by 2002, passing 15-year-old AOL (Nickell and Yamada 2001). In recognition of the achievement, Ms. Matsunaga won the *Woman of the Year* award in 2000 from the *Nikkei Woman* magazine and afterwards was named the best Asian businesswoman by *Fortune* magazine.

Figure 2. DoCoMo Subscribers Growth



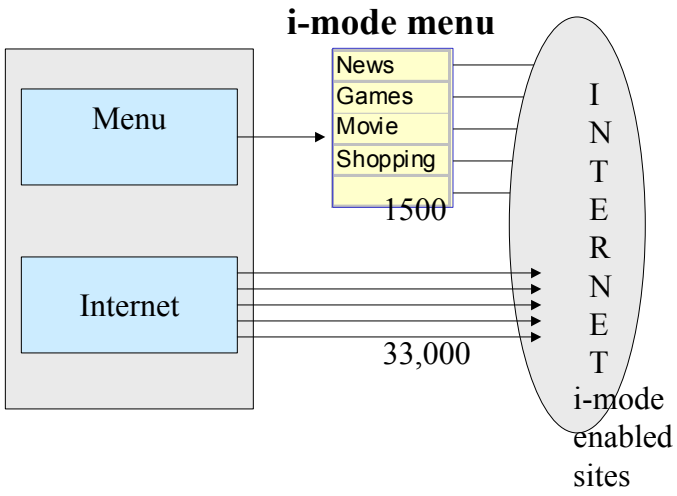
Service Hierarchy of i-mode

There are two classes of content providers on the i-mode service. First, some 1,600 official "i-mode" sites by 800 content providers (as of March 31, 2001) have *reserved* seats on the i-mode's startup menu listed by category. A simple scroll-and-click by category (no need to key in the URL) will give a quick and easy access to the web content. For example, click "stock price", then you will face the service by kabu.com and several others – all those pre-selected by DoCoMo. The second class of content providers is some 40,000 unofficial "voluntary" sites that have made their sites i-mode-compatible. To access their content, phone users need to enter the URLs of these sites, but they may bookmark them on the phone for later use. Given the vast list of offerings, each user is expected to create a virtual private portal (sort of *my-imode*). A key difference between official and unofficial sites is in the way the content provision fee is collected. DoCoMo collects the fee from subscribers through the phone bill and distributes to the official site, while unofficial sites collect it on their own.[2]

DoCoMo closely works with i-mode sites, but at the same time, encourages competition among them. First, multiple i-mode sites are selected for a given service (e.g., Asahi, Mainich, Nikkei, and several more sites for news). Then, each site receives a monthly report showing how they are doing against their competition. As part of "gateway" business policy, DoCoMo is neutral to all i-mode sites, letting the market determine the winners and losers.

[2] There exist companies like IP Square (www.ip2.co.jp) that collect content fees for unofficial sites at a fee.

Figure 3. i-mode Server Hierarchy



i-mode Technology

When the information on a website is to be downloaded and displayed on a wireless device, the screen is too small to display all the Hypertext Markup Language (HTML) code, and wireless transmission (unreliable and slow) is not the optimal setting for Hypertext Transmission Protocol (HTTP) that is designed for wireline Internet. Thus, some modification is necessary to make the technology phone-friendly. There are competing standards of language and protocols in doing this. One example is Wireless Access Protocol (WAP) originally developed by Phone.com (now merged with software.com to become OpenWave), later joined by Ericsson and Nokia. WAP is designed to optimize the wireless data service system under the wireless constraints, but it requires a substantial amount of work in rewriting HTML/JavaScript-based websites in the new languages WML (Wireless Markup Language), HDML (Handheld Device Markup Language) and WMPScript.[3] WAP is quite popular outside Japan. 77 of the world's wireless carriers (including Japan's KDDI) representing 50% of the global subscribers have licensed WAP technologies from Phone.com (Lehman Brothers 2000 (b)). In Japan, however, DoCoMo together with *Access* developed an alternative set of standards for i-mode. The i-mode standards also require that websites be modified in cHTML (compact HTML, a variant of HTML), but the work requirement is minimal. In addition, i-mode uses HTTP with some adjustment for wireless as communications protocol, and SSL as a

[3] Another option is to keep HTML pages as they are, and use WAP Gateway (by Ericsson, OpenWave and Nokia) that automatically converts HTML or cHTML pages to the WML format and sends to the mobile phone requester.

security layer, thereby making the conversion from wireline Internet as easy as possible. In return for the ease of upgrading the web server, i-mode is less optimized in terms of transmissions requirements. i-mode recently started using a light version of Java (J2ME) as the script language.

From the business perspective, the two key features of DoCoMo's i-mode service are "always-on" Internet access and packet-based charging. The moment a subscriber turns on the phone, he is connected to the Internet as if the connection is always on. Also subscribers pay by the number of packets exchanged (¥0.3 per packet), in addition to a small monthly fixed fee (¥300). A packet is 128 bits or 8 characters long. For example, up-to-date news, stock prices and restaurant guide will each cost you about ¥20-¥40 per access. Packet-based charging, combined with always-on, creates a comfortable usage environment for subscribers, since they can download a file and spend time reading it or composing a reply email at a leisurely pace while "virtually" connected.[4]

DoCoMo's Business Mode

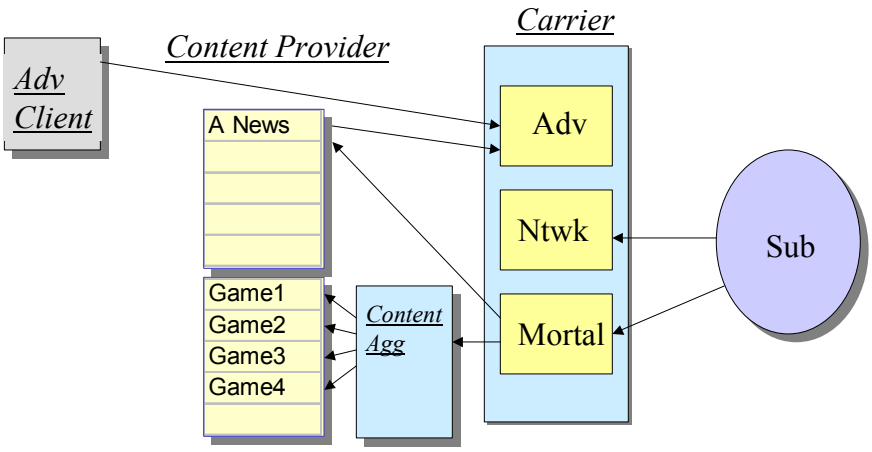
i-mode has brought DoCoMo new sources of revenue (see Figure 4). In addition to the subscription and per-packet data charges, DoCoMo takes a 9 percent cut of its official content providers' revenues in return for its service as a sales channel and collecting payment from subscribers. For example, daily subscription of *Nikkei News* costs ¥300 per month, and horse race results are available at ¥300 per month. Advertisement is another source of revenue to DoCoMo. While content providers can also sell advertisement, there is a limit due to the tiny screen. This means free service to customers may not work in the wireless Net world. Indeed *Asahi Shinbun* (Asahi Newspaper), an official i-mode news provider, for example, offers free news on the wireline website, but charges a monthly subscription fee of ¥100 for wireless access. But other sites like Yahoo maintain free service, wireline or wireless. Some basic services (e.g., yellow page service) are offered by DoCoMo free of charge to subscribers. Usually, third parties (like Cybird) operate these sites and get paid by DoCoMo. About 30% of i-mode sites (called "premium sites") charge subscribers for their service.

DoCoMo earns $15-20 more per month per user for i-mode service. Note also that DoCoMo (at least for now) has significant power over the content providers by controlling the priorities in displaying the content. In that sense, it is more of an NSP like AOL than an ISP. The similarity between AOL's portal and DoCoMo's "mortal" (or "m-portal") is not by coincidence – Mr. Natsuno developed its business model after AOL's.[5]

4 Internally, DoCoMo targets eight seconds of response time (between a click and the first screen).

5 See "NTT DoCoMo: The Future of the Wireless Internet?" Harvard Business School, N9-701-013, Nov. 9, 2000.

Figure 4. Cash Flows in Wireless Supply Chain



Even further, the wireless phone system is well established as a payment mechanism, so this would create a "financial service" business for carriers. They could create a credit card business linking the phone account to the credit card account. The phone acts like a credit card – but instead of swiping through the magnetic tape reader slot, you push the "OK" button on the phone. The carrier also serves as an insurer for content providers. If the subscriber defaults on the payment,[6] the carrier would pay on his behalf – but at an insurance premium.

Competition

Japan has four wireless carriers – DoCoMo, KDDI, Japan Telecom (JT) and Astel – that unevenly divide the 64.6 million wireless (voice) subscriber market. As of January 2001, the market shares of the four are 56%, 27%, 15% and 1% in that order. About two years ago the Big Three each started wireless *data* service under the names of *i-mode* (DoCoMo), *EZWeb* (KDDI) and *J-Sky* (JT), respectively. With 29 million data subscribers out of 64.6 million voice subscribers, the penetration rate of wireless data service is impressive 45% after such a short period of commercial operation. The penetration rate has increased by 3% per month during the past six months. Here are brief backgrounds of DoCoMo's direct and indirect competitors – KDDI, JT, Palm and NTT.

KDDI. In 1953 NTT spun off its international long distance (ILD) business unit in the name of KDD. As its ILD market share and profits erode due to still competition, KDD merged with DDI (domestic long distance carrier and Kyocera-funded wireless service

[6] The default rate is low at less than 2%.

provider *Cellular* that absorbed Nissan-funded *Tuka*) and IDO (Toyota-funded wireless service provider) to create KDDI in October 2000. The rationale behind the merger is, the merger would enable KDDI to compete more effectively against NTT on the wireline services and NTT DoCoMo on wireless services. More importantly, it was a reaction toward the Japanese government announcement that only three licenses for the next generation (3G) service will be granted. KDDI has 62% market share of Japan's ILD and 28% of DLD (Domestic Long Distance). KDDI's key assets include multiple backbone optical fiber networks for domestic and international communications. As part of the merger, KDDI ended up owning three separate wireless networks (Toyota's *IDO*, Kyocera's *Cellular* and Nissan's *Tuka)* – now marketed in two brand names, *AU* and *Tuka*. Recently, KDDI introduced a new CDMA network (first in Japan) *cdmaOne*. As a worldwide standard (unlike PHS and PDC -- Japan's unique technologies), cdmaOne highlighted its roaming capabilities for international travelers. Unfortunately, KDDI experienced technical problems in the early stage of service. Even after full recovery, damage was already done. CdmaOne gained an 11% share with 6.8 million subscribers. Altogether (PDC, PHS and CDMA), KDDI has a 25% share of wireless market (14 million subscribers) in Japan. KDDI also launched its wireless data service (*EZWeb*). With its high-speed service (64Kbps vs. 9.6Kbps at DoCoMo and J-Phone), KDDI has a chance to gain market share with the right strategy. For example, it began to offer deep discounts to student subscribers who tend to appreciate high-speed service. EZWeb has adopted WAP protocols with HDML as the markup language.

Japan Telecom. JT is the third largest integrated telecommunications company in Japan, offering both wireline (including ILD and DDL) and wireless services. *J-Phone,* JT's wireless subsidiary, holds a 16% share of Japan's wireless market, with 9.6 million subscribers. *J-Sky Web*, its wireless data service, enjoys 52% penetration rate, the highest in the world (slightly ahead of i-mode's 51%). J-Sky uses MML (Mobile Markup Language) that is quite close to cHTML and HTML. In particular, *J-Sky Station* that "pushes" customized updated information using point-to-multipoint distribution has proven very popular. J-Phone is owned by Japan National Railway (JNR), East JR, West JR, Vodafone, British Telecom (BT) and AT&T. Recently, Vodafone agreed to buy stakes of JT and J-Phone from West JR and Central JR (Dec 2000), AT&T (Feb 2001), and BT (May 2001). If all the deals are closed, Vodafone will be the largest shareholder of JT (45%) and J-Phone (46%). When asked about the acquisition, Vodafone CEO Chris Gent replied, "The average revenue per user (ARPU) in Japan is twice that in Europe. That is the key reason why a strong presence in Japan is so important for us." (*Japan Times,* May 3, 2001)

Palm and PDAs. Along with the mobile phone, the PDA (Personal Digital Assistant) is fast gaining ground as a general wireless client device. Recently, the two devices are getting closer: mobile phones are getting more like PDAs with enhanced features, and PDAs are getting more like mobile phones with wireless connection. Indeed, *Handspring* PDA, with a module in the slot, works as a phone, and Palm 7 runs in the wireless mode

using BellSouth's Mobitex wireless network. A true merger is Kyocera *Smartphone* that runs Palm OS, but also works as a CDMA phone. (A key benefit is to call a party by clicking on the name in the address book.) Given the popularity of mobile phones in Japan, Japanese PDA manufacturers are poised to capitalize on the existing wireless phone networks and supplement the mobile phones, instead of competing with them (e.g., by creating a network of its own). One concept in that direction is a two-device solution. By putting *Bluetooth*[7] on both the PDA and the mobile phone, an instant wireless connection is established if necessary during the use of the PDA. This has several advantages to consumers over the mobile phone alone. One, PDAs have bigger screens and various personal organizer functions, so such a service may appeal to professionals looking for data-intensive applications. Two, PDAs including Palm already have some interface established with Oracle and Sybase databases and other enterprise applications software (like SAP R/3) through the "Hotsynch" link. This wireline interface can be readily transported to the wireless environment. Thus, PDAs have a lead over mobile phones in accessing corporate data.[8] Three, for international travelers, the same mobile phone may not work in different parts of the world. Under the two-device environment, they may rent a new mobile phone for the local carrier, but can keep the same PDA.

NTT. This DoCoMo's holding company plans to launch a data access service called *L-mode* on wireline phones (available in June 2001). The service is intended to attract housewives by allowing them to access the Internet via wireline phones. The new phone set (to be equipped with a color LCD screen) will be viewed as an extension of phone with a simple user interface (e.g., simpler keyboard, no separate modem, or no starting screen cluttered with cute but mysterious icons). In addition, the phone can be a videophone if it has a camera on it. This approach can go further and serve as a home information system even without a PC – phone as Internet access and video conferencing equipment, fax as a printer, and the answering machine as a unified messaging service (UMS)[9] platform.

DoCoMo's 3G and Global Strategy

DoCoMo announced the plan to launch the next-generation, broadband wireless Internet services *FOMA* (Freedom of Mobile Multimedia Access) using the 3G wireless technologies *W-CDMA* (wideband-code division multiple access) by May 30, 2001 (first in the world). The new generation of mobile phones, some equipped with a camera, hold a promise to become an all-in-one anywhere/anyplace multimedia device. Subscribers can retrieve multimedia data from the Internet or other sources at 64 Kbps (vs. 9.6kpbs at G2). This speed corresponds to about 10 frames of video image per second (note that TV or a

[7] Bluetooth is a short-range (10m) wireless technology that offers a simple point-to-point or point-to-multipoint connection between devices. Bluetooth operates in the 2.4GHz Industrial-Scientific-Medical (ISM) band that does not require a frequency license. See more later.

[8] This does not necessarily mean that PDAs will be designed only for corporate uses. Palm recently licensed its OS to Sony expecting Sony will promote entertainment applications on the Palm platform.

[9] UMS is a service that attempts to aggregate different messaging services (i.e., voice messages at office, home, mobile phone, and emails) into one access. There are alternative ways of implementing this function, but one of them is to use a device like a "smart" phone to automatically check different storage points (IP addresses) and download the messages onto the device.

movie runs 25 frames per second). They can play music, read an e-book, talk face-to-face with a remote party, take a photo and transmit it to friends, scan a barcode, and watch video clips from television or movies.

At the same time DoCoMo is building a portfolio consisting of global wireless carriers. DoCoMo has spent $927 million minority stakes in Hong Kong-based Hutchison Telephone Co. and Taiwan's KG Telecom. In Europe, DoCoMo paid $3.8 billion for a 15 percent stake in Dutch mobile services provider Royal KPN. In the US, DoCoMo invested $9.8 billion for a 16 percent of AT&T Wireless, third-largest US wireless carrier with 15 million subscribers. According to the deal, DoCoMo grants free, exclusive license to AT&T Wireless for all i-mode technology. In exchange, AT&T Wireless will adopt DoCoMo's W-CDMA (Nickell and Yamada 2001). Besides, discussion is ongoing with SKTel (the largest wireless carrier of Korea), whereby DoCoMo will acquire 15% of SKTel and coordinate technology adoptions (W-CDMA plus i-mode) and developments. Thus, DoCoMo expands outside Japan, while Vodafone (CDMA2000 plus WAP) moves into Japan. The idea behind the global portfolio is a global network that enables subscribers to use the same phone across the world – i.e., global roaming capability.[10]

The two-pronged strategy by DoCoMo is often met with skepticism. First, some question whether 3G would deliver consumers enough value to justify the vast investment in frequency spectrum,[11] equipment and handsets. For that reason, many global players take a "wait and see" strategy in 3G adoption. Vodafone hopes to offer wireless services to limited markets in 2002, but is making no promises. Deutsche Telekom is aiming for a year later. In the U.S., the Big Six[12] carriers have not yet made a firm commitment to 3G deployment[13] (Nickell and Yamada 2001). As another hedge, wireless carriers consider upgrading the existing infrastructure to 2.5G. For example, GPRS (General Packet Radio Service) is a 2.5G technology that can offer wireless Internet access speed several times higher than the existing GSM service while allowing the always-on feature and packet-based pricing. CDMA 1xRTT is another 2.5G technology that enhances CDMA services from 14.4Kbps to theoretically 144Kbps, but practically 64K. But DoCoMo is bucking the trend in making the investment, and there is a financial risk.

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[10] Another attempt to achieve global roaming without global equipment standardization is UIM (Universal Identity Module). UIM is a card-shaped module that is plugged into the slot of a mobile phone. UIM contains the information about the subscriber, her account and the carrier. When she travels abroad, she may rent a mobile phone, put the UIM card in the slot, and use the phone against the home account. All calls to her will be referred to this phone. UIM is an extension of SIM (Subscriber Identity Module) that has served a similar feature in Europe.

[11] Different countries allocate frequency spectra for 3G in different ways. European countries used open auctions (total amount raised exceeding $100 billion), while Asian governments (e.g., Japan and Korea) allocate frequencies based on central reviews and (in Korea) charge a fixed amount to the winners. The United States has not yet found a clean frequency band that is available throughout the nation.

[12] The Big Six refers to six major US wireless carriers – Verizon (Vodafone, Airtouch, Atlantic Bell), Cingular (SBC/Bellsouth), AT&T Wireless, Nextel, Sprint and Voicestream.

[13] AT&T Wireless announced its plan to deploy EDGE (Enhanced Data-rates for Global Evolution) by 2002. EDGE is not exactly a 3G standard, but somewhere between GPRS and W-CDMA. EDGE is expected to develop into Voice over IP (VoIP) by 2003. In terms of data rates, GSM runs at 9.6kbps-14.4kbps, GPRS at 115kbps, EDGE at 384kbps, and W-CDMA at 2Mbps in the most favorable conditions (Ericsson 2000).

Next, DoCoMo's W-CDMA is not the only available technology for high-bandwidth wireless services, and there is a battle brewing among multiple standards of 3G including CDMA-2000 developed by Qualcomm. The uncertainty on the technology battle reinforces the wait and see strategy for other wireless carriers. By waiting and adopting the winning technology later, the carrier would offer the benefits of global roaming to the subscribers. However, the logic is somewhat diluted since Qualcomm announced a chip set (for handsets) that could operate for both W-CDMA and CDMA-2000. Given such a dual-mode handset, it matters little to consumers which technology turns out to be the winner, since they can use their home phones anywhere regardless of the underlying technology deployed there. If that is actually true, then DoCoMo's global strategy would be viewed as unnecessary or even wasteful.

On the other hand, some experts argue, such a simple argument (roaming or not) applies only to the voice market. Data business requires much tighter and wider technological coordination among the carrier, equipment makers and content providers. By sharing technologies on a global scale, DoCoMo and its subscribers can enjoy the benefits of a wider line of applications and more R&D efforts to enhance the service quality and value. Mr. Kiyoyuki Tsujimura, managing director in charge of Global Business Department at DoCoMo, characterizes DoCoMo's global strategy by "capital light" strategy. Instead of taking a heavy financial risk or management control at a carrier in a country, DoCoMo focuses on value creation by sharing its technology and experience.

Supply Chain of Wireless Service

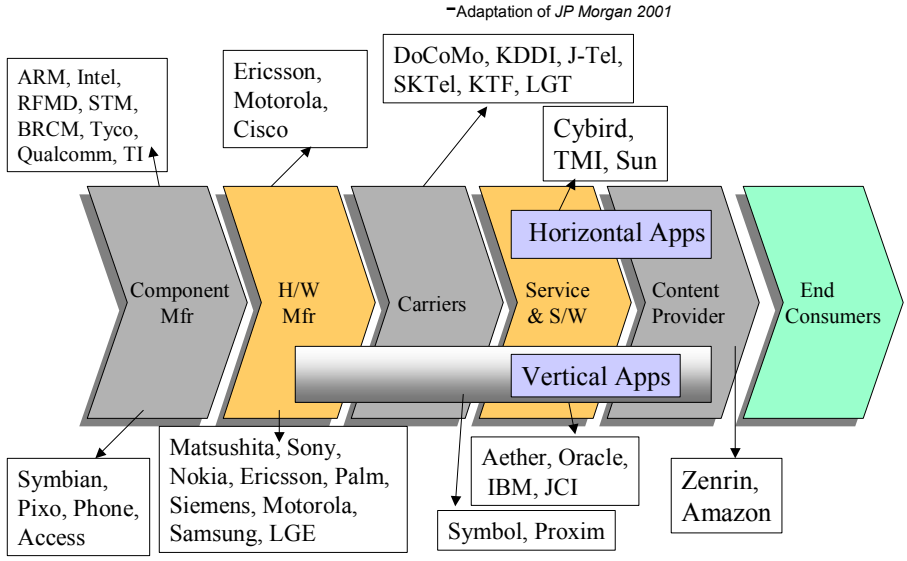
The success of data wireless service comes from a variety of factors, but perhaps most critical is the balanced development of the supply chain. See Figure 5, which is an adaptation of a chart in JP Morgan (2001). We have a brief overview of non-carrier wireless supply chain members.

A. Component Manufacturer

A wide variety of chips, modules, parts and subassemblies are used to build hand phones and network equipment. Chips are developed and manufactured by companies like Qualcomm, ARM, Infineon, Intel, Tyco Electronics, National Semiconductor, Toshiba, NEC, Fujitsu, Texas Instrument, Phillips, Motorola, Samsung, and ST Micro. Handset chips are usually divided into two functions – Radio Frequency (RF) and digital processing. RF converts analog signals to baseband wave, which is then fed to "digital" processing by software or firmware. The digital part contains the core of the communications protocols and processing logic. For example, Qualcomm owns a set of intellectual properties around CDMA protocols, which are captured in their chip sets as software. Qualcomm also sells IP licenses to various parties including CDMA-handset and chip manufacturers.

On the RF side, as wireless applications move up in the frequency band to higher than 2GHz (e.g., 3G, Bluetooth, wireless LAN, fixed wireless, and Home RF), RF is getting more difficult to capture in a single chip, since existing CMOS technology cannot easily handle such high frequencies. Thus, multiple chips or circuitry on a board may be required. This has a negative effect on the cost, size and battery life of the handset. Some (like Tyco) choose to use alternative chip technologies like Gallium Arsenide (GaAs[14]),

Figure 5. Supply Chain of Wireless Service



but it is not so cost-effective as CMOS, and needs more time and experience before reaching the cost performance like CMOS. Other chip companies like Atheros, CSR, GCT and Zeebo attempt to overcome various limits of CMOS for high frequency applications. But all agree that high frequency application especially using beyond 5GHz should ultimately turn to GaAs or other technology due to the physical limitation of CMOS. Whichever chip technology is used, a 3G handset would fast use up battery power and generate excessive heat. It would create a hurdle in delivering the promise of high data rate of 2Mbps (Ledbetter 2001). Module companies like Alps, Kyocera, Murata and TDK use these chips to develop modules that are easily incorporated into handsets.

B. Handset Manufacturers

14 Visit http://www.gaasmantech.org/ for more information on GaAs.

Handset manufacturers like Nokia, Motorola, Ericsson,[15] Siemens, Samsung, Panasonic, NEC, Fujitsu, Sony, LGE, Casio, Kyocera, and Canon design, manufacturer and market handsets. Software on each handset model used to be developed from scratch or by patching up the old one by the manufacturer. But this approach is inconvenient since they have to rewrite the software for every new model. Nowadays developers decouple the set of specific functionalities (i.e., application software) of the handset from the underlying basic portion of software (i.e., OS for the handset). Developers of a new handset now rewrite only the "applications," while keeping the underlying OS somewhat steady over time. They may even use a third-party OS by Microsoft (Windows CE), *Symbian*[16] or *Pixo.*

Of all the applications on the handset, perhaps the most important for wireless data is the microbrowser. The microbrowser is, like other Internet browsers, equipped with basic functionalities such as cHTML player, GIF image display, reasonable security, and recently Java player, but is optimized for wireless communication -- a small screen, limited bandwidth, unreliable communications, a low-power CPU and tiny memory.[17] Most handset manufacturers use a browser developed by a third party. The most popular (70% market share) microbrowser on DoCoMo's i-mode phone is *Compact NetFront* provided by Access[18] (www.access-us-inc.com). For the WAP browser, Phone.com is the market leader. Recently, there is a move for these two browser standards (i-mode and WAP) merging into a single open language platform called *xHTML Basic* (www.w3c.org).

DoCoMo early on recognized the importance of handset manufacturers and involved them in the development of i-mode service. In launching i-mode, DoCoMo took a three-step "user-content-handset" approach -- define target users, develop content lines, and then present specifications to handset makers.

C. Equipment manufacturers

Wireless technology has evolved from analog (1G), through digital (2G), to high-speed digital (3G). Digital communications have materialized a significant efficiency gain by multiplexing among multiple lines, but there are several ways of achieving the gain. Two basic technologies exist in 2G – TDMA (Time Division Multiple Access) and CDMA (Code Division Multiple Access). In TDMA, multiple (eight in GSM) lines share one channel (or a slice of frequency band) across time. It first compresses voice signal into digits, and then send them in a fraction of time (a time slot) on the channel. As one channel is divided into multiple time slots, multiple phone lines can share a single channel, thereby achieving multiplexing. GSM (Global System for Mobiles) of Europe and PDC

[15] Nokia (32%), Motorola (18%) and Ericsson (10%) represent 61% of global handset market in 2000. Japan handset market is well developed, but highly fragmented among twenty-some manufacturers including Matsushita, Mitsubishi, Fujitsu and Sony.

[16] Symbian is a joint venture between Psion, Nokia, Matsushita, Motorola, and Ericsson.

[17] Mr. Robert Hori (CEO of Cybird) refers to this set of constraints facing wireless communications as "lack of everything."

[18] Access also played a key role in developing i-mode's cHTML.

(Personal Digital Cellular) of Japan are different variations of TDMA. Up until the mid-eighties, GSM had been deemed the unifying standard across the world, when a small US company *Qualcomm* introduced an alternative technology CDMA. In CDMA multiple phone lines share multiple channels in a more complicated way, and is thought to be superior to GSM in performance with less interference. Korea's SKTel, KT, LGTel, and US Airtouch (now part of Vodafone) were early adopters of CDMA.

Along the way from 2G to 3G, there arose the demand for *packet*-based protocols. In Japan packet-based charging was made possible through the 2.5G protocols called PDC-P (the last P is for packets). PDC has time slots that are allotted to six phone lines, but does not operate in the unit of data packet. The link between time slots and data packets is specifically made under PDC-P. The key difference is as follows. In PDC, each phone line has designated time slots, so that if one line has no data or voice to send, these slots are sent blank and thus wasted. In that sense, it operates as circuit switching. In PDC-P, however, time slots are dynamically allocated to different phone lines that have packets to send. Hence, the allocation decision is postponed until the last moment, and due to the pooling effect, the scarce bandwidth is better utilized. GPRS and CDMA1x are respectively its counterparts of 2.5G for GSM and CDMA, incorporating packets.[19]

The competition between TDMA and CDMA continues to 3G technologies -- between W-CDMA and CDMA-2000. Note that in 2G the equipment manufacturers were clearly divided between the European (Ericsson and Nokia) and the American (Qualcomm, Lucent, Motorola and Nortel) camps. But the divide line is blurred in 2.5G and 3G, as players cross-license their inventions and agree on royalty payment. The most prominent example is Ericsson buying Qualcomm's infrastructure business. See Figure 6 for the transition of technologies at top three Japanese wireless carriers (DoCoMo, KDDI and J-Phone).[20]

[19] For technical details, see for example Schiller (2000).

[20] In addition to the technologies listed on the table, Japanese wireless carriers (including NTT and Astel) also adopted a digital wireless technology called PHS (Person Handyphone System). The system allowed a small and cheap handset, so it (despite some limitations) could successfully penetrate younger generation's market. But recently, the system has reached its dead end -- losing popularity and profitability. DoCoMo is utilizing this infrastructure to experiment various new services. See "NTT DoCoMo: The Future of the Wireless Internet?" for details.

Figure 6. Transition of Japan Wireless Technologies

	1G	2G	2.5G	3G
Features	*Analog*	*Digital Circuit*	*Digital Packet*	*Digital Packet*
DoCoMo	NTT800MH	PDC	PDC-P	W-CDMA
IDO (KDDI)	NTT800MH Moto 1.5GH	PDC		
Cellular (KDDI)	NTT800MH	CDMA	CDMA1x	CDMA3x
J-Phone	NTT800MH	PDC	PDC-P	W-CDMA

D. Service or Software Provider

A wireless data carrier selects a set of technical or operational standards, and offers them as a *bundled* service. A group of companies exist to partially fulfill or supplement the carrier's bundle by offering a technological solution or service as a middleman or middleware between carriers and content providers.

An important component of the bundle is the multimedia player (software) that enables interactivity, graphic interface and animation on the mobile phone. As we see in Japan, recent wireless applications heavily exploit multimedia files that are put in motion in bright color and with clear sounds, perhaps to compensate for its small screen size. This requires a set of standards on formats, algorithms and protocols to efficiently compress a big multimedia file, transmit it and let the handset decode it – all within the constraints of the wireless. One solution (for example, Emblaze Systems) involves the MPEG4 compression standard and heavy-duty hardware. Multimedia files are compressed in MPEG4 and, upon requests, downloaded onto a handset, which will then decode before playing them. In return arises the burden of heavy computation requirement at the handset CPU that is already busy (about 75% utilized) handling communications. As a result, the handset needs an additional MPEG4 chip set to support the decoding, so it becomes bulky, expensive and power consuming. DoCoMo avoided such a hardware approach on i-mode,[21] and instead has adopted 100% software solution – i.e., by the use of Sun Microsystems's Java.

[21] DoCoMo adopts this approach for video streaming on PHS using a bigger handset named Eggy.

Java offers interactivity, graphic user interface, animation, as well as computing capabilities, without a separate hardware attachment. The main benefit of Java is to download a "program" the user can manipulate on the handset, without frequent accesses to the carrier's application server. To see this point, suppose you download a map only to find that you need to see the westward extension of the map or want to magnify a certain segment of the map. Without Java (or other similar program), you need to send a series of download requests for multiple map images. But with Java, the map of a larger neighborhood may be downloaded upon your initial request, and then you scroll on the phone without any extra contact with the server. This way the transmission requirement is reduced as well, since a digital *data* file (not the bulky *image* file) is downloaded, and the handset recreates the image via a Java application called *Map Viewer*. Thus Java would save subscribers' cost, as well as the carrier's server and transmitter capacity, with an enhanced interface. The same applies to stock chart, airline reservation and numerous other applications.

But this solution is not perfect, either. The Java language (although made *light* for phones) is slow and consumes a lot of memory, so content developers may have to compromise on graphics or features. The problem becomes acute when video is streamed onto the phone. As a supplement, companies like TMI (thinmutimedia.com) propose software-based VOD (video on demand) players. TMI's VOD program uses a lighter compression format than MPEG4, so that while more bandwidth is consumed, the matching decoding process does not so heavily tax the handset's CPU. Hence, it offers a compromised alternative to slow Java or CPU-intensive MPEG4. Similarly, Cybird of Japan proposes *Kamiya*, Java-like middleware (computing, plus graphic player) that is specifically designed for wireless communications, yet compatible with Java. To house and manipulate this and other types of middleware, Qualcomm developed an application platform called BREW (Binary Runtime Environment for Wireless) that is optimized on memory and CPU for wireless "plug-in" applications. BREW also enables plug-in software or middleware to be downloaded and installed onto the handsets deployed in the field.

Another important player in the middle layer of the wireless supply chain is a *master content provider, content service provider* or *content aggregator* (like *Cybird, Bandai, Index* and *MTI* of Japan, or *InfoSpace* and *i3Mobile* in the US). The role of a master content provider is similar to that of a primary supplier supplying subassemblies to a final assembly plant; it aggregates various services of multiple content providers through its mobile portal and resells to phone users via wireless carriers, collecting commissions. The value offered by the middleman is multiple. First, they offer consulting, development, operations, and maintenance services for content holders, handling diverse and evolving technologies (e.g., SMS, WAP and i-mode) for diverse platforms (PDC-P, CDMA, GPRS, etc). Also they allow the sharing of applications servers and the gateway that pushes the content to the handsets. In addition, they co-market multiple services as a bundled service with a consistent interface, often charging one price – like the cable channel distributor charging one basic price for a bundle of channels.

The companies in this middle segment of the supply chain have yet to develop a sound business model. In the case of a plug-in solution provider like TMI, should they charge the *handset manufacturer* a per-copy license fee for embedding the software? Or should they charge *subscribers* a monthly fee for using the plug-in? Alternatively, they could sell *content providers* the license and the development kit. Finally, they can give their software free to all and act as a master content provider for a group of content providers who benefit from such a product or service.

E. Enterprise Solution Provider

As the Internet evolved from B2C to B2B, so does wireless data service evolve to business applications. Enterprises now start making corporate information (e.g., intranet) available in the hands of its employees for higher productivity and cost reduction. Two models exist – one selling the software license and the other selling service in the ASP (application service provider) mode. To the former belongs Aether. It provides various components of software for a secure wireless architecture that combines Internet information with corporate information. An example of the latter[22] in Japan is JCI (www.jcius.com), a type-2 carrier in Japan that resells wireless capacity bought from carriers to corporate customers -- often called MVNO (Mobile Virtual Network Operator). This way corporate clients pay less and benefit from simplified billing. In addition, JCI adds value by enabling the employees to access corporate internal data over wireless lines. A similar business model is adopted by Modia (modia.co.kr) of Korea.

Note that JCI. Modia and Aether exploit the existing wireless phone network for corporate applications. Alternatively, enterprise wireless solution providers may choose to use a proprietary infrastructure for specific needs of the enterprise. Examples include *Symbol* and *Proxim*. Symbol is the solution provider for wireless operations at the New York Stock Exchange trading floor. Transactions are executed on the floor in communications with the office, and formerly the connection used to count on paper and hand signs. Now trade execution and back office coordination is through Symbol's wireless devices. Proxim offers a similar solution based on a proprietary base station and handsets. On the factory floor, for example, one base station will facilitate wireless communications among employees, who may check the production schedule on their wireless handsets and make decisions based on new development. In fact, the same function can be served by base stations used for wireless phone network. In Japan, the outmoded PHS phone network (i.e., frequency, equipment and handsets) is often used as the internal phone system inside a corporation.

F. Content Providers

With easy conversion of HTML to cHTML, i-mode could enlist a host of Web content providers offering various types of services or applications including banking, stock

[22] In the US, companies like @Road, AvantGo, GoAmerica, Netmorf and Verity operate corporate portals in the ASP mode.

quotes and entertainment. Recent phones are Java-enabled, accommodating a host of interactive graphic-rich applications under the name of *i-Appli.* Examples of i-Appli are:

- *Cybird* (content aggregator), in partnership with Zenrin, presents the map on the wireless phone. By using the arrow keys, you can choose the location and scale of the map. Monthly fee: ¥300
- *Mainich Newspaper* presents the play out of Chinese Chess games at top two championships in Japan. The screen displays each move of the players on the chess game board. Monthly fee: ¥200
- *Namco* (software game builder) revived the PacMan game on the mobile phone. Monthly fee: ¥300.
- *NTT Visual* offers mobile Karaoke (or Jukebox) that plays songs with words on the screen. Monthly fee: ¥200.
- *Toshiba* offers an online guide of subway routes and schedules. Key in the origin and destination, then the phone will tell you the route to minimize the fare. Monthly fee: ¥100.
- *104.com* offers a personal organizer function through the mobile phone. Personalize your organizer by selecting from a menu of real-time data sources like weather, directory of your favorite places, public company quarterly reports, events, tidal/wind information for scuba divers, weight control, sports news, and TV programs, as well as keeping your schedule. Monthly fee: ¥200.

To create one's own i-Appli directory, visit the DoCoMo menu, find a favorite site and click on it. The i-Appli portal will download icons and related features. After that, one click will activate the application.

A key challenge facing content providers is coping with the multiplicity of standards. For example, the content site needs some modification on the markup pages for each carrier and handset. The permutation is huge with multiple communications protocol standards (PDC-P, GPRS, CDMA1x, CDMA2000, and W-CDMA) and data transmissions standards (i-mode, WAP and SMS[23]), multiplied by hundreds of handsets. Thus, content providers may develop their services targeting only the large carriers to justify the efforts. This drives scale economy in the carrier business.

Vertical Applications

As wireless devices like mobile phones and PDAs become pervasive as "horizontal" communications devices, they can also serve to facilitate "vertical" applications. Examples of vertical applications are wireless business vertical applications, machine-to-machine (M2M) wireless, and location-based services (LBS).

[23] SMS means "short messaging system" that enables mobile phones to send and receive short text messages. The most popular application is email, followed by simple Internet access like stock quotes and bank account checking. SMS is often used as an intermediate solution (under circuit switching) before going to the full-blown WAP or i-mode.

A. Business Vertical Applications

Since corporate employees embrace mobile phones as the main communications device in and out of their office, one expects to see "wireless PBX" in an effort to save the communications cost.[24] If such a system is installed in a building, the employee can use the public wireless network outside the building, while once inside, the same phone will work as an internal phone. Such a private wireless network can be applied to a hotel or even in the battlefield (in place of the traditional bulky vertical communications system).

A similar concept can be developed into *multimedia* applications. Here is an example. At many big museums, one can rent an audio-device that plays a recorded message explaining the background of a painting if one pushes its ID number. This is a useful service, but the high maintenance cost of such a specialized device prohibits the wide use of such a system. One can consider using one's *own phone* to take a guided tour playing multimedia files. You either call a certain phone number, or the museum system will automatically take over the frequency and run the application (e.g., a video showing an interview with the painter) via their wireless PBX and application server – an example of *vertical roaming* (Ericsson 2000). Or, phones may come with multiple channels (a concept termed as "software radio") that may serve several vertical functions like this, as well as the horizontal function as a phone.

The main potential of such a system is that it can handle both horizontal and vertical applications on the single ubiquitous device, so there can be a rich set of applications delivered at minimal cost.

B. M2M Applications

Wireless technology will penetrate to the Machine-to-Machine (M2M) area of applications in which people are not directly involved. Regarding the size of Japan's wireless service market, Mr. Keiiji Tachikawa, President of NTT DoCoMo, commented, "We have a population of 120 million people, which is the current maximum market. But by 2010, we want to connect 100m cars, 60m bicycles, 50m PCs, 20m pets and 30m parcels. Altogether the potential market can grow to 570m users. So by 2010, non-voice subscribers will account for 70-80% of our business (*The Guardian*, October 20, 2001)."

For example, as part of the *OnStar* service by General Motors, if the airbag is released, the car automatically sends wireless messages to 911 reporting a possible accident and the location of the car (using GPS). Likewise, an elevator will automatically call a repair service shuttle when its sensor detects a sign of trouble – only a slight modification of Otis' REM (Remote Elevator Monitoring). Another service of OnStar is remote door unlock service. Suppose you are shut out of the car with your key inside the car. You call the OnStar service center, and then (after identifying you) the door will be unlocked by wireless remote control from the OnStar service center.

[24] Recently, Cisco acquired two startup companies – *JetCell* and *Exio* – whose products serve as the wireless PBX for GSM and CDMA, respectively.

Future phones are expected to come with Bluetooth. As mentioned earlier, Bluetooth offers cost-effective point-to-point or point-to-multipoint connectivity without the help of the base station. That is, like the infrared on the TV remote control, the signal from one device is directly delivered to the other device without passing through a hub.[25] Thus, one can use the phone to buy an item from a vending machine by pressing the Bluetooth-based "pay" button[26] and charging it on the phone bill. The handset will serve as en electronic ticket for subway rides, as well as a pay method. Similar applications may appear in parking, home electronics, home security, and so forth. In addition, the phone may serve as an ID (also as a fingerprint reader), a passport, a business card, credit cards, and a key to your car, house and office – everything in your wallet.

C. Location-Based Service (LBS)

About 50% of emergency 911 calls come via mobile phones. But the 911 center (officially, Public Safety Answering Point, or PSAP) cannot receive automatic location identification (ALI) from wireless calls. This triggered the Federal Communications Commission (FCC) to establish E911 Mandate Phase II, whereby by October 2001, all new wireless phones be equipped with ALI capabilities. The E911 mandate in turn creates other service opportunities like E411 (i.e., location-specific Yellow Page). There are various enabling technologies[27] of ALI. Some (e.g., GPS) depend on the signals exchanged between 24 satellites and the handset, while others utilize the signals between the carrier network and handsets. Also some technologies (e.g., GPS) require a hardware/software change on the handset, while others need only additional software.

In contrast to the US mandate approach, DoCoMo voluntarily introduced a network-based ALI service on PHS,[28] so that various commercial LBSs developed as incremental revenue sources to DoCoMo. LBSs and location-based software take location data (e.g., XY coordinates) as an input and applies them to specific purposes. Examples of applications are:

- *Location-specific sales promotion.* A department store can push messages to the subscribers in the neighborhood of the department store for special promotion.
- *E411 Wireless Yellow Page.* When a subscriber checks the directory for a restaurant, an ATM, a Arco gas station, a video shop or a drugstore, it will return the locations close to her current location.

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[25] In fact, Bluetooth can also operate as a hub-and-spoke configuration called piconet with up to seven nodes. Any node can be the hub.

[26] Unlike infrared you don't have to point to the device. Yet it will reach the destination up to 10m away.

[27] Location service technologies are divided into two classes – handset-based and network-based. The former is represented by Global Positioning System (GPS), while the latter includes Time Difference of Arrival (TDOA), Angle of Arrival (AOA), and Multipath Fingerprinting. See Lehman Brothers (2000a).

[28] In PHS base stations are closer (about 500m) to each other than in PDC-P (1-2km). This makes network-based LBS approach reliable and accurate on PHS. DoCoMo plans to introduce full-blown GPS-based handsets in 3G.

- *Tracking children and pets.* In 1999 DoCoMo introduced *P-Doco* that wirelessly transmits the location of a badge to a designated phone number. This is used for tracking a small child, pet, vehicle, a cargo container, or any other moving objects.
- *Traffic route Advising.* A motorist is continuously updated on the traffic condition around the route she is taking and advised of alternative routes. The service may capture the historic pattern of the traffic situations and advise a better route in advance depending on time and the current location.
- *Map.* When a subscriber wants to reach a certain destination, the phone can display a map showing the current location and the destination. Soon the phone will be equipped with an electronic compass; as she turns her phone, the map will also turn, so the screen will truly reflect the geography she is facing.
- *Matchmaking Service.* Suppose a teenager subscriber is at a shopping mall. He wants to find whether any of his friends listed on his directory are in the neighborhood. With a few clicks on the phone, he can find the names and locations of those friends. Even further, he may want to find some "new" friends at the mall that meet the criteria he presents. (Of course, he must also meet the criteria presented by the new friends.) The answer to the request may arrive *over time* as the mall's population changes. The service, since it requires i/o-intensive database management (called R-tree), can be handled by more sophisticated LBS servers (see grvt8.com).
- *Information Depository.* Many retail websites (e.g., isize.co.jp/gourmet) carry the icon "iPick." If you click on it and enter your mobile phone number, it will send its phone number, address, business hours, and even a map to your phone number, which is then stored on your 104.com organizer's database. Depending on where you are, the nearest location will pop up upon your request.

The main challenge to LBS is the privacy issue -- in particular, when automatic number identification (ANI) is used in combination with ALI. But there may be numerous powerful and useful applications using both ALI and ANI. One solution is to ask each subscriber to choose who can access and utilize this personal information. Another possibility is to adjust the granularity of location data for specific application. For example, when you are on a vacation trip, you may let your boss know only the city of your present stay, but allow the 104.com service to get the location data detailed enough to advise you where to find your favorite coffee shop in the new neighborhood.

D. Camera on the Handset

In near future, mobile phones will come with an embedded camera. J-Phone already has such a phone and several applications available. With the additional input device, a number of applications can be developed. For example, one can take a picture with the camera and send it to another mobile phone or a PC, thereby serving as an instant color fax. Also one can use the camera for video-conferencing. Another application is bar code reading. Suppose that you see an advertisement of a nice jacket on a magazine. Next to the jacket is a color code. This color code represents the URL of the website where you can order the jacket. You take a picture of the magazine page, and then the phone camera will

extract the color code, translate it into the URL and display the page on the phone. By clicking on the URL, you face the website and place an order. Two clicks may get you the jacket (including the payment).

Epilogue

NTT DoCoMo (and its two Japanese competitors) has demonstrated to the world a model of wireless data service. In Japan the conversion to wireless data service has reached 45% of wireless subscribers within two years of the service launch. The conversion rate will continue to grow as non-switching subscribers reach the time for a new phone. BY 2005, it will reach 95% according to one estimate. More interestingly, i-mode subscribers spend more time checking email (42%) and web surfing (24%) than talking (34%) on the phone (www.commerce.or.jp); i.e., data service has far exceeded voice service in this segment of subscribers. It is safe to say that the wireless data service has passed the first test of whether there is a "business" there. Convinced, DoCoMo is deploying the 3G standard. DoCoMo's expectation is to have 4,000 trial users during the trial period (May 3 to October 1, 2001), and 150,000 full-service users after Oct 1, 2001, which then will grow to 6 million by March 2004. Juniper forecasts that mobile commerce in Japan will grow from ¥39 billion to ¥594 billion by 2005 (*Japan Times,* May 5, 2001). The development also encouraged carriers in Korea, Europe, China and Americas to follow DoCoMo's suit with some modification.[29]

A promise of the mobile phone is to deliver location-specific, time-specific and person-specific information in the multimedia form anytime anyplace. One can make a request like "Show my favorite pizza places within 500m from here that is open at this time." Then, the phone will display the map of the current neighborhood, along with the location of the restaurant and a direction from his current location to the restaurant. The definition of "my favorite pizza" will come from my profile stored on my handset or on the content provider's server, and my current location data from LBS, while the information about pizza places will be extracted from the merchant database containing the name, location, price range and opening hours of merchants.[30]

Several observations merit our attention. First, the success of wireless data should be credited to *DoCoMo's proactive strategy* of creating the market. Before a wide adoption, every technology or standard faces the chicken-and-egg dilemma between service offerings and the user base. DoCoMo early on broke this vicious circle by determining the technical standards and payment schemes, recruiting key content providers, and handholding handset manufacturers through technical innovations. As new technologies (e.g., Java, LBS, Bluetooth, and embedded camera) drive new applications, the value

[29] Clearly, DoCoMo is facing nontrivial technological risk in 3G. Indeed, on April 26, 2001, DoCoMo pulled back (for technical difficulties) from its former announcement by saying that FOMA will be offered as a trial starting on May 30, 2001, while the commercial launch will start on October 1, 2001. Also several new models of Java-based 503i phone are recalled due to technical problems.

[30] Such a "personalized" Yellow Page search service will be indeed available at JCB104.com.

proposition of an i-mode phone has been reinforced, which in turn convinced new users – a standard story of network externalities.

Second, i-mode has become a nationwide phenomenon in Japan, not restricted to a specific segment of subscribers as at the beginning. This would create new opportunities for various *vertical applications* using the ubiquitous horizontal device. Examples include a car security system that tracks your car and, if lost, disables the ignition, and network-based games participated by many players.

Third, 3G will clearly speed up the existing service and enrich the wireless data experience with new applications and enhanced services. But it will *not* be a complete last-mile solution. Take sports news as an example.[31] Presently, wireless data service tells you the final score of a baseball game, adding that Ichiro Suzuki helped his team (Seattle's Mariners) win the game with a timely home run in the fifth inning. Even with 3G, it is unlikely you will be able to watch the whole game on your handset. Rather, the phone will play a 10-second-long video clip showing Ichiro's home run – either on the pay-per-view or subscription basis. The download will take about the same or at most twice the playing time.

Fourth, will m-commerce work? Perhaps yes only on special occasions requiring *immediacy*, and not involving serious search. For example, most of FM stations in Japan have the following service available – when you hear a certain song on the station, you can check the i-mode website to find the singer and title of the song now playing, and then you can reserve the CD and pick it up at the nearest store – all on two clicks on the phone.

Fifth, will wireless data service work in the rest of the world? Currently, Japan represents 82% of mobile Internet users in the world, while Korea, Europe and US each represent 12%, 5% and 1%. Some (including Matsunaga) argue that the Japanese value mobility higher than others, using rice balls, bento (lunchbox) and Sony Walkman as supporting evidence. The other factor is the disappointing experience Europe had with WAP. For these reasons, Japan's wireless data experience may not be soon replicated in Europe and US.

Lastly, DoCoMo is facing a significant pressure from its competitors due to the monopoly power it enjoys in Japan. Also joining the forces are unofficial sites (representing more than half of the traffic) who played a critical underground role in enriching and popularizing i-mode.[32] Based on these developments, it is too early to claim that the current business model and operational practice in Japan's wireless service market is a stable equilibrium in the long run.

[31] Based on private communications with Robert Hori.

[32] One measure DoCoMo took to help unofficial sites was to put SSL on the new Java-enabled 503i series of handsets. Now unofficial sites can handle wireless transactions with reasonable security protection.

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Useful Websites

[Statistics/Market Research]
Statistics on wireless provided by Yusei, the Japanese FCC equivalent:

- http://www.yusei.go.jp/eng/Statistics/index.html

More comprehensive archive on the current Japanese industries by a private research institute:

- http://www.nri.co.jp/english/report/index.html

Monthly magazine on mobile media:

- http://www.c-media.com/mmm/

Website about mobile contents:

- http://www.mcf.to/

Search site about i-mode contents:

- http://www.ohnew.co.jp/index.html

[Three Wireless Carriers in Japan]

- http://www.nttdocomo.com/top.shtml
- http://www.au.kddi.com/index.html
- http://www.j-phone.com/h/index.html

[Others]
Top wireless contents providers in Japan:

- http://www.cybird.co.jp/english/
- http://www.indexweb.co.jp

The leading micro-browser developer in Japan:

- http://www.access.co.jp/english/index.html

For introductory information on Japan's industry in English:

- http://www.japaninc.com/