

Voice over IP on Wireless Networks

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EXECUTIVE SUMMARY

(Future wireless) devices and systems must deliver voice, data, messaging, multimedia, and entertainment seamlessly between one another.

-Craig Barrett, Intel CEO, March 20, 2001

This paper focuses on the future of VOIP (Voice over Internet Protocol) over wireless infrastructure and devices. The adoption of high bandwidth internet connectivity as well as the proliferation of wireless web-enabled devices should accelerate the development of wireless voice and data services over IP. As users access the Internet through high speed and ‘always on’ connections, the quality and convenience of web-based calling increases. Improved quality, reduced costs and additional value added features for mobiles workforces, ‘click-to-call’ customer service, and voice and data conferencing will drive VOIP usage. In fact, IP telephony may be the primary industry driver for the build-out of wireless LANs. The proliferation of wireless LANs may reduce the demand for capital intensive 3G wireless systems by providing the connectivity that most people need without the high costs associated with 3G.

A draft version of this paper dated 3/9/2001 predicted Wi-Fi becoming the standard technology for wireless LANs in home environments given its dominance in the corporate market. On 3/20/2001, Intel announced that it would abandon the HomeRF networking standard in favor of Wi-Fi for its next-generation of consumer wireless networking devices.

INTRODUCTION

Megatrends in voice communications and the potential role of VOIP over wireless

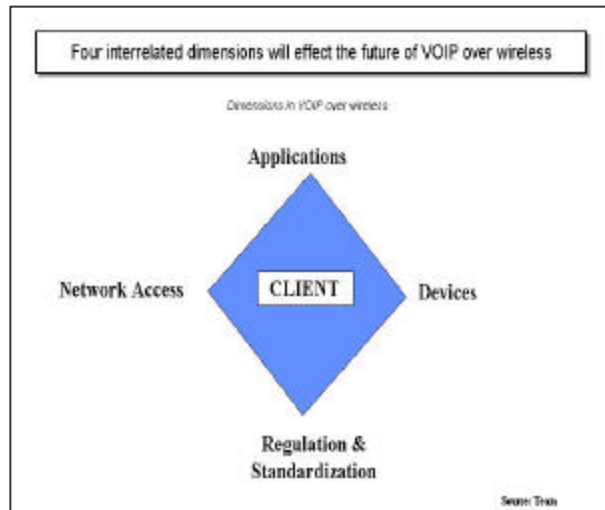
Since the early nineties the telecommunication landscape has changed considerably. One megatrend is the convergence of switch-based telecommunication and IP data networks. This means that voice will be carried in future not only through the conventional networks, but increasingly through the data networks infrastructure. Some telecommunication companies are already focusing the major share of their infrastructure investment budgets on IP networks which are able to carry data as well as voice.

Another megatrend is the move from fixed to seamless wireless communication. Societies are becoming increasingly mobile and the demand for wireless communication is increasing rapidly. Telecommunication companies have invested billions of dollars in the build-out of wireless network infrastructures or, as in Europe, the auctioning of UMTS auctions in order to provide wireless 3G services. However, doubts have been raised whether these investments can be amortized and when next generation 3G communication services will be available.

Where are these trends leading us to? What are the future applications which support or circumvent these trends and investments? This paper will focus on the future of Voice over IP (VOIP) carried over wireless networks. This paper will look into the future. It will provide insights into how and why VOIP over wireless might be one of the next disruptive communication methods which can significantly alter the competitive landscape in the telecom services industry. It will try to identify what are the drivers of new voice services and will give examples of significantly value adding applications in the VOIP over wireless field.

Primarily four major dimensions will drive the emergence of VOIP over wireless. These interrelated dimensions are network access, applications, devices and regulation. Based on the underlying trends in the network infrastructure, the paper will first demonstrate the importance of network access. The availability of access is related to the demand for devices and applications. Regulations and standards will support or hinder the emergence of new access

methods and applications. These dimensions are symbolized in the VOIP-diamond:

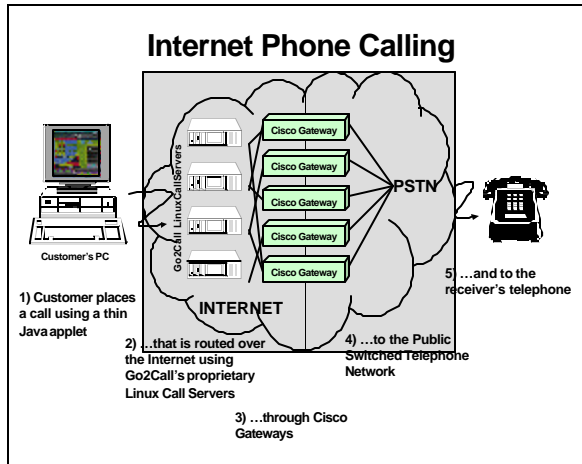


Technological foundation of VOIP over wireless networks

In order to understand the interplay of these dimensions it is important to consider the technological foundation which enables VOIP over wireless infrastructure. First, the basic functionality of a fixed line VOIP call is demonstrated, in order to provide an understanding to see the differences with a conventional PSTN enabled telephone call. Second, we apply this concept to the wireless infrastructure, distinguishing between wireless LANs and conventional switch-based wireless access. It is important to be able to distinguish between these access options in order to understand eventually what balance might be found between the dimensions and how this will affect the competitive position of VOIP over wireless networks in the telecommunication landscape.

To illustrate the present situation and the direction of this paper, imagine a caller in the US who intends to call her friend in Germany using Voice over IP. She will use her PC and the call will be directed through her internet connection to a server of her Internet Telephony Service Provider (ITSP). The ITSP will route the user's call through the backbone infrastructure (e.g. the internet) to a gateway in Germany, where the call is transferred to the public telephone network and eventually guided to the friend's telephone. As today's technology enables real time, full duplex voice transmission, her friend in

Germany might not recognize that she is using her PC in the US to place the call.

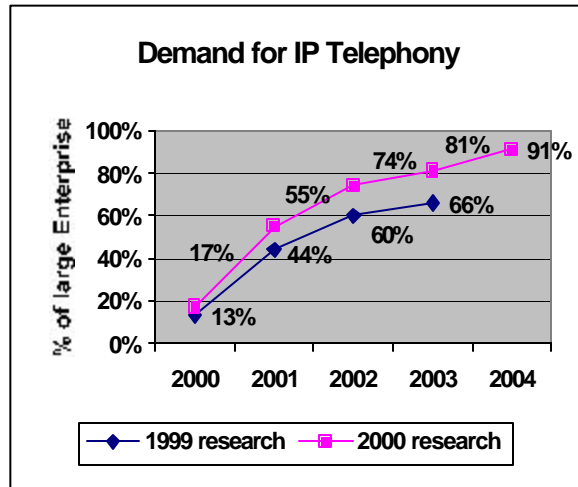


Source: Go2Call.com

PC-to-phone calls have been the most common VOIP applications. However, the near future might bring along very disruptive changes to this situation. First, we assumed that the call is placed from a PC to a phone. However, the German friend might also use her PC or IP phone to answer or call her friend in the US. Alternatively she might place the call through the a web-enabled wireless device to return the call to her US friend, who can use either her phone, or her PC or her wireless enabled device to answer the call. This will be possible through the availability of IP or web-enabled devices and through the increasing availability of broadband network (fixed as well as wireless) access options.

Presently, this technology is primarily used by consumers to do private phone calls over the internet. However, as the technology, namely software for applications, billing etc. as well as the hardware and network infrastructure develops, VOIP is becoming more and more accepted in the business community. With improved service and quality, enterprises are willing to invest in this technology given that the incremental investment for businesses is very low. The IP/LAN infrastructure is already available for the data exchange. The implementation of additional voice traffic over the IP/LAN infrastructure is insignificant. The Phillips Group expects a huge increase IP telephony that will provide basic voice telephony service. For enterprises with more than 500 employees, the Group forecasts in its 2000 research report the 81% of large companies plan to start IP telephony implementation in 2003. This

figure has been revised upwards from Phillips' 1999 research report.

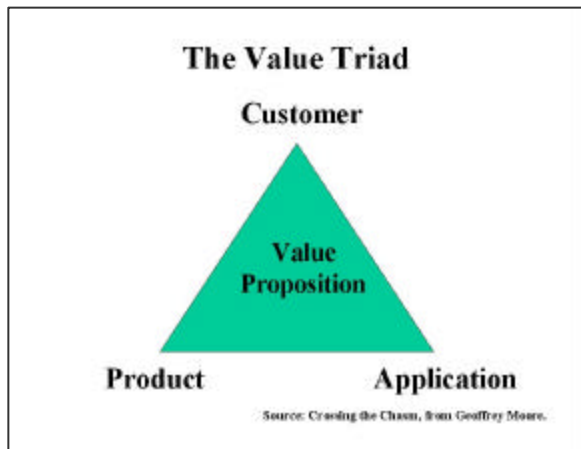
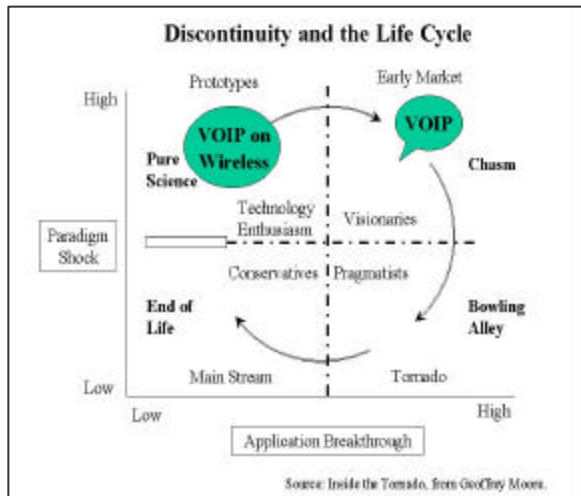


Source: The Phillip's Group (2000)

Based on the success of wireless PSTN telephony, IP telephony on wireless LANs may grow at similar rates. The benefits of mobility and the opportunity to use a device in many locations is dominant. Moreover, voice over IP involves more than just telephony. This paper will try to identify potential success factors for VOIP and demonstrate some applications which might bring the expected breakthrough of VOIP over wireless.

Theoretical Foundation

Our theoretical foundation is based on the Technology Adoption Life Cycle proposed by Geoffrey Moore in his books, “Crossing the Chasm” and “Inside the Tornado”. Current VOIP technology is in the early market part of the cycle. Some visionary companies, working hard by providing better and more varied IP telephony services may soon move across Moore’s “chasm” due to the higher bandwidth and the resultant improvement in quality. Meanwhile, a group of innovative companies foresee new markets and are trying to develop prototype wireless devices and VOIP applications. They are trying to optimize the current IP structure as complementary in the wireless communication world. We also examined the value proposition of the VOIP on wireless based on “THE VALUE TRIAD” – Customer, Application and Product introduced in the books.



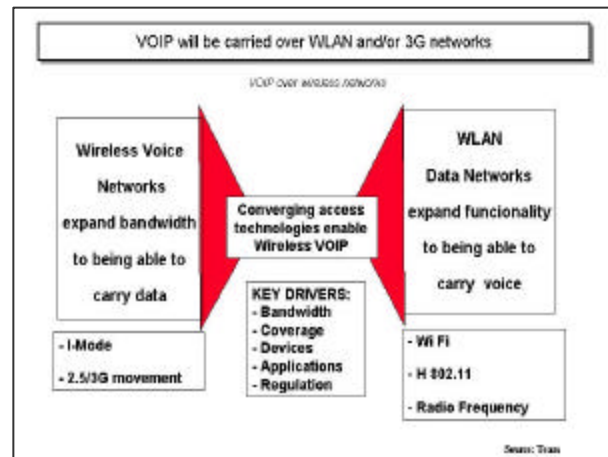
NETWORK ACCESS TECHNOLOGY

The driving forces behind local wireless LAN/IP access

The key elements in a telecommunication network infrastructure are the access network (last mile) and the backbone infrastructure. As the IP backbone infrastructure is rapidly expanding in terms of capacity and economies of scale, the backbone does not constitute a bottleneck in the IP telephony communication process. However, access to the network is a bottleneck on the origination as well as on the termination side of a communication process. In other words, the business as well as the end consumer still has limited access options. He or she might be limited to fixed access (e.g. normal telephone) to place a call or have a low bandwidth wireless connection.

Access is therefore an important component in driving the development towards wireless VOIP communication. Due to the growing availability of wireless LAN networks, especially in the business community, the VOIP market is expected to explode within the next years (see Phillips Group/Chart 1). The penetration of the in-building wireless LAN connection expedites the popularization of VOIP. The prime underlying drivers are the low incremental cost of network access (e.g. additional wireless antenna, cost) and the availability of increasingly powerful software to manage data networks simultaneously for data as well as for voice.

Different access technologies will be available to provide wireless IP access. Wireless devices will connect to in-building antennas or communicate directly among each other. They will be able to carry voice as well as data simultaneously. Presently, wireless voice carriers are investing in their networks to expand network capacity in order to be able to carry data next to voice (3G development). On the other side, data network providers are expanding their services to be able to carry voice over IP next to data. Depending on which access network will be faster to support emerging data+voice applications, the competitive landscape in the telecommunications market will be affected considerably.



Imagine the following situation in order to distinguish between the two access options. A Kellogg student is sitting in the atrium. Will he use in future his cellular phone which might have poor reception as the next tower is outside somewhere in Evanston – or – will he use his wireless internet enabled device and place the call via the wireless LAN antenna in the atrium and the data network connecting Northwestern University to the world. This option is already available today offering choice between the two network access alternatives.

What are the predominant driving forces in providing future VOIP wireless services? It is important to consider the network dynamics and key technological success factors. Wireless cellular networks already provide wide coverage for voice, however, VOIP applications require more. Additionally, there is a wide array of different competing standards which hamper a common standard for wireless devices. The emerging wireless LAN networks are presently constrained to indoor facilities and software applications and devices to carry voice are not yet widely available. However, due to lower costs and presently available technology, this access technology might leapfrog other wireless access technologies rapidly to carry a considerable proportion of voice in future.

Next to technological and cost/price considerations there are other factors which will determine the dominant future access technology. Wireless carriers dominate so far the consumer contact to the wireless voice consumer. Once voice is carried over wireless IP, a large group of potential new entrants can offer the voice service and compete for the client relationship. With barriers to entry and switching costs falling, the access technology can play a very

important role in the competitive landscape for VOIP wireless services.

Valuable applications, like new voice+data applications, will be a driving force in changing the network dynamics. Telecom companies are only interested to further invest in network access if these investments can be amortized over time. The latter is only possible through new applications and increasing demand for the voice+data services provided. In the short term it seems unlikely that the cellular wireless infrastructure will be extended geographically and with regards to bandwidth to the level that VOIP over wireless can be offered. It seems technologically and economically more feasible, that network access will be a hybrid of indoor wireless LANs (Wi-Fi) and outdoor 2.5G wireless networks which support VOIP.

For example, Nokia is offering wireless LANs to complement future 3G networks in selected dense areas. This solution brings mobile broadband access to laptops in places like airports, convention centers, hotels and meeting rooms. With 11 Mbit/s access and a build-in SIM card, professionals as well as consumers working with mobile laptops or other wireless devices can make most of their time while they are on the move. Wireless LAN enable consumers to maximize the needs of consumers for the internet in reading, corresponding, publishing, researching and browsing, meeting, listening to music, shopping and making telephone calls in the most cost efficient way through IP.

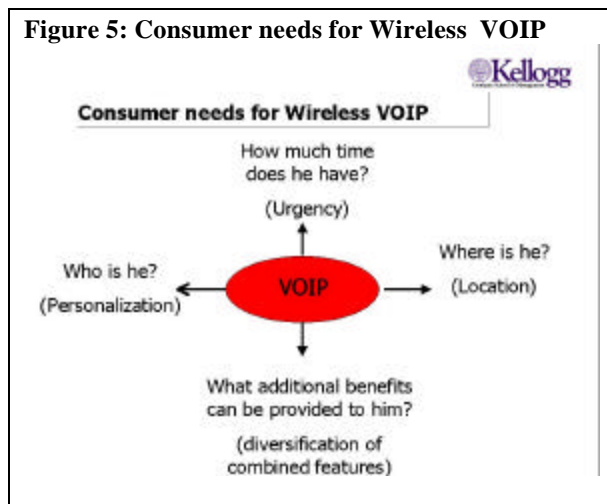
What are the applications lying ahead for consumers as well as business clients? What will they prefer and what value added do they receive in utilizing wireless VOIP applications in future?

THE CONSUMER

In order to understand the forces that will drive the future market for wireless data and voice, we must analyze consumers and understand his or her needs.

There are two clear market segments for VOIP over wireless: the business consumer and the private consumer. However, before going into consumer segmentation, it is interesting to understand the higher level dimensions of needs for VOIP over wireless. We are going to use these four dimensions to frame the applications for our market segments.

The higher level dimensions of consumer needs (private and business) for VOIP over wireless market. We identified four dimensions in which we can examine the needs for a VOIP wireless market. They are: Time, personalization, mobility and combined diversification of features. (Figure 5)



- **Time:** Consumers need products and applications that save them time, provide immediate solutions and thus facilitate tasks that otherwise would be time-consuming.
- **Personalization:** Products and services have to be easily configurable and flexible for a variety of consumer's needs and applications. Individuals and businesses have unique needs. The new technology must be easily configurable to fulfill particular needs and to be flexible for dynamic changes in such needs.

- **Combined Diversification of features:** There is a strong need for innovative applications that combine voice and data into combined applications. A key factor to understand applications for VOIP wireless is to identify opportunities within the overall wireless data applications that also have applications for voice and vice versa.
- **Mobility:** It has to be wireless. There is a strong consumer need for products and services with reliable connectivity, speed and quality that give the consumer complete mobility for combined voice and data communication.

Value proposition for the consumer

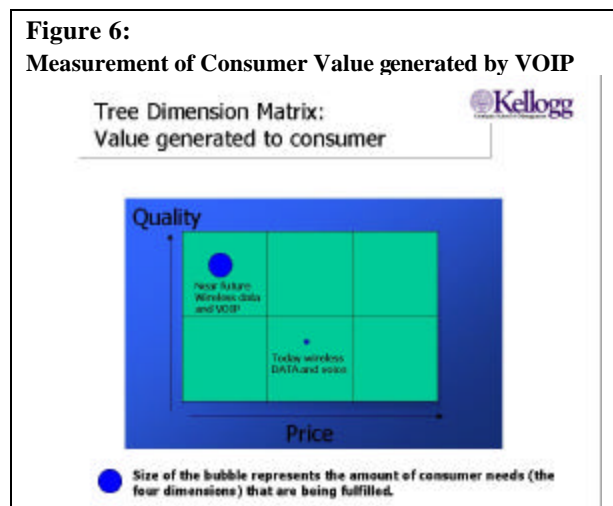
Within the context of client needs, we can measure the level of value creation to the consumer in three dimensions (Figure 6):

Price: Cost to the consumer.

Quality: Reliability of the system and overall quality performance of the products and applications being provided.

Needs fulfillment: The amount of the four dimensions of needs that are being fulfilled.

Given these three dimensions here is where we are today and where we expect to be in the near future. See the graphic below.



Consumer Segmentation

We consider two clear distinct segments for VOIP over wireless market: The **business consumer** or what we might call the **enterprise worker consumer** segment and the **private customer segment**.

Business Segment

In order to understand the consumer needs and changes that the wireless VOIP will bring let's take a look in the following example:

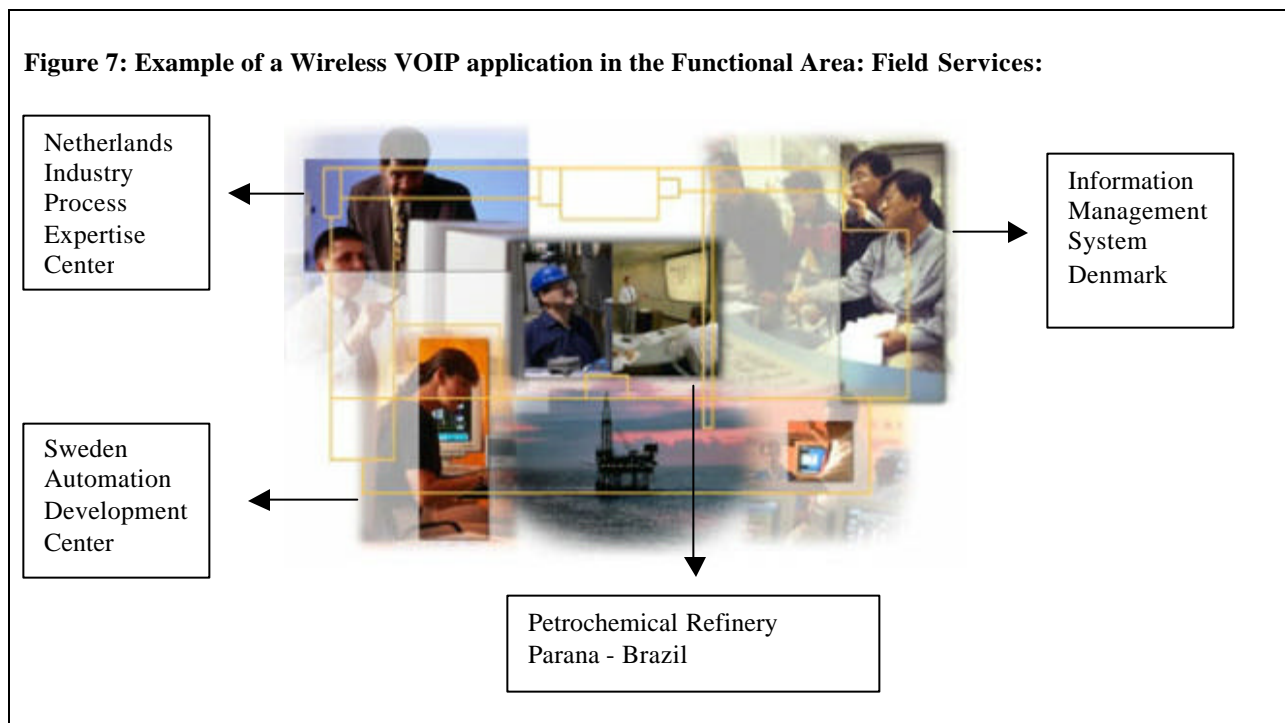
A project was developed by a diversified industrial systems technology company ABB (Asea Brown Boveri) that consisted of energy automations, information technology, and management systems for a petrochemical refinery in Brazil. The project had three different project teams from different areas of intelligence and expertise of ABB worldwide: The energy systems expertise developed in Netherlands, the automations systems developed in Sweden and the information management system that was developed in Denmark.

Engineers for these three countries working with a project team from Brazil to develop and implement the project. After the project was completed and tested, the project teams left the plant for their respective countries. A few weeks after the engineers left the plant, problems started to happen with the data collected from the management information system. The field engineers from Brazil were sent to the plant to identify and correct the problem.

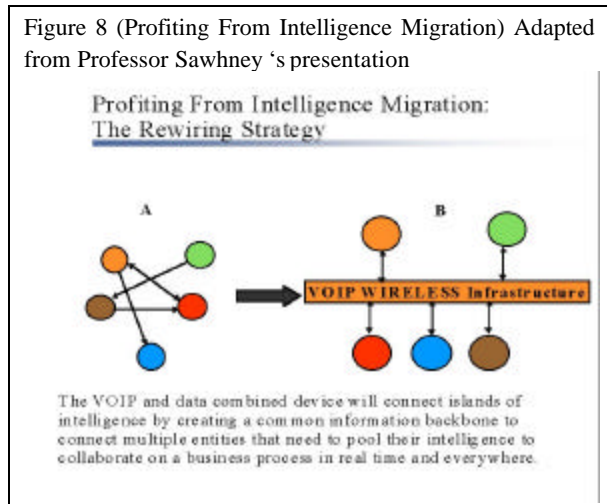
The problem was extremely complex and involved the integration of all different parts of the project. Engineers in the field needed constant support from the expertise groups that had developed all areas of the project. After two weeks of work involving all the engineers from the different countries, nothing had been achieved. The project manager decided to bring one expert from each of the countries to the site to work on the problem.

By working together on site with all the information and expertise available at the same time, the engineers were able to find out and correct the problem in one day.

Figure 7: Example of a Wireless VOIP application in the Functional Area: Field Services:



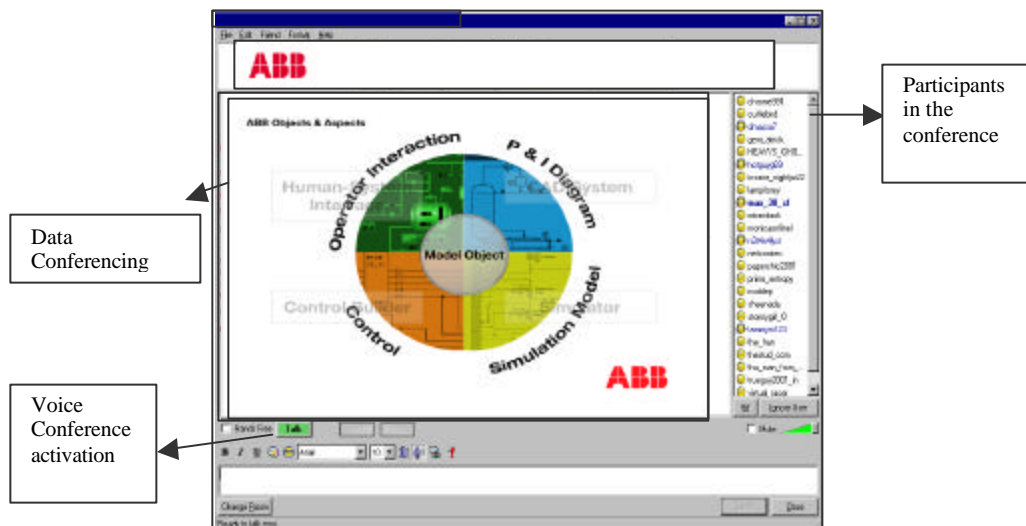
Now let us use the theory of intelligence migration (Figure 8) to explain what happened and what is the breakthrough of VOIP over Wireless.



What was happening in the beginning when the field engineers were trying to solve the problem was like situation **A** in the above slide. Once the project manager brought together the experts from different countries the flow of information became like situation **B**. But the whole operation was very time consuming and expensive including engineering hours, travel expenses, etc.

The situation above identifies a need for a device (Figure9) that could eliminate the communication problems and would make it possible for the engineers to work in their respective countries as if they were together in the plant.

Figure 9: The application device.



This clearly fits all four dimensions of our customer needs:

- **Time:** The device would allow the field engineers to work simultaneously on the problem and thus solve the problem in one day.
- **Mobility:** The device would be carried to all parts of the plant in which there is a need for data gathering. With such devices all engineers in their respective countries would see the information simultaneously.
- **Combined diversified features:** This device would have real time data sharing so that all parts involved in the solution of the problem could see the data simultaneously. In addition the device would carry VOIP so that the engineers could discuss the data in voice conferencing.
- **Personalization:** A personalized application software (for this particular company) could be carried in this device such that it would improve the convenience and security of the process.

Evaluating the operation with the device in our value creation matrix we would get low cost, high quality and high needs fulfillment. The total cost of the operation as it happened was about \$25,000.

On the other hand, the cost of the operation if we had the VOIP data capabilities would have been around \$1,000. The costs would be even more significant if we consider the costs to the client of having the system not working for two weeks.

Lets now take a look at what this product would look like (Figure 9).

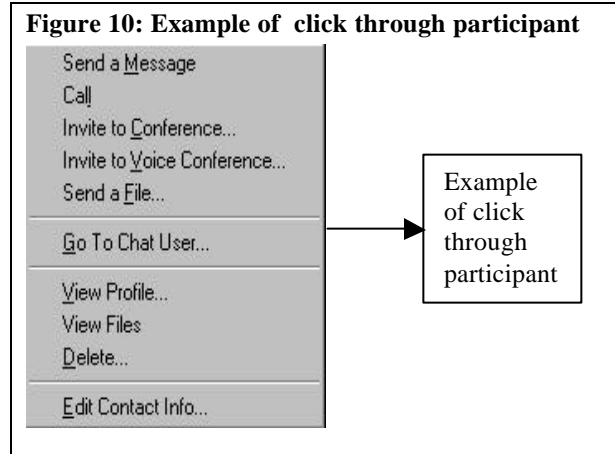
The product will be a tablet on which standard voice and video conferencing would run. There would also be specific applications customized by the client and for the client.

The data conferencing area there will present data selected by one of the participants of the conference that will be shared with all of the others.

The voice conferencing is a “talk” button that allows people in the conference to press to talk and all the others will be simultaneously listening.

There will also be a status line showing all the participants in the conference and their status such as whether a particular member of a project is on line and how long he has been on-line. Features might also include how long since the last time he or she made a comment.

Additional capabilities would include private messages from one participant to another. For instance, the following menu window could appear when you click on a participant. This would allow several individual applications between participants (Figure 10).



Additional products or variations of this VOIP data application might include a smaller (mobile phone or PDA) version of the product for less complex conferencing tasks. Once we have the technology drivers that we will discuss later in our paper we can have a powerful number of applications that can be developed for individual needs.

Looking at all individual needs within all functional areas in several different industries, we will find that there are huge opportunities for such applications in all functional areas and industries. See Figure 11.

Figure 11. Field Service and General Management functions across different industries

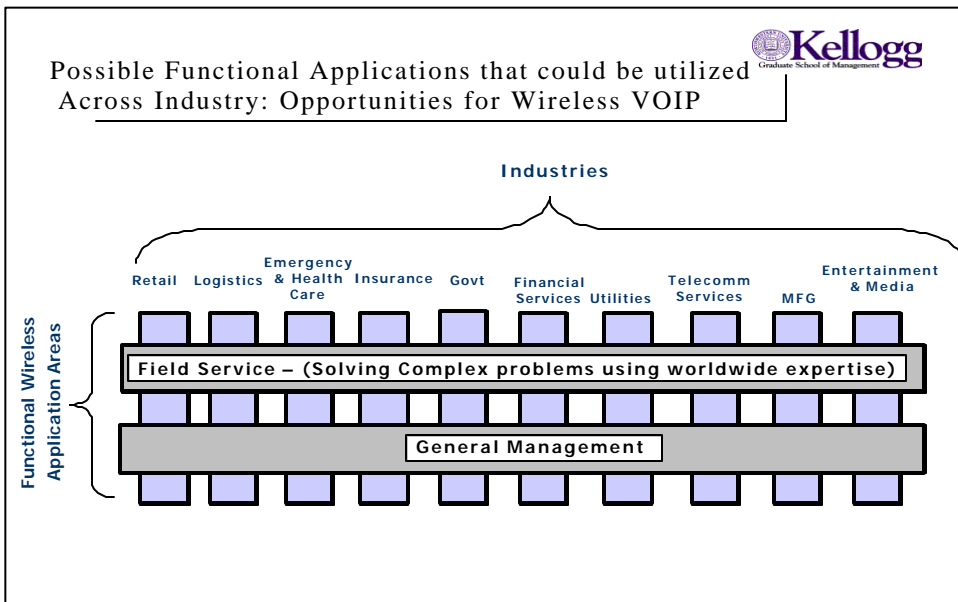


Figure 11 shows two different functional areas across different industries. The field service functional area that was illustrated in our example can have uses in several industries, but again this is just one functional area. The same ideas can be applied for all functional areas across industries.

Imagine for instance how the flow of information happens between several functional areas in a marketing department. If the general manager wants some information from the finance person responsible for a particular brand, he or she could just click on his name in our product and in seconds, wherever the finance person is, he can just send the file to the general manager. There is no need for emails or to wait until you can find the personal responsible for the reports. Such a product fulfills all four dimensions of consumer needs and has applications in all functional areas of a large variety of industries.

The Private Customer Segment:

What is the value in this segment today? There is very little that can be provided to the private consumer for Voice IP over wireless. Data over wireless tech is just breaking through and when we discuss data combined with voice, it still uses the traditional cellular wireless services for voice and a different channel for data such as WAP.

Aside from the NTT Docomo’s I-mode and some 3-G applications in Europe, even the data applications have poor quality such as text only data and are expensive. However, breakthrough technologies are about to change this scenario completely and open the stage for the a strong VOIP wireless market.

Given the developments in technology providing value in all three dimensions of our value generating matrix, we might identify the following needs and applications that would fit our private consumer segment:

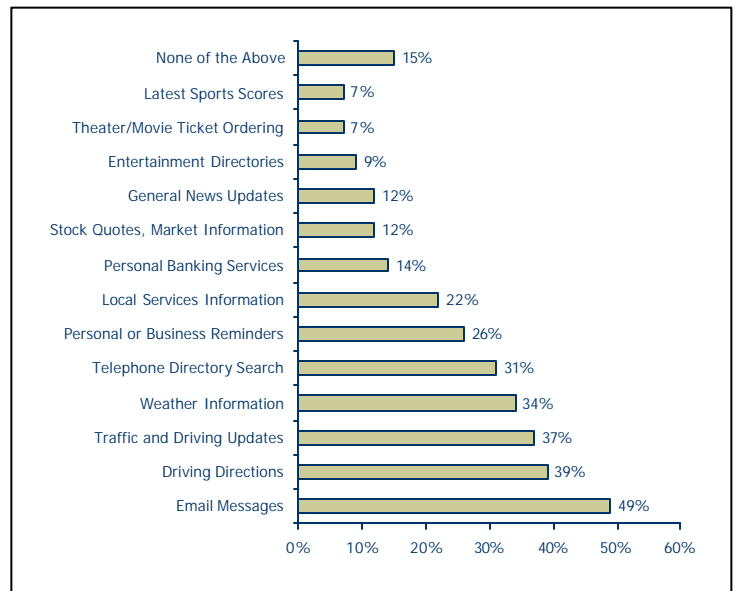
The Near Future:

There are huge opportunities in the near future for wireless VOIP. First, technology is transforming fixed internet access to wireless access. This, just by

itself generates numerous opportunities for consumer applications such as “click-to-call” on traditional web sites.

Such “click-to-call” applications would enhance traditional data wireless applications and thus provide great fulfillment in all four dimensions of consumer needs for a VOIP wireless device that we have discussed.

Lets look at the actual Wireless applications and where VOIP is relevant (Figure 12):



Source: JP Morgan

Depending on culture and trends for the general consumer (Figure 12), the breakthrough applications that may drive demand for the wireless applications and VOIP can be something as simple as girls in the mall conferencing to their friends about where is that good looking guy that has just sent them his picture and is now taking part in their conference.

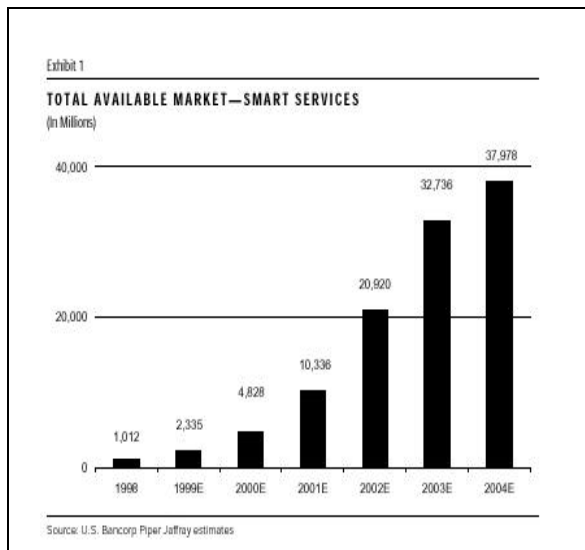
Such entertainment applications have driven the market for the I-mode in Japan and also have just started winning the rapidly growing market in Latin America. Once you have voice capabilities and data capacity in your wireless device, for each different service we mentioned in the Figure 12, we might find voice applications that would generate new revenue streams and business models.

DEVICES

The convergence of a number of forces that have a powerful impact worldwide has been developing a rapidly growing market for smart devices. The two primary trends that drive this potential market are the rapid rise and ubiquity of the Internet and wireless communications networks. The metrics that roughly define the market opportunity are:

- The Internet is growing from 200 million users in 1999 to 500 million by 2003 (IDC estimates).
- Mobile communications subscribers will increase from 300 million at 1999 to 1 billion by 2003 (U.S. Bancorp Piper Jaffray estimates).
- The overlap in mobile phone users and Internet users is nearly 100%.

Computing platforms and handset platforms will transform themselves over the next several years to support a wide range of mobile data and voice services as part of the “airtime” component of many subscribers. This is expected to create a global m-commerce market of \$38 billion by 2004 (IDC estimates).



These figures are derived from projections of voice-centric and data-centric handsets, and do not include the market for personal digital assistants – which is estimated at \$16.7 billion by 2004, for a total combined market of \$54.7 billion.

Mobile devices play a critical role in determining the nature of the wireless experience and there are as many experiences to be had as there are major

variants of devices (more than 140 by end of year 2000). Devices include data-enabled phones, PDAs, Pocket PCs, laptops, tablets, smart appliances, telemetric devices, and many others. The projections for shipments of smart handheld devices show a huge market potential – global volume of 45.4 million units and value of US\$ 19 billion by year 2004.

Table 17: Market Growth Forecasts for Smart Hand-Held Devices

Smart Handheld Device Shipments		1998	1999	2000E	2001E	2002E	2003E	2004E	CAGR%
United States									
Shipments (000s)		3,364	3,638	5,302	7,246	9,897	13,991	20,764	40.7%
Value of Shipments (millions)		\$2,670	\$2,728	\$3,519	\$4,371	\$5,385	\$6,877	\$8,514	24.0%
Average System Price (\$)		\$794	\$750	\$664	\$603	\$544	\$477	\$400	-11.9%
Global									
Shipments (000s)		6,449	7,426	10,302	14,316	20,436	29,865	45,419	44.9%
Value of Shipments (millions)		\$4,622	\$5,071	\$6,671	\$8,552	\$11,166	\$14,862	\$19,419	30.6%
Average System Price (\$)		\$698	\$683	\$648	\$597	\$546	\$491	\$426	-9.9%

Source: IDC.

Until recently, wireless data and wireless voice have been experienced through different and separated devices. Wireless data has been notoriously complex over the years. The reasons for this lack of success have been many, but there are some considerations to point out. First, networks designed for voice are not well suited for data. Second, competing air interface standards (e.g., GSM, TDMA, CDMA, PDC) have proliferated over the last several years, increasing complexity. Operating systems for handheld devices have also proliferated as 3Com, Microsoft, and many others vie for hegemony in the next great platform struggle. Finally, wireless data has been characterized by slow transmission speeds, poor quality, low security, and high costs.

But, with the advent of new technologies, the combination of voice and data in one device, and especially with the experienced / converted market for an “all-in-one” device (e.g., NTT DoCoMo’s i-mode phone), the race among diverse players to bring out multi-purpose portable gadgets has intensified and accelerated in the past few years. NTT DoCoMo has sold more than 19 million (Feb 2001) of its Internet-based i-mode phones units in Japan since its launch in April 1999. Targeting this promising wireless market, nearly all leading firms from both the computing and communications industries are jostling to form alliances they think they need. Among them are:

- A \$1 billion venture between Cisco Systems, main supplier of the network equipment that is

the “plumbing” of the Internet, and Motorola, a pioneer of wireless technology, to develop mobile Internet products.

- Motorola has also joined Nextel, along with Netscape and Unwired Planet, two Internet software specialists.
- A partnership between Microsoft and British Telecom to create new internet and corporate-data communications services for the British company’s 13 million mobile customers spread across 10 countries.
- An agreement between Cisco and Qualcomm to develop a high-speed wireless Internet service for US West, a regional telephony company.

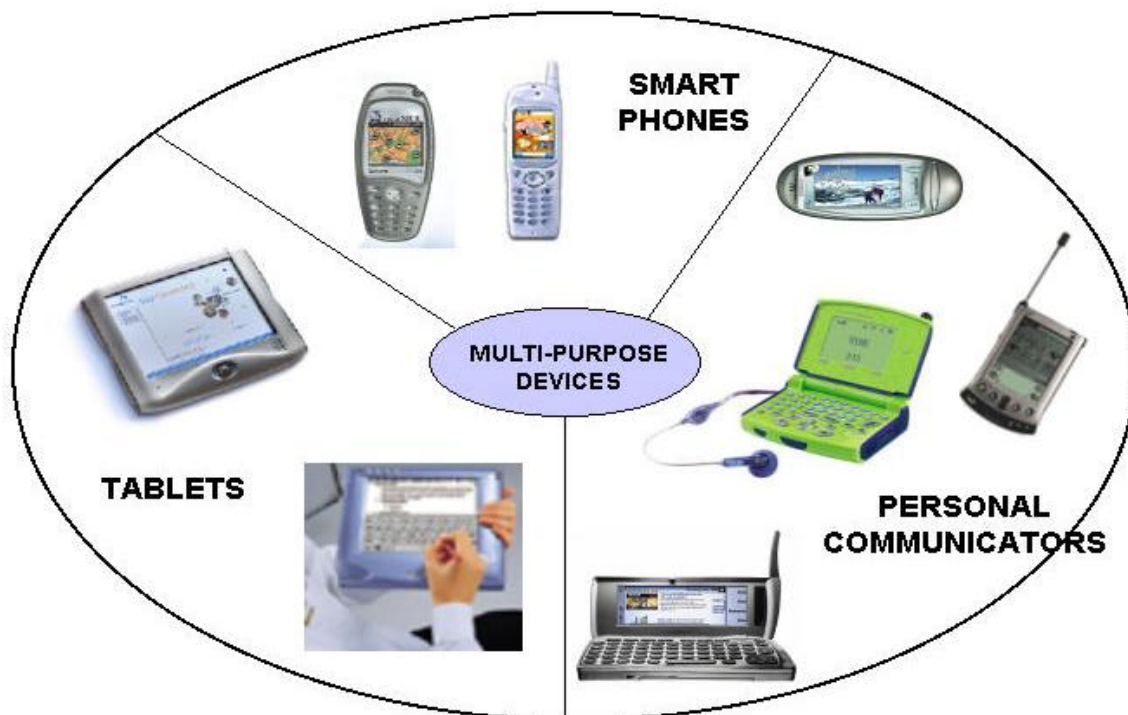
Also, companies have engaged in a remarkable collaboration to produce standards for a smooth convergence between the wireless and computer industries. About 90 companies, ranging from the biggest equipment manufacturers to Microsoft, have joined the WAP (Wireless Application Protocol) Forum in order to develop a common protocol that allows users to gain access to the World Wide Web without typing fiddly letters. Over 1,000 companies have come together to on another project, Bluetooth, designed to allow various wireless devices talk to

each other over infrared beams.

Regarding devices, both data and voice players are engaged in developing multi-purpose gadgets, aiming to bring the next “killer app” into the market. The question is what this all-in-one device will look like. Most people like their mobile phones small and their windows onto the Internet large. In an attempt to fulfill these consumer needs, there is a diverse range of devices that are coming up into the market and that can be segmented in 3 main subsets.

MULTI-PURPOSE DEVICES

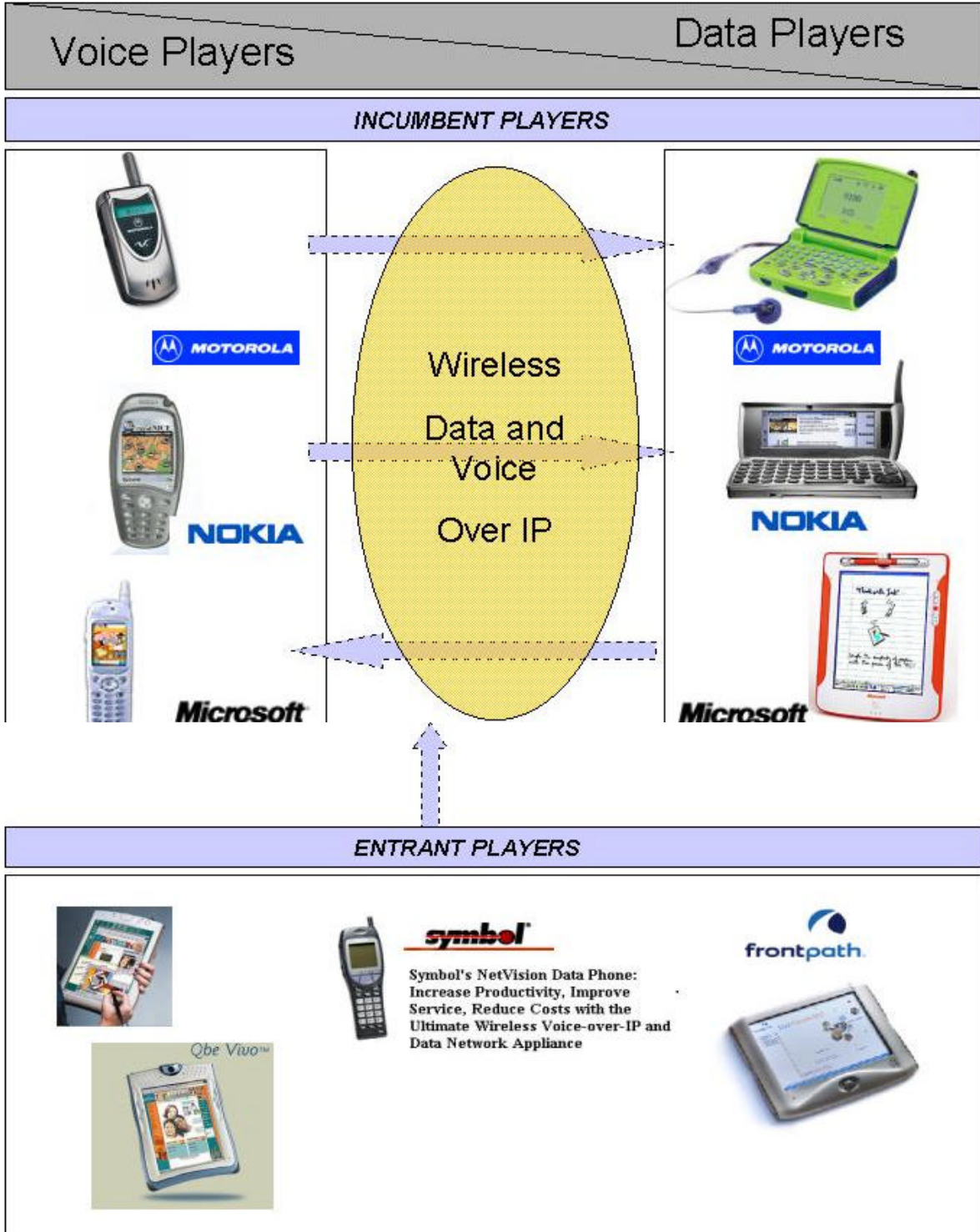
Avid to capture this huge potential market, players have been working on both mobile phone and computer-derived designs and features. In this sense, telecommunications manufacturers are bringing devices that look like computers and computing manufacturers are also extending their product line to phone derived designs.



In this effervescent scenario, there are not only the incumbent players (Motorola, Nokia, Sony, Palm) but

also some new, small manufacturers (NadaPC, Frontpath, Symbol, Aqcess).

ALL-IN-VOICE” DEVICES PLAYERS RACE



One of the main drivers to define these new devices is the operating system. In this battlefield there is one of the most ambitious alliances. Symbian, a joint venture initiated by Psion, a British hand-held computer firm, and the three biggest mobile phone makers – Nokia, Ericsson and Motorola, has been joined by other big players such as NTT DoCom, IBM, Oracle, Sun Microsystems, and Matsushita. Symbian partners control more than 90% of the world market for mobile handsets, and the bid is to turn the EPOC operating system into the standard for smart phones. On the other side is Microsoft, which wants to turn Windows CE into the operating system for a whole range of devices, from set-top-boxes for cable televisions to notebook computers. The result is an operating system that is maybe too clumsy for mobile phones. While this is not the reality, Microsoft has just launched its smart-phone platform – Stinger – that merges the capabilities of a Pocket PC into a mobile phone.

All these moves within the computing and communication industries influence the way people will communicate, work, and interact in the near future. More and more, people will be connected to each other, to their families, to their workplace through these innovative, “always on” devices, making use, and benefiting from the convenience and cost savings these advances can bring to society.

Considering the business segment potential and the needs of mobile workers – data capacity and voice combined – leads us to imagine the most likely device will combine a reasonable screen to accommodate visualization of different data and phone features. This outcome, prompted by a combination of health worries (cellular health issues) and convenience is currently believed to be an integrated device: an earpiece for phone calls and a hand-held device for data.

We believe in the potential of devices that make use of data and voice over IP, which could be, for example, a combination of the advantages of a tablet (large screen for data visualization) with the cost benefits and improved quality of voice over IP. The technical specifications required to have a device with VoIP are quite simple: operating system, modem speed of 28.8K or above, microphone and audio playback capacity, speakers or headset, and a computer. This is not far away from the reality when we evaluate the devices that are currently in the market as the diverse tablets that are coming up (e.g.,


Qbe Vivo Personal Computing with speech recognition) as well as the multi-purpose phones that combine access to the Internet and also has a phone feature using VoIP (e.g., Symbol’s Net Vision Data Phone with VoIP with WLAN). In conclusion, we believe that with the expandability of wireless LANs, the current developments and improvements in devices, the convenience of software for VoIP (such as Net2Phone, Go2Call), and the reasonable costs associated to these technologies, it is very feasible and achievable that a wireless device combining data and voice over IP can fulfill, and attend the needs of promising new business market. Examples of devices combining voice and data features are below.



Qbe Vivo Personal Computing Tablet

Some of the device features:



- Windows Operating System
- Touch-screen navigation
- Wireless enabled (IEEE 802.11b and Wi-fi standards)
- Speech Recognition & Built-in Noise Cancelling Microphone Array (L&H Voice Xpress software)
- Digital Camera Module



Symbol Net Vision Data Phone

Some of the device features:

- VoIP technology (ITU H.323)
- Wireless LAN (TCP/IP with IEEE 802.11 protocols)
- Web browser that access the Internet and a corporation intranet.
- Technology for diverse applications:

Healthcare	Retail
	
<ul style="list-style-type: none"> • Monitor patient status/information • In-building communication between hospital staff 	<ul style="list-style-type: none"> • Scan bar codes to check prices and inventory • Quick response to distrib. center and customer inquiries

COMPETITIVE LANDSCAPE

The adoption of high bandwidth internet connectivity as well as the proliferation of web-enabled devices should accelerate the development of Internet telephony. As users access the Internet through high speed and ‘always on’ connections, the quality and convenience of web-based calling increases. This should provide a competitive boost to the ISPs and ITSPs that can facilitate these calls as well as the manufacturers of web-enabled devices that are used to originate and receive them. The rising availability of mobile connectivity drives the development of IP telephony and the convergence of voice and data on IP networks.

Major Telecom Service Providers

New technologies, such as optical fiber have dramatically increased the bandwidth availability in the last five years in the U.S. resulting in downward pricing pressure and the transport of more data than voice. The PSTN phone networks of the major telecommunication service providers also contribute to the capacity glut for voice and data. The PSTN networks have huge investments tied up in them, work very well for voice, and provide corporate customers with long-distance phone rates as low as 3 cents a minute.

However, AT&T, WorldCom, Qwest, Global Crossing and other companies are building out next generation wireless and IP networks for combined voice and data transmission. These companies need to leverage their network assets and provide differentiated services to their customers. IP networks should turn out to be more efficient in the long run and more attractive to consumers by offering more convenience and new premium services such as video-conferencing. In the near term however, IP networks still lack a lot of features that are taken for granted in the phone networks such as the ability to put a call on hold, billing systems, etc. Additionally, the major service providers are justifiably cautious about cannibalizing the revenue generated over their phone networks. The massive shift to the convergence of voice and data on IP networks may take some time while investment and call management issues are sorted out. That said, large firms like AT&T and WorldCom are offering VOIP services on a limited scale on corporate networks.

Equipment manufacturers - wireless LAN and IP phone equipment

The corporate market for phone systems is on the verge of a transformation with the development of IP technology. IP LAN Telephony enables IP phones to be connected directly to the LAN and offering additional functionality to the company’s existing phone system. According to a Phillips Group study in November 2000, 17% of large enterprises in the U.S. will begin implementing this technology in 2000, increasing to 55% in 2001. Factors driving customer expectations around IP communications include: 1) anticipated savings resulting from convergence of voice-data networks based on open standard systems, 2) rapid development of convergence and eBusiness transforming applications (eCRM, voice-enabled websites and the virtual enterprise), and 3) availability of enterprise-class IP communications technology. The thinking is that a single IP communications server at a central site can serve IP phones at multiple locations over an IP enterprise network. By enabling convergence in both the LAN and WAN, IP telephony will result in lower total cost of ownership.

The Philips Group projects that the wireless LAN industry is expected to grow from \$300 million in 1999 to \$1.7 billion by 2004. Their study forecasts that IP telephony technologies will be the primary industry driver for wireless LANs (The Philips Group, 2000).

Some have argued that the proliferation of Wi-Fi protocol LANs may reduce the demand for expensive 3G wireless systems by providing the connectivity that most people need without the high costs associated with leasing spectrum to provide border-to-border coverage. (Fortune, 2001)

ITSPs and ISPs - Internet calling for consumers and small businesses

Internet calling, also known as Voice over Internet Protocol (VOIP), is expected to have hit \$266 million in revenues worldwide in 2000, up more than fourfold from 1999 according to an industry survey by Frost and Sullivan, a San Jose, California-based consultancy.

Internet calling enables value-seeking consumers to call from personal computers (or web-enabled devices) to traditional telephones. While presently less competitive as a substitute for local and long-distance calling, Internet calling has a substantial competitive advantage in international calling when the high settlement charges of some national telecom monopolies can be avoided.

ITSP's (Internet Telephony Service Providers) often in marketing partnerships with ISP's (Internet Service Providers) provide internet calling services to consumers by developing software applications and managing networks of "gateway" computers that manage the linkages between circuit-switched phone and packet-switched networks.

In January of 2001, Ovum projected the PC-to-phone service market will increase from 5 percent of all current Internet users to 23 percent of Internet users (166 million users) by 2006, with the industry's revenues increasing to \$6.2 billion. Piper Jaffray estimates the total number of minutes for all forms of Internet telephony will reach 1.2 trillion by 2003, or approximately 17% of the 7 trillion minutes of global voice telecommunications traffic in 1999. Low-cost, high quality international calling creates a compelling value proposition to consumers and small businesses, which stand to save 90% off the average cost of \$0.55 per minute for international calls originated around the world (Telegeography).

The proliferation of (wireless) IP telephony will be driven by improvement in quality and end-user demand on the part of businesses and consumers. Perhaps the shift will be analogous to the rise in popularity of e-mail and the stagnation of the fax. IP economies tell us that IP telephony minutes should experience fantastic growth and increase total information flow while more cumbersome circuit-switched systems experience negative growth.

Disruptions

Such developments will further erode the competitive position of the major telecommunication companies that are highly dependent on voice transmission over the PSTN for revenue. With evolving technologies for IP call management and the drive to reduce network redundancy, newcomer IP telecom providers can bypass the legacy systems of their larger

competitors and offer services to businesses and consumers with lower costs.

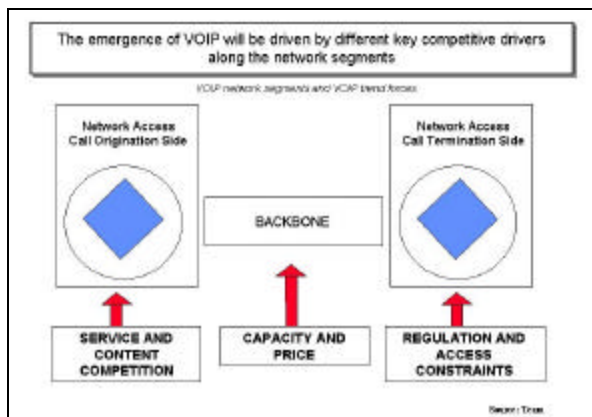
Secondly, and analogous to the demise of the Iridium satellite telephone network, improved connectivity with superior devices can be achieved when user environments are more selectively targeted. Iridium and perhaps 3G networks are designed to provide additional services to phone customers over wide geographic areas but the build-out of these networks has yet to be proven cost-effective. Wi-Fi protocol LANs have become the protocol of choice in corporate environments. If this technology continues to be built out in office buildings, campuses, and airports, through network externalities, it may come to dominate the home LAN market as well. Then consumers and workers would be able to move from the office to home without changing network cards/modems and retaining the full functionality of their laptop, tablet, etc. device. With much of their full-service connectivity needs being met in these environments, the urgency to use access additional services on 3G networks may be reduced.

(A draft version of this paper dated 3/9/2001 predicted Wi-Fi becoming the standard technology for wireless LANs in home environments given its dominance in the corporate market. On 3/20/2001, Intel announced that it would abandon the HomeRF networking standard in favor of Wi-Fi for its next-generation of consumer wireless networking devices.)

Finally, ISPs can offer phone service to their customers either on their own or in alliances with ITSPs that have the software and gateway computers to make this service practical. This will serve to erode further any remaining pricing power of the PSTN-centric service providers. For some uncertain period, IP calls will likely be terminated by switching them onto the PSTN network and ringing the traditional telephone of the intended recipient. As IP telephones become more prevalent, more and more calls will be IP end-to-end and the reliance on the old phone networks will be reduced.

Regulation & Standardization

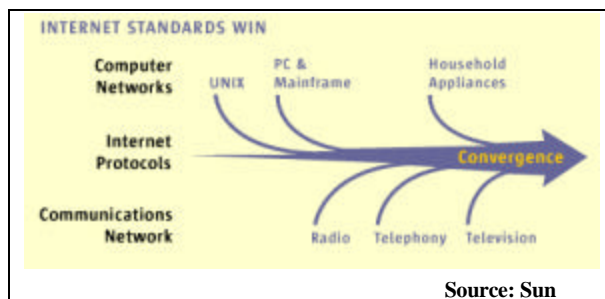
Regulation and standardization will have a major influence on how VOIP over wireless will develop. Regulation determines primarily the access to networks and indirectly the emergence of devices and applications. In addition, regulation is constantly influenced by the emergence of new applications and the use of new devices. For instance, IP Telephony forces regulators in many countries to consider the technological advances and to set up new frameworks of how to deal with it. IP telephony enables individuals in other countries to use the internet in order to bypass national telecommunication networks. Those national telecommunication carriers will fail to collect a substantial part in their phone termination fees. As those incumbent carriers usually contribute substantial funds to the respective country trade balance, regulators in those countries have to find new ways to cope with the emergence of new applications.



Regulation is most likely to develop its major influence on network access at the call termination side. The last mile on the termination side will be a major barrier, as not every person has, for instance, constant internet access or IP telephony might be declared illegal. New regulation may also support the process of opening up access on the termination side as well as further increases in the adoption of IP coverage. On the origination side of a communication process, services and content competition will dominate as major access problems do not exist. Eventually, the backbone of the communication process is not of further interest, as this is the commodity part of a communication process – the major competitive drivers are price and capacity. Regulation, in the sense of opening up the

communication channels, might therefore significantly influence the future of wireless VOIP.

Standardization is another aspect of regulation. Standards will strongly influence on what network access and devices the industry players will focus their investments on. Once dominant trends develop, often investments are moved into this field in order to being able to amortize investments over a large client base. For instance, in case the Wi-Fi network access standard develops to the dominant access mode, device and network manufacturers will ensure that their investments are recoverable in a Wi-Fi dominated access environment. Once the Wi-Fi standard gains significant market share, other investments, for instance in conventional wireless networks, might be jeopardized, as the voice+data applications will be channeled through access points which offer the most benefits at the least cost.



Generally it can be seen that internet standards will dominate the convergence of telecommunication and information technology networks. The benefits achieved through compatibility of standards on the data side will be enhanced while integrating voice.

Another issue related to regulation is the availability of broadband frequencies and how the effect of wireless communication is evaluated on the human being and its environment. Both, the allocation and evaluation of potential health hazards will influence how far wireless VOIP applications will develop. Especially in the private end consumer market, limited access will have a large impact on whether certain applications will be developed. Most probably, VOIP will then be channeled through the available fixed line connections (DSL, Cable, copper, electricity connections, etc.). In the household itself, the additional wireless benefits might not be as large as in the business community. Consumers might use the wireless option primarily because they want to be flexible with the devices they use inside as well as outside of the household.

Conclusions

Fixed line VOIP has increased its market share rapidly due to low incremental cost for businesses. The move towards wireless VOIP will be driven by the emergence of new low cost wireless access infrastructure and new applications and devices which are able to carry data and voice. With the rapid adoption of VOIP in the business segments, private consumers will follow suit. VOIP over wireless infrastructure incorporates mobility, common standards and a wide wealth of value adding voice and data applications.

IP access technology with low incremental costs will lead to the convergence of voice and data traffic

The adoption and diffusion of new applications depends on access and network effects. VOIP over wireless applications will require broadband IP access. The current cellular infrastructure is not capable of supporting those applications outside of densely populated locations where 3G networks are operational. People will most probably first encounter widely used wireless VOIP services in the business environment. Businesses have the advantage of operating LAN networks for their data communication and can rapidly expand the functionality of their networks with low incremental cost to enable fixed as well as wireless VOIP communication. With the build out of wireless networks outside of buildings, business as well as private clients will have the opportunity to use VOIP services independent of location.

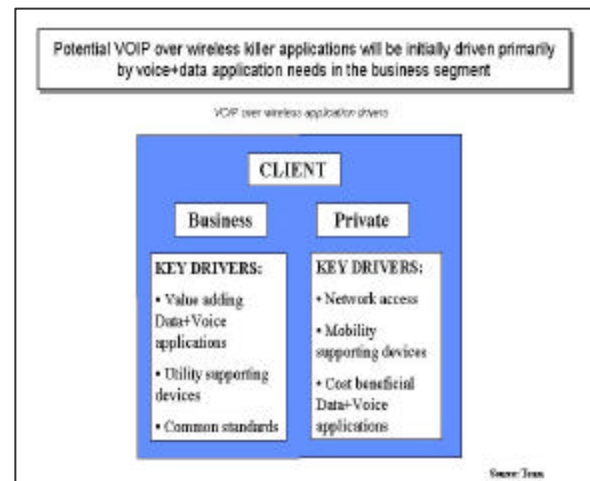
Voice over IP communication will drive the build-out of wireless LANs based on the Wi-Fi standard and that build-out will reduce the demand for 3G wireless services

Next generation technology services such as high-speed wireless voice and data services over IP will be most efficiently provided through corporate and home networks using the Wi-Fi standard common in corporate environments today. Connectivity in these locales will create a viable and low cost alternative to 3G services. The build-out of wireless LANs will give consumers the high-bandwidth internet connections where they need them the most, on one standard, with one set of equipment (e.g. wireless cards) and without having to log on and off. With

connections assured at home, at the office and at key public places (e.g. airports, universities, 2000 Starbucks locations) the demand for 3G wireless services may be reduced.

Integrated voice and data applications offer value which will be exploited first by business clients

Key drivers will be value adding data and voice applications which provide a benefit over pure data or voice communication. Wireless VOIP applications will provide their full benefits in work scenarios requiring data with integrated voice exchanges as well as mobility. The breadth of potential applications is enormous. Communication might be revolutionized again as large efficiency gains are possible when voice is carried on the same network as with data.



The primary needs of a business and private clients are different. Businesses are searching foremost for value adding applications for their workforce (used in different offices, client sites or on field work). Relevant is the utility and compatibility of services and devices which support data and voice communication in different work scenarios. The private consumer, however, will first need the access to the application in order to adopt the services. As happened with the diffusion of PCs, the consumer commonly first learned about the use of computers at work, before deciding to invest herself into a new PC and its applications in order to use it at home. Other concerns are related to investments in devices which support mobility and are cost beneficial to use.

Devices converge to provide multiple functionality

Devices will increasingly converge to provide added functionality for voice and data communication. These hybrid devices (e.g. combined cellular and PDA) will operate independently of the respective networks and will support business as well as private applications. The most likely device will combine a reasonable screen to accommodate visualization of different data and phone features. This outcome, prompted by a combination of health worries (cellular health issues) and convenience is currently believed to be an integrated device: an earpiece for phone calls and a hand-held device for data.

Appendix A: Technology Briefing

Radio Frequency

The term *radio frequency* refers to alternating current having characteristics such that, if the current is input to an antenna, an electromagnetic (EM) field is generated suitable for wireless broadcasting and/or communications. These frequencies cover a significant portion of the electromagnetic radiation spectrum, extending from 9 kHz, the lowest allocated wireless communications frequency (it's within the range of human hearing), to thousands of GHz. Many types of wireless devices make use of RF fields, such as cordless and cellular, radio and television broadcast stations, satellite communications systems, and two-way radio services. The lower the frequency is, the higher the wavelength.

Wi-Fi (802.11)

Wi-Fi is an open standard technology that enables wireless connectivity between laptops and local area Networks. Today's Wi-Fi products, which transmit in the unlicensed spectrum at **2.5GHz**, are capable of speeds of up to **11 Mbps**, about seven times faster than a typical TI connection. A few years back, when Wi-Fi transmission speeds were much slower, this system appeared to have little value. But as the technology evolved, the benefits became apparent. Cooperate users found it convenient to be able too more around the office (or campus) without the need for a physical LAN connection. And Wi-Fi had the additional ability to connect outside buildings as well. ¹ The biggest benefit is not having a string wires across rooms.

These wireless access technology can be applied to places like airport, hotels, restaurants. One example is that Microsoft and Starbucks will begin offering Wi-Fi access starting from this year.

These in door wireless access technologies provide an alternative of using the Wireless device in door to transmit Voice through local LAN while maintain a hi-speed of data transmission through IP system. The alternative challenge the 3G technology and market, which aim to improve the of data transmission in Voice device.

Bluetooth

Bluetooth is a proposed open specification to standardize data synchronization between dis parate PC and handheld PC devices. The idea of bluetooth is to create a single digital wireless protocol to address end-user problems arising from proliferation of various mobile devices – including smart phones, smart pages, handheld PCs and notebooks- that need to keep data consistent from one device to another. Bluetooth operates using FM modulation combined with frequency hopping (1,600 hops per second) to lesson interference. The nominal link range is 10 meters, and the gross data rate is **1 Mbps**. Bluetooth radios will operate in a picocell topology in the 2.4 GHz range of unlicensed ISM (Industrial, Scientific and Medical) spectrum. The bluetooth baseband technology will support both SCO (Synchronous Connection Oriented) links for voice and AC (Asynchronous Connectionless) link for Packet data.

Bluetooth can support

1. an asynchronous data channel in asymmetric mode of maximally 721 kbps in either direction and 57.6kbps in the reverse direction; alternatively, the data channel can be supported in symmetric mode of maximally 432.6 kpbs
2. up to three simultaneous synchronous packet voice channels
3. A channel which simultaneously support both asynchronous data and synchronous voice. Full-duplex communication will be supported using TDD (Time Division Duplex) as the access technique. Voice coding will be accomplished using the CVSD (Continuously variable slope Delta) modulation technique. Security will be provided through encryption and authentication, using the challenge-response mechanism. Frequent hopping, a spread spectrum technique is used to improve performance in the unlicensed and heavily used ISM band.

¹ Why Wi-Fi is the next big thing, by William Gurley – Above the Crowd. Fortune March 5, 2001

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Appendix C: Interviews and Presentations

Adam Dean, Business Development, Go2Call.com
Ed Benforado, Business Development Manager - Smart Phones, Motorola
Eric Hampel, Strategy Consultant/ Certification Management, Siemens
Fabian De La Rua, CEO Selig. Wireless content portal and WAP
First Tuesday Event, January 17 2001: Mobile Wednesday
Janice Webb, Senior Vice President, Motorola/ Internet Software and Content Group
Jay Peir, Product Manager, Covigo
John Nix, Founder, Go2Call.com
Larry Spear, Founder, Go2Call.com
Mikel Manitiuis, Chief Wireless Architect, Sun Microsystems
Robert Lutz, Sun Microsystems
Troy Roberts, Vice President, Clarent Corporation – VOICE over IP
Wilson Monteiro, General Manager ABB (Asea Brown Boveri), Brazil

Appendix D: Websites

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