THE ROLE OF VOIP: FUTURE EVOLUTION PATHS OF VOICE COMMUNICATIONS

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Abstract

This paper analyzes the future evolution paths of voice communications services. The focus is on defining the role and success potential of different types of VoIP services, ranging from IM-like do-it-yourself VoIP to operator-managed VoIP services with QoS guarantees and PSTN interconnectivity.

The paper proposes a simple model for voice service classification, and analyzes the end-user value and market potential of different VoIP services classes. The concepts of network effects and disruptive technologies form the framework for analyzing the evolution paths of voice communications from circuit-switched networks to VoIP services. Substitution effects between fixed, wireless, and mobile domains are recognized as an important factor affecting the success potential of VoIP services. Based on the discussion, some remarks are made regarding the QoS and pricing issues of different types of VoIP services.

Key Words

VoIP, instant messaging, disruptive technology, network effects

1. Introduction

During the past decade, the communication habits of people have changed tremendously. Technologies such as e-mail, mobile telephony, and SMS messaging have become an important part of every-day communication for the majority of the people in developed countries. Emerging technologies such as MMS, instant messaging, push-to-talk, and different types of VoIP services are currently being taken into use in the markets. All of these technologies are generally serving the same purpose, the inherent desire of people to communicate with each other.

Figure 1 illustrates these different communications means. In the figure, person-to-person communications services are placed on a matrix based on two different qualities. Firstly, the services are divided into three groups: mailing, messaging, and calling, based on the immediacy of the communication. Secondly, the services are differentiated on the basis of the content that can be conveyed by them, i.e. text, images, voice, or video.

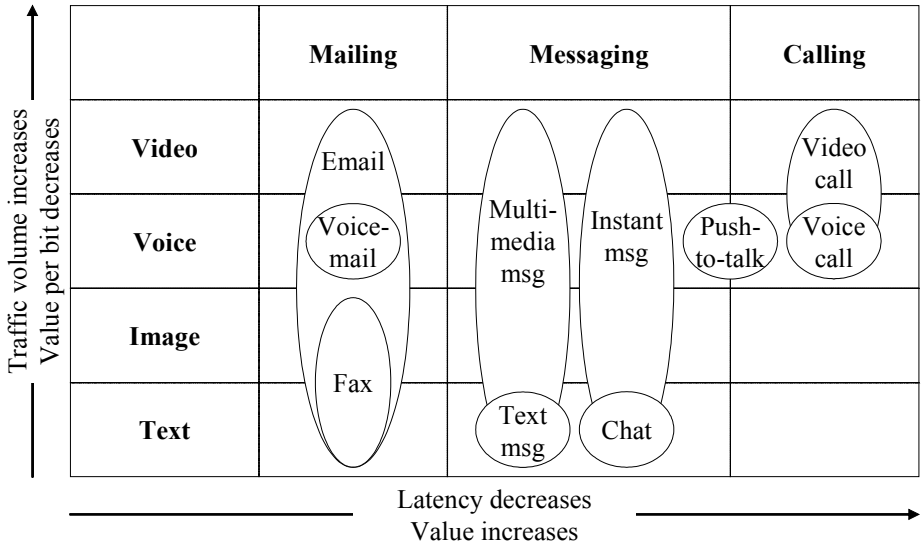

Figure 1: Classification of person-to-person communications services

In the figure, the latency requirements of the services become stricter when moving from left to right (from mailing to calling), and the end-user value increases. Capacity requirements increase when moving from bottom to top (from text to video), whereas the end-user value per transmitted bit usually decreases. Other dimensions of end-user value not shown in the figure include e.g. mobility and reachability of the users, as well as the technical quality of the calls.

Mobility increases the value of telephony services by allowing people to maintain their ability to communicate regardless of time or place. This "anywhere, anytime" dimension removes the location dependence of voice communications and brings value e.g. in increased productivity of business users. The other dimension of mobility is that it makes people more reachable: most people are always carrying mobile phones and rarely turn them off. Increased reachability increases the network value as the number of on-line users in the network increases.

In addition to fixed and mobile networks, there exist a number of wireless technologies that provide local mobility inside e.g. a home or office building. Cordless phones utilizing radio technologies such as DECT can be used as a wireless extension to fixed PSTN networks. In packet-switched IP

networks, Bluetooth and various WLAN technologies can be utilized. Table 1 shows the categorization and examples of different technologies in different network domains.

Table 1: Examples of technologies in different network domains

	Fixed	Wireless	Mobile
Circuit-switched	PSTN, ISDN	DECT Bluetooth	GSM UMTS CS
Packet-switched	ADSL Cable	WLAN Bluetooth	GPRS/EDGE UMTS PS

The technical quality of voice communications depends on the codecs used in the terminals and on the QoS characteristics of the networks (e.g. available data rates, delay/jitter values, and experienced packet loss). MMS and non-optimized push-to-talk messaging services may experience end-to-end delays of over 10 seconds. Push-to-talk over Cellular (PoC) services specified by the Open Mobile Alliance (OMA) are required to have significantly smaller end-to-end delays of less than 1.6 seconds, whereas the reference end-to-end delay limit for good-quality circuit-switched phone calls is 150 milliseconds. (OMA 2004, ITU-T Rec. G.114)

2. Conceptual framework

2.1 Network effects

Network effects, as defined by Katz & Shapiro (1985), are present in goods for which *"the utility that a given user derives from the good depends upon the number of other users who are in the same "network" as is he or she"*. Person-to-person communications is a perfect example of services experiencing network effects. For more detailed discussion on the terminology and different types of network effects, see Liebowitz & Margolis (1994).

Because of the network effects, the value of a certain network service increases with the number of people using it. Three different “laws” have been proposed for modeling the growth of network value as a function of the number of users. Broadcasting services such as news sites aimed at individuals benefit from additional users in a linear way, following the so-called Sarnoff’s Law (value ~ n). Services aimed at facilitating transactions, such as marketplaces and auction sites, follow the Metcalfe’s Law where the network value grows as approximately square of the number of users (value ~ n^2). Services aimed at building communities follow the Reed’s Law, where the value grows in exponentially due to the group-forming dynamics (value ~ 2^n). (Reed 1999)

The network effects related value of VoIP varies considerably between different types of VoIP services. Some services provide interconnection to traditional PSTN and mobile networks, whereas some are totally independent and based on proprietary technologies with no interoperability or interconnectivity. Furthermore, some services are available only on fixed networks whereas some are enabling use also on wireless and mobile devices.

Technical fragmentation decreases the value of network services. A good example is the current instant messaging (IM) market, which is dominated by three major players providing proprietary services: Yahoo!, AOL, and Microsoft. In the consumer market, none of the three services are interoperable, which reduces the value of all. As a side-effect, new "multi-network" IM services have emerged in the market, integrating many different IM protocols in one software client and allowing users to connect to many IM services using a single user interface.

Interconnection arrangements increase the value of network services. VoIP services interconnecting with PSTN and mobile networks have higher value for the users, as they provide the ability for people to communicate also with non-VoIP users. Many of the VoIP services provided by incumbent telecom operators are providing interconnectivity with traditional services.

User on-line time is also an important variable having an effect on the value of network services. Although the fixed telephone network reaches the majority of households and businesses in developed countries, the users are not reachable when outside their homes or offices. Mobile networks providing effectively ubiquitous access have a positive impact on the value of telephone networks, making users in practice "always on-line".

2.2 Technological innovation and disruptive technologies

VoIP services are currently taking over markets traditionally served by circuit-switched PSTN networks. This kind of technological discontinuity is inevitable in all industries and markets, as new innovations replace existing technologies. Issues related to technological evolution and discontinuities as well as adoption of new technologies and innovations have been studied extensively in economics and management sciences. For a literature review on typology and terminology of technological innovation, see (Garcia & Calantone 2001).

A useful concept for analyzing different types of VoIP services is the one of sustaining and disruptive technologies and innovations by Christensen (1997). Sustaining technologies are such that improve the performance of established products along dimensions that customers have historically valued. Disruptive technologies, on the other hand, are initially underperforming the established products when measured by the historically valued metrics. They have other features that are initially

valued by a small amount of customers either in a new market or at the low end of the existing market. Products based on disruptive technologies are typically cheaper, simpler, smaller, and often more convenient to use. Figure 2 illustrates the difference between of sustaining and disruptive technological change.

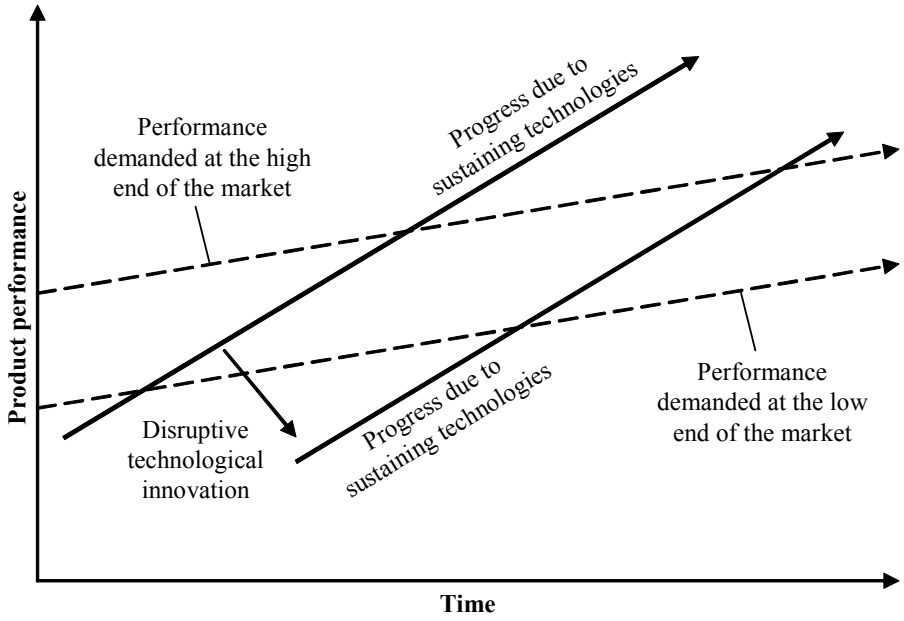

Figure 2: Sustaining and disruptive technological change (Adopted from Christensen 1997)

As shown in the figure, technologies can progress faster than market demand. The performance of products in the market eventually overshoots the market, giving customers more than they need and are willing to pay for. This leaves space for initially underperforming disruptive technologies that may be fully competitive in the future. (Christensen 1997)

Christensen & Raynor (2003) distinguish between two different types of disruptions: low-end and new-market. Low-end disruptions attack the least profitable and most over-served customers at the low end of the original value network. New-market disruptions, in contrast, compete against non-consumption, creating a new value network. For recognizing the low-end and new-market disruptive potential, Christensen & Raynor introduce a set of questions to be considered. This "three litmus test" is illustrated in Figure 3.

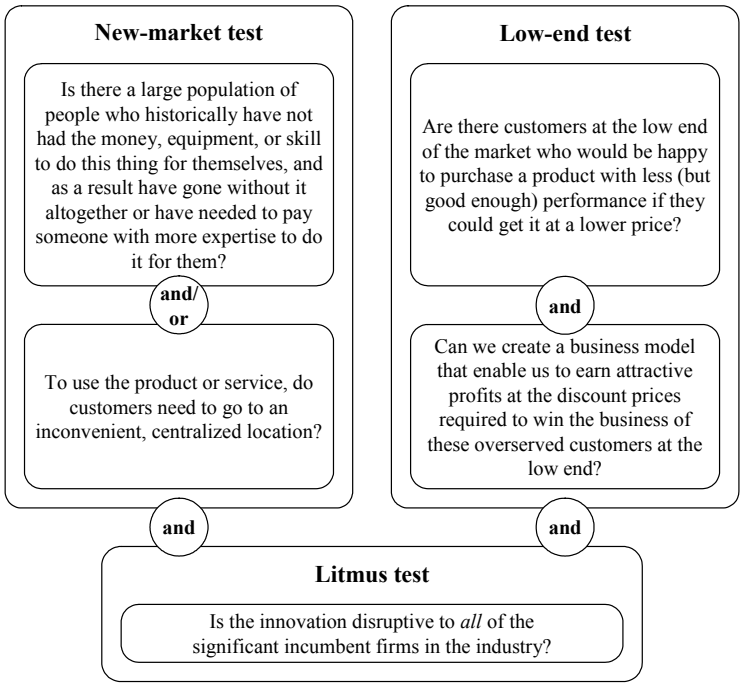

Figure 3: Three litmus test for recognizing disruptive technologies (based on Christensen & Raynor 2003)

In our view, the emergence and evolution of different types of VoIP services include both sustaining and disruptive types of technological advances, discussed in more detail later. From the point of view of incumbent telecom operators, it is important to recognize the disruptive potential of different VoIP services, as they might provide possibilities for new entrant firms to overtake the businesses of the incumbents.

3. Different classes of VoIP services

When discussing VoIP services, extra caution is required to separate "apples from oranges". A number of different types of VoIP services exist, with different players managing the required network infrastructure and servers. Differences exist also e.g. in the pricing schemes, addressing models, level of interconnection to PSTN and mobile networks, and in the level and effects of regulation.

The scope of this paper is limited to VoIP services actually used and experienced by consumers and business users. The use of IP networks as part of operators' backbone networks or as trunk lines between privately owned PBXs is out of scope. Accordingly, we recognize three fundamentally different classes of VoIP, named after an analogy to existing, well-known services and systems. The classes are PBX-like VoIP, PSTN-like VoIP, and IM-like VoIP, and their characteristics are summarized in Table 3.

Table 2: Characteristics of different classes of VoIP

	PBX-like VoIP	PSTN-like VoIP	IM-like VoIP
Examples	Cisco CallManager,	Vonage, Net2Phone (U.S), Ipon, Sonera Puhekaista (Finland)	MSN Messenger, ICQ, Yahoo! Messenger, Skype, AOL Instant Messenger
Domains	Fixed, Wireless	Fixed, Wireless	Fixed, Wireless, Mobile
Typical users	Large enterprises, SMEs	Consumers, Small businesses	Consumers
Managed by	Corporation (IP PBX) / local service provider (IP Centrex)	Broadband ISP / local service provider	Global service provider
Typical pricing scheme	Free calls inside the LAN. PSTN-like pricing on outgoing calls.	Free / low-cost calls to other VoIP users. PSTN-like pricing on outgoing calls.	Free calls to other VoIP users. PSTN-like pricing on outgoing calls.
Global phone numbers allocated to users	Yes	Yes	No
PSTN-interworking	Two-way	Two-way	Only outgoing / none
QoS control	High	Medium / Low	Low
Regulation	Regulated as private ECS	Under discussion. (Regulated as PATS in Finland)	Not regulated

3.1 PBX-like VoIP

PBX-like VoIP systems are deployed by companies as replacements to existing circuit-switched PBX and Centrex systems. Analogous to the circuit-switched systems, companies can manage the VoIP service by themselves or outsource the management to specialized service providers. The alternatives are commonly described as IP PBX and IP Centrex, respectively. Many of the corporate VoIP systems are based on standardized technologies and protocols, but the systems usually have proprietary enhancements and extensions and are generally non-interoperable between manufacturers.

In corporate VoIP systems, the company-internal voice calls inside office buildings and between branch offices are carried using an IP-based data network. External calls to and from the PSTN networks are interconnected through VoIP gateway devices. In the internal IP network, it is possible to use either special VoIP phones or software clients installed in PCs, and some manufacturers have introduced also WLAN-enabled VoIP handsets.

In corporate VoIP systems the IP network is private. Therefore, the QoS level of the VoIP calls can be more easily controlled and managed than in public VoIP services.

3.2 PSTN-like VoIP

PSTN-like VoIP class includes services targeted mainly for households as a replacement for the primary or secondary fixed PSTN lines. The services are provided by broadband ISPs as well as independent third-party service providers. Subscribers are allocated phone numbers from national numbering plans, and the services provide two-way interworking between IP and PSTN networks. The subscribers can connect to the services in three ways, either by using special adapters to connect regular analog phones to the broadband modems, by using special VoIP phones, or by installing a so-called soft-phone software client on their PCs. It is also possible to connect cordless phone systems to the adapter, or use WLAN-enabled VoIP phones.

PSTN-like VoIP services are straightforwardly competing with the traditional PSTN telephony services. The pricing of IP-to-PSTN calls is driven by the terminating costs of the PSTN network operators, whereas intra-provider IP-to-IP calls typically carry lower prices or are completely free-of-charge. An important differentiator to traditional PSTN services is the inherent portability of the VoIP service, meaning that subscribers can connect their phone adapters to any location provided with Internet access, and place and receive phone calls from their own number.

The regulation of PSTN-like VoIP services is currently an open topic. For an overview of the VoIP-related issues in the European regulatory framework, see (Analysys 2004).

3.3 IM-like VoIP

The third class consists of instant messaging (IM) –like VoIP services. The services are typically provided by a global service provider as a part of broader instant messaging service integrating e.g. text messaging, video calls, and file transferring. The most popular services are currently Yahoo! Messenger, MSN Messenger, AOL Instant Messenger, ICQ, and Skype. The services are typically based on proprietary non-interoperable technologies and protocols.

IM services require a special software client to be downloaded and installed on PCs or other computing devices such as PDAs or smart phones. Before being able to communicate with each other, users have to log in to the IM service, which can be running either on centralized servers or be decentralized using a peer-to-peer type of approach. The IM service keeps the presence state (e.g. on-line, busy, away, out-to-lunch) of each user, and communicates it to other users. Communications is possible in one-to-one or one-to-many fashion, and usually only between people that have authorized each other for the communication. The users are not associated with any global phone numbers as is the case in the other classes, implicating that although IP-to-PSTN calls may be possible, PSTN-to-IP calls are not.

The most appealing feature of the IM-like VoIP services is that they are usually "free" to use, i.e. the user only has to pay for the Internet access. Instead of charging the users for the VoIP services, the service providers are currently relying on other business models, such as selling advertisement space and charging for calls to PSTN networks.

In most countries, IM-based VoIP services are currently not facing any regulatory requirements.

4. Evolution paths and transition effects

In this section, possible evolution paths of voice communications are presented and analyzed. The "big picture" underlying the discussion is shown in Figure 4.

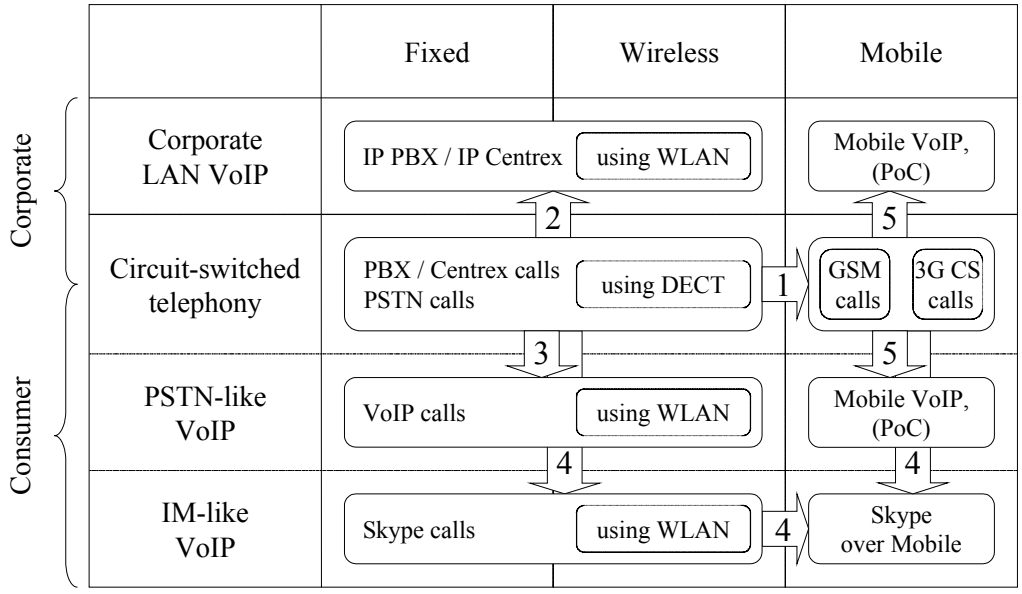

Figure 4: Evolution paths of voice communications

The arrows in Figure 4 illustrate our view on the most important future evolution paths in the voice communications market. Today, most of the voice calls take place in the circuit-switched networks. A major transition is happening from fixed to mobile networks (arrow 1), commonly known as fixed-to-mobile substitution. Another clearly visible trend is the transition of corporate voice traffic from circuit-switched to VoIP systems (arrow 2). In the consumer market, PSTN-like VoIP services are being offered by both incumbent operators and new players (arrow 3). Independently from this evolution, IM-like VoIP is also becoming more and more popular, first in fixed and later in mobile networks (arrows 4). Finally, there exists a possible evolution path towards operator-driven mobile VoIP services, both for the consumer and corporate PBX markets (arrows 5).

In the following subsections, the most visible ones of these evolution paths are discussed in more detail. The concepts of network effects and disruptive technologies introduced in Section 2 are used as a basis for the discussion. Selected examples from various markets are used to clarify and illustrate the evolution paths.

4.1 Fixed-to-mobile substitution

Fixed-to-mobile substitution (FMS), meaning the substitution of subscriptions and calls from fixed to mobile networks, is a major trend acting as barrier and competitor to different VoIP evolution paths. In the European Union, the penetration of mobile subscriptions is already over 80% and there is evidence that fixed-line calls are increasingly being replaced by mobile calls. Finland has experienced the effects of fixed-to-mobile substitution earlier than most of the other European countries. Figure 5 shows the evolution of the number of calls and call minutes originated in fixed and mobile networks during the years 1995-2003. The FMS effect is clearly visible from year 2000 onwards.

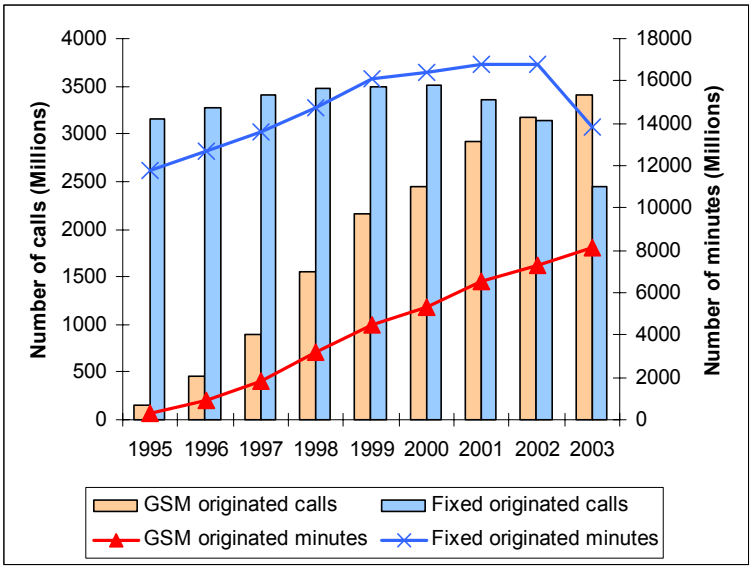

Figure 5: Numbers of outgoing calls and call minutes from fixed and mobile phones in Finland 1995-2003 (Source: Statistics Finland 2004)

Network effects act as an evident driver for FMS, as discussed earlier in Section 2.1. Mobile subscribers are usually carrying the phones all the time and rarely turn them off. Whenever there is a need for a person to either place or receive a phone call, the mobile phone is available, if any. Although the fixed-line possibility might exist, the convenience of using a single, assured way of communicating starts to dominate. Furthermore, as the fixed-to-mobile tariffs are often higher than

mobile-to-mobile tariffs, subscribers have an incentive to start using only mobile phones for voice calls.

Some recent developments in wireless technologies such as WLANs can be seen as a barrier to FMS. Although users might prefer using a single mobile device for placing and receiving phone calls, the calls do not necessarily have to utilize mobile networks. In locations where WLAN or Bluetooth coverage is available, dual-mode handsets could use these unlicensed networks for VoIP calls and data sessions. The unlicensed networks can be privately owned by companies and consumers, but also by the mobile operators. Interworking between cellular and unlicensed networks is currently developed in 3GPP as well as in a recent industry initiative called Unlicensed Mobile Access (UMA 2004).

4.2 Evolution towards PBX-like VoIP

The second evolution path already clearly visible in today's communication market is the substitution of corporate PBX systems from circuit-switched to IP-based technologies. This evolution path is competing with the fixed-to-mobile substitution trend, and the two can be seen as barriers to one another. Common arguments for PBX-like VoIP systems include the reduced cost of building and maintaining a single, integrated voice and data network infrastructure, as well as the possibility to use new, enhanced services provided by the VoIP system. Furthermore, the easy portability of VoIP terminals from one physical location to another reduces administrative work-load costs.

From the point of view of network effects, PBX-like VoIP systems have very similar characteristics to traditional PBX and Centrex systems. The systems provide a private, company internal addressing space, as well as interconnection to global PSTN networks using globally addressable phone numbers. The emergence of mobile handsets supporting WLANs and VoIP will improve the mobility and reachability of VoIP users, much in the same way as DECT in the circuit-switched systems.

When applying the concepts of disruptive technologies on the PBX-like VoIP systems, we conclude that the systems present more sustaining than disruptive type of technological evolution. The systems are not conforming to the definition of new-market disruptions, as they are fulfilling essentially the same needs than traditional PBXs. The systems are not a good fit for low-end disruptions either, as the value proposition is usually to provide more advanced PBX features than in circuit-switched systems.

4.3 Evolution towards PSTN-like VoIP

PSTN-like VoIP services have recently emerged in the consumer and SME market, providing an alternative to traditional PSTN services. The services are driven by the increasing penetration of broadband Internet subscriptions and competitive offers of new players in the service provider market. The services are provided by broadband ISPs (both incumbents and new entrants) as well as third party service providers providing only the VoIP service on top of Internet access service provided by someone else.

The market for PSTN-like VoIP services is still in its infancy, and the services have not yet achieved very significant user bases. In the U.S., Vonage has currently over 300.000 lines in service and is adding about 25.000 new lines per month (Vonage 2004). In June 2004, 600.000 or 25 percent of the Finnish households were subscribing to broadband services, and the number of PSTN-like VoIP lines was approximated to be 10.000 (Tikkanen et al. 2004).

The PSTN-like VoIP services can straightforwardly utilize the network effects of interconnection to global PSTN networks. Phone numbers are allocated to all the subscriptions from the national numbering plans, thus making the subscribers globally reachable. VoIP software installed in WLAN-enabled terminals can be used to improve the mobility and reachability of the service, and it is also possible to connect a circuit-switched cordless phone system to the service using the VoIP adapter.

In our view, the PSTN-like VoIP service represents more a sustaining than disruptive type of technology. It does not have potential to be a new-market disruption, as the penetration of similar PSTN and mobile services is already almost 100% among the households and SMEs in the developed countries. It could pass the low-end disruption test, as there likely exists subscribers that would be happy to subscribe to a lower-cost telephony service, provided that they have an existing broadband subscription. However, the PSTN-like VoIP services are certainly not disruptive to all the incumbent operators of the telecom industry, as many of these are providing these kinds of VoIP services themselves. Therefore, the services fail the final litmus test, and can not be considered to be a disruption.

4.4 Evolution towards IM-like VoIP

In contrast to the other, generally sustaining types of evolution paths, the IM-like VoIP services represent a more disruptive type of technology evolution. Whereas the other VoIP types are more strongly tied to the business models and value networks of the traditional telecom industry, IM-like services have their roots in the Internet and web world. The IM-like services are characterized by the presence-based addressing of users. The users are reachable and can reach other users only when

logged in to the service, and are not allocated any global phone numbers. Therefore, the control and management of the service and its features is extremely centralized to the hands of few global players. The most powerful players in the market include Microsoft, Yahoo!, and AOL, as well as a smaller new entrant Skype.

Usually, the IM services use a centralized directory for the associating static usernames and identities with dynamic IP numbers of users. These directories also keep track on the presence state of the users. Skype differs from the other services in that it is not using this kind of a central directory. Instead, it is relying on a decentralized directory, utilizing a peer-to-peer type of multi-tiered network architecture. A certain amount of users act as so-called supernodes, communicating with each other so that each one has a full knowledge of all available users. This is claimed to improve the scalability of the system and bring cost savings (Skype 2004).

IP-to-IP calls using IM services are typically free, and some of the services provide also a possibility to make IP-to-PSTN calls with competitive tariffs. PSTN-to-IP calls are not possible, as the users are not identified by any global phone numbers. Despite this shortcoming, clear evidence of demand for these kind of services exists. As an example, during its first year of operation Skype was downloaded by over 12.9 million different users, and the number of simultaneous users currently exceeds 1 million. (Skype 2004)

The network effects in IM-like services are more problematic than in the other VoIP classes. The current services are all based on proprietary non-interoperable technologies and protocols, decreasing the end-user value of the services. Each service provider is trying to reach the critical mass and produce the dominant design to the market, but none of them have succeeded so far. Standardized solutions have been developed in IETF on two different tracks, including the recently published set of XML-based Extensible Messaging and Presence Protocols (XMPP, Saint-Andre 2004) and SIP-based solution under development in the SIMPLE working group (IETF 2004). Services conforming to these have not reached any substantial subscriber base yet. For more information on the network effect related market power aspects in the IM market, see Faulhaber (2002).

In our view, IM-like VoIP is a low-end disruptive technology, passing the three litmus tests as defined by Christensen & Raynor (2003). Firstly, there exist customers who are willing to use the services even though the technical quality is lower than in the existing PSTN services as a result of non-interoperable services and lack of two-way interconnection to existing networks. Secondly, we believe that it is possible for at least some of the service providers to create business models that allow them to also earn profits even though the IP-to-IP telephony service would remain free. Current models are mostly based on advertising revenues and charging of IP-to-PSTN calls. Peer-to-

peer type of IM technologies such as the one used by Skype are also likely to reduce the required investments on centralized server capacity, helping to build sustainable business models. The third and final test requires the innovation to be disruptive to all the significant incumbent firms in the industry. In our view, this is also true, as none of the incumbent telecom operators could consider IM-like VoIP to be a sustaining innovation to their existing services.

IM-like VoIP represents a new way of voice communications between people that could be described as a sort of "club voice" service. The IM systems enable and require users to form club-like groups of friends, relatives, and colleagues, between which the communication takes place using presence information as an aid to forward the calls correctly. Two-way interconnection with public PSTN-like services with global phone numbers is not possible, but the users are willing to accept this as the incentive of free calls is very strong.

Only a certain, quite small amount of voice calls are currently able to utilize the IM-like way of communication. In most cases, the call participants have to be subscribed and logged-in to the same IM service, and sit by their home or office PCs equipped with microphones and speakers. Understandably, the network effect related value of such service is quite low. In the near future, however, the users might have WLAN coverage in their homes and offices and IM software running on their WLAN-enabled mobile phones. Full-quality IM-like VoIP services will most probably not be running over mobile networks in the near future because of opposite interests of mobile operators, but there will undoubtedly be room for lower-quality push-to-talk type of VoIP services also in the mobile domain.

5. Service quality and pricing

The IP network architecture is driven by the rapid growth of best effort traffic. Due to increasingly high router capacities, decreasingly low latencies, and statistical multiplexing voice calls already now achieve sufficient end-to-end quality in the backbone and broadband access networks in the absence of congestion. In practice, congestion is an issue only in the edge routers, but this is proposed to be solved using local prioritization and access control in favor of delay-sensitive traffic (see e.g. Roberts 2004). The cellular radio spectrum is a scarce resource and more sensitive to IP congestion, but local prioritization is likely to ultimately solve the issue of voice quality also in wireless access.

The IP paradigm causes a fundamental change to the voice service architecture by separating the control plane from the user plane. This separation is visible both in the standardized architectures such as SIP, and in the proprietary ones such as Skype. One implication is that the business responsibilities of the voice control servers and the IP transport network are often assigned to

different operators. This separation of business responsibility suggests that also the pricing of control and transport will become separate.

The operator of the voice control servers will charge subscribers for call control transactions. If the regulator requires strict tracking and storage of call data, the control operator may be able to justify pricing per transaction, although it is simpler to assume flat rate pricing to take place as monthly subscription fees. The IP transport operator, on the other hand, has little reason to separate the pricing of voice traffic from the general IP transport. In the long run, voice is likely to be part of the flat rate or volume-based pricing of the general IP transport. Among other things, this means that distance disappears as a pricing parameter.

This new separated pricing structure is emerging first for the aforementioned "club voice" services, i.e. the IM-like VoIP services not dependent on interoperability with the legacy PSTN voice services. The PSTN-like VoIP service is evolution maintains the interoperability with PSTN, extending it also to pricing mechanisms. For these services, this implies a rather slow evolution toward the new VoIP pricing structure.

6. Conclusions

In the paper, we presented possible evolution paths of voice communications, and the role of VoIP services as part of this evolution. Fixed-to-mobile substitution was recognized as the strongest barrier to VoIP evolution. Consumers and business users are increasingly using mobile phones as their only communications devices, decreasing the market potential of VoIP services targeted mainly to the fixed domain. On the other hand, the emergence of WLAN-like technologies in private home and office networks, as well as in multi-mode mobile handsets can increase the potential of VoIP services.

In the paper, three different classes of VoIP services were introduced, and their role as part of future voice communications infrastructure analyzed. Whereas the evolution of PBX-like and PSTN-like VoIP classes was found to be sustaining in nature, the IM-like VoIP services represent a more disruptive type of technology evolution. The IM-like VoIP services are still experiencing considerably lower levels of network effects than other voice services, but the argument of WLANs as VoIP service driver applies also here.

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