IP Telephony: The technology which will see off the PSTN

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Introduction

It's been some time now that expressions like "Voice over IP", "Fax over IP" and the likes are heard extensively in the telecommunications industry. These technologies, often termed "X over IP (XoIP)", are all considered as part of the new wave of IP Telephony services. The idea is utilizing data networks to deliver telecommunications services which are currently provided by the Public Switched Telephone Network (PSTN). The incentive is pretty straightforward: cutting costs and yet being able to provide the previous services, not to mention the added capabilities to deliver a multitude of other services, hardly imagined feasible with the PSTN.

Venturing into the actual implementation has proved to be a hard-to-overcome challenge and a plethora of standards are still being considered to make the new architecture a reality. Description of the main problem in short, is that the current data networks, e.g. the Internet, have not been designed with telecommunications services in mind. They have been optimized to carry data which is bursty in nature. With bursty, we mean a discrete series of packets of data which travel through the net from a source to a destination with frequent idle times in transmission. It is not strictly continuous and generally the users don't mind the jitter and extended delays of the data packets; examples applications are E-Mail, Transaction processing and file transfer. This design is in obvious contradiction to the requirements of the telecommunications services. Specifically, they need a network infrastructure which is either connection-oriented in nature or at least can resemble its behaviors and therefore is able to guarantee a stream of data free of any kind of interruption.

Fundamentals -The PSTN versus the Internet (Switching Modes and Networking Modes)

Switching modes and networking modes are arguably the main distinctions between the PSTN and the Internet [1]. Inclination towards connection-oriented networks is gaining momentum as real-time applications are becoming more and more important. In this mode of networking, the connection is setup first and the intended information for transmission follows the same path from the source to destination. A connection-oriented network can either use circuit switching, like PSTN, DWDM and SDH/SONET networks, or packet switching, like X.25, Frame Relay, and ATM networks (Virtual Circuits).

On the other hand, in a network operating in connection-less mode, there is no connection setup before the transmission of the actual data, and the data packets are routed based on the information which their headers provide. Because of this individually addressed and routed behavior of packets, real-time applications face an uncertain amount of end-to-end delay. It should be mentioned that only packet-switched networks can be in connectionless mode (Datagram Switching). The famous and most visible example of this type of network is the Internet. The relations between different networking and switching modes are depicted in the Table 1.

Table 1. Relation between networking and switching modes (Adapted from [1])

Connection-Orientated		**Connectionless**
Circuit Switched	**Packet Switched**	
	Virtual Circuit	**Datagram Switching**

Features of Internet Telephony

Having talked about the motivation behind Internet Telephony and given a quick overview of the basic differences between the Internet and the PSTN,we now move on to introduce the rich features of this emerging technology [2].

Adjustable quality: As the parameters of the connection can be negotiated by the end-users, if supported by both parties, they can opt for a very high quality, hence high bandwidth, communication, or they can choose to use minimal bandwidth and hence have a low quality communication.

Security: As known to all, the basic Internet communication, does not provide security. But, by using encryption in both signaling and media exchange, secure communications can be realized in Internet Telephony.

User identification: User identification features in PSTN are very rudimentary compared to what can be provided through protocols utilized for Internet Telephony.

User interface: Access to services provided by PSTN is through a rather limited handset and through utilization of often cryptic set of digits and characters. The graphical user interface of Internet Telephony passes through this barrier and offers an intuitive interface to its user.

Feature Ubiquity: The current offered services are often tied to some specific carrier and even a rudimentary feature like Caller ID is not supported in all international calls. Internet Telephony does not suffer from this problem since the Internet protocols are internationally recognized and utilized.

Shared facilities: The most important result of utilization of Internet Telephony is the fact that carriers are concerned with maintenance of one single network, hence reducing the service prices for end-users.

Advanced services: As the Internet protocols offer extensive flexibility, developing new and advanced services in Internet Telephony has proved to be much simpler compared with PSTN environment.

IP Telephony Technologies

Among the numerous technologies and protocols that make up the whole IP Telephony structure, we briefly mention the most discussed parts which are Quality of Service (QoS) provisioning structures and Call Signaling [3].

There have been various structures proposed to provide QoS in data networks over the last few years, among them are Integrated Services (IntServ) [4], Multiprotocol Label Switching and its Generalized form (MPLS/GMPLS)[5] and Differentiated Services (DiffServ) [6]. Since discussing about their details are out of scope of this article, we only mention few characteristics of DiffServ which is the simplest one. The focus of the designers of DiffServ was on producing a less complicated architecture compared to other previous architectures and to IntServ in particular. That is, sophisticated classification, marking, policing, and shaping operations are performed only at network boundaries, allowing the other internal routers some breathing space. It uses Per-Hop Behaviors (PHBs) for classifying different types of traffic, levels of which, in descending order of priority, are Expedited Forwarding (EF), Assured Forwarding (AF) and Best Effort (BE).

Signaling comprises initiation, management and tear-down of sessions examples of which are fax, voice, video and the like. Currently there are two protocols that can provide an end-to-end solution: H.323 [7] and Session Initiation Protocol(SIP) [8]. H.323 is a binary protocol which consists of a complex suite of protocols that reuse many older services and methods borrowed from Integrated Services Digital Network (ISDN). Being binary, among other short-comings of H.323 in comparison with SIP which is text-based, makes H.323 a platform dependant protocol. SIP, in addition to other advantages, is capable of supporting user mobility by proxying and redirecting requests to the user's current location. One important difference between the two, is that H.323 is considered an umbrella protocol, on the other hand, SIP reuses many already well-established Internet protocols for performing its operation

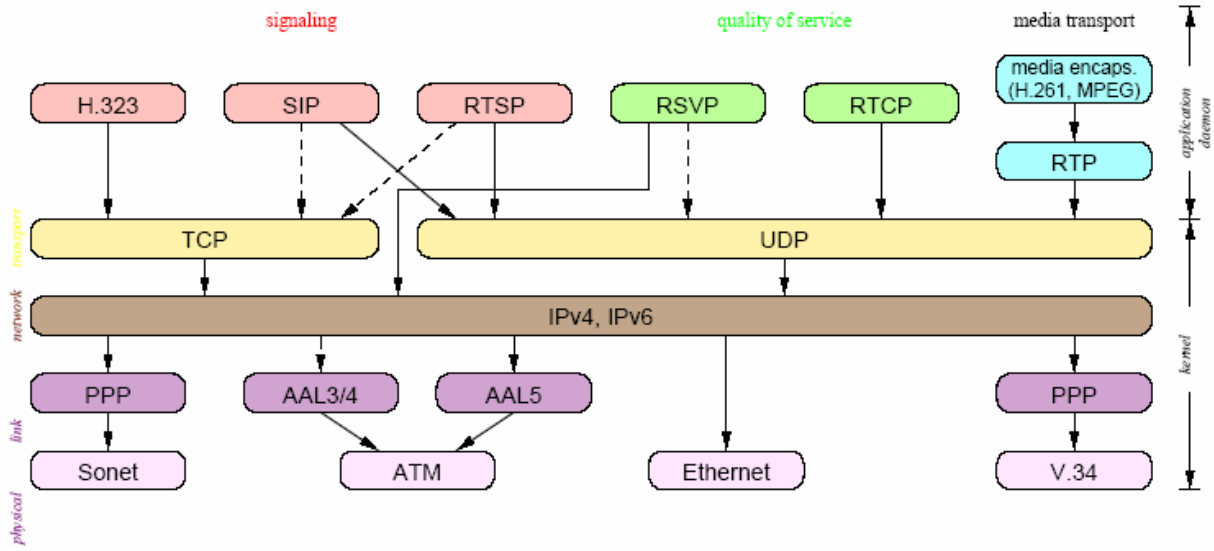

Fig. 1 Internet telephony protocol stack (Adapted from [2])

[9]. Hence, SIP seems to be the protocol of choice among other standards in the voice and fax transmission domains. It is worth mentioning that there are also some other centralized architectures such as MGCP [10] and H.248/Megaco [11], in which the call control and services could be centrally added to the network. These centralized architectures are losing the market to distributed ones in the new deployments. Figure 1 shows the Internet Telephony Protocol Stack which helps to grasp the relations between all these various protocols.

Fax over IP: A success story

It should be mentioned that fax parameters negotiation requires far more signaling with strict timing requirements compared to voice, and the direct result of this matter is the need for a higher quality of service. At the same time, any viable alternative infrastructure for providing telecommunication services has to be able to support the legacy equipment already in place in the user side. So, the case of real-time fax can be considered the ultimate test of the V/FoIP networks, if from which they come out successfully, the PSTN will be a technology only mentioned in history books in few years time.

Fax over Internet protocol (FoIP) has two possible approaches to be accomplished: Real-time (T.37 Rec.)[12] and Store-and-Forward (T.38 Rec.)[13]. Store-and-Forward or non-real-time usually uses E-mail capabilities to transfer fax between the end-points. In real-time approach [14], as the name suggests, fax is transferred in real-time manner and without delay; like the way we currently send fax using the PSTN. Real-time approach is the ultimate goal since it is the real-time faxing which makes the transition from the PSTN to the Internet-based architecture smooth.

A simple fax transmission scenario is depicted in Figure 2. Fax A communicates with T.38 gateway using the standard PSTN T.30 protocol [15]. In turn, T.38 gateway, which is a composite component, exchanges SIP signalling with other network's T.38 gateway. The T.38 Recommendation specifies the necessary SDP (Session Description Protocol) [16] headers in this SIP signaling. At the last stage of this chain, T.38 gateway of network B communicates with Fax B using the standard PSTN T.30 protocol.

IP Telephony Trends and Economics –Final Remarks

At this last section of this article, we would like to provide some tangible statistics measuring the current size of the industry [17], [18] & [19]. P.Jaffray (www.piperjaffray.com) reports that minutes of communication services traveling over IP telephony networks will grow from 70 billion minutes and 6% of all the PSTN traffic in the year 2003 to over a trillion minutes by the year 2006. In the United States alone, the PSTN is handling about 3.6 trillion minutes of traffic monthly.

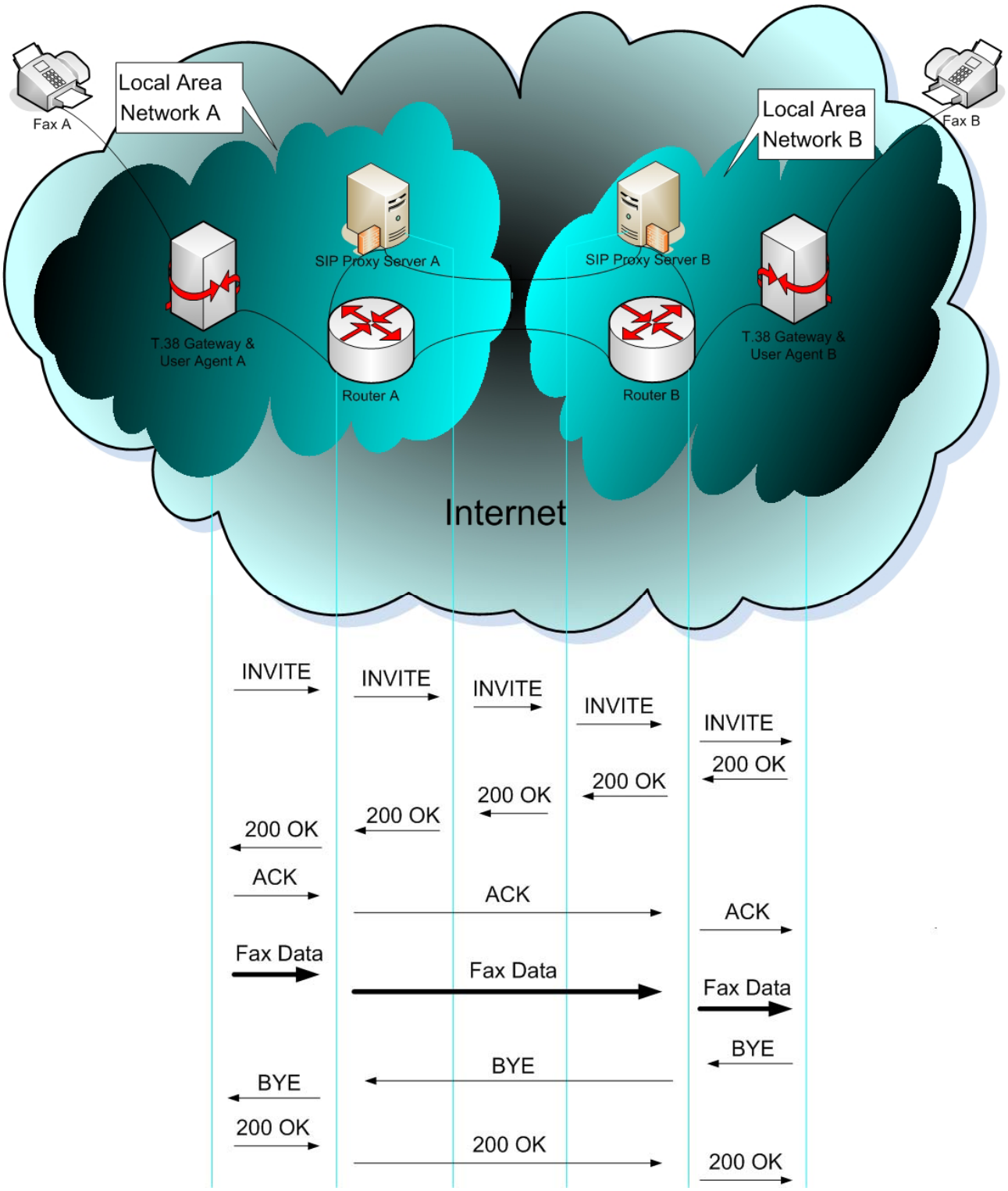

Figure 2. A fax transmission scenario

Most companies are unaware of just how much time and money is lost by traditional faxing. According to a Gallop/Pitney Bowes survey, the average Fortune 500 company spends $40 million per year on phone service, 40 percent of which goes to faxing. According to Kauffman Group, a fax technology consulting company, by switching to fax over IP, companies can save as much as 70 percent on their long distance phone bill. When calculating the full benefits of fax over IP, companies must take into account the cost of fax machines which can be as high as $2,000 to $3,000 per machine, the cost of operating and

maintaining those machines and the wasted labor. Companies can eliminate all of this by switching to fax over IP.

There are various statistics available showing the current size of this industry and a number of predictions regarding the growth of the market over the next years. While there are differences between these numbers, even the most conservative analysts are predicting phenomenal growth. Despite all these positive projections, there is an intense battle going on in various sections of the IP Telephony architecture with no unquestionable winner in most sections. As a result, the enterprises and small scale customers are caught in the confusion of the available standards and are trying to foresee the dominant market players. We finish our discussion of this hot topic here and would like to refer the interested reader to the resources mentioned at the end, for getting a comprehensive view on the topic.

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