International Journal of Advance Scientific Research
(ISSN – 2750-1396)
VOLUME 03 ISSUE 10 Pages: 221-232
SJIF IMPACT FACTOR (2021: 5.478) (2022: 5.636) (2023: 6.741)
OCLC – 1368736135

Journal Website: http://sciencebring.com/index.php/ijasr

Research Article

NETWORK ASPECTS OF IP TELEPHONY

Submission Date: October 14, 2023, **Accepted Date:** October 19, 2023,
Published Date: October 24, 2023
Crossref doi: https://doi.org/10.37547/ijasr-03-10-36

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Abstract

The material in the previous chapter gave, to a first approximation, the answer to the question: what is IP telephony? Before discussing in more detail the various approaches to architecture, protocols and options for building systems and equipment, it is useful to pay attention to another question: what is IP telephony for?

Keywords

Computer-phone. IP telephony. analog-to-digital converter (ADC). Domain Name System (DNS).

Introduction

To answer this question, consider the three most commonly used IP telephony scenarios:

– “Computer-to-computer”;
– “Computer-phone”;
– “Telephone-telephone”.

The computer-to-computer scenario is implemented based on standard computers equipped with multimedia tools and connected to the Internet.

The components of the IP telephony model for the computer-to-computer scenario are shown in Fig. 1. In this scenario, analogue speech signals from subscriber A's microphone are converted to digital form using an analogue-to-digital converter (ADC), typically at 8000 samples/s, 8 bits/sample, resulting in 64 Kbps. The digital speech data samples are then compressed by an encoder to reduce the bandwidth needed to

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transmit them by a ratio of 4:1, 8:1 or 10:1. Speech compression algorithms are discussed in detail in the next chapter [1-4]. The output data after compression is formed into packets, to which protocol headers are added, after which the packets are transmitted through the IP network to the IP telephony system serving subscriber B. When the packets are received by subscriber B's system, the protocol headers are removed, and the compressed voice data arrives at the device, which expands them into their original form, after which the speech data is again converted into analogy form using a digital-to-analogue converter (DAC) and enters the phone of subscriber B. For a typical connection between two subscribers, IP telephony systems at each end are simultaneously implemented as transfer functions, and receiving functions. The IP network shown in Fig. 1 means either the global Internet or the corporate network of an enterprise Intranet [5-9].

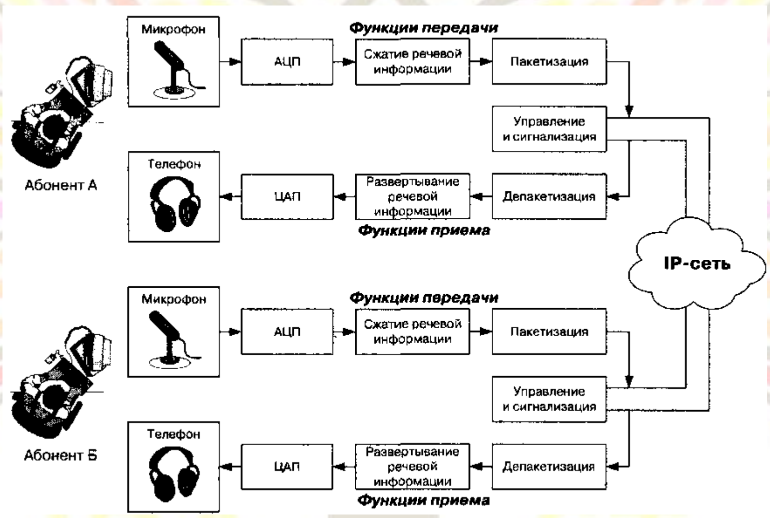

Fig. 1 Computer-to-computer IP telephony scenario

To support the computer-to-computer scenario, the Internet service provider should have a separate server (gatekeeper) that converts user names into dynamic IP addresses. The scenario itself is aimed at a user who needs the network mainly for data transmission and requires IP telephony software only occasionally for conversations with colleagues [10-14]. The effective use of computer-to-computer telephony is usually associated with increased productivity in large companies, for example, when organizing a virtual presentation on a corporate network with the ability not only to see documents on the Web server but also to discuss their contents using an IP phone. In this case, PSTN elements can be used between two IP networks, and identification of the called party can be carried out both based on E.164 and based on IP addressing. The most common software for this purpose is the Microsoft NetMeeting package, available for free download from Microsoft [15-19].

Let's consider the scenario for establishing a computer-to-computer connection presented in Fig. 1 in more detail.

To conduct telephone conversations with each other, subscribers A and B must have access to the Internet or another network with the IP protocol. Let's assume that such an IP network exists and both subscribers are connected to it. Let's consider a possible algorithm for organizing communication between these subscribers.

1. Subscriber A launches his IP telephony application that supports the H.323 protocol.
2. Subscriber B has already launched his IP telephony application that supports the H.323 protocol.
3. Subscriber A knows the domain name of subscriber B in the Domain Name System (DNS) element, enters this name in the "who to call" section in his IP telephony application and presses the Return button.
4. The IP telephony application contacts the DNS server (which in this example is implemented directly on the personal computer of subscriber A) to convert the domain name of subscriber B into an IP address.
5. The DNS server returns the IP address of subscriber B.
6. The IP telephony application of subscriber A receives the IP address of subscriber B and sends him an H.225 Setup signalling message.
7. When receiving the H.225 Setup message, subscriber B's application signals him about an incoming call.
8. Subscriber B receives the call and the IP telephony application sends a response message H.225 Connect.
9. The IP telephony application of subscriber A begins interaction with the application of subscriber B following recommendation H.245.
10. After the end of interaction via the H.245 protocol and the opening of logical channels, subscribers A and B can talk to each other via the IP network.

Despite the deliberate simplicity of presentation, the example considered is quite complex, which is due to the complexity of IP telephony technology. This example does not show all the steps and omits very significant details that a service provider needs to deploy an IP telephony network. All these more complex points will be discussed in chapters 5-11 of this book, but here we will make one more simplification [20-26].

The very nature of the computer-to-computer scenario in Fig. 1 determines the concentration of all necessary IP telephony functions in a personal computer or other similar end-user device. When describing other scenarios in this chapter, instead of a cumbersome illustration of the end device components, only a simplified illustration of an IP telephony terminal will be given. Such an analogue of Fig. 1 is a simplified representation of the same scenario in Fig. 2 [27-31]. We will return to a detailed consideration of the procedures for analogy-to-digital and digital-to-analogy conversion, compression, packetization, etc. in the next chapter.

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Crossref doi Google Scholar WorldCat MENDELEY
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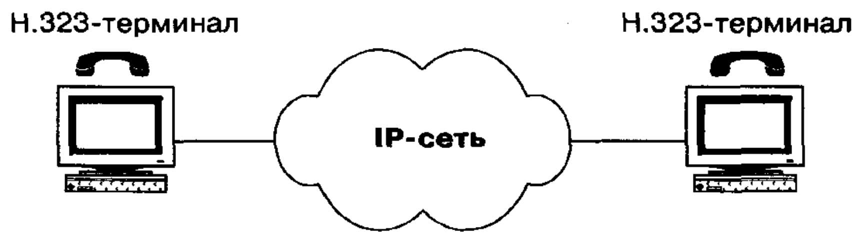

Fig. 2 Simplified computer-to-computer IP telephony scenario (analogous to Fig. 1)

Replacing images also has a deeper meaning. The name of the "computer to computer" scenario does not mean that the user must have at his disposal a standard PC with a microphone and speakers, as shown in Fig. 1. The main requirement for such a scheme is that both users must have personal computers connected to the network. These PCs must always be turned on, connected to the network and have IP telephony software running to receive incoming calls. With all this, there must be full compatibility between IP telephony software and hardware obtained from different suppliers, i.e. users wishing to talk to each other must have identical software, for example, implementing the H.323 protocol.
Taking these circumstances into account, under the name "computer" in all scenarios we will understand the user terminal included in the IP network, and under the name "phone" - the user terminal included in the circuit switching network of any type: PSTN, ISDN or GSM.
And one more, more significant remark. Until now, the discussion of the "computer-to-computer" scenario in Fig. 1 and 2 assumed that both users were connected to the same IP network (Internet, Intranet or other IP network). Within the framework of the TIPHON project, which is the subject of the next paragraph of this chapter, another, more complex modification of the computer-to-computer scenario is considered. This modification, shown in Fig. 3, provides for the organization of communication between IP network subscribers, taking into account that the call transits through a circuit switching network (CCN). Note that in this and the following figures, the public telephone network (PSTN) is used as the CCS, although the materials presented in this chapter are valid for ISDN, GSM, etc.

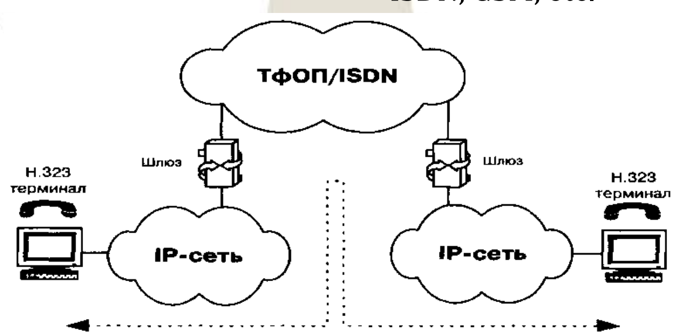

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Fig. 3 Simplified computer-to-computer IP telephony scenario. Connecting IP network users through transit CCM

The next scenario - "phone-computer" - is used in various kinds of Internet reference and information services, in product sales services or technical support services. A user who has connected to a company's WWW server has the opportunity to contact a help desk operator. This scenario is likely to be increasingly sought after by the business sector over the next few years. Companies will use this technology to grow their Web pages (and their presence on the World Wide Web). Computer users will be able to view catalogues in "real-time," order products almost instantly, and receive many other services. This is quite consistent with the lifestyle of modern consumers, associated with the need for additional convenience and saving time [32-35]. Already today, all the benefits and convenience of centralized purchasing of consumer goods (for example, CDs, books, software, etc.) are realized and e-commerce transactions are already routinely carried out.

The TIPHON project is considering two modifications to this IP telephony scenario:

- from a computer (IP network user) to a telephone (PSTN subscriber), in particular, in connection with providing IP network users with access to telephone services, including reference and information services and Smart Network services;
- from a PSTN subscriber to an IP network user with identification of the called party based on E.164 numbering or IP addressing.

The TIPHON project deserves closer attention, and it has already been promised to devote the entire next paragraph of this chapter to it.

In the first of the mentioned modifications of the "computer-phone" scenario, a connection is established between an IP network user and a circuit-switching network user (Fig. 4). It is assumed that the connection is initiated by the user of the IP network.

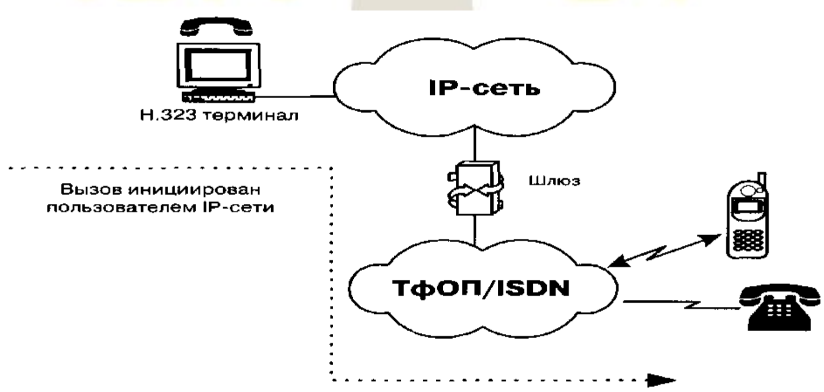

Fig. 4 Calling a PSTN subscriber by a user of an IP network according to the "computer-telephone" scenario.

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A gateway (GW) for interconnecting PSTN and IP networks can be implemented in a separate device or integrated into existing PSTN equipment or IP networks. The CCM network shown in the figure can be a corporate network or a public network.

Following the second modification of the "computer-phone" scenario, a connection is established between an IP network user and a PSTN subscriber, but its creation is initiated by the PSTN subscriber (Fig. 5).

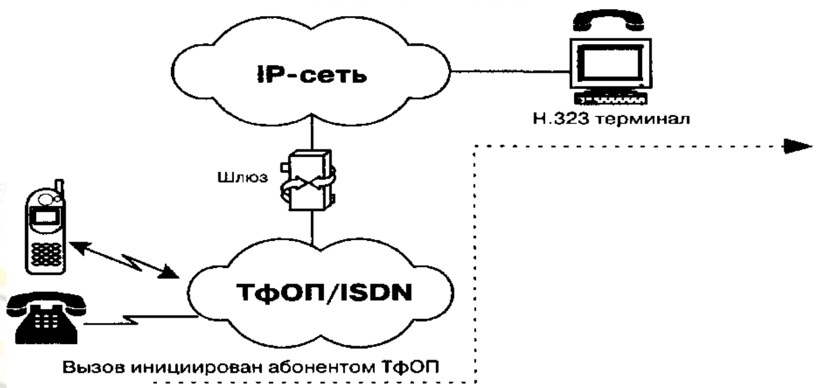

Fig. 5 An IP network user is called by a PSTN subscriber according to the "computer-telephone" scenario

Let's take a closer look at the example shown in Fig. 5 simplified architecture of an IP telephony system according to the "telephone-computer" scenario. When trying to call a directory information service using packet telephony services and a regular telephone, in the initial phase subscriber A calls a nearby IP telephony gateway. From the gateway, subscriber A is asked to enter the number to which the call should be directed (for example, a service number) and a personal identification number (PIN) for authentication and subsequent charging, if it is a service for which the call is paid by the caller. Based on the called number, the gateway determines the most accessible path to a given service. In addition, the gateway activates its speech encoding and packetization functions, establishes contact with the service, monitors the call process and receives information about the status of this process (for example, busy, ringing, disconnected, etc.) from the originating party through the control protocol and alarms. A disconnection from either side is transmitted to the opposite side via the signalling protocol and causes the established connections to be terminated and the gateway resources to be freed to service the next call. To organize connections from the service to subscribers (Fig. 4), a similar procedure is used. Popular software products for this version of the computer-to-phone IP telephony scenario are IDT Net2Phone and DotDialer, which organize calls to regular subscriber telephone sets anywhere in the world. The efficiency of combining voice and data services is the main incentive for the use of IP telephony in computer-to-computer and computer-to-phone scenarios, without causing any harm to the interests of traditional telephone network operators.

The phone-to-phone scenario is significantly different from other IP telephony scenarios in its social significance since the purpose of its use is to provide ordinary PSTN subscribers with an alternative option for long-distance and international telephone communication. In this mode, modern IP telephony technology provides a virtual telephone line via IP access.

As a rule, servicing calls in this IP telephony scenario looks like this. The IP telephony service provider connects its gateway to a switching node or PSTN station, and via the Internet or a dedicated channel connects to a similar gateway located in another city or another country.

A typical IP telephony service in a phone-to-phone scenario uses a standard telephone as the user interface, and instead of the PSTN toll component, uses a private IP network/intranet or the Internet. Thanks to the routing of telephone traffic over an IP network, it has become possible to bypass public networks and, accordingly, not pay for long-distance/international communications to the operators of these networks. It should be noted that the idea of using alternative transport mechanisms to bypass the PSTN network is not new. Suffice it to recall statistical multiplexers, voice transmission over a Frame Relay network, or voice transmission equipment over an ATM network.

As shown in Fig. 6, IP telephony service providers provide telephone-to-telephone services by installing IP telephony gateways at the input and output of IP networks. Subscribers connect to the provider's gateway via the PSTN by dialling a special access number. The subscriber accesses the gateway using a personal identification number (PIN) or Calling Line Identification service. After this, the gateway asks you to enter the phone number of the called subscriber, analyses this number and determines which gateway has the best access to the desired phone. Once contact is established between the ingress and egress gateways, further connection establishment to the called party is carried out by the egress gateway through its local telephone network.

PSTN prices for communication with the input gateway, Internet provider prices for transportation and remote PSTN prices for communication between the output gateway and the called subscriber.

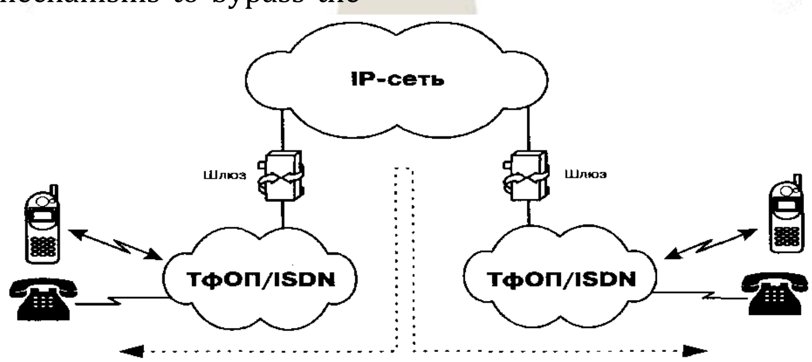

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Fig. 6 Connection of PSTN subscribers via a transit IP network according to the "phone-to-phone" scenario

One of the algorithms for organizing communication according to the "phone-to-phone" scenario is the issuance by the service provider of its calling cards. Having such a card, a user who wants to call another city dials the number of this service provider, then in the additional dialling mode enters his identification number and PIN code indicated on the card. After the authentication procedure, he dials the recipient's phone number.

Other algorithms for implementing this scenario are also possible: information about an alternative account can be used instead of a calling card. An invoice for payment can be sent to the subscriber after the conversation, similar to how this is done with a long-distance connection in the PSTN.

The scenarios discussed above are summarized in Table 1.

Table 1 Internetworking Options

Scenario	Incoming network	Transit network	Outgoing network	Note
"computer-computer"	IP	IP	IP	Fig. 1 and 2
	IP	PSTN	IP	Fig. 3
	IP	PSTN	PSTN	Fig. 5
"computer-phone"	PSTN	IP	IP	Fig. 4
	PSTN	PSTN	IP	Fig. 4
	IP	IP	PSTN	Fig. 5
	PSTN	IP	PSTN	Fig. 6
"phone-phone"	PSTN	PSTN	PSTN	Don't consider

Of the nine options for three scenarios presented in the table, the last option remains outside the scope of this book for a very obvious reason - it belongs to classical (and not IÐ-) telephony, described in many dozens of other books.

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