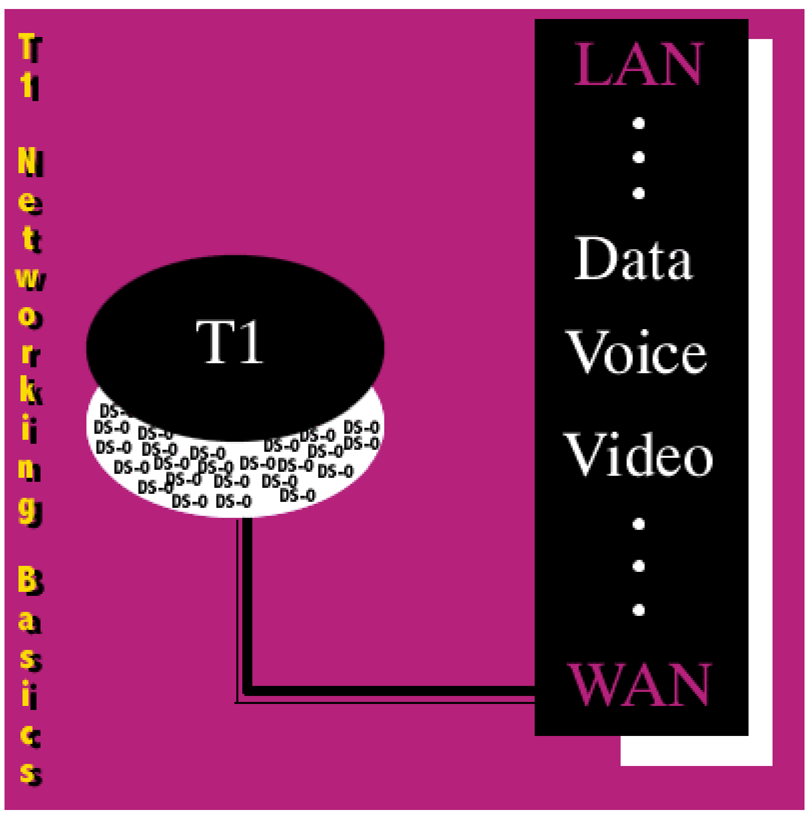
T1 Networking Made Easy



Toll Free (888) 785-7393

Boston (508) 660-0340
Minneapolis (612) 893-1725
Baltimore (410) 444-7999
Seattle (425) 348-8083
Fort Lauderdale (954) 783-4320
Los Angeles (909) 597-7461

Toll Free (888) 785-7393
Boston (508) 660-0340 Baltimore (410) 444-7999 Fort Lauderdale (954) 783-4320
Minneapolis (612) 893-1725 Seattle (425) 348-8083 Los Angeles (909) 597-7461

The T1 Carrier

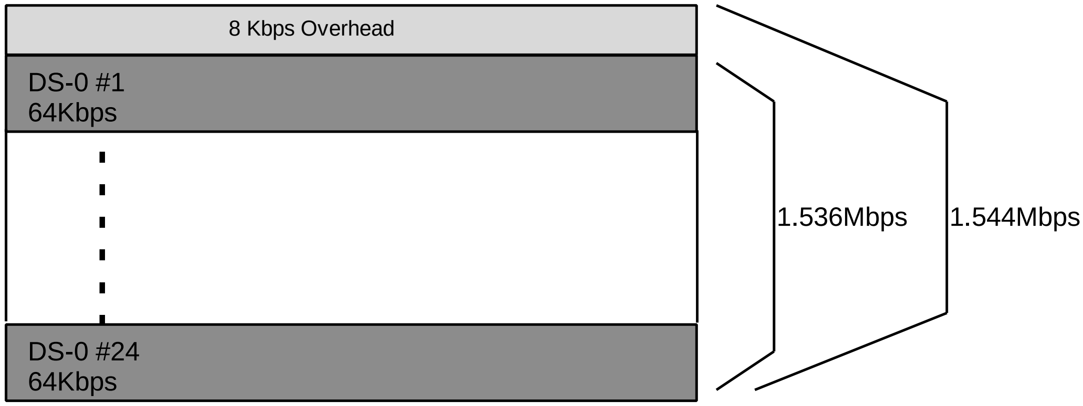
The T1 is what telephone companies have traditionally used to transport digitized telephone conversations between central offices. As early as the 1960's, a single T1 circuit made it possible for a telephone company to deliver 24 high quality voice conversations. Since a T1 is a fully digital service, there was no possibility of cross-talk, which is common in analog carrier networks where copper pairs pickup emissions from neighboring pairs. Significant increases in noise immunity were also achieved by adopting this new digital transmission standard.

Since the early 1980's, T1 service has been available to private industry throughout the country. This document will discuss the various types of T1 services available, how to deploy them, implement them effectively and understand the general guidelines of T1 networking.

What Does a T1 Look Like?

T1 Bandwidth

The bandwidth of a T1 is commonly known to be 1.544Mbps. This represents the maximum bit carrying ability of a T1. The overhead necessary to frame a T1 is 8Kbps. Therefore, the total usable bandwidth is 1.536Mbps, or the equivalent of 24 DS-0 channels. A single DS-0 has a bandwidth of 64Kbps and is designed to carry a digitized telephone call. Today, T1 technology is being used in private and public networks to carry both voice and data traffic.



- 24 64Kbps DS-0 Channels provide 1.536Mbps in usable bandwidth
- Total bandwidth = 1.536Mbps + 8Kbps (overhead) = 1.544Mbps

Figure 1: T1 Bandwidth

T1 Physical Characteristics

A T1 is physically made up of two balanced pairs of copper wire (commonly known as twisted pair). The pairs are used in a full duplex configuration where one pair transmits information and the other pair receives information. Customer Premises Equipment (CPE) typically terminate a T1 with a RJ-48C jack. The following illustration shows a typical T1 cable and interface.

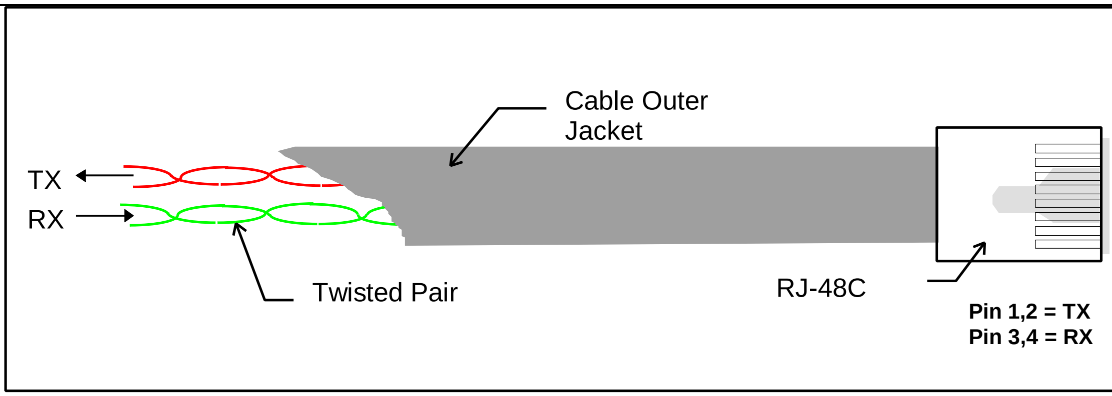


Figure 2: Typical CPE T1 Cabling

T1 Framing

A T1 is framed to provide 24 logical 64Kbps channels (channels are referred to as a DS-0). Each channel is designed to carry a single digitized telephone call. Since telephone calls are digitized at a rate of 64Kbps, we can send a call over a single DS-0. Therefore, a T1 provides 24 X 64Kbps in usable bandwidth. This equates to 1.536Mbps. The total bandwidth of a T1 is actually 1.544Mbps, which includes 8Kbps in overhead.

T1 framing is necessary to provide a common data format and to provide a means for synchronization on a network. There are two common framing standards currently in use.

D4 framing is the principal framing method that was initially used with T1 networks. D4 describes a frame made up of 24 one byte samples from each of the 24 DS-0s (192 bits). A single framing bit is sent in front of every 192 bit structure ([24 X 8] + 1 = 193 bits per frame).

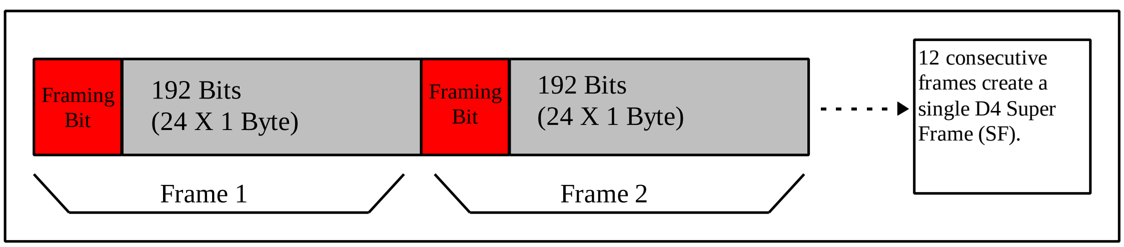


Figure 3: D4 Frame Format

Extended Super Frame (ESF) is a newer framing method used on T1s. It uses fewer framing bits than D4 and provides a means for gathering performance data from the T1.

Line Code

Two line codes are supported for T1 transmissions; Alternate Mark Inversion (AMI) and Binary 8 Zero Substitution (B8ZS). Although line code is not directly associated with T1 framing, the following is generally true:

- A D4 SF T1 *usually* uses AMI line coding
- AN ESF T1 *usually* uses B8ZS line coding

T1 networking

TELCOs

A general understanding of telephone company architecture is required in order to fully understand T1 networking and the various voice and data applications supported. The following explanation, along with the associated figures, provides a generalized (not so technical) view of public voice and data networks.

In most cases, especially when long distance communications is required, a network connection is established through two carriers. A Local Exchange Carrier (LEC) is responsible for providing local connectivity to the customer premises and an Inter-Exchange Carrier (IXC) is responsible for carrying information between various LECs.

If a person lives in Washington, DC and needs a telephone line, they would most likely deal with Bell Atlantic (the incumbent LEC). The following diagram shows the portion of the network connection that the LEC would provide.

Toll Free (888) 785-7393

Boston (508) 660-0340 Baltimore (410) 444-7999 Fort Lauderdale (954) 783-4320
Minneapolis (612) 893-1725 Seattle (425) 348-8083 Los Angeles (909) 597-7461

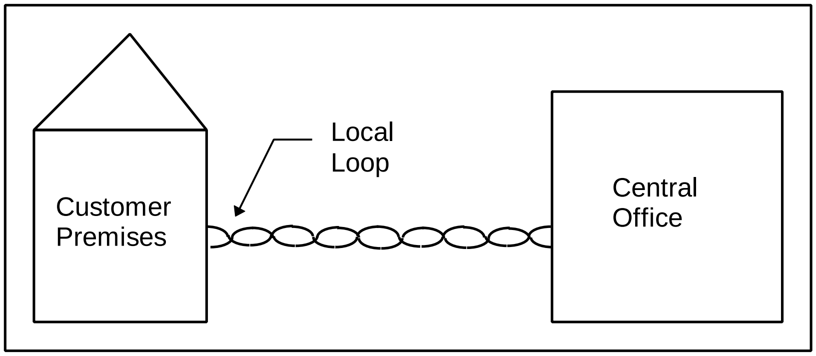


Figure 4: Local Network Connection

The Central Office (CO) in this example is the LEC switching office that operates in this customers region. If this customer requires additional voice or data services, additional connections can be established in the same manner.

This portion of the network only provides for local communication to the CO. If long distance communications are necessary, an IXC would carry the information to the destination CO. If a telephone call were to be made from Washington to Los Angeles, the network connection at the CO would be passed to a Point of Presence (POP) for the long distance carrier of choice. At the remote end of the connection, the IXC would pass the call from its local POP to the destination CO. This is depicted in the following diagram.

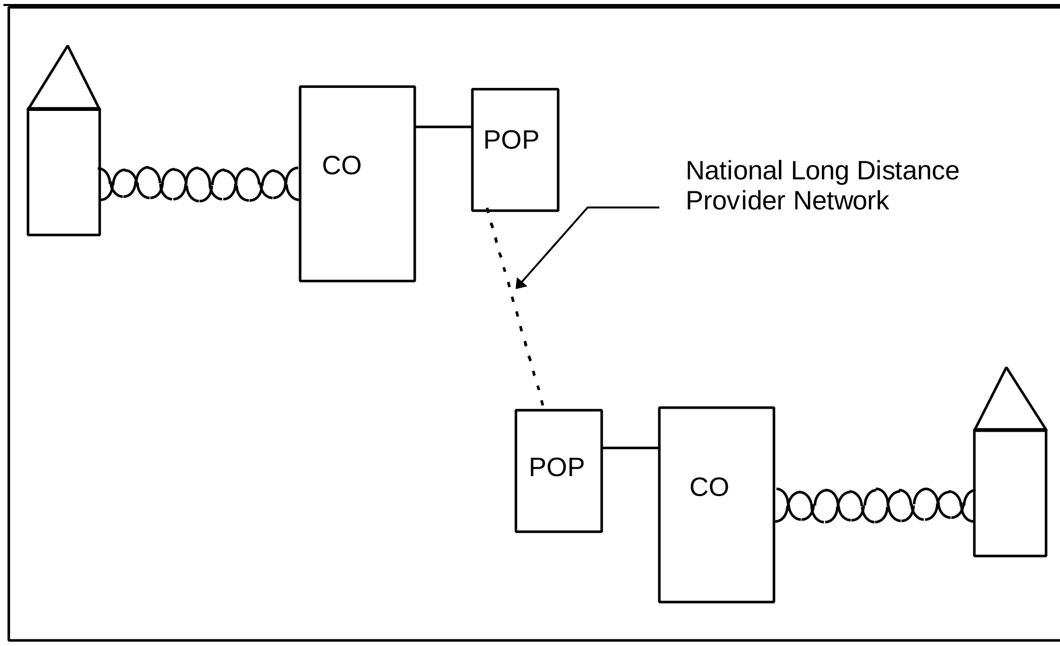


Figure 5: Long Distance Network Connection

PSTN Access With a T1

There are a number of ways in which to access the Public Switched Telephone Network (PSTN). The most common way is to do so via a standard analog telephone line (figure 4), or what's commonly called Plain Old Telephone Service (POTS). Although this is a very simple solution to accessing the PSTN, it may not be the most economical or most feasible choice.

Lets assume that a company has a requirement for 24 telephone lines into its headquarters. In order to fulfill this requirement, 24 POTS lines can be ordered from the local telephone company. If the monthly cost for each POTS line is $27.00 (not including long distance) this company would pay a total monthly fee of $648.00.

The alternative to this scenario is to use a T1 access line for the voice requirement. Lets assume that a Channelized T1 LOOP for access to the PSTN (see figure 6) costs $500.00 per month. That would constitute a $148.00 monthly savings ($1,776.00 yearly).

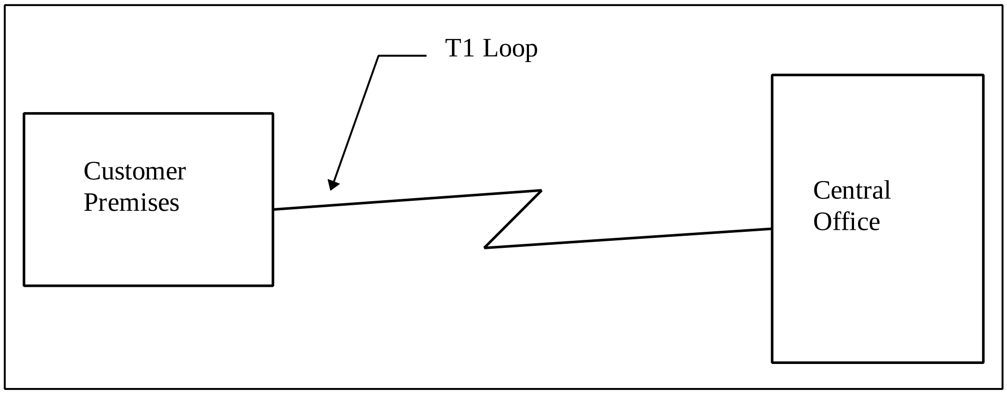


Figure 6: T1 Access Line

Since a T1 interface is now being presented to the user, one of the following would be required:

- Ensure that the Customer Premises Equipment (CPE) provides a T1 interface.
- Convert the T1 into 24 standard analog lines. This would require channel bank.

If the T1 is going to be used in a voice application and needs to be connected to a telephone system, a T1 interface is most likely going to be present on the telephone system. In this case all that would be required to terminate the T1 is a Channel Service Unit (CSU). A CSU is required anytime a T1 circuit is connected to CPE. It is the device responsible for isolating the public network from the end-user network and also serves as a test point that allows the carrier to run many standard tests. In some cases a CSU is built into the Customer Premises Equipment which provides for direct connection to the T1 (no external CSU required).

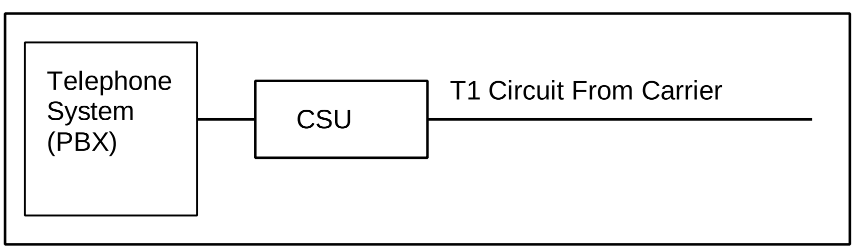


Figure 7: T1 Circuit Terminated With a CSU

If the T1 is to be used in an analog application, a channel bank would be necessary in order to convert the 24 digital voice channels into 24 individual analog voice lines. Some devices that require analog interfaces are old telephone systems and modems. The following diagram shows a channel bank converting a T1 into 24 analog circuits for connecting a rack of modems.

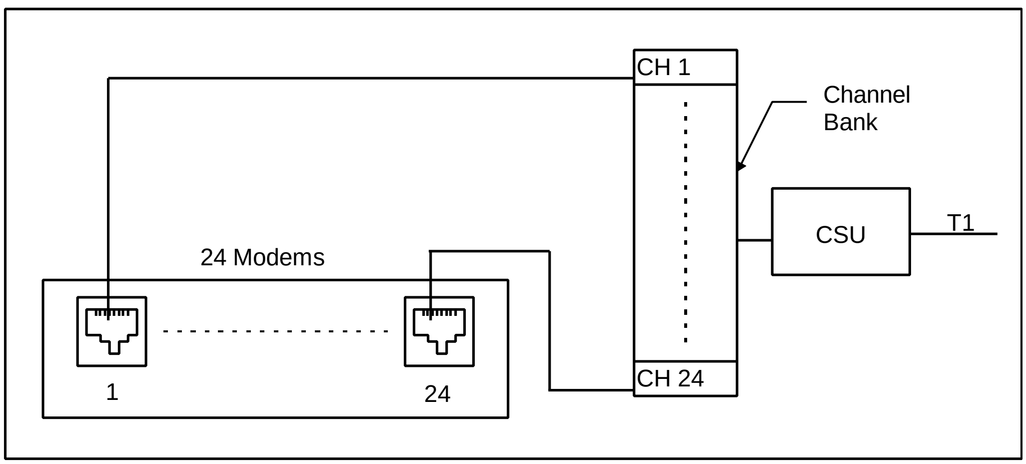


Figure 8: T1 Channel Bank Application

Summary of PSTN Access With a T1

Accessing the Public Switched Telephone Network with a T1 is similar in concept to accessing the PSTN over a standard analog telephone line. In both cases a local loop is deployed between the CO and the customer's premises. In the case of T1 access, a T1 loop is used and in the case of a single analog line, an analog loop is used. With the connection in place, the CO is responsible for switching all local telephone calls and routing all long distance call to the IXC of choice.

Data Networking With T1s

T1 technology has been used in data networks since the 1980s. Serial data connectivity is the most common T1 data application. In most cases, T1 data circuits are deployed to provide a means for serial communications. The following diagram shows a typical T1 point to point data application:

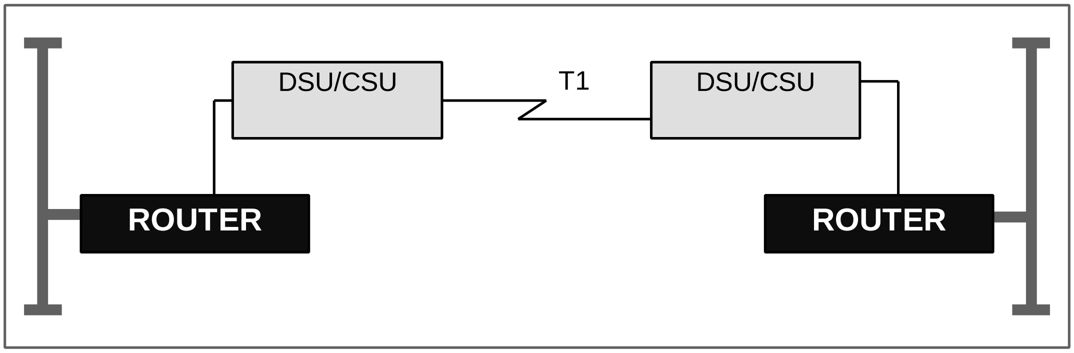


Figure 9: Point-to-Point LAN Connectivity

In the previous diagram, a T1 Channel Service Unit / Data Service Unit (CSU/DSU) is used to terminate the circuit at both ends. The CSU/DSU is responsible for terminating the T1 and converting the T1 signaling and channelization into the appropriate user serial interface such as RS-530, V.35 and RS-449.

Multi-port CSU/DSUs are also available for applications supporting multiple data channels. The following diagram shows how these devices would be used in a Wide Area Network.

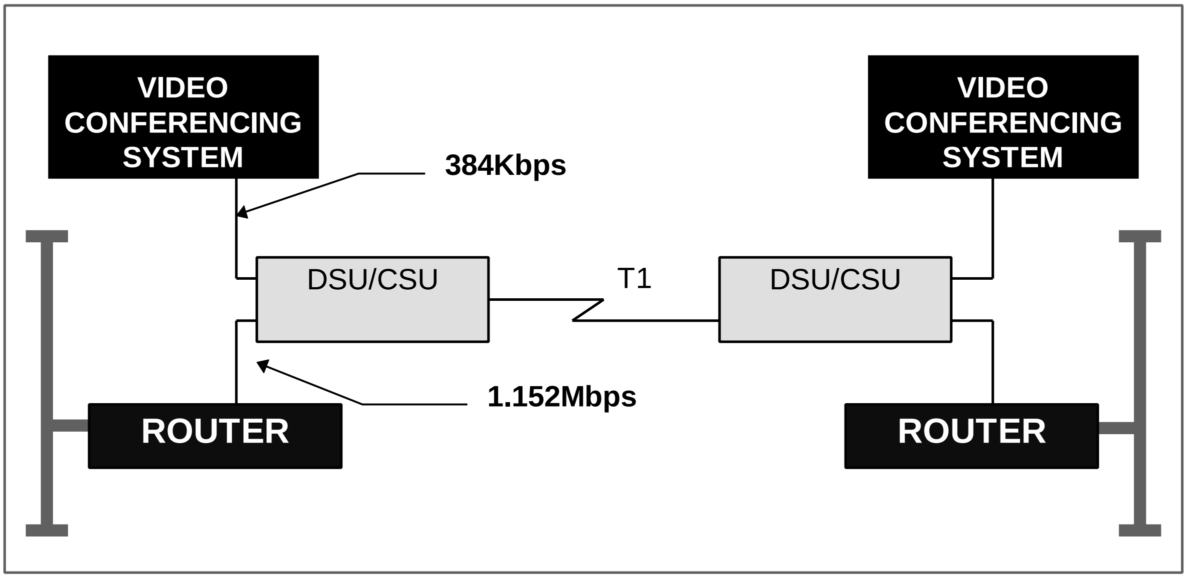


Figure 10: Point-to-Point Network With Two Data Channels

The two-port CSU/DSUs used in Figure 10 allow the user to divide the T1 bandwidth between two applications. In this example the video application is given a total of 384Kbps (6 X DS0) and the router application is given 1.152Mbps (18 X DS0).

A combination of single port and multi-port CSU/DSUs can also be used in applications that require connectivity to more than one remote location. These types of applications usually require a special circuit configuration provided by the local telephone company. The following diagram shows a single location communicating with two remote locations.

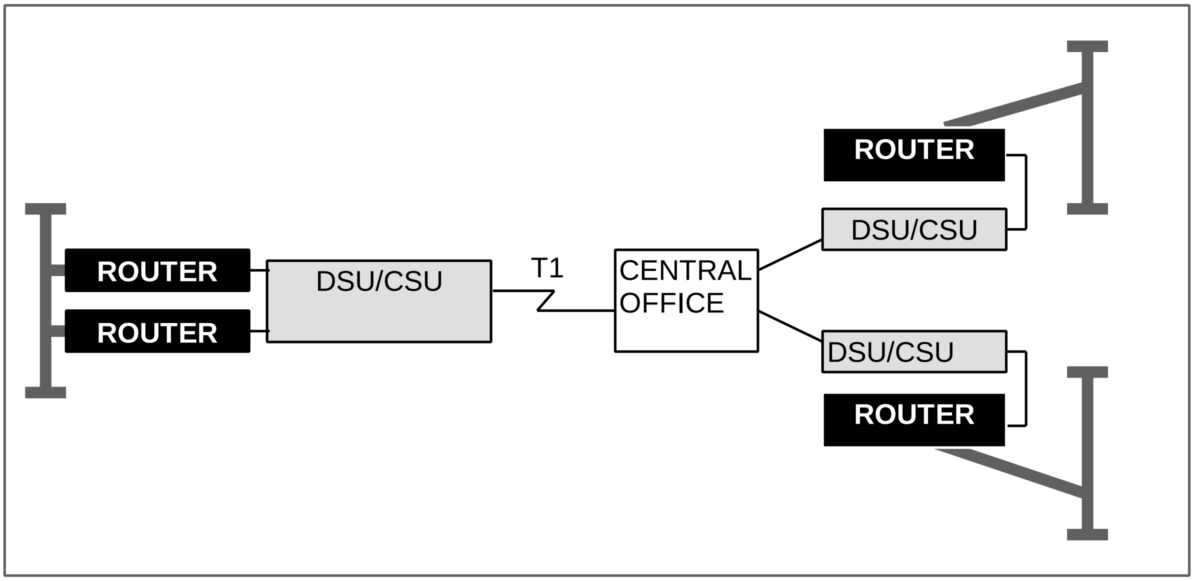


Figure 11: T1 Access With Multiple Remote Locations

In figure 11, the CO is cross connecting the three circuits with a Digital Access Cross Connect System (DACS). This allows the central office to map the appropriate number of channels on the T1 at the central site to the remote locations.

Voice and Data Networking With T1 Access

Utilizing a T1 for voice and data integration is a common practice. In many cases, the primary reason for combing two information mediums (voice and data) is to reduce the monthly cost for voice and data communications links. The following diagram shows the network configuration for an organization that is not integrating voice and data:

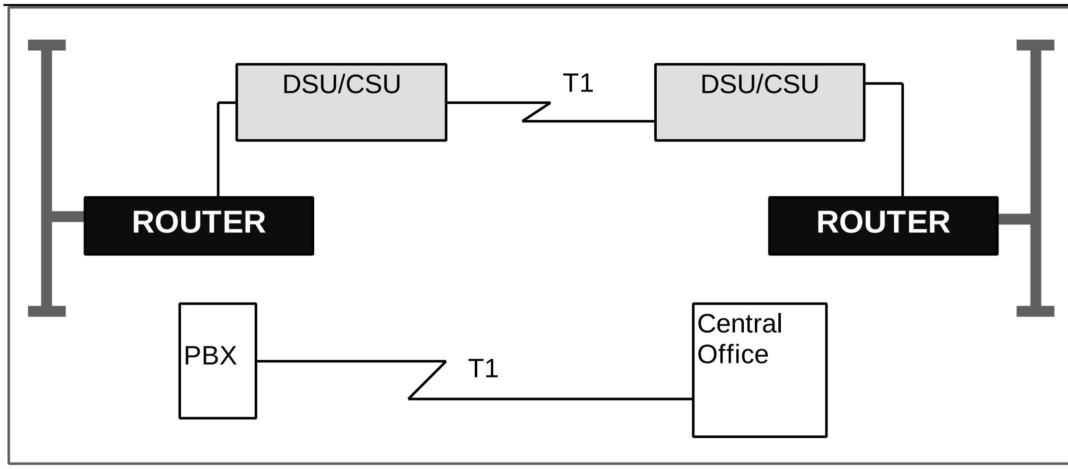


Figure 12: Non-Integrated Voice and Data Application

If the voice an data requirements in the previous diagram do not require the full T1 bandwidth that is available, both applications can be consolidated onto a single T1 circuit. This is shown in the following diagram:

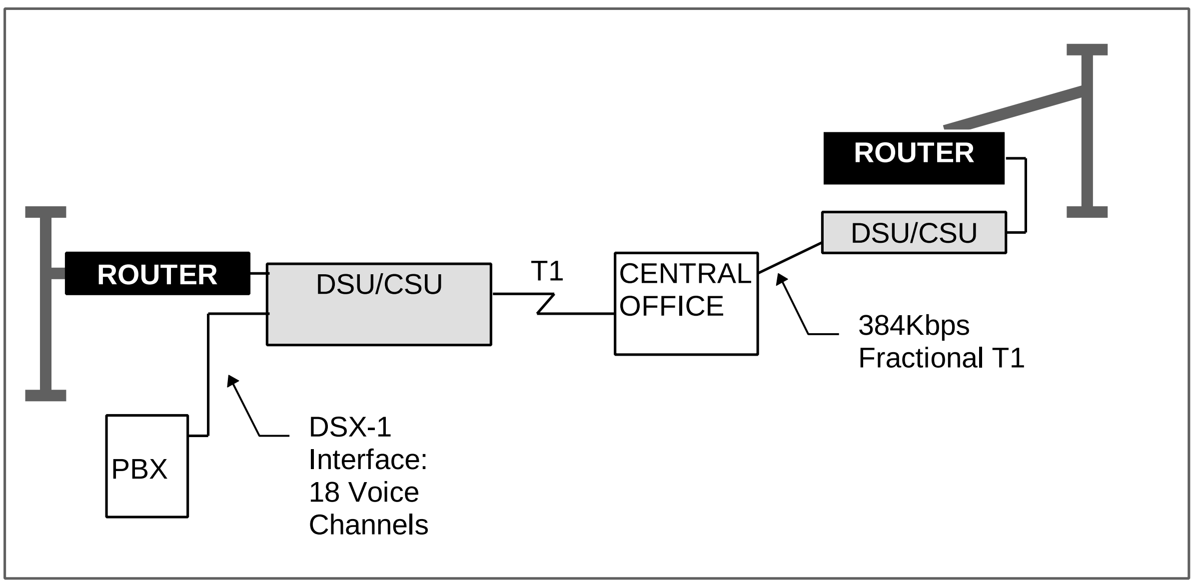


Figure 13: T1 Access With Voice and Data Integration

If the organization depicted in figures 12 and 13 required a total of 18 voice channels for a PBX connection and a single 384Kbps data connection to a remote site, the diagram shown in figure 13 would be the favored network configuration. In this example, the organization is paying for a single T1 loop from its premises to the central office. This eliminates the additional circuit shown in figure 12. If the monthly cost for the additional T1 loop were $500, this would provide a $6,000 saving per year.

The CSU/DSU used in this application provides the user with a DSX-1 port that is used to pass the T1 circuit to the PBX. This is the same interface that is found on the subscriber side of a CSU (see figure 7).