Understanding the Issues/ Troubleshooting Problems

Testing has shown that a vast majority of analog lines in the U.S., Europe and the Pacific Rim will support x2, but certain conditions in the network or the local loop may prevent x2, either intermittently to a certain destination or at any time from certain analog lines.

This paper explains the circumstances under which x2 speeds cannot be achieved and gives troubleshooting advice. It is intended to help the majority of customers whose lines can support x2 speeds and to impart an understanding of why a small minority cannot achieve x2 speeds.

Expectations

Currently, due to restrictions set on the output power allowed in the U.S., Canada and other countries, the maximum speed is bounded at 53.3 Kbps. Support for 56 Kbps (and above) is contained within the code, but server code being shipped today is restricted to 53.3 Kbps. U.S. Robotics and others are endeavoring to have these regulations modernized, so this restriction may be removed in future releases.

Certain line conditions and network configurations also produce impairments that may restrict the actual rates achieved, with x2 just as with V.34 (and V.34+). As of today, the majority of users are probably finding their connect rates in the 46-48 Kbps range. Very few (we believe less than 5 percent) will not achieve x2 speeds at all. This paper is intended to help the 95 percent get x2 running as it should, and to impart an understanding of why those 5 percent do not achieve x2.

It should also be understood that there will be continuous improvements made to the code, and it is quite possible, if not likely, that future code releases will increase performance and reduce the occurrences of x2 not functioning in certain environments.

Requirements

x2 requires the following:

1. A digital connection at one end.

One end of an x2 connection must terminate at a digital circuit, meaning a "trunk-side" channelized T1, ISDN PRI, or ISDN BRI. Line-side T1 will not work because an extra analog section is added. In a trunk-side configuration, once the user's analog call is

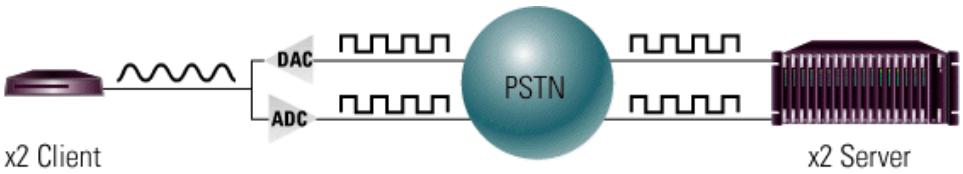
converted to digital and sent through the carrier's network, the call stays digital until it reaches a U.S. Robotics server modem through a T1, PRI or BRI circuit.

2. x2 support at both ends.

x2 must be supported on both ends of the connection -- by the client modem as well as by the remote access server or modem pool at the host end. Typically, the remote user will be using a U.S. Robotics Sportster, Courier, or Megahertz modem dialing into an MP I-modem, NETServer I-modem, Courier I-modem, or Total Control Enterprise Network Hub remote access server.

3. Only one analog section.

There can only be one analog section in the phone network along the path of the call between the x2 server modem and the client's modem, and it should be at the client's local loop. If the digital connection at the server side is channelized T1, it must be "trunk-side" and not "line-side." With line-side service from the phone company, there typically is an additional analog section (this limitation is described below).



Essential Components of an x2 Connection: Digital at One End, x2 at Both Ends, and Only One Analog Section.

The Telephone Network

The analog telephone network is designed primarily for voice, not data. Many tradeoffs must be balanced when implementing a telephone network, and decisions are often -- and should be -- made with providing reliable and efficient *voice* service as the primary focus. Data traffic often benefits from these efficiencies, but there are circumstances where certain equipment is employed that is perfectly logical for voice, yet interferes with high-speed data transmission.

Let's assume that the first two requirements of x2 are met -- one end of the connection is digital and both ends support x2 -- and focus on the third requirement.

x2 technology is based on the assumption that there is only one analog section in the path between the analog modem and the x2 digital host equipment. This analog-to-digital converter (ADC, or codec) is commonly found at the local switching office where the subscriber's analog line is attached to the telephone switching equipment. From that point on, it must remain digital all the way to the x2 digital host equipment. There are two parts of the path where additional analog sections may occur:

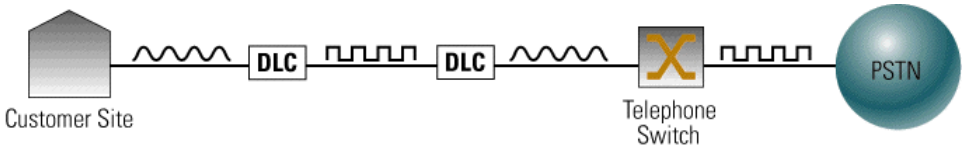
1. The local analog loop between your modem and the switching office

As mentioned above, a typical situation is where the line remains analog from the analog modem to the local switching equipment. It is also common for some of the circuits to be provided over digital circuits (such as over T1/E1 circuits or fiber) to

equipment located in the neighborhood. In many cases it is provided as a digital extension of the switching equipment.

This is good for x2 because it extends the digital portion of the network to the neighborhood and reduces the length of the analog portion (the portion most susceptible to interference and distortion). The equipment that aggregates lines and performs signal conversion is often called a DLC (digital loop carrier).

There are other cases, often when the switching equipment is not capable of digital "extensions," in which analog lines are provided from the switching equipment. In these cases, the analog signals are converted to digital for transmission over the digital carrier to the neighborhood, then converted back to analog for delivery to the subscriber's home or business.



Although this is a simple method of modernizing the local loop, providing higher quality voice transmission and more lines over fewer copper wires (reducing the need to tear up streets to add capacity), the additional analog-to-digital conversion prevents the operation of x2.

There are also other conditions that affect the local loop and either prevent x2 or reduce the maximum speed. The farther a customer's site is from the switching equipment, the more likely that "load coils" have been installed on the line. Load coils are typically employed on longer wire lengths, and are used to offset some of the negative effects of these longer loop lengths on voice transmission. They will often reduce the speed, affecting V.34 and other modulation techniques as well as x2. Other problems may include poor wiring either in the telephone network or even inside homes or businesses.

2. Problems within the network

Many problems that can occur within the network will likely be intermittent and vary from call to call, and are more likely to occur on long-distance calls. The reason these are intermittent is that the "path" a call takes varies from call to call, and a call from one point to another may take a different path each time the call is placed depending on the current utilization of "inter-office trunks" and other switching gear.

The most common issue is a digital pad where the digital bits (PCM) are manipulated to reduce the volume. This causes problems for x2, but it has been overcome using complex mathematical computations within the modems at each end. The presence of digital pads may cause a minor speed reduction, but it should not prevent x2 from being achieved altogether.

It is possible that we have not identified all the possible pads. If you see a line that should work, but does not, please try to grab the **ATI6**, **ATI7**, **ATI11** and **ATY11**

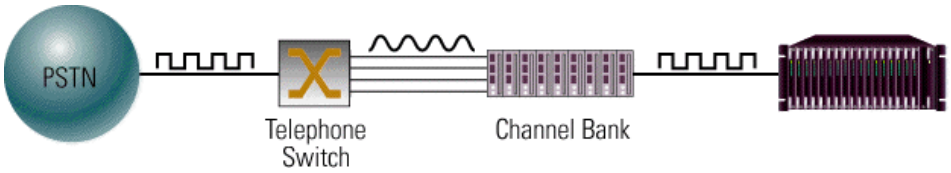
screens from a call to a known good x2 host from that line. Call U.S. Robotics technical support with the information.

T1 or PRI Lines and “Trunk-Side” Service

The x2 server requires a trunk interface -- a T1 (channelized or PRI) or E1 (R2 or PRI) trunk connected directly to the chassis (or a BRI line connected to an I-modem). In a **trunk-side** configuration, once the user’s analog call is converted to digital and sent over digital trunks through the carrier network, the call stays digital until it reaches the Total Control chassis through a T1 or PRI trunk.

A Trunk-Side Configuration.

A **line-side** configuration is not suitable for x2 because the call undergoes more than one analog-digital conversion. An example of line-side service: some central offices (COs) implement channel banks that break T1 signals down, carry the signals over two-wire connections and bring those connections back into another T1 through a second channel bank. Line-side service might be used in a CO where there is older equipment. Line-side service also causes a phenomenon called “near-end echo,” which introduces impairments.



A Line-Side (T1) Configuration.

Troubleshooting Calls (x2 Client)

Troubleshooting Courier Calls

Follow the steps very methodically. Silly oversights have been made by the best of us!

Checklist (Details for each item are below and in Appendix A.)

1.	Examine the Courier status messages.
2.	Verify that the host is x2-capable.
3.	Ensure that the modem has proper x2 software and that it’s enabled.
4.	Ensure that the S-registers are set properly.
5.	Ensure that the analog line is capable of x2.
6.	Disconnect any other devices that share the analog line.

1. Examine the Courier status messages.

From a terminal screen, call an x2 server (for example, in the U.S., call the USR BBS at 847-982-5092). After connect, hang up using either the disconnect feature on your terminal program or +++ and then **ATH**.

Enter **ATI11**. In the field "x2 status" a few words appear that give excellent clues for solving the problem. If you see 0s and 1s, you achieved x2 (enter **ATI6** to confirm).

See Appendix A for a description of these status messages, and go from there.

FOLLOW THE REMAINING STEPS IF YOU DO NOT HAVE A COURIER OR IF YOU NEED TO DIG FURTHER.

2. Verify that the host is x2-capable.

To be sure, try the USR BBS at 847-982-5092. This is a known-good x2 host.

3. Ensure that the modem has proper x2 software and that it's enabled.

Enter **ATI7** from a terminal screen. "x2" should appear as one of the Options.

```
USRobotics Courier V.Everything Configuration Profile...
Product type            US/Canada External
Options                 HST,V32bis,Terbo,VFC,V34+,x2
Fax Options             Class 1,Class 2.0
Clock Freq              20.16Mhz
Flash ROM               512k
Ram                     64k
Supervisor date         02/25/97
DSP date                02/25/97
Supervisor rev          7.1.4
DSP rev                 2.2.1
Serial Number           000954000856xxxx
```

Ensure that you have current, released, code. The correct code is:

Courier Analog (20 MHz and 25 MHz models)

```
Supervisor date     02/25/97 (or later)
DSP date            02/25/97 (or later)
Supervisor rev      7.1.4 (or later)
DSP rev             2.2.1 (or later)
```

If x2 is not shown as a modulation type, but they have the correct code, it needs to be enabled. With the exception of some promotions, x2 is an extra-cost feature in the U.S. and is not enabled by default unless an x2 modem was purchased (not just an x2-upgradeable). See Appendix B for details on how to get x2 enabled.

Sportster Flash

```
EPROM date   2/20/97 (or later)
DSP date     2/20/97 (or later)
EPROM rev     4.0.1 (or later)
DSP rev      10.2.1 (or later)
```

If x2 is not shown in a Sportster's I7 Options field, it does not have the correct code. See Appendix B for details on how to obtain the x2 code upgrade.

4. Ensure that the S-registers are set properly.

For troubleshooting and other control reasons there are S-Registers employed that can shut off x2 or features that are required for x2. Essentially, you need to ensure that:

a) x2 is not disabled and

b) V.8 is enabled.

Under normal circumstances, entering **AT&F1&W** will enable this. If you are working with an upgraded Courier, ensure that the higher registers (such as S69 and S70) are not 255, they should usually be 0. This is a common issue with upgrades.

Courier Analog V.Everything

```
S58=0        x2 is enabled, etc.
S54=64       3200 symbol rate is enabled, v8 CI disabled, etc.
&N0          Don't limit the upper speed
&U0          Don't limit the lower speed
```

Sportster 56K

```
S32=2        x2 is enabled (note: NOT S32=0, this disables V.8,
             which effectively disables x2!!!!)
```

5. Ensure that the analog line is capable of x2.

There are a couple ways to do this, and none are 100% reliable. Keep in mind that this is currently an art, not a science. These techniques represent the best we can do without sophisticated measuring equipment and on-site evaluation.

- Ensure that you are **NOT** dialing from a PBX line. (PBXs are less likely to support x2.)

- Dial into the U.S. Robotics "Socrates" server at 888-877-9248. Log in as **`x2 test`**. A program analyzes the line and reports **`Yes`** or **`No`** and gives a frequency response from the perspective of the Socrates server. Make several calls to ensure a consistent result.

- Dial into an x2 host from a terminal program. Set S14=0 prior to dialing to prevent a disconnect on escape. At the "login" prompt (or whatever is displayed after connect) type **+++** to get to the modem's command prompt. While still online, enter (and capture the results if possible): **ATI4I6I7I11Y11**

- Send **ATI4I6I7I11Y11**again after 45-60 seconds online. This will show the true "settle-in" speed, as the first thirty seconds or so might be slightly erratic.

```
Freq     Level
 150     20
 300     16
 ...
3300     11
3450     13
3600     17
3750     23
```

Results of the Y11 Command.

High-End Rolloff

Examine the values of 3300 and 3750 from the Y11 screen. These values indicate the degree of "rolloff" in signal power at the high end of the frequency spectrum.

Subtract the value for 3300 and from the value of 3750. If the difference is equal to or greater than 25, that is very good evidence of an additional analog-to-digital conversion (codec). An additional codec pair in the path makes achieving x2 either not possible or extremely unlikely.

Signal Attenuation at 3750 Hz

Another criteria that should be looked at is the value of 3750. If it is greater than 50-55, this is a sign of a poor local loop, and it's likely to cause poor performance or prevent x2 from being achieved.

NOTE: in the field trials, we found several sites that had greater than 50 dB attenuation at 3750, but did get x2. Most of the sites with greater than 50 had low connect rates (30s, low 40s) and often retrained back to V.34. (Many of those who obtained 30s were thrilled, as they were only able to get low 20s with V.34.)

Other Important Values

Other values to collect (if it is not practical to obtain the I-screens in their entirety) are SNR and round-trip delay (from I11) and 150 and 300 from Y11.

6. Disconnect any other devices that share the analog line.

Although the following actions should not be necessary for normal operation, they will aid troubleshooting.

Disconnect (not just hang up) all other phones, answering machines, caller ID boxes, and modems, from all telephone wall jacks at the location. Use only one standard telephone cable (usually silver and 7ft long) between the modem and a wall jack.

Telephone cable extenders and Y-adapters can have adverse affects on x2 (and V.34 for that matter) connections. Multiple devices sharing the same line may affect x2 performance, especially if they are daisy-chained. Disconnect the other devices and connect the modem directly to the wall jack.

7. Contact U.S. Robotics Technical Support.

To expedite your request, please collect the following data first:

- ❏ The phone number for the POP being called.

From a call to the service provider, preferably while online:

- ❏ From the Y11 screen, the values for 150, 300, 3300, and 3750.
- ❏ From the I11 screen, the Round-trip delay and SNR values.

From a call to a known-good x2 host, the same parameters.

- ❏ From the Y11 screen, the values for 150, 300, 3300, and 3750.
- ❏ From the I11 screen, the Round-trip delay and SNR values.

If practical, the full I4, I6, I7, I11, Y11 online screen captures, obtained 45 seconds after connect are best!

Troubleshooting x2 Servers
(Courier I-modems and Total Control Quad Modem Cards)

Troubleshooting x2 servers is an extension of the x2 client troubleshooting steps. Be sure to consider the client issues discussed in the previous section. Be careful not to assume anything.

1. Call the x2 server from a known-good analog line.

Call from a known x2-capable analog line and check for an x2 connect message. If you get an x2 connect message, the correct software is installed and enabled.

This does not mean x2 is fully operational (there could be other issues). If x2 works from a known-good line, but does not work from a particular line, go through the client troubleshooting steps above for that line. And be sure to test from a wide base (at least several) of different locations!

IF YOU CANNOT GET x2 FROM A KNOWN-GOOD LINE:

2. Ensure that the host has proper x2 software and that it's enabled.

Courier I-modem

At the I-modem, enter **ATI7**. x2 should appear under Options as a supported option. If not, obtain the correct software, install it, and enable it (see Appendix B for enabling instructions). x2 is NOT an extra-cost feature of I-modems, but it does require registration and enabling.

```
Supervisor date     03/04/97 (or later)
DSP date            03/03/97 (or later)
Supervisor rev      2.1.4 (or later)
DSP rev             2.1.4 (or later)
```

Total Control Quad Modem Cards

```
Supervisor date     03/03/97 (or later)
DSP date            02/28/97 (or later)

Double-sided        5.0.7 (or later)

Single-sided        5.1.7 (or later)
```

Be sure they are up-to-date and the feature is enabled on the NMC. Feature enable is determined from the NMC, not the I7 screen of the quads.

TCM (Total Control Manager SNMP Software)

Check this from TCM -- Select the NMC, then select **Programmed Settings**, then **Added Cost Features**. x2 should be shown as enabled. You can check this only from TCM; the NMC console port does not provide this information.

3. Ensure that the S-registers are set properly.

As with the clients, there are a number of S-Registers that control how x2 works and that can disable all or some of the functionality. Those registers and the recommended values for full x2 functionality are shown in the following screen.

```
B0  C1  E1  F1  Q0  V1  X1
BAUD=19200  PARITY=N  WORDLEN=8  DTE=GATEWAY NAC
DIAL=TONE   ON HOOK   TIMER     LINE=ISDN PRI

&A3  &B1  &C1  &D2  &G0  &H1  &I0  &K1  &L0  &M4  &N0
&P0  &R1  &S0  &T4  &U0  &X0  &Y1  %N6

S00=001  S01=000  S02=043  S03=013  S04=010  S05=008  S06=002  S07=060
S08=002  S09=006  S10=014  S11=070  S12=050  S13=000  S14=000  S15=000
S16=000  S17=000  S18=000  S19=000  S20=000  S21=010  S22=017  S23=019
S24=150  S25=005  S26=001  S27=000  S28=008  S29=020  S30=000  S31=000
S32=009  S33=000  S34=000  S35=000  S36=000  S37=000  S38=000  S39=011
S40=000  S41=000  S42=126  S43=200  S44=015  S45=000  S46=255  S47=032
S48=000  S49=016  S50=100  S51=000  S52=005  S53=000  S54=064  S55=000
S56=000  S57=000  S58=000  S59=000  S60=000  S61=000  S62=000  S63=000
S64=000  S65=000  S66=000  S67=000  S68=000  S69=002  S70=000  S71=001
S72=001  S73=001  S74=000  S75=000  S76=000  S77=000  S78=000

LAST DIALED #:  T9825092
LAST DNIS #: 1111                LAST ANI #: 8471111111

OK
```

IMPORTANT:
Make sure to “Restore the Modems from Factory Defaults” after upgrading to 5.0.7/5.1.7 to ensure that new registers have valid settings. These settings should be made to all modems in the chassis (or pools that are receiving x2 calls, if pooling functionality is configured).

For Quad Modem code version 5.0.7 or 5.1.7, make sure the setting for S10 is 14. For versions 5.6 and 5.7, use S10=7.

4. Ensure that the lines are “trunk-side.”

In most cases, you can assume that there are no analog-to-digital conversions in the network (behind your CO switch), but if all else fails, that should be investigated.

- Dial into an x2 host from a terminal program. Set S14=0 prior to dialing to prevent a disconnect on escape. At the “login” prompt (or whatever is displayed after connect) type **+++** to get to the modem’s command prompt. While still online, enter (and capture the results if possible): **ATI4I6I7I11Y11**

- Send **ATI4I6I7I11Y11**again after 45-60 seconds online. This will show the true "settle-in" speed, as the first thirty seconds or so might be slightly erratic.

```
Freq     Level
 150     20
 300     16
 ...
3300     11
3450     13
3600     17
3750     23
```

Results of the Y11 Command.

Examine the values of 3300 and 3750 from the Y11 screen. These values indicate the degree of "rolloff" in signal power at the high end of the frequency spectrum.

Subtract the value for 3300 and from the value of 3750. If the difference is equal to or greater than 25, that is very good evidence of an additional analog-to-digital conversion (codec). It is VERY likely that it is a "line-side" T1. The additional codec pair in the path makes achieving x2 either not possible or extremely unlikely.

It is possible (though unlikely) that certain line configs, certain switch types or certain network environments may cause problems. If there are any, we want to get to the bottom of them immediately!! Contact U.S. Robotics Technical Support.

Appendix A - Courier x2 Status Messages

These messages come from the x2 status field of the I11 screen after an x2 call attempt that failed to achieve x2 modulation. As of late April 1997, this functionality exists only in Courier modems. It is planned to be implemented for other products in maintenance releases.

Channel is x2-capable but feature not installed	The user has the proper x2 firmware installed, is calling an x2-capable server, and the line is good, **BUT** the user did not enable the "x2 feature" properly (**x2** does not appear under **Options** in the **ATI7** screen). **Solution:** First, power the modem off and then on again (the final step in enabling x2) and try the call again. It's also possible that x2 was not enabled properly in the modem. See Appendix B for instructions on enabling the Courier modem.
x2 disabled on local modem	S-Register 58 enables/disables x2. **Solution:** Make sure S58=0 to enable x2.
Remote modem is not x2	The modem that the user is calling (or is answering from) is not an x2 modem. Make sure the POP is x2-capable.
Multiple CODECs in channel	Either there are multiple analog-to-digital conversions in the network path, or some other anomaly is causing high-end rolloff (a dramatic reduction of signal power at frequencies above 3300 Hz). This is often caused by an additional analog-to-digital conversion on the local loop, but it should be noted this additional ADC could be anywhere in the call path. x2 does not work in either circumstance.
Remote modem is not a Server	The user has called another x2 client (such as another x2 Courier V.Everything or an x2 Sportster). One end of the connection must be a digitally served x2 server. Calls from x2 client to x2 client will attain V.34 speeds.
3200 baud disabled on local modem	**Solution:** Enable the 3200 symbol rate by setting S54=64 (enables 3200 symbol rate, disables V.8 Call Indicate, etc.).
Channel will not support 3200 baud	The channel is not capable of supporting 3200 symbol rate -- an x2 requirement. It is likely that this is caused by severe impairment on the analog local loop (other than multiple codecs).

THE FOLLOWING ARE SERIOUS ERRORS. IF YOU SEE THEM PLEASE CALL U.S. ROBOTICS TECHNICAL SUPPORT.

Conditions that produce these errors are extremely rare. They will most likely be resolved in future code updates.

Unspecified negotiation failure	x2 should have worked, but didn't. Follow the client troubleshooting steps and see if this problem exists when calling different, known x2-capable, hosts. Collect as much data as possible and call U.S. Robotics Technical Support! It will be very valuable to help engineering root out the cause if they know whether you are never able to achieve x2 or if the problem arises only when calling certain destinations!
Incompatible versions	Reserved for future use. Make sure you are running released code (not beta code).

Appendix B - Enabling x2 in USR Products

With the exception of products shipped as x2, all U.S. Robotics products need to have updated firmware installed and the feature enabled. The MP I-modem and NETServer I-modem family of products need only to have updated software, they do not need to be enabled. The method of obtaining that software, and enabling the feature, varies by product.

Courier V.Everything (Analog)

1. Get the latest x2 code from **http://totalservice.usr.com/upgrade/**
2. Send the code to the modem using either SDL or an XMODEM file transfer.
3. Call U.S. Robotics host to enable x2.
4. Enter **AT&F1S0=0&W**
5. Turn the modem OFF and then back ON.
6. Enter **ATI7** and look for x2 in the options:

```
Options                    HST,V32bis,Terbo,VFC,V34+,x2
```

Sportster

The only way to upgrade Flash-upgradeable Sportsters is to use the Flash Gordon utility. The Flash Gordon utility is currently available through resellers.

Sportsters without Flash memory require a chip update which will require customers to contact Customer Support using the Internet or by phone at (847) 982-5151.

Sportster 128 ISDN

This is not an analog-capable product and there are no plans for x2 support.

Total Control Quad Digital (and Analog/Digital) modems

1. Get a feature key for your chassis from **http://totalservice.usr.com** (The web site will ask you for your NMC's serial number and you'll get back a feature key that will enable x2 in all of the modems in that chassis.)

2. Update all system components to TCS2.5 (or later), in the following order:

   - TCM 4.3.1 (or later)
   - NMC 4.3.1 (or later)
   - Quad Modem 5.0.7/5.1.7, or Quad I-modem 1.0.5/1.1.5 (or later)
   - T1 card (PRI 2.5.1 or Channelized T1-386 4.1.5) or later

3. Through TCM software, run **Actions** | **Software Command** | **Restore From Default**.

Appendix C - Glossary

analog-to-digital converter (ADC)	A device that samples incoming analog voltage waveforms, rendering them as sequences of binary digital numbers. Passing waveforms through an ADC introduces quantization noise.
basic rate interface (BRI)	An ISDN line that provides up to two 64-Kbps B-channels and one 16-Kbps D-channel over an ordinary two-wire telephone line. B-channels carry circuit-oriented data or voice traffic while D-channels carry call-control signals.
call-control signaling	Operations associated with establishing and tearing down virtual circuits through a network. For example, dialing.
central office (CO)	The facility at which individual telephone lines in a limited geographic area are connected to the public telephone network.
codec	Coder-decoder -- a device that converts analog signals on one side to digital signals on the other, or vice versa.
digital loop carrier (DLC)	A device that, when used in concert with a digital line, provides an alternative to stretching multiple lower-bandwidth analog lines over longer distances.
digital pad	A sort of fixed “volume control” that attempts to equalize the loudness of signals from various types of lines.
digital-to-analog converter (DAC)	A device that reconstructs analog voltage waveforms from an incoming sequence of binary digits. Does not in itself introduce noise.
digital signal processor (DSP)	A processor that is optimized for performing the complex mathematical calculations inherent in processing digital signals. A discrete DSP may be reprogrammed. A DSP integrated in a chipset typically contains its own ROM and cannot be reprogrammed.
high-end rolloff	Reduction in signal power at the upper frequencies of the voiceband.
line-side T1	A T1 that undergoes at least one analog-to-digital conversion in the path between the x2 server modem and the PSTN.
load coil	Used to offset some of the negative effects of longer local loop lengths on voice transmission. Load coils improve voice quality but reduce data-carrying capacity, especially at V.34 and x2 speeds.
local loop	The path (wiring) between a customer location and the local telephone company’s central office. This is often a completely analog connection over two copper wires.
near-end echo	Interference in the receive signal caused by reflection of the transmit signal from the “hybrid” at the local CO.
primary rate interface (PRI)	A four-wire ISDN line (or "trunk") with the same capacity as a T1, 1.544 Mbps. PRIs contain 23 64-Kbps B-channels and one 64-Kbps D-channel. The D-channel carries call-control signaling for all the B-channels.
private branch exchange (PBX)	A telephone switch that is privately owned and located on a customer’s premises -- typically a business or hotel.
signal-to-noise ratio (SNR)	A measure of link performance arrived at by dividing signal power by noise power. Typically measured in decibels. The higher the ratio, the clearer the connection.
T1	A four-wire digital line (or "trunk") with the same capacity as a PRI line, 1.544 Mbps. T1s contain 24 DS0s, each of which carries 56 Kbps (call-control signaling is carried within the DS0).
trunk-side T1	A T1 line that has a direct digital connection to the phone network, and therefore undergoes no analog conversions in the path between the x2 server modem and the PSTN.
x2 client modem	A modem equipped with x2 software that is attached to a standard analog telephone line. In order to connect at x2 speeds (32–56 Kbps), the device at the other end of the connection must be an x2 server modem that is attached to a trunk-side T1, BRI, or PRI line.
x2 server modem	A digital modem equipped with x2 software that is attached to a trunk-side T1, BRI, or PRI line. Client modems must be equipped with x2 software in order to connect at x2 speeds (32–56 Kbps). Current products that can act as x2 servers include the Total Control Enterprise Network Hub, NETServer I-modem, MP I-modem and Courier I-modem.