Feature

Is Your Network DOOMED?

Courtesy of Id Software

By Laura Chappell and Roger Spicer

"Get him! Get him! He's right behind you! Nice shot dude!" The loud voices over a speakerphone were a tip-off to Tom Rogers, network systems support analyst at Chevron Information Technology Company: Network users were playing DOOM, which has become the game of choice at Chevron. Although Chevron does not sanction network games, some users still find time to fit in the occasional battle.

As IPX-capable games have boomed over the past several years, more and more network administrators are finding their users playing games over the network. Should this network game craze concern you? How much traffic do these games cause? Can games conflict with other network software? How do you locate games and filter their traffic from the network? How do network games affect WANs? Can you remove games from network servers and client workstations?

To answer these questions, we set up an ImagiTech Game Analysis Lab and invited some of Northern California's top game players to play games on our network. We defined a "top game player" as someone who typically scores in the top ranking on the games we tested. Our game players were quite adept at shooting while moving and spinning 360 degrees.

To rate how games affect network performance and to determine how they communicate over the network, we used Novell's LANalyzer for Windows to monitor network traffic while the games were being played. (See Figure 1 on p. 10 for analysis data.) This article presents both our testing methodology and our results. It also offers some options for detecting network games on the network and preventing users from playing them.

The Game Lab

Our game lab consisted of five game-playing workstations on a 10Base-T network running NetWare 3.12, NetWare 4.01, and NetWare 4.1. These workstations ranged from a lowly 486SX 33MHz machine with 4MB of RAM (barely enough to launch Windows 3.1) to a Pentium 90 MHz machine with 32MB of RAM. Two of the workstations had SoundBlaster sound boards; two didn't. None of them had joysticks.

Our game workstations used a variety of network interface boards: two NE2000 boards, one SMC8000 board, one Hewlett Packard 100 VG-AnyLAN board (running at 10Mbit/s), and one 3COM Etherlink III board. The five game stations and three servers were directly connected to an SMC 10Base-T hub. We loaded the Link Support Layer (LSL), the network board drivers, and IPXODI on the game stations, but we did not load NETX or virtual loadable module (VLM) files on these stations.

The network also included a workstation running Novell's LANalyzer for Windows, which we used to define a baseline of network activity before game play. Our baseline activity averaged 10 packets per minute for Service Advertising Protocol (SAP) and Routing Information Protocol (RIP) updates between the servers. When defining game play packets per second, we subtracted approximately 10 packets per minute to account for normal network activity.

To analyze how the games affected the network, we monitored the following:

Illustrations: Norman Fedelle

- Game type
- Maximum number of players
- Configurable socket number
- Game startup sequence
- Addressing scheme (broadcast versus unicast)
- Overhead on the network (utilization and packets per second)

Game Type

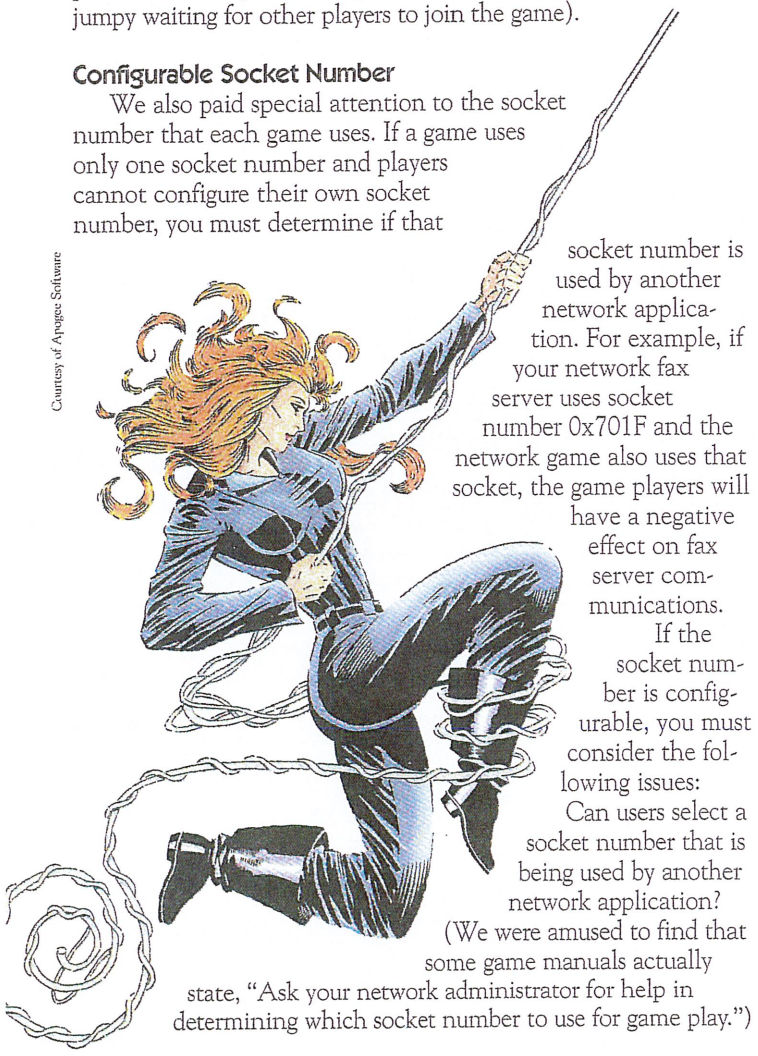
As you might expect, the type of game your users play—whether it is a strategy game, an adventure game, or a high-action combat game—determines, to a large extent, how much network traffic is generated. If your users want to play games on the network, your best bet is a tank game. In general, we found tank games to be the most network-friendly because they tend to be slow-moving games with infrequent tank location updates. Unfortunately, the most taxing game for a network is also the most popular—the high-action combat game.

Maximum Number of Players

Most of the games we reviewed support four players. A game that supports configurable sockets, however, can actually have multiple, four-player games in progress. Some of the newer games support up to 12 players—although getting 12 players into a single game requires some excellent organizational skills and a lot of patience on the part of the game players (who often get jumpy waiting for other players to join the game).

Configurable Socket Number

We also paid special attention to the socket number that each game uses. If a game uses only one socket number and players cannot configure their own socket number, you must determine if that socket number is used by another network application. For example, if your network fax server uses socket number 0x701F and the network game also uses that socket, the game players will have a negative effect on fax server communications. If the socket number is configurable, you must consider the following issues: Can users select a socket number that is being used by another network application? (We were amused to find that some game manuals actually state, "Ask your network administrator for help in determining which socket number to use for game play.")



Courtesy of Apogee Software

How many socket numbers can be assigned to the game? If a game allows players to specify up to 10 different socket numbers (10 simultaneous games) and each player in a four-player match uses one socket number, up to 40 players can load the network with game traffic.

Game Start-up Sequence

We looked at the game startup sequence to see if the first player uses continuous broadcast packets to announce his or her presence to the other players. If the game uses continuous broadcast packets, could an initiating station flood the network with "I'm here" packets?

Addressing Scheme (Broadcast or Unicast)

Broadcast packets are addressed to a generic broadcast address (FF-FF-FF-FF-FF-FF) and will be processed by all devices on a network. By default, a switch or a bridge will forward broadcast packets to all connected segments. Unicast packets, on the other hand, are addressed to a specific station on the network.

Excessive broadcast communications can cause heavy network traffic and overload the network cabling system. In our tests, we checked if any of the network games use broadcast packets as their primary means of communicating player status.

Overhead on the Network (Utilization and Packets per Second)

Of course, the big question is how do games actually affect network traffic? To answer this question, we looked at the average utilization percentage of game traffic as well as the average number of game packets per second. We also looked at the game traffic to determine if the game uses a fixed packet size. If so, does the game pad the packets to meet the requirement for a fixed packet size? Padding packets to meet a required packet size wastes network bandwidth.

The Good, the Bad, and the Ugly Results

If your users are avid network game players, we have good, bad, and ugly news: The good news is that most of today's popular games are not as chatty as we had expected. Game manufacturers now have a fairly good understanding of network traffic requirements and have improved their games accordingly.

Our tests showed that most game manufacturers have learned that game traffic should rarely be broadcast over the network. In some of the games we tested, new players use broadcast packets to announce their presence to all players, but in general, their traffic is minimal. One of the hot-selling games is broadcast-based, but it's a tank game and broadcasts a minimal number of packets.

The bad news is that today's games support increasing numbers of players and simultaneous games. Players have more power to select their own socket numbers—a feature that will challenge most network administrators. As a result, multiple, consecutive games can be played on the network, and network administrators cannot filter out game traffic based on a fixed socket number.

The ugly news is that some older games and some poorly developed games generate a lot of network traffic by broadcasting their game traffic. These are the games you want to keep off the network.

The following sections summarize our analysis of today's most popular network games. (If you are not familiar with a particular game, see "Choose Your Weapon: The Games We Tested" on

Game Variables	DOOM 1 v1.1	DOOM 2	Heretic	Hexen	Descent	Rise of the Triad*	Command & Conquer	Mortal Kombat 3**	NetWars v2.06
Number of Maximum Players	4	4	4	4	8	11	4	10-12	4
Default Socket Number (hex)	869C	869B	869B	869B	5100	ABCD	8813	4545	750y
Configurable Socket	Yes: 1-64000	Yes: 1-64000	Yes: 1-64000	Yes: 1-64000 (command-line configure)	No	Yes	Yes: 0-16384 (added to 0x4000)	No	No
Target MAC Address	Broadcast	Broadcast and Unicast	Broadcast and Unicast	Broadcast and Unicast	Broadcast and Unicast	Broadcast and Unicast	Broadcast and Unicast	Broadcast and Unicast	Broadcast
Fixed Packet Size	495	No	No	No	No	No	116	No	181
Variable Average Packet Size	Fixed	83 Bytes	87 Bytes	87 Bytes	142 Bytes	79 Bytes	Fixed	217 Bytes	Fixed
Lab: Number of Players	2	2	2	2	2	2	2	2	2
Lab: Average Packets/s	75	75	72	65	18	70	30	150	120
Lab: Average Utilization % (Ethernet)	2-3%	1%	1%	1%	1%	1%	1%	2-4%	1%
Trace filenames	DOOM1.TR1	DOOM2.TR1	HERETIC.TR1	HEXEN.TR1	DESCENT1.TR1	ROTTPLAY.TR1	C&C.TR1	MK3.TR1	NETWAR1.TR1

Figure 1. *To find out how games communicate on the network, we used Novell's LANalyzer for Windows to capture and analyze the packets they generated. *Client-server based; synchronization within communications. **Standalone play automatically generates network traffic. (You can download trace files from the* NetWare Connection *WWW site at http://www.nwconnection.com.)*

p. 16.) If you would like to examine our LANalyzer for Windows trace files for each of these games, you can download the files from the *NetWare Connection* World-Wide Web (WWW) site at http://www.nwconnection.com. (For instructions on how to view these files with Novell's LANalyzer for Windows, see "Viewing the Sample Trace Files from Our Tests" on p. 18.)

DOOM 1 (v1.1)

DOOM 1 was the first really exciting multiplayer game for the network. You may have heard rumors that the first version of DOOM threatens network performance. For once an industry rumor is correct. DOOM 1 v1.1 has one major fault: All game communications are broadcast-based.

DOOM 1 v1.1 uses a fixed packet size of 495 bytes. We ran two sessions of DOOM 1—a four-player and a two-player session. In our tests, a four-player session of DOOM 1 generated an average of 100 packets per second and increased the network load by 4 percent. Our two-player session increased utilization by 2-3 percent with an average of 75 packets per second.

In this version of DOOM, the default socket number is 0x869C, as shown in Figure 2. (See p. 12.) However, since DOOM 1 v1.1 allows users to select their own socket numbers, multiple DOOM 1 games can be played simultaneously—a potentially lethal network adventure. If you have a network analyzer and see unusually excessive broadcast traffic on the wire, check for the default socket 0x869C. You may have some DOOMers playing a Deathmatch. (If you have never played DOOM, a Deathmatch is a head-to-head game in which players try to obliterate each other from the game. Our players selected the Inferno episode and the Ultra-violent skill level, the most difficult episode and the most violent skill level available in DOOM 1.)

DOOM 2

The DOOM developers did a complete turnaround in their communications architecture when they designed DOOM 2. This version uses minimal broadcast traffic to exchange player information for the game startup sequence. We ran both a four-player and a two-player session of DOOM 2. In the four-player session, we monitored network traffic as the players joined the game over the course of one minute. In our tests, DOOM 2 generated 210 broadcast packets just for the startup sequence.

Although a two-player DOOM 2 session averages only 75 packets per second, a four-player session puts an average of 380 packets per second on the network—enough traffic to affect a WAN link. In a two-minute period, we noticed 5,958 packets of DOOM 2 traffic from four players. When our players let the game idle, we noticed an average of 130 packets per second.

The DOOM developers also opted for a more efficient variable packet size: DOOM 2 packets average 83 bytes. Although you will see more packets per second on the network with DOOM 2 than you would with DOOM 1, the average utilization of a two-player DOOM 2 session is only 1 percent due to the smaller variable packet sizes (a marked improvement over DOOM 1). The average utilization caused by a four-player DOOM 2 session is 4 percent.

DOOM 2's default socket number is 0x869B, as shown in Figure 3. (See p. 12.) Once again, however, DOOM 2 allows configurable sockets. As a result, users can play multiple, simultaneous games on the network.

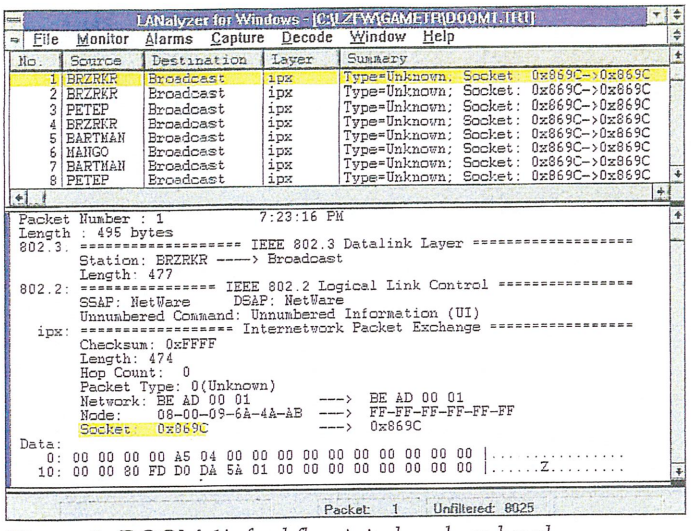


Figure 2. DOOM 1's fatal flaw is its broadcast-based communications system.

Heretic

Heretic is based on the DOOM gaming engine and uses the same default socket number (0x869B) as DOOM 2. The communications architecture is also basically the same. Heretic uses broadcast packets only during the game startup sequence. Once the players join the game, Heretic uses unicast communications.

We ran a two-player session of Heretic and found that the average packet size is 87 bytes and the average number of packets per second is 72. In our tests, Heretic caused a 1 percent increase in network utilization.

Hexen

As the newest Id Software game based on the DOOM gaming engine, Hexen uses the same communications structure and default socket number (0x869B) as DOOM 2 and Heretic.

Our two-player Hexen session caused a 1 percent increase in network utilization with an average packet size of 87 bytes and approximately 65 game packets per second. Broadcast packets are used just for the game startup sequence; unicast communications are used for game play.

One nice feature of Hexen is that players cannot select a new socket number from a menu. They must know how to change the default socket number from the command line.

Descent

Our DOOM fanatics were quite impressed with Descent because it offers plenty of action. Fortunately, this game was designed very well. Descent uses minimal broadcast traffic for the game startup sequence. Players broadcast their player names, and the first player responds with his or her name and the game title. As you can see in the decode of packet number 20 shown in Figure 4, the game starter (BRZRKR) broadcasts information such as the game title "Tuck's Kingdom." (See p. 14.) This player is the only one who can actually start game play after all of the other players have joined the game.

As players join the game, the first player broadcasts the current player list in packets that also define the name of the application and the game name (DESCENT: First Strike). (Take a look at packet 247 of the DESCENT.TR1 file available on the *NetWare Connection* WWW site for an example. See p. 18.)

Descent uses variable packet sizes (ranging from 78 bytes to 559 bytes) for the game startup sequence, but once game play has begun, almost all packets are 142 bytes long. We ran a two-player game and noticed an average of just 18 packets per second, with a 1 percent network utilization load. We also ran a four-player Descent game and noticed an increase to only 75 packets per second.

Descent uses socket number 0x5100; players cannot use any other socket number. As a result, you can easily spot Descent on the network using a network analyzer. (In addition, the game starter transmits some packets to address 00-00-00-00-00-00. Using this address is another good way to find Descent.)

Descent allows up to eight players, but based on our findings, we do not think that the utilization and packets per second rate will go above 2 percent utilization and 150 packets per second.

Rise of the Triad

Rise of the Triad (ROTT) is unique because it runs as a true client-server application. For multiplayer mode, one computer must be configured as a server. This station can be a dedicated ROTT server, or a player can run client software on top of the server software and participate in the game. All other gaming stations run client software only. Up to 11 people can participate in a single game.

When ROTT games are started, the ROTT server transmits a series of 71-byte broadcast packets at a rate of one packet per second. These transmissions create minimal network traffic. When a three-player game is in full swing, however, an average of 140 packets are transmitted per second, and the average packet size is 79 bytes. For a three-player game, the average load on the network is below 1 percent. A two-player game creates 70 packets per second, with less than 1 percent utilization.

ROTT's default socket number is 0xABCD. Players can configure the socket number but cannot enter a number that starts with 0. This limitation is helpful since many NetWare socket numbers start with 0. For example, the NetWare Core

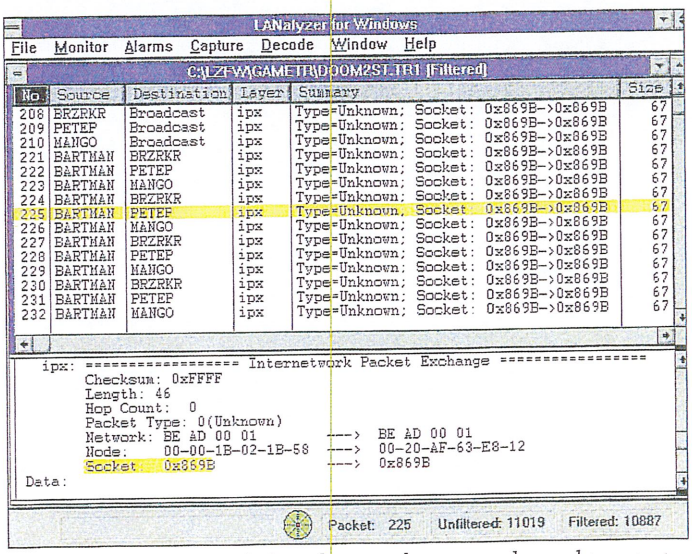
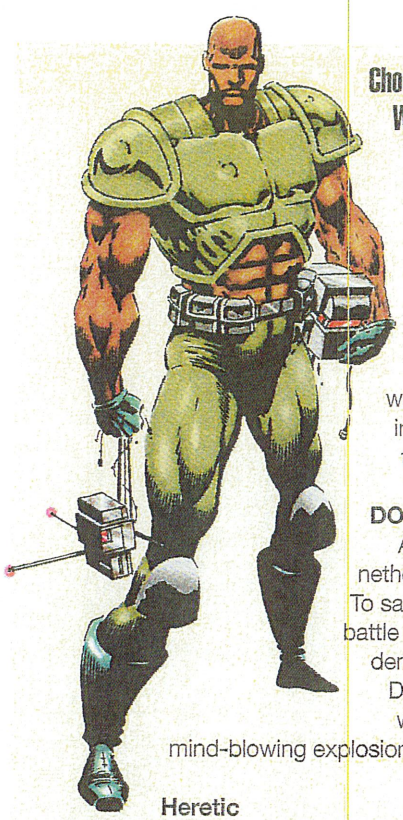


Figure 3: In DOOM 2, broadcast packets are only used to set up the game.



Courtesy of Id Software

Choose Your Weapon: The Games We Tested

DOOM 1 (v1.1)
You are the "toughest space trooper ever to suck vacuum" in this lightning-fast, virtual reality adventure. Your mission is to shoot your way through a monster-infested holocaust and live to tell the tale.

DOOM 2
All of the forces of the netherworld have overrun Earth. To save the planet, you must battle mightier, nastier, deadlier demons and monsters than in DOOM 1. Use more powerful weapons and survive more mind-blowing explosions in this bloody blast-fest.

Heretic
Cast spells from the Tomes of Power and wield fantastic weapons such as the Firemace and the Hellstaff—all in an attempt to destroy the undead who slaughtered your race.

Hexen
Hexen is a world littered with the corpses of the nonbelievers (those who don't believe in the evil magic of the undead) and inhabited by the undead who executed them. Only three humans—a warrior, a mage, and a cleric—have escaped the undead's spell, and now they have sworn to crush the evil regime that threatens to destroy the world. Separated upon entering the mystical portal, the humans are forced to attempt on their own what they had hoped to do together: They must find the undead's stronghold, destroy them, and restore order to the world.

Descent
You begin deep below the surface of Lunar Base 1 where an unknown alien race has taken over the chasm of the Post Terran Mining Corporation. Run down mine shafts, travel through never-ending tunnels, and fight your way past robotic menaces in a truly 3-D environment. Move up, move down, and shoot everything in between.

Rise of the Triad
You are a member of HUNT, a high-risk, United Nations taskforce. As the victim of a surprise attack during a routine surveillance mission, your only choice is to blaze through hundreds of armed soldiers, automatons, and undead, eluding traps at every turn. Explore huge game levels (up to a million square feet each), complete with realistic fog and lightning. Look up and down, spring off jump pads, fly, and more!

Command and Conquer
Welcome to the New World Order, a gritty, high-tech world in which the art of electronic intelligence and covert surveillance reigns supreme. Guerrilla strategies and savage combat are the norm. Build bases, muster forces, and destroy your enemies.

Mortal Kombat 3 (MK3)
You must pull out all the stops in this gory, action-packed game. Choose from eight characters and then join the fray on 3-D rendered backgrounds using secret moves that you encode just before battle. Digitized sound and music tracks are identical to the arcade version of MK3.

NetWars
You are the pilot of an intergalactic craft that can hurtle through space to locate and destroy enemy warriors and their craft. Navigational assistance allows you to find your enemies and blow them to smithereens in order to keep the galaxy safe. ■

Fortunately, because MK3 uses only one socket number (0x4545), you can easily locate players.

NetWars

NetWars is a relatively simple game that is bundled with Personal NetWare and Novell DOS. Four players can play NetWars at a time, but considering that NetWars is broadcast-based, it's too bad that it is not a two-player game. Originally developed in 1989, NetWars has an old-fashioned game architecture: It uses broadcast packets with a fixed packet size of 181 bytes.

NetWars does not allow configurable sockets, but it uses more than one static socket. In fact, up to four sockets can be used at a time (one for each game player). These socket numbers typically start with 0x750y (y can be 0 through 9 and A through F).

Playing Standalone Games on the Network

Many people believe that standalone games do not affect network performance. However, if users copy standalone games onto a network server and launch them from the server, several problems can occur:

First, the entire game must be downloaded to the client station before the game begins. If the game's scenery constantly changes or if players have a lot of mobility (such as flying, jumping, running, or viewing the landscape in 360 degrees), the game will create constant traffic from the server to the client.

This type of game play is difficult to locate on the network because the game sessions look like other application sessions. For example, in Figure 6, a client station is playing Windows Solitaire from the server instead of from the local drive. (See p. 18.) The communications look normal for many network operations. Although Solitaire generates minimal traffic (a maximum of 30 packets per second on average), more sophisticated games will increase the load.

Eliminating Network Games

If your network is experiencing a high number of "bullets per second" (game traffic) as opposed to "packets per second" (regular network traffic), you do have some options.

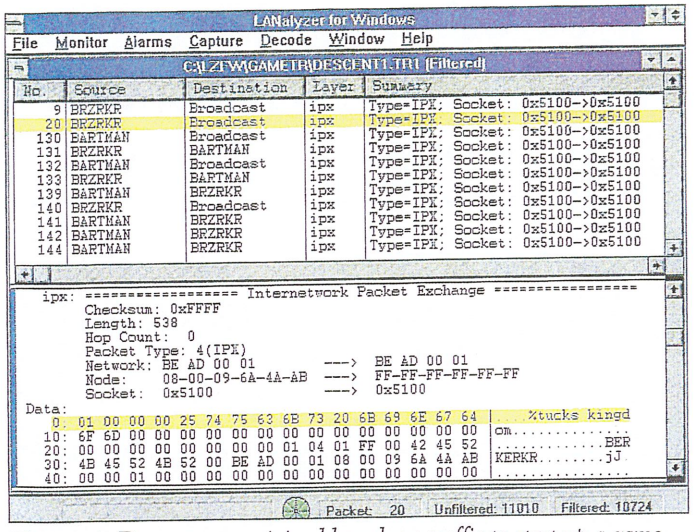


Figure 4. Descent uses minimal broadcast traffic to start up a game.

Protocol (NCP) socket number is 0x0456, SAP is 0x0452, and RIP is 0x0453.

Since ROTT allows up to 11 players per game and configurable sockets, network traffic increases when concurrent multiplayer games are in progress.

Note: Although we did not have a decode utility that allowed us to look at the function of the data above the IPX header, we did notice that much of the ROTT traffic is sequential. For example, in BARTMAN's packet 7690 which is highlighted in Figure 5, you can see the character "M" is the byte after the end of the IPX header. In BARTMAN's next packet, the first character will be an "N," and so on. Take a look at the trace file on the *NetWare Connection* WWW site (http://www.nwconnection.com) to see the sequential nature of ROTT communications. (See p. 18.)

Command and Conquer

Because Command and Conquer has an impressive installation program, you expect a fast-action adventure game, which typically creates heavy network traffic. However, Command and Conquer is a tank game, and as mentioned earlier, tank games typically have low overhead. After all, how fast can a tank move?

Although Command and Conquer allows up to four players, we had only two players participating in the game at one time. We noticed that Command and Conquer has a fixed packet size of 116 bytes and hit an average of 30 packets per second with 1 percent network utilization. The game uses a combination of broadcast and unicast packets to exchange player information.

Although Command and Conquer allows players to define socket numbers (the default is 0x8813), they cannot define a socket number lower than 0x4000. The game automatically adds 0x4000 to each user-defined socket number. This is a nice feature because many NetWare services use socket numbers below 0x4000 (such as NCP 0x0451, SAP 0x0452, and RIP 0x0453). Although multiple games can run concurrently with various socket numbers, Command and Conquer has low overhead.

Mortal Kombat 3

Mortal Kombat 3 (MK3) capitalizes on the blood-and-guts combat craze by offering an almost exact duplicate of the arcade game. MK3 supports up to 10-12 players. However, this game differs from other network games because only two players can challenge each other face-to-face.

We were surprised to find a definite architectural flaw in MK3: It broadcasts traffic onto the network even when players are playing in standalone mode. We loaded our network drivers (LSL, NE2000, IPXODI, but not VLM.EXE), installed the game, and launched it. No operating parameters were selected before the game's demo sequence began to run, but broadcast traffic increased on the network.

Apparently, the game default assumes that network communications are "on." Even if you are just playing against your computer, MK3 sends broadcast packets to determine if other players are on the network. We launched additional workstations to see if they all performed this way. All workstations running MK3 transmitted broadcast packets even though the players were not playing against each other.

We went into the game setup and selected "network=off," thinking that changing the setting would stop the broadcast packets. However, MK3 continued to broadcast traffic while in standalone mode. Apparently, the game autosenses the IPX driver and begins sending fixed 93-byte broadcast packets as soon as you launch the application. To stop your MK3 station from broadcasting packets, you must either physically disconnect your station from the network or quit the game.

Once an actual network game is started, however, most communications between players are unicast, averaging 150 packets per second with variable packet sizes. In a two-player MK3 session, network utilization jumps between a steady 1 percent to bursts of 4 percent.

Since MK3 allows up to 10-12 players (the documentation states that the number of allowable users depends on what the network bandwidth will support), game traffic can peak at 20 percent with five challenges occurring simultaneously. This game is deadly on a busy LAN or on any WAN link. The MK3 manual does warn users against playing the game on opposite sides of a router: "Playing the game between players on opposite sides of a Router can be a cause of lost packets and other delays. It is recommended that the game not be played in this fashion since it creates a system load on the Router that can disturb other users of the LAN."

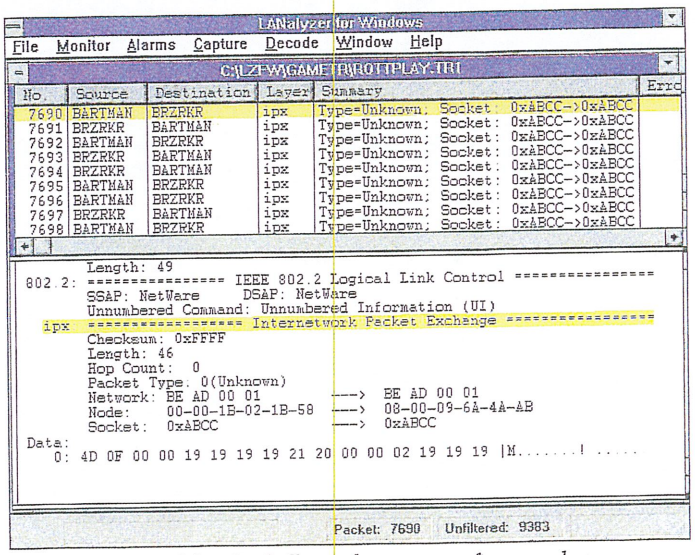


Figure 5. Rise of the Triad allows players to configure sockets numbers. In our tests, we chose 0xABCC.

Viewing the Sample Trace Files from Our Tests

If you want to examine the trace files from our tests, you can download them from the *NetWare Connection* World-Wide Web (WWW) site (http://www.nwconnection.com). You must use Novell's LANalyzer for Windows to view the following trace files:

DOOM1.TR1 (DOOM 1)	ROTTPLAY.TR1 (Rise of the Triad)
DOOM2.TR1 (DOOM 2)	C&C.TR1 (Command & Conquer)
HERETIC.TR1 (Heretic)	MK3.TR1 (Mortal Kombat 3)
HEXEN.TR1 (Hexen)	NETWAR1.TR1 (NetWars)
DESCENT1.TR1 (Descent)	SOL.TR1 (Windows Solitaire)

NAMES-ET.CSV (our name file for easier viewing of trace files)

Once you download these files, follow the instructions below to unzip and view them on a LANalyzer for Windows system.

1. Unzip the files using PKUNZIP v2.04g or above. **Important:** If you want to use the name file we have supplied, make a backup of your original name file (NAMES-ET.CSV) before copying our file into your LANalyzer for Windows directory.
2. Copy the trace files to your LANalyzer for Windows directory on your LANalyzer station.
3. Launch LANalyzer for Windows and select File > Open Packet File from the main menubar.
4. Double-click on the trace file listed in the LANalyzer for Windows directory or type in the trace filename. Click on OK. ■

First, you should try to educate the game players. Explain how games can affect network traffic, emphasizing how extra utilization and packets can affect network performance, especially across WAN links. Depending on your company and network, you may be able to establish "play" hours before or after work hours. If that doesn't work, there are a few alternatives you might want to try:

If DOOM 1.0 or 1.1 is a problem, download KILLDOOM.ZIP (24,278 bytes) from the Novell User Forum library on CompuServe (type GO NOVUSER and choose General Utilities). KILLDOOM is a freeware utility that broadcasts "bad" packets to the default DOOM socket number. If you are unsure of the socket number your players are using, you can configure KILLDOOM to broadcast to a range of sockets. The good news is that it is a "clean kill": The game will simply end. Unfortunately, if you configure the utility to broadcast to a large range of socket numbers, you can cause an IPX broadcast storm. Read the README.TXT file before you use this utility.

If you want to attack some of the games where they reside on the network drive, take a look at Ungame by DVD Software, Inc. Ungame includes a database with thousands of signatures and game titles, and it uses this database to search through the files in specified directories for unique "signatures."

You can configure Ungame to record any games found in a log file or to erase it off the disk. You can try the shareware version for 30 days. Download UNGAME11.ZIP (89,693 bytes) from the NetWare User Forum library on CompuServe (type GO NOVUSER and choose the Management section). The full product includes a list of more than 2,100 games.

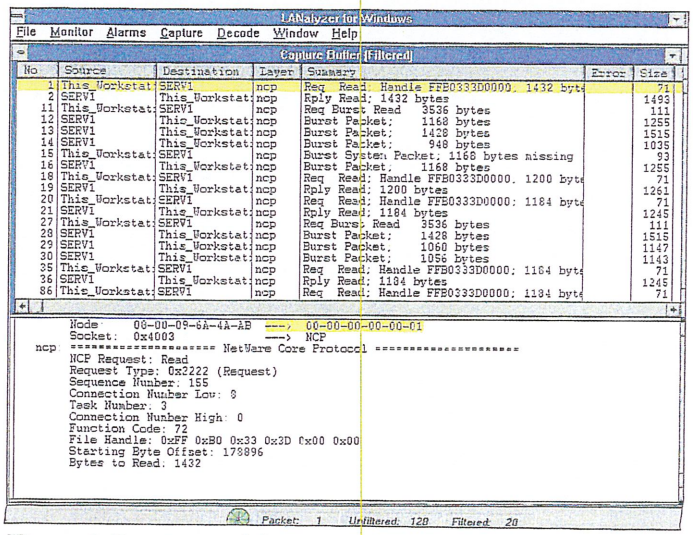


Figure 6. Running standalone games from the server generates traffic.

Summary

According to Dana Hollander, president of DVD Software, Inc., "The greatest problem caused by games is the loss of productivity—people are paid to work, not play." What should you do about all this fun at the office? First, monitor your network utilization. If you see dramatic increases, investigate the cause—you might have a Deathmatch going on behind closed doors. If a game has become a problem and it uses a fixed socket number (for example, Mortal Kombat 3), you can easily use a network analyzer to find the stations that are eating up network bandwidth or bogging down the WAN link.

We do not believe that you can win the battle against network games, but at least game manufacturers are becoming aware of the impact their products have on network traffic. Fewer broadcasts, variable packet sizes, and nonconflicting socket numbers will make games enjoyable for everyone on the network.

Contact Information. All of the games mentioned in this article are available through retail channels. You can also contact the following companies for more information:

- **DOOM 1, DOOM 2, Heretic, and Hexen.** Call Id Software at 1-800-434-2637 or go to http://www.idsoftware.com.
- **Descent.** Call Interplay Productions at 1-800-INTERPLAY or 1-714-553-6655.
- **Rise of the Triad.** Call Apogee Software at 1-800-276-4331 or 1-214-278-5655.
- **Command and Conquer.** Call Westwood Studios at 1-800-874-4607 or 1-619-693-1200.
- **Mortal Kombat 3.** Call GT Interactive Software at 1-970-522-1844 or go to http://www.gtinteractive.com.

Credits. Our thanks go to Jill Poulsen, Peter Kuo, and Dana Hollander at DVD Software, Inc. (You can reach Dana on CompuServe at 76131,1450.) Our top players were Tom Poulsen (BERZERKER), Bart Poulsen (BARTMAN), Roger Spicer (CODEMAN), Laura Chappell (BUBBLES), Pete Pressley (PETEP), and Jeff Mangasarian (MANGO).

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