FILE EXCHANGE PROTOCOLS

AND

ZERO CONFIGURATION NETWORKING

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1. Introduction

The purpose of this paper is to describe in detail some of the major file exchange protocols that are currently used on computing systems. The protocols that will be covered are AFP (AppleShare File Protocol), FTP (File Transfer Protocol), SMB (Server Message Block), NFS (Network File System), WebDAV, and Zero Configuration Networking.

1.1 Client-Server

In a client-server networking architecture, personal computing applications connect to a server. Some different server types include database servers, file servers, and mail servers. A good example of this relationship would be viewing a website on a computer, with one's computer being the client and the machine where the website is hosting being the server.

1.2 Peer-to-Peer

Peer-to-peer networks consist of mostly clients interacting with each other rather than using a shared server. In recent years, peer-to-peer networks have become increasingly popular and controversial for the use of file sharing. Prominent files sharing applications include *LimeWire*, *Morpheus*, and *Napster*. These networks work by having the client act as both a client and a server (commonly referred to as Ad-Hoc).

1.3 Hybrid

Hybrid networking consists of both client-server and peer-to-peer.

2. AppleShare File Protocol (AFP)

The AppleShare File Protocol is a product of Apple Computer, which was introduced with Mac OS 7.6 in circa 1996. AFP, as it is commonly referred to, is a presentation layer (used for the delivery and formatting of the information) protocol that is used for the exchange of files on Mac OS X and a classic Mac system. The first version of this was AFP 1.x, in System 7, which was later succeed by AFP 2.0 and then AFP 3.0 version in Mac OS X. AFP 3.0 relies entirely on TCP/IP for communication, only using the companies' AppleTalk software as a service discovery protocol. [1] AFP had used an AppleTalk server until the current version of Mac OS X 10.4, which only utilizes AppleTalk for its communication medium (See Figure 2).

2.1 AFP Mac OS X Releases

AFP Release	Mac OS Version	Comments
3.0	10.0.3 Server	• Notable for its use of UNIX-style POSIX permissions model. The largest file size that could be transferred was two terabytes.

1 AppleShare File Protocol

AFP Release	Mac OS Version	Comments
3.1	10.2 Server	• Changes for Kerberos support, Network File System (NFS), and Secure AFP connections through a secure shell. The new capacity for file exchange was increased to 8 terabytes.
3.2	10.4 Server	• Added more support for Access Control Lists and the ability to view metadata files in Apple's Spotlight searching technology. All of these changes occurred in Mac OS X Server 10.4. AFP currently supports access control list permissions.

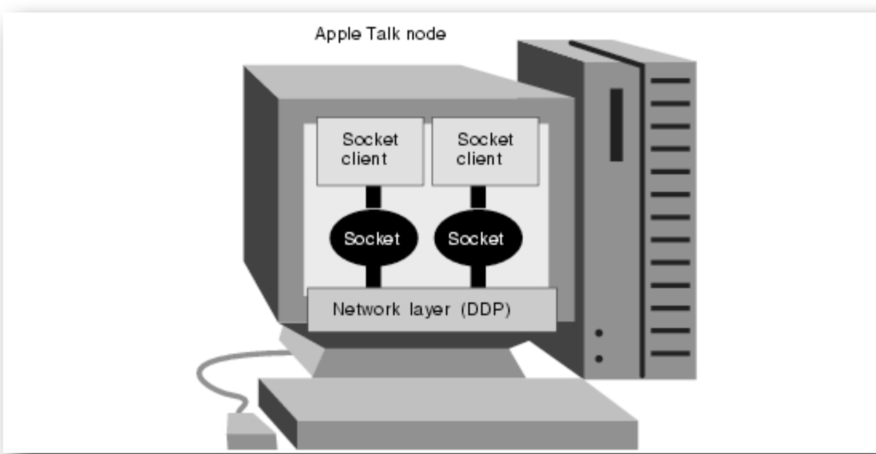
2.2 Brief Background on AppleTalk

AppleTalk began in 1984 with the introduction of the Macintosh computer. Over the past few years, Apple has been using TCP/IP functionality instead of AppleTalk. AppleTalk can be used as a hybrid (client-server and peer-peer). There are four components to the AppleTalk network: *sockets*, *nodes*, *networks*, and *zones*.

2.2.1 Sockets

A *socket* is an addressable location in an AppleTalk node. It is where the AppleTalk software directly interacts with the network layer. The software, which is limited to the upper layer, contains processes known as socket clients.

Socket clients have one or more sockets, which send and receive datagrams. Certain sockets can be assigned statically or dynamically. Statically assigned sockets are reserved for use by certain protocols or other processes. Dynamically assigned sockets are assigned by the Datagram Delivery Protocol (DDP) to socket clients upon request.[2]



[2] AppleShare File Protocol

Figure 1. An AppleTalk Socket.

2.2.2 Nodes

Nodes are devices that are connected on the AppleTalk network. These devices can be any device, ranging from another Macintosh, to a Windows machine, or even a printer. Printers cannot upload files onto the network, but can only print. Each specific node on the AppleTalk network is restricted to only one network and one zone.

2.2.3 Networks

AppleTalk *networks* are a series of nodes attached to a cable. This cable can be connected to a bridge or a router to further extend the connections of the network. There are two different kinds of networks involved: non-extended networks and extended networks.

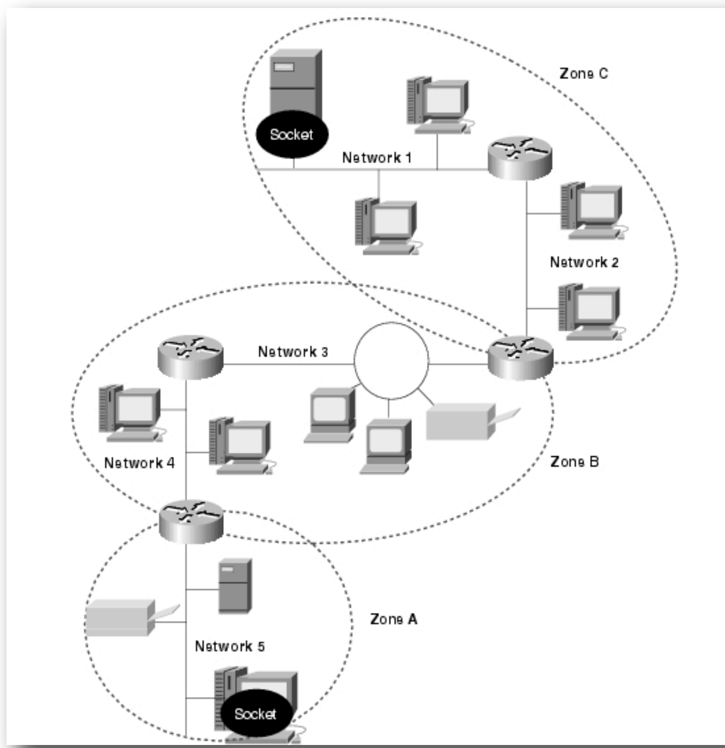


Figure 2. AppleTalk Internetwork Components.

2.2.3.1 Non-Extended Networks

Non-extended networks are physical segments that have only a single network segment, which is in the number range of 1 to 1024 (See Figure 3). Each specific node number must only have one zone configured and can transfer information over Ethernet or wireless. Currently, non-extended networks are not as widely used as extended networks.

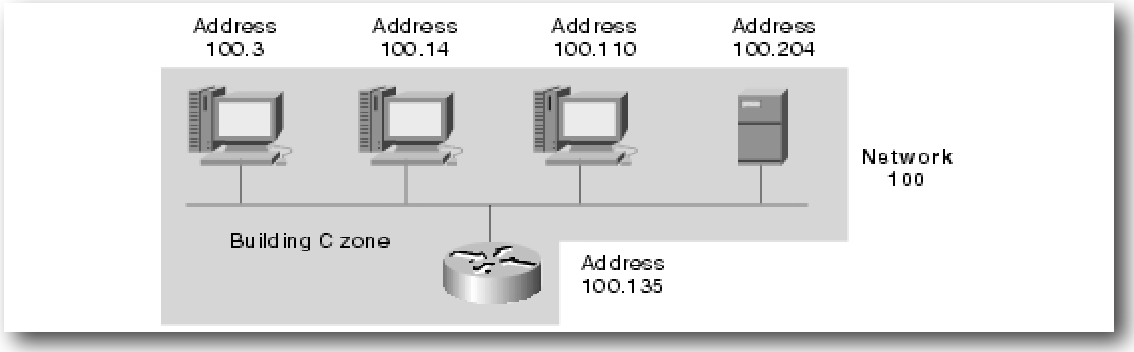


Figure 3. Non-Extended Network Diagram.

2.2.3.2 Extended Networks

An *extended network* is a physical network segment that is given multiple network numbers (also known as a cable range) (See Figure 4). Extended networks can contain a single network number or multiple sequential network numbers. These extended networks can transfer information over Ethernet or wireless.

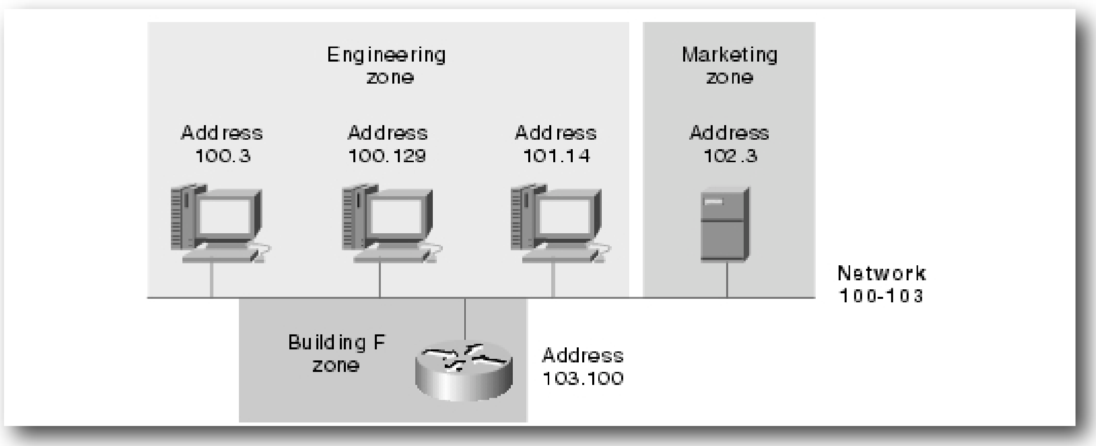


Figure 4. Extended Network Diagram.

2.2.4 Zones

AppleTalk *zones* are groups of nodes or networks that are defined when the network administrator administers the network. In example, Clarkson University's buildings have their own subnetwork within Clarkson's network (machine1.snell.clarkson.edu, machine2.sc.clarkson.edu). Snell would be its own zone as well as the Science Center. As far as an autonomous system is concerned, AppleTalk zones are controlled by a single entity, with various subnetworks underneath it. Autonomous systems and AppleTalk zones essentially operate in the same fashion.

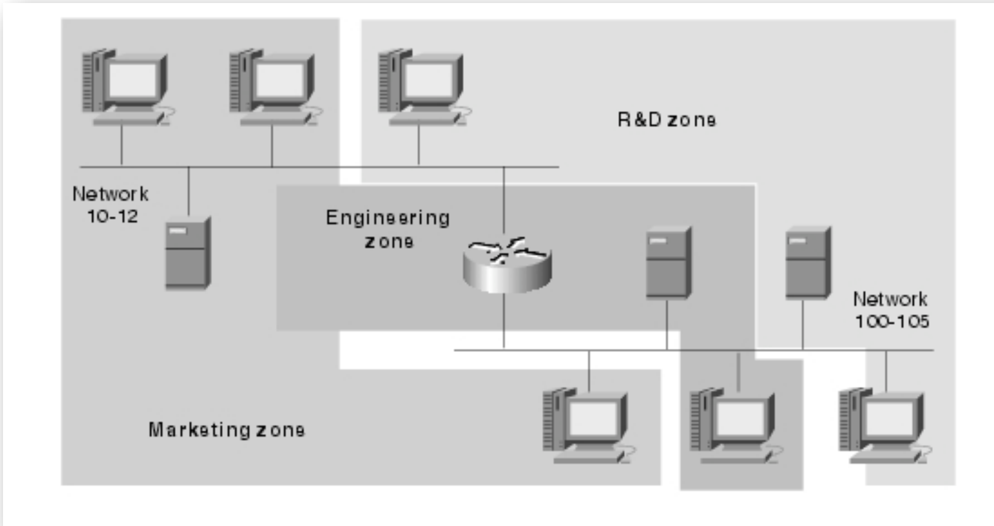


Figure 5. An AppleTalk Zone.

3. File Transfer Protocol (FTP)

File Transfer Protocol, or FTP, is a protocol used for the sharing of files across a network. Other functions of FTP include indirectly controlling a remote machine, and transfer data regarding reliability. The first version of FTP was first introduced in 1971, and was used as the first proposed file transfer mechanism.[3] In 1982, The File Transfer protocol definition was changed to: "a protocol for file transfer between HOSTs on the ARPANET, and its main function was to transfer files efficiently.[4]"

3.1 Data Transfer

Using FTP, files can only be exchanged through a data connection (See Figure 4). The control connection is for the transfer of commands, which describe the functions to be performed, and the replies to these commands.[5] There are other commands that deal with the transfer of data between host machines.

Included in FTP is the Protocol Interpreter and the Data Transfer Protocol (DTP). The user protocol interpreter has control over sending commands and translating the data it receives. The server protocol interpreter reads the commands, sends responses, and directs the DTP for initialization of the data connection for the transfer of data.

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3 Postel, 2

4 Postel, 2

5 Postel, 2

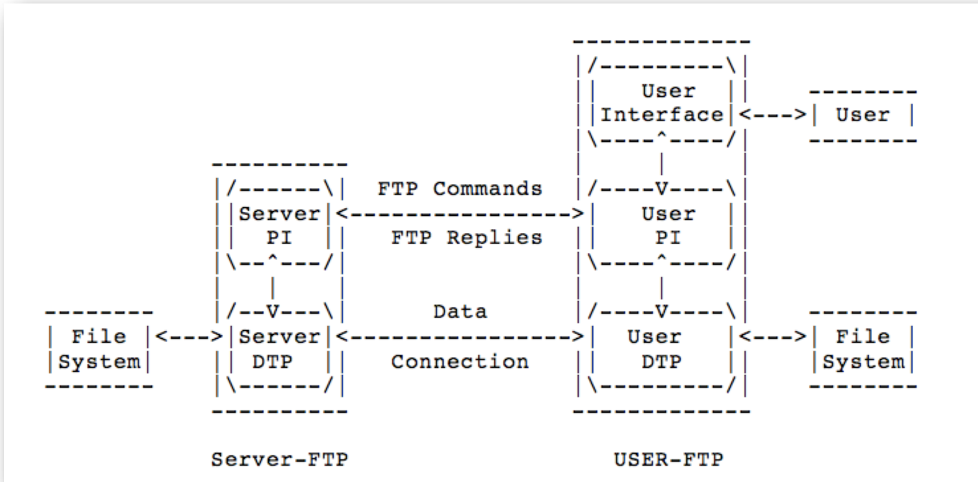

Figure 6. The FTP model.

4. Server Message Block (SMB)

The Server Message Block, or SMB, protocol was invented at IBM by Dr. Barry Feigenbaum. The idea for SMB originated when Dr. Feigenbaum wanted to take the DOS "Interrupt 33" local file access into a networked file system.[6] The version that is used now has been refitted by Microsoft. In 1998 Microsoft launched its own file protocol based off of SMB, called Common Internet File System (CIFS), intended for use with the Windows workgroup. In 1998, Sun Microsystems also created its own version of SMB called WebNFS.

The SMB protocol has been very significant to Windows. In the case of computer users who do not use Windows, an open source implementation called Samba was created for this specific purpose.

4.1 Client-Server Relationship

SMB operates from a client-server approach. This approach is done when a client connects to the server, and the server replies to the message. SMB servers can provide access to let the servers file become visible on the network. Hard disks can be hidden (through changing permissions) on the network, and peripherals (printers, etc.) can be connected remotely. It is common for SMB to slow down network traffic, as the server broadcasts itself over an entire subnetwork or network.

5. Network File System (NFS)

The Network File System (NFS), protocol was created by Sun Microsystems in 1984. NFS allows a computer to connect and obtain files or data on a remote machine, but viewing the remote disk as local disk. The file system used for NFS contains a hierarchical with regular files that are encoded in UTF-8 for multilingual uses.[7]

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6 Server Message Block

7 RFC 3530

The NFS mount function permits NFS clients to attach remote directory trees to a mount point in the local file system.[8] In order to mount an NFS file system, permissions are needed for the primary file system machine. Once the user has been authenticated, remote access is granted to the file system.

6. Andrew File System

The Andrew file system, or AFS, is a distributed networked file system with regards to scalability and security. AFS was first developed at Carnegie Mellon University. The files on the system are cached onto a local machine and when the files are located on the network, the local machine can read the files more quickly than through other networked file systems. AFS uses Kerberos to authenticate users, as well as implementing access control lists for the directories and users.

7. WebDAV

Web-based Distributed Authoring and Versioning called WebDAV, is a group of HTTP extensions for editing and managing files on remote web servers collaboratively. WebDAV is primarily a client-server relationship.

7.1 WebDAV Background

WebDAV first took shape when Jim Whitehead asked the W3C to hold special meetings about distributed authoring on the Web, and the possibility of proposing solutions to that problem. A web browser called *WorldWideWeb*, which was written by Tim Berners-Lee, had the option of editing and viewing web pages. As the internet progressed, Whitehead wanted to have editing and viewing pages included in newer software, since as it had faded out. After the W3C meeting, several people agreed that an IETF working group should be created, in order to standardize a new protocol. Soon after, the WebDAV group chose to focus in distributed authoring.

8. Zero Configuration Networking

The Zero Configuration Networking Group was chartered in 1999 to promote the work of Dynamic Configuration for IPv4 Link-Local Addresses that the group had created. This protocol was shipped with the Macintosh Operating System (9 and X), the Windows Operating System (98 through the present), and in nearly all network printers from most major suppliers.

Zero Configuration Networking (ZeroConf) allows a user to connect to devices, either wired or wireless, through a small network without a DHCP or DNS server (See Figure 7).

8 http://www.ussg.iu.edu/usail

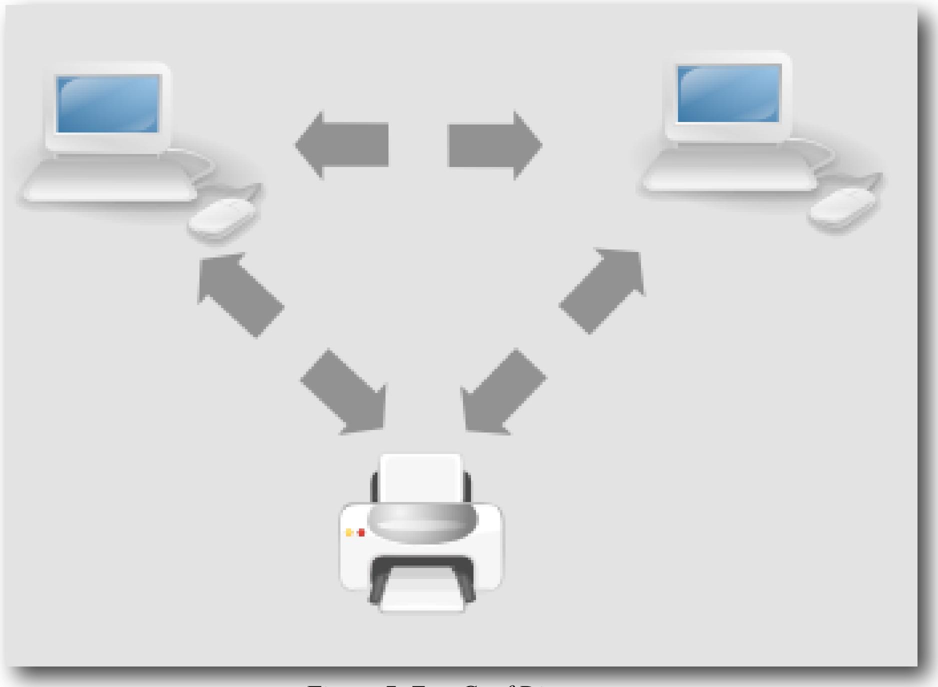


Figure 7. ZeroConf Diagram.

A computer can exchange files with another machine, sharing files via peer-to-peer, and can connect to a printer without the need of a LAN. With the exception of Zero Configuration Networking, problems can arise when an LAN shuts down and information cannot be transmitted.

8.1 Using IP Addresses With and Without DHCP

An IP address is needed to connect to a device on a network. The two most ideal ways to retrieving an IP address are manual input and DHCP.

Manual

Windows and Macintosh lets one input the IP address manually through a graphical user interface (GUI) application.

DHCP

Once an IP address is located through the DHCP client, the computer can be configured to connect to other devices. In example, this is used for a client connecting to a DHCP server for an amount of time. In the case of Zero Configuration Networking, the DHCP client is not used in favor of the link-local address.

Selection of an IP Address

In 1998, Mac and Windows were outfitted with the ability to obtain a link-local address. If the DHCP server happens to fault, a link-local address is assigned with the prefix address of

169.254.x.x using Multicast DNS (mDNS). The host machine must complete a scan of the network using an Address Resolution Protocol (ARP) probe to resolve any conflicts, which then claims a link-local address so that the user can be assigned an address and use the network for printing or sharing a document on the local network. The address that the computer is assigned cannot be placed into service until the same, if any, address on the network is free for use.

IPv6

IPv6 is the next generation of internet protocol that will be implemented over the course of the next 5-10 years (IPv4 addresses would be exhausted within the next several years). Zero Configuration Networking currently only supports IPv4.

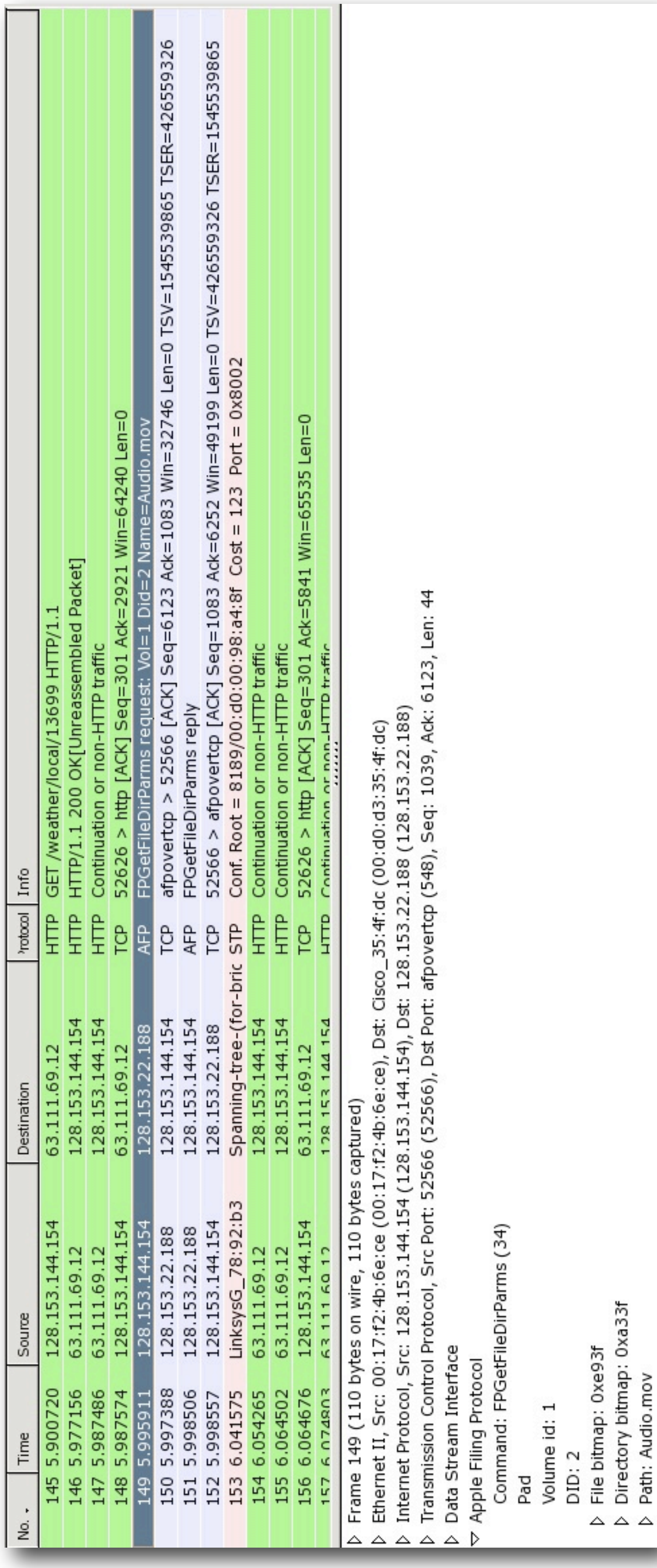
9. Conclusion

All of these major networking protocols transfer data from one point to another, whether it be peer-to-peer, client-to-server, or both. All major operating systems have connections to network protocol installed. AFP is currently the most useful file sharing protocol, as the ease-of-use and its hybrid connections cannot be matched by any other protocol. The AFP connection is built into the Mac OS X operating system, can connect very quickly, and the remote disk can be mounted as if it was a local drive. The transfer of data and the exchange of ideas will keep networks advancing for many years to come.

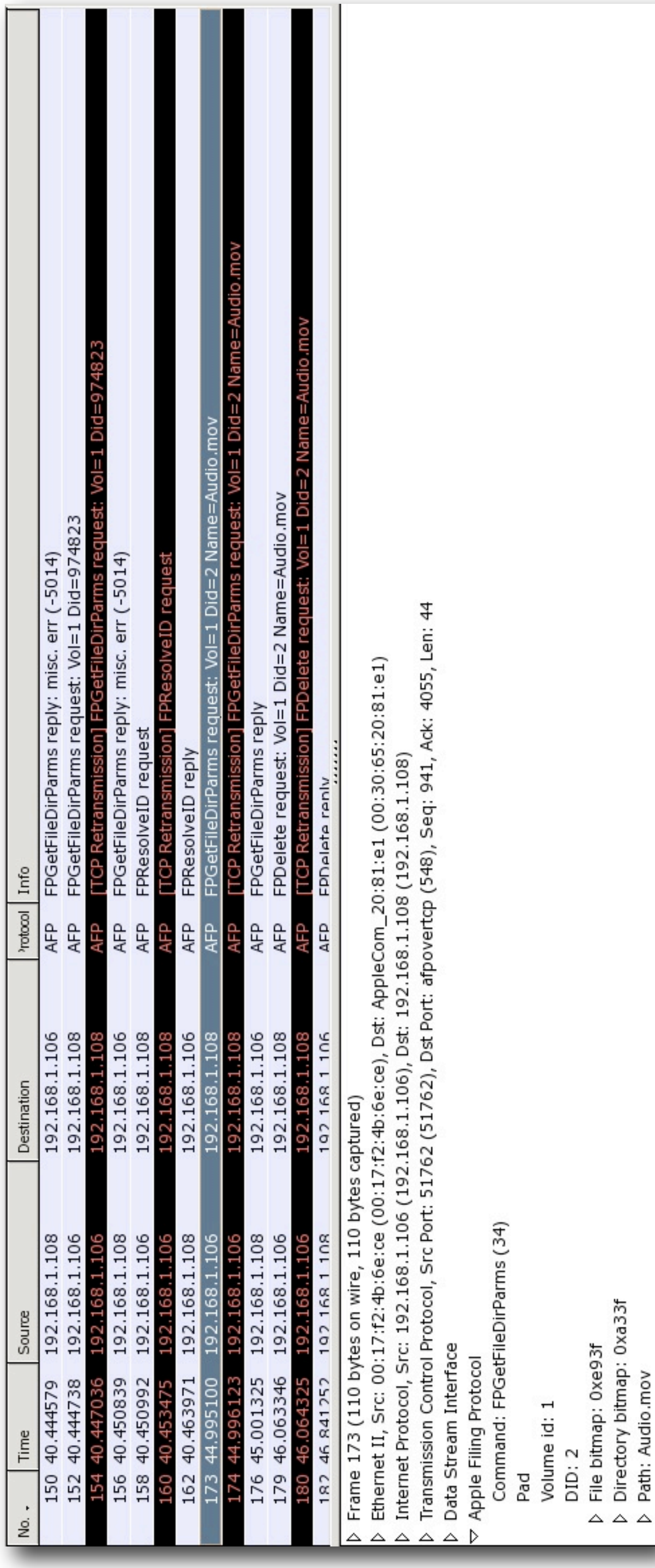
10. Ethereal Traces

The AFP over TCP, AFP without TCP, SMB, and FTP traces are in example on pages 12 through 15. The complete details of these traces can be found on the project website at http://www.clarkson.edu/projects/itl/mpX52/fa2006/wernerjs/traces.htm.

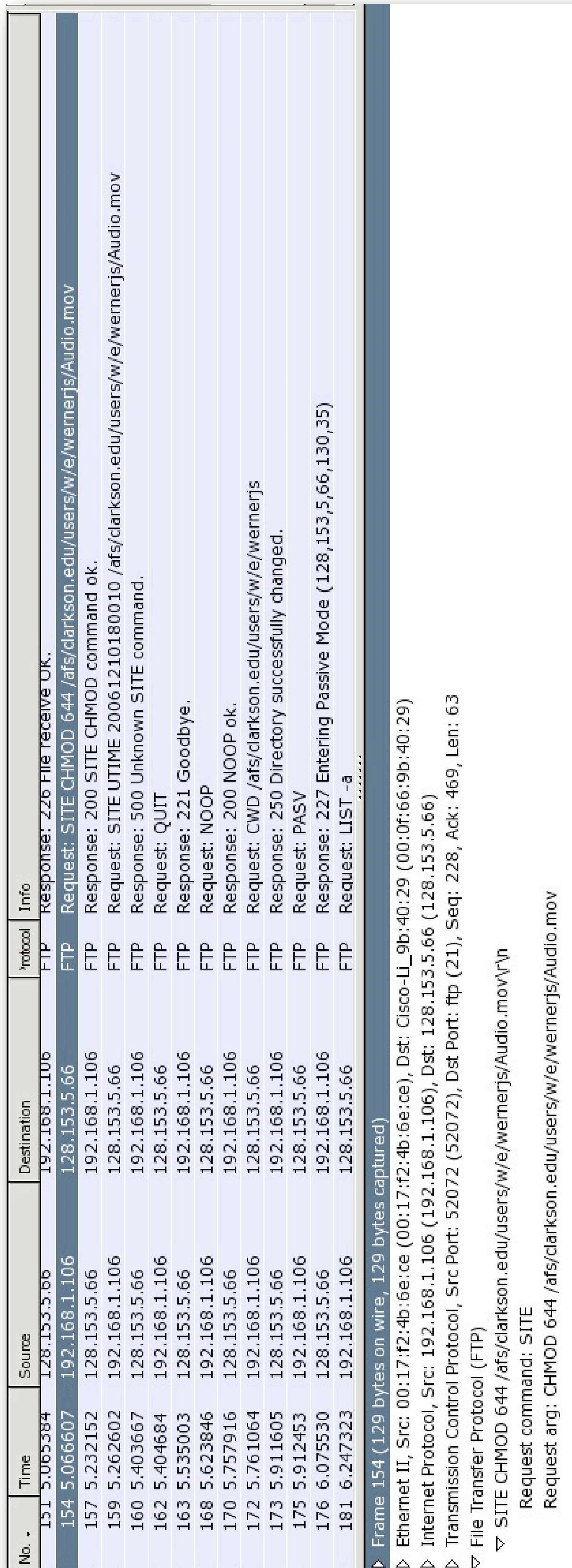
10.1.1 AFP Over TCP Trace



10.1.2 AFP Over Bonjour (ZeroConf) Trace



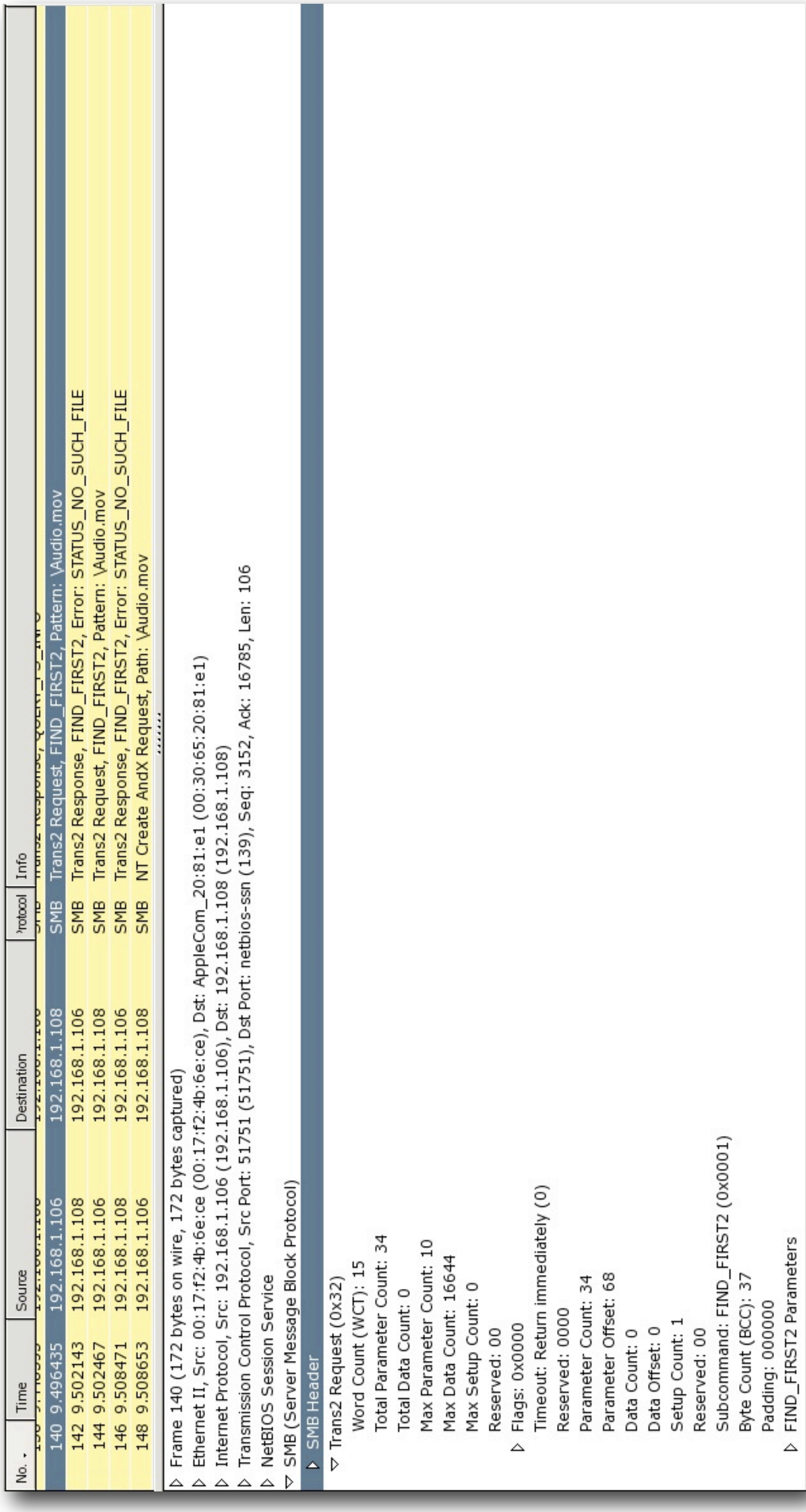
10.1.3 FTP Trace



No.	Time	Source	Destination	Protocol	Info
151	5.065384	128.153.5.66	192.168.1.106	FTP	Response: 226 File receive OK.
154	5.066607	192.168.1.106	128.153.5.66	FTP	Request: SITE CHMOD 644 /afs/clarkson.edu/users/w/e/wernerjs/Audio.mov
157	5.232152	128.153.5.66	192.168.1.106	FTP	Response: 200 SITE CHMOD command ok.
159	5.262602	192.168.1.106	128.153.5.66	FTP	Request: SITE UTIME 20061210180010 /afs/clarkson.edu/users/w/e/wernerjs/Audio.mov
160	5.403667	128.153.5.66	192.168.1.106	FTP	Response: 500 Unknown SITE command.
162	5.404684	192.168.1.106	128.153.5.66	FTP	Request: QUIT
163	5.535003	128.153.5.66	192.168.1.106	FTP	Response: 221 Goodbye.
168	5.623846	192.168.1.106	128.153.5.66	FTP	Request: NOOP
170	5.757916	128.153.5.66	192.168.1.106	FTP	Response: 200 NOOP ok.
172	5.761064	192.168.1.106	128.153.5.66	FTP	Request: CWD /afs/clarkson.edu/users/w/e/wernerjs
173	5.911605	128.153.5.66	192.168.1.106	FTP	Response: 250 Directory successfully changed.
175	5.912453	192.168.1.106	128.153.5.66	FTP	Request: PASV
176	6.075530	128.153.5.66	192.168.1.106	FTP	Response: 227 Entering Passive Mode (128,153,5,66,130,35)
181	6.247323	192.168.1.106	128.153.5.66	FTP	Request: LIST -a

Frame 154 (129 bytes on wire, 129 bytes captured)
Ethernet II, Src: 00:17:f2:4b:6e:ce (00:17:f2:4b:6e:ce), Dst: Cisco-Li_9b:40:29 (00:0f:66:9b:40:29)
Internet Protocol, Src: 192.168.1.106 (192.168.1.106), Dst: 128.153.5.66 (128.153.5.66)
Transmission Control Protocol, Src Port: 52072 (52072), Dst Port: ftp (21), Seq: 228, Ack: 469, Len: 63
File Transfer Protocol (FTP)
SITE CHMOD 644 /afs/clarkson.edu/users/w/e/wernerjs/Audio.mov\r\n
Request command: SITE
Request arg: CHMOD 644 /afs/clarkson.edu/users/w/e/wernerjs/Audio.mov

10.1.4 SMB Trace



11. Comparison Table

	Client-Server Peer-to-Peer Hybird	File Size Limit
AFP	Hybrid	16 TB*
FTP	Client-Server	50-200MB*
NFS	Client-Server	Varies
SMB	Client-Server	2 GB
AFS	Client-Server	2 GB
WebDAV	Client-Server	500 MB

*AFP - 16 TB as of OS 10.2. OS 10.3 has not stated any kind of file limit.

*FTP - 50-200 MB depending on the FTP client.

Works Cited

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