CS 580 Client-Server Programming
Fall Semester, 2012
Doc 18 Protocol
Nov 1, 2012

References

Hypertext Transfer Protocol - HTTP/1.0, Berners-Lee, Fielding, Nielson, rfc1945, http://www.w3.org/Protocols/rfc1945/rfc1945

Hypertext Transfer Protocol -- HTTP/1.1, Fielding, Gettys, Mogul, Masinter, Leach, Berners-Lee, rfc2616, http://www.w3.org/Protocols/rfc2616/rfc2616.html

Uniform Resource Identifiers (URI): Generic Syntax, Berners-Lee, Fielding, Masinter, rfc2396 http://www.rfc-editor.org/rfc/rfc2396.txt

RFC 1939, http://www.rfc-editor.org/rfc/rfc1939.txt

The Gnutella Protocol Specification v0.4, Document Revision 1.2, http://www9.limewire.com/developer/gnutella_protocol_0.4.pdf

Reading

Post Office Protocol RFC 1939, http://www.rfc-editor.org/rfc/rfc1939.txt

Protocol

Requirements for a "good protocol"

- Well defined
- Complete
- Parsable
- Extendable
- Available protocol document

Old Assignment Protocol

Client Command	Server Response
login;screenName:foo;password:bar;;	ok:success;;
transmitMessage:Hello World;;	ok:success;;
transmitMessage:Hello \\2;;	ok:success;;

messages;block:1;;	ok:2;
	text:Hello \\2:sender:foo:time:02/03/2009 13\:29\:45;
	text:Hello World:sender:foo:time:02/03/2009 13\:29\:42;;

fuss;;	error:Invalid command f;;
quit;;	ok:quit;;

Well defined

Every bit of data sent in either direction has to have its place in the protocol description.

Protocol is a Language

Common formal description:

BNF and Augmented BNF

Format of the description language needs to be part of the protocol document.

Examples are important

Complete

The protocol must cover all possible situations.

Garbage data
Old client or server (different protocol versions)
Illegal requests
Boundary conditions
Etc.

Parsable

Both clients and servers are computer programs.

A computer program's IQ is generally 0.

Design goals

Distinct information packets or messages

- Allow parsing independent of semantics

Consistency

- Allow for code reuse

Flexibility

Allow parsing independent of semantics

Client foo Command	Server Response
login;nickname:foo;password:foopass;;	ok:success;;
waitingList;;	ok:1;nickname:bar;;
startconversation:bar;;	acceptconversation;; (assuming bar accepts)
message;text:Hello;;	message;text:Message from bar: sender:bar;time: 02/08/2010 20\:13\:37;;
quit;;	ok:quit;;

How does

the server parse each set of commands?

The client parse each response

Available

Different groups may write clients and servers at different times.

Central registry for Internet protocols

Self regulating:

- RFC - Request For Comment
- IETF - Internet Engineering Task Force

Official:

- ISO
- ANSI

Protocol Types

S**ynchronous**

Client sends request to server

Server responds with a reply

HTTP, POP, SMTP, GOPHER, XMODEM

S**ynchronous**

Client and server both send information to each other concurrently.

TELNET, RLOGIN, ZMODEM

A hybrid protocol is also possible

Protocol Design Issues

Protocol design is difficult!

Learn from examples

Some issues

Protocol extendibility and versioning

Byte order used for sending values

ASCII vs. Binary protocol

Synchronous vs. Asynchronous

State

Timeouts

HTTP

HTTP

Stateless (http 1.0)

Assigned port 80

Basic Server-Client Interaction (http 1.0)

Client: Open connection

Server: Accept/Reject connection

Client: Send request

Server: Send response to request

Connection closed

HTTP Message Format

```
HTTP-message   =   Simple-Request              (HTTP/0.9 messages)
        | Simple-Response
        | Full-Request                         (HTTP/1.0 messages)
        | Full-Response


Full-Request   =       Request-Line
        *( General-Header   | Request-Header  | Entity-Header )
        CRLF
        [ Entity-Body ]


Full-Response  =      Status-Line
        *( General-Header   | Request-Header   | Entity-Header )
        CRLF
        [ Entity-Body ]


HTTP-header   = field-name ":" [ field-value ] CRLF

Entity-Body      = *OCTET
```

HTTP Full Request

Request-Line = Method SP URI SP HTTP-Version CRLF

```
rohan 13-> telnet www.eli.sdsu.edu 80
Trying 130.191.226.80...
Connected to www.eli.sdsu.edu.
Escape character is '^]'.
GET /courses/fall00/cs580/index.html HTTP/1.0

HTTP/1.1 200 OK
Date: Tue, 05 Sep 2000 19:31:14 GMT
Server: Apache/1.3.9 (Unix) PHP/3.0.12
Last-Modified: Mon, 04 Sep 2000 21:03:56 GMT
ETag: "14c199-7e8-39b40e3c"
Accept-Ranges: bytes
Content-Length: 2024
Connection: close
Content-Type: text/html
X-Pad: avoid browser bug

<HTML>
<HEAD>
      <TITLE>CS 580: Course Web Site</TITLE>
… stuff removed here…
Connection closed by foreign host.
```

2 CRLF's end the full request

Header

2 CRLF's ends Header

Body

Positional Data verses Name-Value Pairs

1.0; CERN/3.0; Thursday, 21-Mar-96 17:00:45 GMT; text/html; 2686; Tuesday, 27-Feb-96 05:34:12 GMT

MIME-Version: 1.0
Server: CERN/3.0
Date: Thursday, 21-Mar-96 17:00:45 GMT
Content-Type: text/html
Content-Length: 2686
Last-Modified: Tuesday, 27-Feb-96 05:34:12 GMT

Which is more error prone?

Which is easier to extend?

Name-Value Pairs & Orderer

```
MIME-Version: 1.0
Server: CERN/3.0
Date: Thursday, 21-Mar-96 17:00:45 GMT
Content-Type: text/html
Content-Length: 2686
Last-Modified: Tuesday, 27-Feb-96 05:34:12 GMT
```

```
Server: CERN/3.0
Content-Type: text/html
MIME-Version: 1.0
Content-Length: 2686
Last-Modified: Tuesday, 27-Feb-96 05:34:12 GMT
Date: Thursday, 21-Mar-96 17:00:45 GMT
```

Adding new Fields

MIME-Version: 1.0

Server: CERN/3.0

Date: Thursday, 21-Mar-96 17:00:45 GMT

Content-Type: text/html

Forwarded: by http://rohan.sdsu.edu/ for cs.sdsu.edu

Content-Length: 2686

WhitneyInfo: Hi Mom

Last-Modified: Tuesday, 27-Feb-96 05:34:12 GMT

Name value pairs in methods

Objective C

```
[aDictionary setValue: @"hi Mom" forKey: @"message"];
```

Java

```
aDictionary.put("Hi Mom","message");
```

Name-Value Pairs are your Friends
Don't Program without them

How to Indicate the End of a Message

Use termination sequence

Make the length of the message known

HTTP uses both

Header ends in CRLFCRLF

Header contains length in bytes of message body

```
HTTP/1.0 200 Document follows
MIME-Version: 1.0
Server: CERN/3.0
Date: Thursday, 21-Mar-96 17:00:45 GMT
Content-Type: text/html
Content-Length: 2686
Last-Modified: Tuesday, 27-Feb-96 05:34:12 GMT
```

Detecting End of a Message

What if the terminating sequence is part of the message?

What if a HTTP header contains CRLFCRLF

POP3

POP3

Post Office Protocol

Purpose: Allow PC's, Macs, etc. to download mail from server

Port number 110

Protocol uses ASCII only

Stateful protocol

Multiple requests & responses on same connection

Format of commands to server

keyword blank argument1 [blank argumentk] CRLF

| keyword | = 3, 4 characters, no spaces

| argument | <= 40 characters, no spaces

keyword and arguments are separated by single space character

Server Response

Status keyword additionalInfo

Status is either "+OK" or "-ERR0.3."

A single line response ends in CRLF

If response requires more than one line:

- Each line ends in a CRLF
- The response ends in CRLF.CRLF
- If a line starts with a "." prepend a "." to it

When Client reads the first CRLF how does it know it is at the end of message?

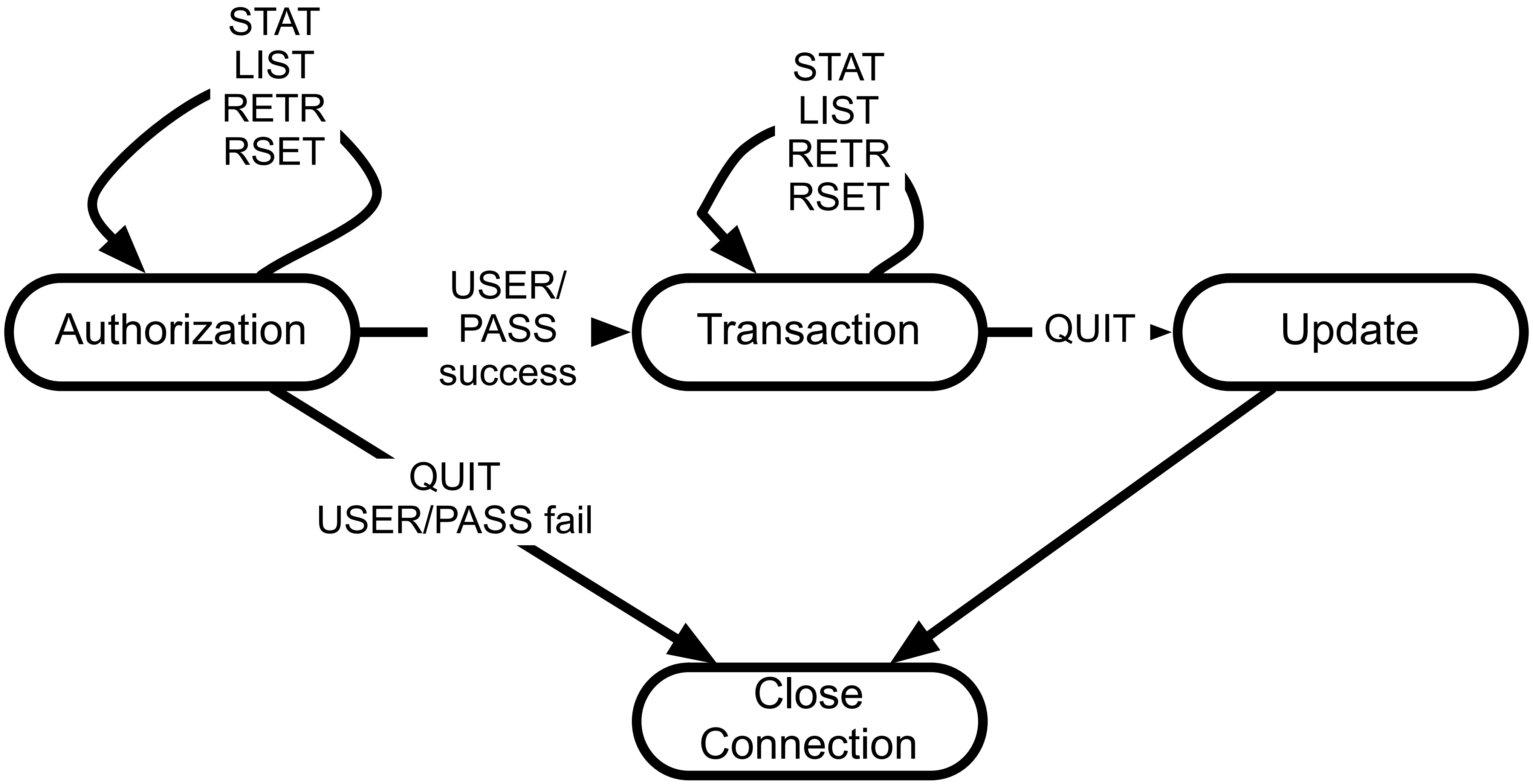
Timeouts

A POP3 server may have an autologout timer

A server must wait at least 10 minutes before timing out an idle client

The POP3 server on cs.sdsu.edu times out in 2 minutes

Client Connect States



Authorization State

Server acknowledges connection from client with

```
+OK  "message"

+OK UCB Pop server (version 2.1.2-R3) at sciences.sdsu.edu starting.
```

Commands: USER, PASS, APOP, QUIT

USER PASS

Combination is used to progress to transaction state

USER must come first

PASS or QUIT must come after USER

Example

```
Ti 38->telnet cs.sdsu.edu 110
Trying 130.191.226.116...
Connected to cs.sdsu.edu.
Escape character is '^]'.
+OK QPOP (version 3.1.2) at sciences.sdsu.edu starting.
USER whitney
+OK Password required for whitney.
PASS typeYourPasswordHere
+OK whitney has 116 visible messages (0 hidden) in 640516
octets.
```

Transaction State

Commands: STAT, LIST, RETR, RSET, QUIT

STAT

Arguments: none
Returns "+OK" numberOfMessages SizeOfMail

```
STAT
+OK 22 45595
```

LIST

Arguments: a message-number (optional)
Returns: size of message in octets

Examples

```
LIST 2
+OK 2 3064
```

```
LIST
+OK 116 visible messages (640516 octets)
1 2980
2 3064      ( message 3 - 116 deleted to save space )
116 1290
.
```

Transaction State

RETR

Arguments: a message-number

Returns: the message

```
RETR 21
+OK 825 octets
Received: from [130.191.9.18] (ebb2p9.sdsu.edu [130.191.9.18]) by sciences.sdsu.edu
 (4.1/8.6.10) with SMTP id UAA29486 for <whitney@saturn.sdsu.edu>; Mon, 11 Mar
1996 20:16:07 -0800 (PST)
X-Sender: whitney@cs.sdsu.edu (Unverified)
Message-Id: <v02110100ad6aaaf097b6@[130.191.9.70]>
Mime-Version: 1.0
Content-Type: text/plain; charset="us-ascii"
Date: Mon, 11 Mar 1996 20:16:50 -0800
To: whitney@saturn.sdsu.edu
From: whitney@saturn.sdsu.edu (Roger Whitney)
Subject: Sample Mail
X-UIDL: 826604201.000

this is a test
..
the end
---
Roger Whitney              Math & Computer Science Dept.
whitney@cs.sdsu.edu                  San Diego State University
http://www.eli.sdsu.edu       San Diego, CA 92182-7720
(619) 594-3535
(619) 594-6746 (fax)

.
```

Transaction State

DELE

Arguments: a message-number to delete

Returns: a confirmation of deletion

Marks a message to be deleted

NOOP

Arguments: none

Returns: a positive response

Does nothing

Why NOOP?

QUIT

Arguments: none

Returns: a positive response

Send POP3 server to UPDATE state

Update State

Updates mail box to reflect transactions taken during the transaction state, then logs user out

If session ends by any method except the QUIT command during the transaction state, the update state is not entered

Gnutella

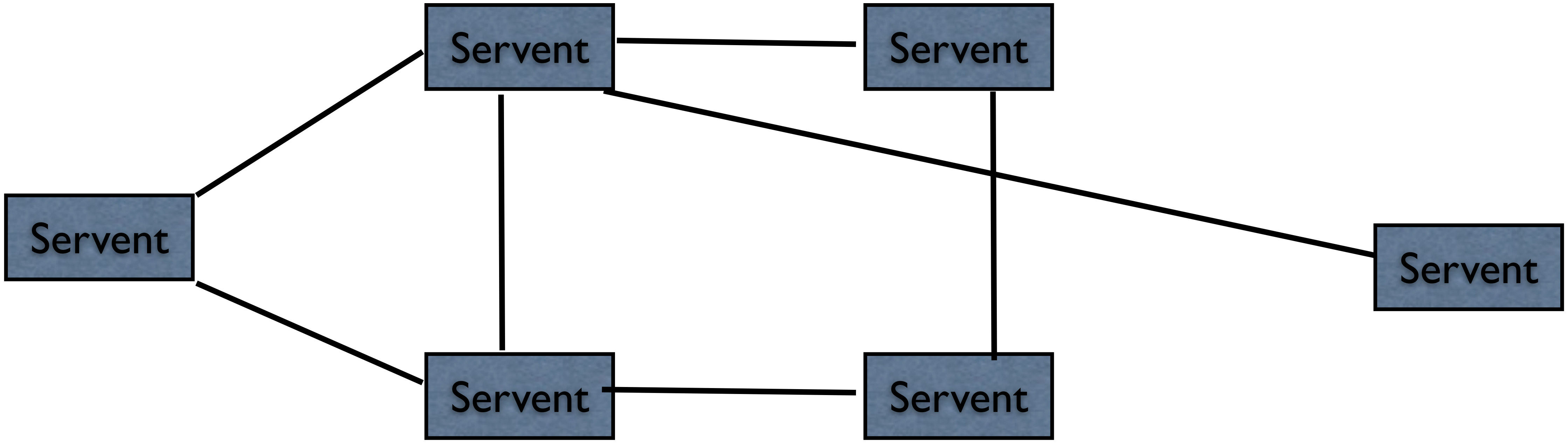
Gnutella

Peer-to-peer

Gnutella program is both a server and a client: servent

No central server

Protocol does not discuss how one knows about other servents



Basic Operation

Servent connects to 1 or more remote servents

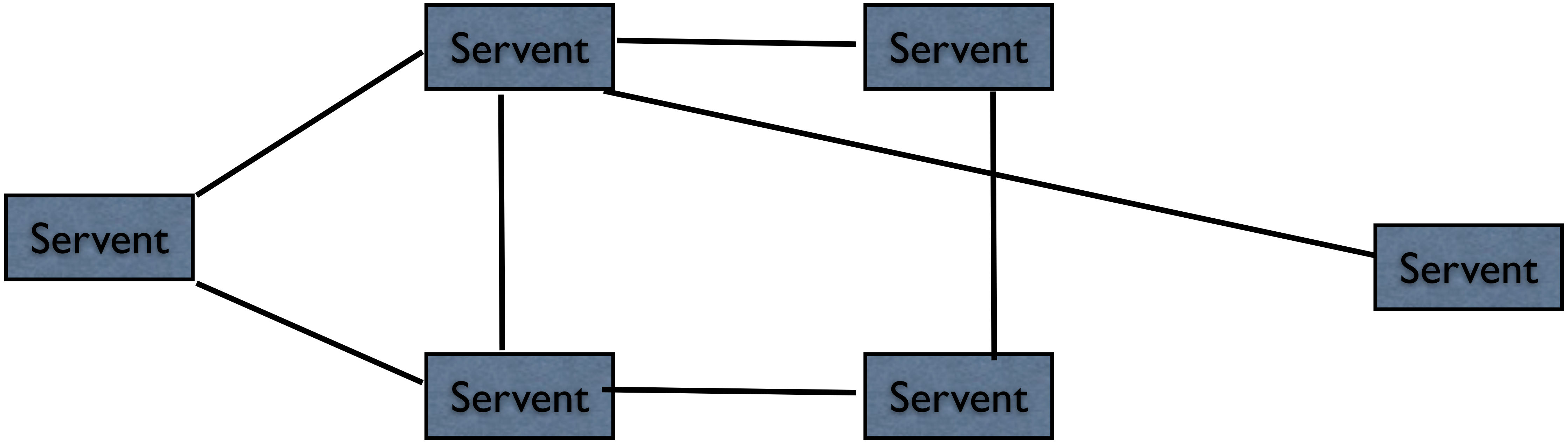
Can

Ping the network

Send a request for a file to see who has it

To get a file from a servent

Connect to the servent directly with http request



Basic Protocol

Connect to another servent with

GNUTELLA CONNECT/<protocol version string>\n\n

Where <protocol version string> is 0.4

If the remote servent accepts the connection it must respond with

GNUTELLA OK\n\n

Both servents then can then send messages

Requests and Responses

Ping – who is on the network

Pong – response to a ping

Query – search the network for data

QueryHit – response to query

Push – Used to allow servents work behind firewall

Each Request/Response starts with a header

Header

	Descriptor ID		Payload Descriptor	TTL	Hops	Payload Length	
Byte offset	0	15	16	17	18	19	22

Payload Descriptor

Value	Meaning
0x00	Ping
0x01	Pong
0x40	Push
0x80	Query
0x81	QueryHit

Descriptor ID

16 byte string

Uniquely identifies Request/Response

TTL

Time to live

Number of times message will be forwarded by servents

Many servents will set TTL to 5 if is it larger

Each servent that gets the message reduces TTL by one before forwarding the message

Header

Hops

Number of times message has been forwarded

Each servent that gets the message increase Hop by one before forwarding

Payload Length

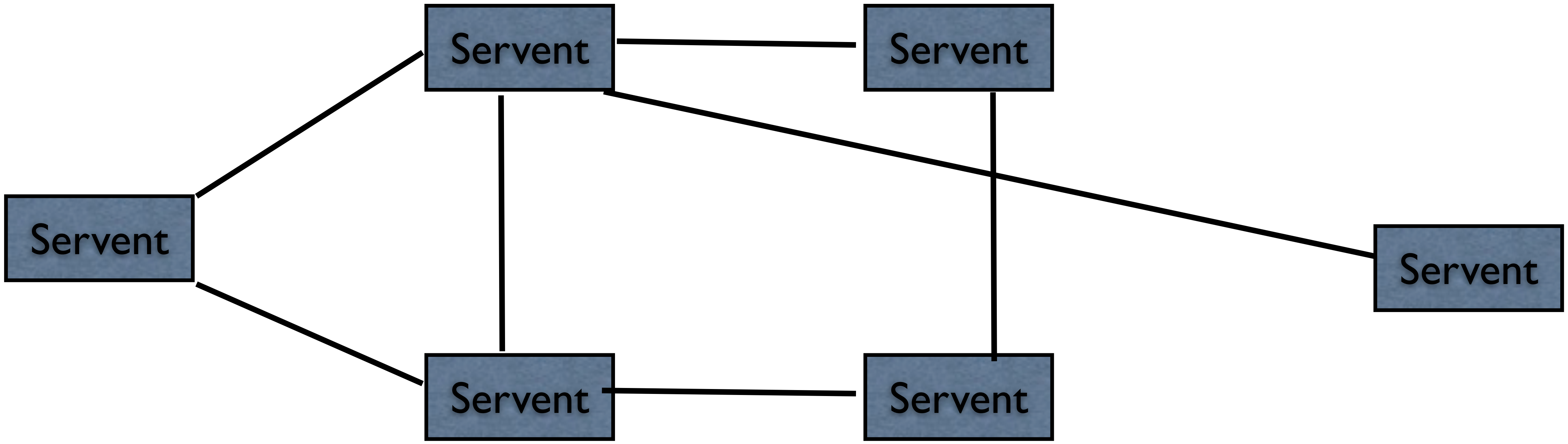
Length of rest of message

Ping 0x00

Header

	Descriptor ID		Payload Descriptor	TTL	Hops	Payload Length	
Byte offset	0	15	16	17	18	19	22

Descriptor 0x00



Pong 0x01

Sent only in response to a ping

Servent can cache pongs of other servents

Payload

	Port		IP Address		Number of files shared		Number of kilobytes shared	
Byte offset	0	1	2	5	6	9	10	13

Port that responding servent can accept incoming connections

IP Address of responding servent

This field uses big-endian format

Query 0x08

Payload

	Minimum Speed		Search Criteria	
Byte offset	0	1	2	…

Minimum Speed

Minimum speed (of connection) in kb/second of servents that should respond to this message

Search Criteria

Nul (0x00) terminated search string

Length of string must be included in the payload length field

QueryHit 0x81

Sent in response to a Query

Descriptor ID in header should contain same value as the Query

Payload

	Number of hits	Port		IP Address		Speed		Result Set		Servent Identifier	
Byte offset	0	1	2	3	6	7	10	11	…	n	n+16

Number of hits

Number of hits in the result set

Port

Port number on which responding servent can accept incoming connections

IP Address

IP Address of responding servent

This field uses big-endian format

Speed

Speed of responding host’s connection in kb/second

QueryHit 0x81

Payload

	Number of hits	Port		IP Address		Speed		Result Set		Servent Identifier	
Byte offset	0	1	2	3	6	7	10	11	…	n	n+16

Result Set

	File Index		File Size		File Name	
Byte offset	0	3	4	7	8	…

File Index

A number used by host to identify the file

File Size

Size in bytes of the file

File Name

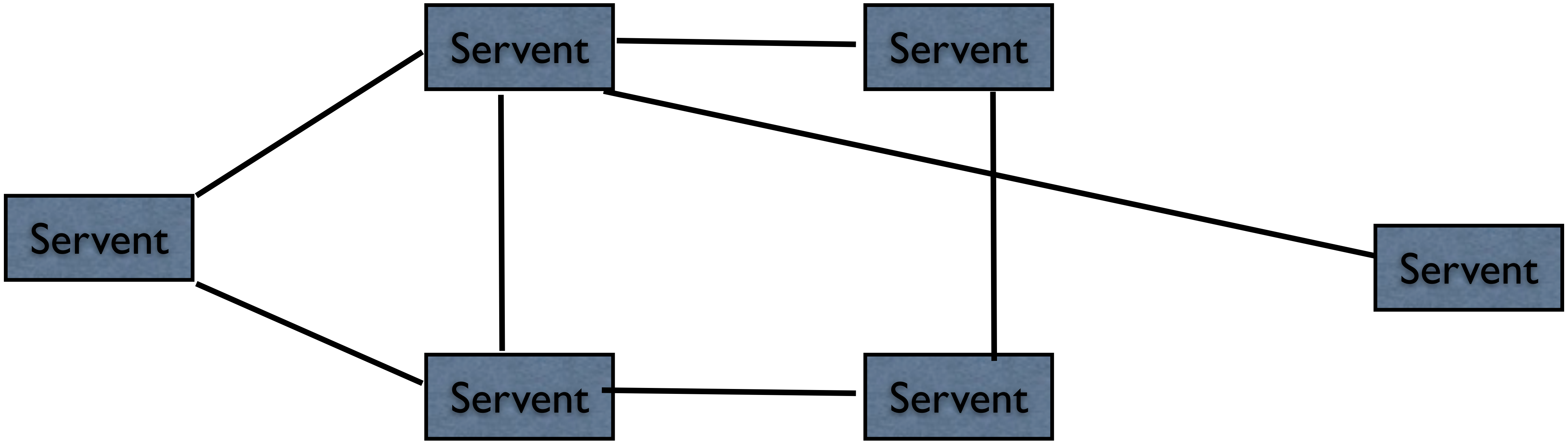
Double-nul (0x0000) terminated name of the file

Servent Identifier

A 16-byte string uniquely identifying the responding servent on the network.

“This is typically some function of the servent’s network address”

Query Example



Extended Query Hit

Payload

	Number of hits	Port		IP Address		Speed		Result Set		Trailer		Servent Identifier	
Byte offset	0	1	2	3	6	7	10	11	…	n	m	m+1	m+17

Trailer

	Vender Code		Open Data Size	Open Data	Private data	
Byte offset	0	3	4	5	6	n

How do we know if the trailer exists?

How do we know the length of the private data?

Push 0x40

	Servent Identifier		File Index		IP Address		Port	
Byte offset	0	15	16	19	20	23	24	25

Servent Identifier

A 16-byte string uniquely identifying the servent on the network that should push the file

File Index

Index of the file to push

IP Address

IP Address of to which the file should be pushed

This field uses big-endian format

Port

Port to which the file should be pushed

Some Routing

Pong messages

Can only be send along path the carried the Ping

Servents should not forward a pong if they did not see the ping

QueryHit

Can only be send along path the carried the Query

Servents should not forward a query hit if they did not see the query

Push

Can only be send along path the carried the QueryHit

Servents should not forward a push if they did not see the query hit

Fowarding

Forward all Ping and Querys to all directly connected servents except to the one that sent it

Decrement TTL and increment Hops field

Don’t forward messages that you have seen before

File Downloads

In response to a QueryHit download the file by using http.

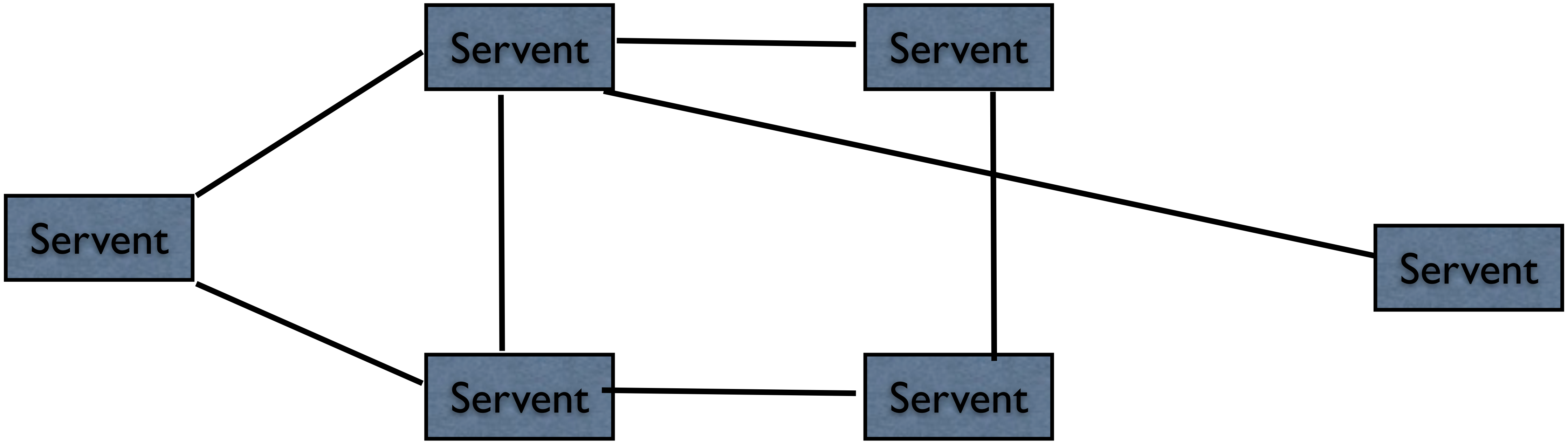
Request the file uses following format:

```
GET /get/<File Index>/<File Name>/ HTTP/1.0\r\n
Connection: Keep-Alive\r\n
Range: bytes=0-\r\n
User-Agent: Gnutella\r\n 3  \r\n
```

Remote servent responses with:

```
HTTP 200 OK\r\n
Server: Gnutella\r\n
Content-type: application/binary\r\n
Content-length: fileSize\r\n
\r\n
```

File Example


Servent
Servent
Servent
Servent
Servent
Servent