

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed,

the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not scalable to very large number of peers and/or RFCs, it will do for this project. Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

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Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

1 Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

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The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
```

...

```
<cr> <lf>
```

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- `ADD`, to add a locally available RFC to the server's index,

- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
- **Port**: the port to which the upload server of the host is attached, and
- **Title**: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

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```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an **ADD** simply echoes back the information provided by the host:

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The response to a **LOOKUP** may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a **LIST** lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a

`makefile` with your submission, or a file with instructions on how to compile and run your code. We would like to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore, if you fail to include such a file, we will *subtract 5 points* from your project grade.

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header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
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In other words, the data part of the response lists one RFC per line, along with the information about the host

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Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a ADD request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
 2. the port number (of type integer) to which the upload server of this peer is listening.
- 2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a new process that handles all communication with this peer. In particular, this process receives the information from the peer and updates the peer list and index, and it also returns any information requested by the peer. When the peer closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- **ADD**, to add a locally available RFC to the server's index,
- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
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For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

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Port: 5678
Title: A Preferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```


The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
 - creating server processes that wait for connections,
 - creating client processes that contact a well-known server and exchange data over the Internet,
 - defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
 - creating and managing a centralized index at the server based on information provided by the peers,
- and

- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.

- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to

handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open

connection, and in response the server provides the peer with a list of other peers who have the RFC; if no

such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is

not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending

the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

"carriage return," and `<lf>` denotes "line feed."

`method <sp> RFC number <sp> version <cr> <lf>`

`header field name <sp> value <cr> <lf>`

`header field name <sp> value <cr> <lf>`

`<cr> <lf>`

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

`GET RFC 1234 P2P-CI/1.0`

`Host: somehost.csc.ncsu.edu`

`OS: Mac OS 10.4.1`

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
...
```

```
<cr> <lf>
```

```
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
```

```
Date: Wed, 12 Feb 2009 15:12:05 GMT
```

```
OS: Mac OS 10.2.1
```

```
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
```

```
Content-Length: 12345
```

```
Content-Type: text/text
```

```
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

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```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: A Preferred Official ICP
```

```
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the server's index. A lookup request from this host would like this:

```
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Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
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Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

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```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
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The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

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between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

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- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
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2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

"carriage return," and `<lf>` denotes "line feed."

`method <sp> RFC number <sp> version <cr> <lf>`

```
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, GET, and only two header fields, Host (the hostname of the peer from which

the RFC is requested) and OS (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer thishost.csc.ncsu.edu who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

1 Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
```

...

```
<cr> <lf>
```

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- `ADD`, to add a locally available RFC to the server’s index,

- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
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For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

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Port: 5678
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ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
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Port: 5678
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```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an **ADD** simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proferred Official ICP thishost.csc.ncsu.edu 5678
```

The response to a **LOOKUP** may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a **LIST** lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a

`makefile` with your submission, or a file with instructions on how to compile and run your code. We would like to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore, if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

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- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open

connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
```


Content-Type: text/text
(data data data ...)

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
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Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proferred Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called "Requests for Comments" (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which

keeps information about the active peers and maintains an index of the RFCs available at each active peer.

- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open

connection, and in response the server provides the peer with a list of other peers who have the RFC; if no

such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is

not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending

the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
 2. the port number (of type integer) to which the upload server of this peer is listening.
- 2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a new process that handles all communication with this peer. In particular, this process receives the information from the peer and updates the peer list and index, and it also returns any information requested by the peer. When the peer closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request

- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- `ADD`, to add a locally available RFC to the server's index,
- `LOOKUP`, to find peers that have the specified RFC, and
- `LIST`, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- `Host`: the hostname of the host sending the request,
- `Port`: the port to which the upload server of the host is attached, and
- `Title`: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Preferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
```

```

<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>

```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proferred Official ICP thishost.csc.ncsu.edu 5678
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The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

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CSC 573 – Internet Protocols

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Spring 2014

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additional details on each component of the system will be provided shortly.

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- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to

handle the communication to each new peer.

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connection, and in response the server provides the peer with a list of other peers who have the RFC; if no

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2/4

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```

```
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```
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There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

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```

```
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3/4

The response message is formatted as follows:

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header field name <sp> value <cr> <lf>
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Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

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There are three methods:

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```

The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
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<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
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In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
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CSC 573 – Internet Protocols

Project #1

Spring 2014

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2/4

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```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

1 Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer thishost.csc.ncsu.edu who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
```

```
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
```

```
<cr> <lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
...
```

```
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called "Requests for Comments" (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

“carriage return,” and <lf> denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, GET, and only two header fields, Host (the hostname of the peer from which

the RFC is requested) and OS (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
```

...

```
<cr> <lf>
```

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

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OS: Mac OS 10.2.1
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Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
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header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
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Also, three header fields are defined:

- Host: the hostname of the host sending the request,
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For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

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ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

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CSC 573 – Internet Protocols

Project #1

Spring 2014

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Although this

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Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

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- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is

not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

"carriage return," and `<lf>` denotes "line feed."

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
```

header field name <sp> value <cr> <lf>
<cr> <lf>

There are three methods:

- **ADD**, to add a locally available RFC to the server's index,
- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
- **Port**: the port to which the upload server of the host is attached, and
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For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

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```

```
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```

```
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```

```
Title: A Proffered Official ICP
```

```
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```

4/4

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
```

```
<cr> <lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
...
```

```
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an **ADD** simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

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The response to a **LOOKUP** may contain multiple lines for a given RFC, each line containing information about a

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

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In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

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client-server systems and build a number of fundamental skills related to writing Internet applications, including:

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- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
```

```
...
<cr> <lf>
```

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
```

Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- **ADD**, to add a locally available RFC to the server's index,
- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
- **Port**: the port to which the upload server of the host is attached, and
- **Title**: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an **ADD** simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a **LOOKUP** may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called "Requests for Comments" (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which

keeps information about the active peers and maintains an index of the RFCs available at each active peer.

- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open

connection, and in response the server provides the peer with a list of other peers who have the RFC; if no

such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is

not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending

the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
 2. the port number (of type integer) to which the upload server of this peer is listening.
- 2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a new process that handles all communication with this peer. In particular, this process receives the information from the peer and updates the peer list and index, and it also returns any information requested by the peer. When the peer closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request

- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

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OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
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Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
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header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- `ADD`, to add a locally available RFC to the server's index,
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and whose upload port is 5678 would first transmit the following two requests to the server:

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4/4

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The response message from the server is formatted as follows, where the status code and corresponding phrase are

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```
version <sp> status code <sp> phrase <cr> <lf>
```

```

<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>

```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
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```

```
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
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The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

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Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

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additional details on each component of the system will be provided shortly.

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- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to

handle the communication to each new peer.

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connection, and in response the server provides the peer with a list of other peers who have the RFC; if no

such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

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the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

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The server waits for connections from the peers on the well-known port 7734. The server maintains two data

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1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

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new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

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closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
```

```
Host: somehost.csc.ncsu.edu
```

```
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

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P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- **ADD**, to add a locally available RFC to the server's index,
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Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
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- **Title**: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Preferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
while a list request would be:
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Preferred Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,

- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and OS (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

1 Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer thishost.csc.ncsu.edu who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Preferred Official ICP
```

```
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
```

```
<cr> <lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
...
```

```
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

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if you fail to include such a file, we will *subtract 5 points* from your project grade.

Spring 2014

Project Objectives

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Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

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send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host
somehost.csc.ncsu.edu.

Then, A sends to B a request message formatted as follows, where <sp> denotes “space,” <cr> denotes

“carriage return,” and <lf> denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, GET, and only two header fields, Host (the hostname of the peer from which

the RFC is requested) and OS (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server’s index,
- LOOKUP, to find peers that have the specified RFC, and
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Also, three header fields are defined:

- **Host:** the hostname of the host sending the request,
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Port: 5678
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```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
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Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
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```
LIST ALL P2P-CI/1.0
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Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

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RFC 123 A Proferred Official ICP thishost.csc.ncsu.edu 5678
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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

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- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each

peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

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Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

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removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

"carriage return," and `<lf>` denotes "line feed."

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

1 Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- **ADD**, to add a locally available RFC to the server's index,
- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
- **Port**: the port to which the upload server of the host is attached, and
- **Title**: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
ADD RFC 2345 P2P-CI/1.0
4/4
```

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an **ADD** simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a **LOOKUP** may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a **LIST** lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to

handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open

connection, and in response the server provides the peer with a list of other peers who have the RFC; if no

such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is

not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending

the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

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Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer. When the peer closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
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For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

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Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

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LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:
`P2P-CI/1.0 200 OK`

`RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678`

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which

keeps information about the active peers and maintains an index of the RFCs available at each active peer.

- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open

connection, and in response the server provides the peer with a list of other peers who have the RFC; if no

such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is

not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending

the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
 2. the port number (of type integer) to which the upload server of this peer is listening.
- 2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a new process that handles all communication with this peer. In particular, this process receives the information from the peer and updates the peer list and index, and it also returns any information requested by the peer. When the peer closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request

- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- `ADD`, to add a locally available RFC to the server's index,
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For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

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Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Preferred Official ICP
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```

4/4

```
Host: thishost.csc.ncsu.edu
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Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
```

```
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proferred Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

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In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
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- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
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Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called "Requests for Comments" (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.

- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to

handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open

connection, and in response the server provides the peer with a list of other peers who have the RFC; if no

such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is

not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending

the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

"carriage return," and `<lf>` denotes "line feed."

`method <sp> RFC number <sp> version <cr> <lf>`

`header field name <sp> value <cr> <lf>`

`header field name <sp> value <cr> <lf>`

`<cr> <lf>`

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

`GET RFC 1234 P2P-CI/1.0`

`Host: somehost.csc.ncsu.edu`

`OS: Mac OS 10.4.1`

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Preferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

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```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a ADD request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

Title: Requirements for IPsec Remote Access Scenarios

while a list request would be:

```
LIST ALL P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
```

```
<cr> <lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
...
```

```
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,

- creating client processes that contact a well-known server and exchange data over the Internet,
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- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

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removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

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closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

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connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and OS (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

1 Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

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The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

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```
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header field name <sp> value <cr> <lf>
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There are three methods:

- ADD, to add a locally available RFC to the server's index,
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Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
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For instance, peer thishost.csc.ncsu.edu who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Preferred Official ICP
```

ADD RFC 2345 P2P-CI/1.0

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Host: thishost.csc.ncsu.edu

Port: 5678

Title: Domain Names and Company Name Retrieval

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

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Host: thishost.csc.ncsu.edu

Port: 5678

Title: Requirements for IPsec Remote Access Scenarios

while a list request would be:

LIST ALL P2P-CI/1.0

Host: thishost.csc.ncsu.edu

Port: 5678

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

version <sp> status code <sp> phrase <cr> <lf>

<cr> <lf>

RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>

RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>

...

<cr><lf>

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

P2P-CI/1.0 200 OK

RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678

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Submission and Deliverables

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

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Although this

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2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
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Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

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the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

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the peer and updates the peer list and index, and it also returns any information requested by the peer.

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closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

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the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

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The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

“carriage return,” and <lf> denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, GET, and only two header fields, Host (the hostname of the peer from which

the RFC is requested) and OS (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
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```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
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header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
```

...

```
<cr> <lf>
```

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

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A typical response message looks like this:

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P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
ADD RFC 2345 P2P-CI/1.0
```

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```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is

not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

"carriage return," and `<lf>` denotes "line feed."

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
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Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

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```
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header field name <sp> value <cr> <lf>
```

header field name <sp> value <cr> <lf>
<cr> <lf>

There are three methods:

- **ADD**, to add a locally available RFC to the server's index,
- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
- **Port**: the port to which the upload server of the host is attached, and
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For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
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```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: A Proffered Official ICP
```

```
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
```

```
<cr> <lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
```

```
...
```

```
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an **ADD** simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
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The response to a **LOOKUP** may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a **LIST** lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

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Note: the peer should print the responses it receives from the server to the standard output in the same format.

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

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- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
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Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to

handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
```

```
...
<cr> <lf>
```

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
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Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
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Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

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header field name <sp> value <cr> <lf>
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There are three methods:

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Port: 5678
Title: A Proffered Official ICP
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```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

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Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

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```
LIST ALL P2P-CI/1.0
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Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

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```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

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CSC 573 – Internet Protocols

Project #1

Spring 2014

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Although this

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2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from the peer and updates the peer list and index, and it also returns any information requested by the peer. When the peer closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a ADD request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```


In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index. When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a new process that handles all communication with this peer. In particular, this process receives the information from the peer and updates the peer list and index, and it also returns any information requested by the peer. When the peer closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes “carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

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The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
```

<cr> <lf>

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

P2P-CI/1.0 200 OK

Date: Wed, 12 Feb 2009 15:12:05 GMT

OS: Mac OS 10.2.1

Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT

Content-Length: 12345

Content-Type: text/text

(data data data ...)

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

method <sp> RFC number <sp> version <cr> <lf>

header field name <sp> value <cr> <lf>

header field name <sp> value <cr> <lf>

<cr> <lf>

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
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For instance, peer thishost.csc.ncsu.edu who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

ADD RFC 123 P2P-CI/1.0

Host: thishost.csc.ncsu.edu

Port: 5678

Title: A Proffered Official ICP

ADD RFC 2345 P2P-CI/1.0

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Host: thishost.csc.ncsu.edu

Port: 5678

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Once a peer downloads a new RFC from another peer, it may transmit a ADD request to add a new record into the

server's index. A lookup request from this host would like this:

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Host: thishost.csc.ncsu.edu

Port: 5678

Title: Requirements for IPsec Remote Access Scenarios

while a list request would be:

LIST ALL P2P-CI/1.0

Host: thishost.csc.ncsu.edu

Port: 5678

The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
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<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,

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Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

`method <sp> RFC number <sp> version <cr> <lf>`

`header field name <sp> value <cr> <lf>`

`header field name <sp> value <cr> <lf>`

`<cr> <lf>`

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
```

Host: somehost.csc.ncsu.edu

OS: Mac OS 10.4.1

1 Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

version <sp> status code <sp> phrase <cr> <lf>

header field name <sp> value <cr> <lf>

header field name <sp> value <cr> <lf>

...

<cr> <lf>

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

P2P-CI/1.0 200 OK

Date: Wed, 12 Feb 2009 15:12:05 GMT

OS: Mac OS 10.2.1

Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT

Content-Length: 12345

Content-Type: text/text

(data data data ...)

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

method <sp> RFC number <sp> version <cr> <lf>

header field name <sp> value <cr> <lf>

header field name <sp> value <cr> <lf>

<cr> <lf>

There are three methods:

- ADD, to add a locally available RFC to the server's index,
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- Host: the hostname of the host sending the request,
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For instance, peer thishost.csc.ncsu.edu who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

ADD RFC 123 P2P-CI/1.0

Host: thishost.csc.ncsu.edu

Port: 5678

Title: A Preferred Official ICP

ADD RFC 2345 P2P-CI/1.0

4/4

Host: thishost.csc.ncsu.edu

Port: 5678

Title: Domain Names and Company Name Retrieval

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Preferred Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

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Note: the peer should print the responses it receives from the server to the standard output in the same format.

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until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

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if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI). Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

"carriage return," and `<lf>` denotes "line feed."

`method <sp> RFC number <sp> version <cr> <lf>`

```
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, GET, and only two header fields, Host (the hostname of the peer from which

the RFC is requested) and OS (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer thishost.csc.ncsu.edu who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

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until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

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CSC 573 – Internet Protocols

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Spring 2014

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- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

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structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

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1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

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the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

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The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

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the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

1 Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
```

...

```
<cr> <lf>
```

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
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(data data data ...)
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The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

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header field name <sp> value <cr> <lf>
<cr> <lf>
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There are three methods:

- `ADD`, to add a locally available RFC to the server’s index,

- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
- **Port**: the port to which the upload server of the host is attached, and
- **Title**: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
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Port: 5678
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4/4

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The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
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<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an **ADD** simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
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```

The response to a **LOOKUP** may contain multiple lines for a given RFC, each line containing information about a

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line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

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CSC 573 – Internet Protocols

Project #1

Spring 2014

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2/4

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The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

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The Application Protocol: P2P

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- 404 Not Found
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Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- **ADD**, to add a locally available RFC to the server's index,
- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
- **Port**: the port to which the upload server of the host is attached, and
- **Title**: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an **ADD** simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a **LOOKUP** may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a **LIST** lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and

provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from the peer and updates the peer list and index, and it also returns any information requested by the peer. When the peer closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
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Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
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For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

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Port: 5678
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```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a ADD request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
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Port: 5678
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```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
```

```
RFC 123 A Proferred Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

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until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

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1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

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- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
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have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
 2. the port number (of type integer) to which the upload server of this peer is listening.
- 2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a new process that handles all communication with this peer. In particular, this process receives the information from the peer and updates the peer list and index, and it also returns any information requested by the peer. When the peer closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

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Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- **ADD**, to add a locally available RFC to the server's index,
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For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

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Port: 5678
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```

4/4

```
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server's index. A lookup request from this host would like this:

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Title: Requirements for IPsec Remote Access Scenarios
```

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```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
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The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

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<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
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In other words, the data part of the response lists one RFC per line, along with the information about the host

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```
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CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

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- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

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1. the hostname of the peer (of type string), and
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2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

"carriage return," and `<lf>` denotes "line feed."

`method <sp> RFC number <sp> version <cr> <lf>`

`header field name <sp> value <cr> <lf>`

`header field name <sp> value <cr> <lf>`

`<cr> <lf>`

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

`GET RFC 1234 P2P-CI/1.0`

`Host: somehost.csc.ncsu.edu`

`OS: Mac OS 10.4.1`

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
...
```

```
<cr> <lf>
```

```
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
```

```
Date: Wed, 12 Feb 2009 15:12:05 GMT
```

```
OS: Mac OS 10.2.1
```

```
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
```

```
Content-Length: 12345
```

```
Content-Type: text/text
```

```
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: A Preferred Official ICP
```

```
ADD RFC 2345 P2P-CI/1.0
```

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```
Host: thishost.csc.ncsu.edu
```

```
Port: 5678
```

```
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.

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CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI). Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.
- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

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Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host

`somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes "space," `<cr>` denotes

"carriage return," and `<lf>` denotes "line feed."

`method <sp> RFC number <sp> version <cr> <lf>`

```
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, GET, and only two header fields, Host (the hostname of the peer from which

the RFC is requested) and OS (the operating system of the requesting host). For instance, a typical request message would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

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The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: Date (the date the response was sent), OS (operating system of responding host),

Last-Modified (the date/time the file was last modified), Content-Length (the length of the file in bytes),

and Content-Type (always text/plain for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
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header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
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For instance, peer thishost.csc.ncsu.edu who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

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Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proffered Official ICP
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```

4/4

```
Host: thishost.csc.ncsu.edu
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Title: Domain Names and Company Name Retrieval
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Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

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while a list request would be:

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LIST ALL P2P-CI/1.0
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Port: 5678
```

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```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
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RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
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CSC 573 – Internet Protocols

Project #1

Spring 2014

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Although this

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- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data

structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

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Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

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the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and

its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system.

The peer may

send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a

server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at

the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download

connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
```

1 Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
```

...

```
<cr> <lf>
```

data

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- `ADD`, to add a locally available RFC to the server’s index,

- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
- **Port**: the port to which the upload server of the host is attached, and
- **Title**: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an **ADD** simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proferred Official ICP thishost.csc.ncsu.edu 5678
```

The response to a **LOOKUP** may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a **LIST** lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a

`makefile` with your submission, or a file with instructions on how to compile and run your code. We would like to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore, if you fail to include such a file, we will *subtract 5 points* from your project grade.

1/4

CSC 573 – Internet Protocols

Project #1

Spring 2014

Project Objectives

In this project, you will implement a simple peer-to-peer (P2P) system with a centralized index (CI).

Although this

P2P-CI system is rather elementary, in the process I expect that you will develop a good understanding of P2P and

client-server systems and build a number of fundamental skills related to writing Internet applications, including:

- becoming familiar with network programming and the socket interface,
- creating server processes that wait for connections,
- creating client processes that contact a well-known server and exchange data over the Internet,
- defining a simple application protocol and making sure that peers and server follow precisely the specifications for their side of the protocol in order to accomplish particular tasks,
- creating and managing a centralized index at the server based on information provided by the peers, and
- implementing a concurrent server that is capable of carrying out communication with multiple clients simultaneously.

Peer-to-Peer with Centralized Index (P2P-CI) System for Downloading RFCs

Internet protocol standards are defined in documents called “Requests for Comments” (RFCs). RFCs are available

for download from the IETF web site (<http://www.ietf.org/>). Rather than using this centralized server for downloading RFCs, you will build a P2P-CI system in which peers who wish to download an RFC that they do not

have in their hard drive, may download it from another active peer who does. All communication among peers or

between a peer and the server will take place over TCP. Specifically, the P2P-CI system will operate as follows;

additional details on each component of the system will be provided shortly.

- There is a centralized server, running on a well-known host and listening on a well-known port, which keeps information about the active peers and maintains an index of the RFCs available at each active peer.
- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).
- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.
- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open

connection, and in response the server provides the peer with a list of other peers who have the RFC; if no such active peer exists, an appropriate message is transmitted to the requesting peer. Additionally, each peer may at any point query the server to obtain the whole index of RFCs available at all other active peers.

- Each peer runs a *upload server* process that listens on a port *specific to the peer*; in other words, this port is not known in advance to any of the peers. When a peer A needs to download an RFC from a peer B, it opens a connection to the upload port of peer B, provides the RFC number to B, and B responds by sending the (text) file containing the RFC to A over the same connection; once the file transmission is completed, the connection is closed.

The Server

The server waits for connections from the peers on the well-known port 7734. The server maintains two data structures: a list with information about the currently active peers and the index of RFCs available at each peer. For

simplicity, you will implement both these structures as linked lists; while such an implementation is obviously not

scalable to very large number of peers and/or RFCs, it will do for this project.

Each item of the linked list of peers contains two elements:

1. the hostname of the peer (of type string), and
2. the port number (of type integer) to which the upload server of this peer is listening.

2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
- the hostname of the peer containing the RFC (of type string).

Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

Initially (i.e., when the server starts up), both linked lists are empty (do not contain any records). The linked lists are

updated as peers join and leave the system. When a peer joins the system, it provides its hostname and upload port to

the server (as explained below) and the server creates a new peer record and inserts it at the front of the linked list.

The peer also provides the server with a list of RFCs that it has. For each RFC, the server creates an appropriate

record and inserts it at the front of the linked list representing the index.

When a peer leaves the system (i.e., closes its connection to the server), the server searches both linked lists and

removes all records associated with this peer. As we mentioned earlier, the server must be able to handle multiple

simultaneous connections from peers. To this end, it has a main process that initializes the two linked-lists to empty

and then listens to the well-known port 7734. When a connection from a peer is received, the main process spawns a

new process that handles all communication with this peer. In particular, this process receives the information from

the peer and updates the peer list and index, and it also returns any information requested by the peer.

When the peer

closes the connection, this process removes all records associated with the peer and then terminates.¹

The Peers

When a peer wishes to join the system, it first instantiates an upload server process listening to any available local

port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

The Application Layer Protocol: P2P

The protocol used to download files among peers is a simplified version of the HTTP protocol we discussed in class.

Suppose that peer A wishes to download RFC 1234 from peer B running at host `somehost.csc.ncsu.edu`.

Then, A sends to B a request message formatted as follows, where `<sp>` denotes “space,” `<cr>` denotes

“carriage return,” and `<lf>` denotes “line feed.”

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
Host: somehost.csc.ncsu.edu
OS: Mac OS 10.4.1
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¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

3/4

The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
```

Content-Type: text/text
(data data data ...)

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- ADD, to add a locally available RFC to the server's index,
- LOOKUP, to find peers that have the specified RFC, and
- LIST, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- Host: the hostname of the host sending the request,
- Port: the port to which the upload server of the host is attached, and
- Title: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Proferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

4/4

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a `ADD` request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
```

while a list request would be:

```
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are

the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
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In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
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CSC 573 – Internet Protocols

Project #1

Spring 2014

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additional details on each component of the system will be provided shortly.

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keeps information about the active peers and maintains an index of the RFCs available at each active peer.

- When a peer decides to join the P2P-CI system, it opens a connection to the server to register itself and provide information about the RFCs that it makes available to other peers. This connection remains open as

long as the peer remains active; the peer closes the connection when it leaves the system (becomes inactive).

- Since the server may have connections open to multiple peers simultaneously, it spawns a new process to handle the communication to each new peer.

- When a peer wishes to download a specific RFC, it provides the RFC number to the server over the open

connection, and in response the server provides the peer with a list of other peers who have the RFC; if no

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The server waits for connections from the peers on the well-known port 7734. The server maintains two data

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 2. the port number (of type integer) to which the upload server of this peer is listening.
- 2/4

Each item of the linked list representing the index of RFCs contains these elements:

- the RFC number (of type integer),
- the title of the RFC (of type string), and
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Note that the index may contain multiple records of a given RFC, one record for each peer that contains the RFC.

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When a peer wishes to join the system, it first instantiates an upload server process listening to any available local port. It then creates a connection to the server at the well-known port 7734 and passes information about itself and its RFCs to the server, as we describe shortly. It keeps this connection open until it leaves the system. The peer may send requests to the server over this open connection and receive responses (e.g., the hostname and upload port of a server containing a particular RFC). When it wishes to download an RFC, it opens a connection to a remote peer at the specified upload port, requests the RFC, receives the file and stores it locally, and then closes this download connection to the peer.

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header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
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There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

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3/4

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header field name <sp> value <cr> <lf>
...
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(data data data ...)
```

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The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

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```
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header field name <sp> value <cr> <lf>
<cr> <lf>
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There are three methods:

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4/4

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the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
```

```

<cr> <lf>
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RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
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In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

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CSC 573 – Internet Protocols

Project #1

Spring 2014

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2/4

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```

```
header field name <sp> value <cr> <lf>
```

```
header field name <sp> value <cr> <lf>
```

```
<cr> <lf>
```

There is only one method defined, `GET`, and only two header fields, `Host` (the hostname of the peer from which

the RFC is requested) and `OS` (the operating system of the requesting host). For instance, a typical request message

would look like this:

```
GET RFC 1234 P2P-CI/1.0
```

```
Host: somehost.csc.ncsu.edu
```

```
OS: Mac OS 10.4.1
```

¹ Since multiple processes may manipulate the linked lists of the server simultaneously, these lists must be locked so that at most one process

may access them to read or modify at any one time. For simplicity, we will not require that you implement locking.

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The response message is formatted as follows:

```
version <sp> status code <sp> phrase <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
...
<cr> <lf>
data
```

Four status codes and corresponding phrases are defined:

- 200 OK
- 400 Bad Request
- 404 Not Found
- 505 P2P-CI Version Not Supported

Five header fields are defined: `Date` (the date the response was sent), `OS` (operating system of responding host),

`Last-Modified` (the date/time the file was last modified), `Content-Length` (the length of the file in bytes),

and `Content-Type` (always `text/plain` for this project).

A typical response message looks like this:

```
P2P-CI/1.0 200 OK
Date: Wed, 12 Feb 2009 15:12:05 GMT
OS: Mac OS 10.2.1
Last-Modified: Thu, 21 Jan 2001 9:23:46 GMT
Content-Length: 12345
Content-Type: text/text
(data data data ...)
```

Application Layer Protocol: P2S

The protocol used between a peer and the server is also a request-response protocol, where requests are initiated by

peers. The format of a request message is as follows:

```
method <sp> RFC number <sp> version <cr> <lf>
header field name <sp> value <cr> <lf>
header field name <sp> value <cr> <lf>
<cr> <lf>
```

There are three methods:

- **ADD**, to add a locally available RFC to the server's index,
- **LOOKUP**, to find peers that have the specified RFC, and
- **LIST**, to request the whole index of RFCs from the server.

Also, three header fields are defined:

- **Host**: the hostname of the host sending the request,
- **Port**: the port to which the upload server of the host is attached, and
- **Title**: the title of the RFC

For instance, peer `thishost.csc.ncsu.edu` who has two RFCs, RFC 123 and RFC 2345 locally available

and whose upload port is 5678 would first transmit the following two requests to the server:

```
ADD RFC 123 P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
Title: A Preferred Official ICP
ADD RFC 2345 P2P-CI/1.0
```

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```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Domain Names and Company Name Retrieval
```

Once a peer downloads a new RFC from another peer, it may transmit a **ADD** request to add a new record into the

server's index. A lookup request from this host would like this:

```
LOOKUP RFC 3457 P2P-CI/1.0
```

```
Host: thishost.csc.ncsu.edu
Port: 5678
Title: Requirements for IPsec Remote Access Scenarios
while a list request would be:
LIST ALL P2P-CI/1.0
Host: thishost.csc.ncsu.edu
Port: 5678
```

The response message from the server is formatted as follows, where the status code and corresponding phrase are the same as defined above.

```
version <sp> status code <sp> phrase <cr> <lf>
<cr> <lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
RFC number <sp> RFC title <sp> hostname <sp> upload port number<cr><lf>
...
<cr><lf>
```

In other words, the data part of the response lists one RFC per line, along with the information about the host

containing the RFC. The response to an `ADD` simply echoes back the information provided by the host:

```
P2P-CI/1.0 200 OK
RFC 123 A Proffered Official ICP thishost.csc.ncsu.edu 5678
```

The response to a `LOOKUP` may contain multiple lines for a given RFC, each line containing information about a

different peer having the RFC. Finally, the response to a `LIST` lists all the records in the server's database, one per

line. If the request contains an error or the requested RFC is not found in the index, an appropriate status code and

phrase is returned, and the data part of the response is empty.

Note: the peer should print the responses it receives from the server to the standard output in the same format.

Submission and Deliverables

Submit your source code (*no object files!*) using `submit` by midnight on the day due. There are several weeks

until the due date for you to work on this project, therefore no late submissions will be accepted. Include a `makefile` with your submission, or a file with instructions on how to compile and run your code. We would like

to ensure that the TA does not spend an inordinate amount of time compiling and running your programs. Therefore,

if you fail to include such a file, we will *subtract 5 points* from your project grade.