

P2 Report – Discovery and Download

Overview

I have implemented a text-based user-interface for a distributed file-space , which allows the discovery, search and download of files. As part of the implementation, a control-plane protocol has been created which uses Ipv6 multicast enabling nodes that are part of the multicast group to send discovery messages to identify other nodes that are part of the distributed file-space, and to send search messages to these nodes for a file name or path. The discovery and search functionality is then used as the foundation to enable the download of files through the use of TCP which establishes a one-to-one communication between two nodes for the file transfer to take place.

Discovery

Before any of the other functionalities can occur, each node would have to initiate a discovery protocol which involves sending advertisement messages to the multicast group to let other nodes know about its presence. Each node would also have to be able to receive all the advertisement messages. This is done by each node entering the “:nodes” command. This causes the nodes to enter the multicast group and for them to simultaneously send and receive advertisement messages using multi-threading. A total of 10 messages are sent by each node to ensure that it is properly received before the nodes leave the multicast group. After this communication has occurred, the user-interface displays all the nodes discovered and key information about each which is included in advertisement message such as the id and port number of each node, along with the search capability of each node.

A series of tests are included below to demonstrate the operation of this functionality.

- Only one node in the multicast group sending advertisements.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :nodes
+++ Initiating discovery protocol...
20231109-174443.600| joined IPv6 multicast group /[[ff02:0:0:0:0:2:2694]:2694
20231109-174443.602| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:51410:20231109-174443.601:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174444.603| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:52797:20231109-174444.602:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174445.604| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:96429:20231109-174445.603:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174446.606| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:84914:20231109-174446.605:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174447.607| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:46182:20231109-174447.606:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174448.608| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:25590:20231109-174448.608:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174449.609| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:50259:20231109-174449.608:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174450.610| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:83148:20231109-174450.609:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174451.611| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:49067:20231109-174451.610:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174452.612| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:24290:20231109-174452.611:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174453.710| left IPv6 multicast group
+++ No available nodes
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help']
```

- Two nodes in the multicast group sending advertisements.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :nodes
+++ Initiating discovery protocol...
20231109-174235.749| joined IPv6 multicast group /[[ff02:0:0:0:2:2694]:2694
20231109-174235.752| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:85400:20231109-174235.750:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174236.758| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:13838:20231109-174236.758:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174237.759| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:31167:20231109-174237.758:advertisement:2694:search=path
-filename:
20231109-174237.773| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:82080:20231109-174237.011:advertisement:2694:search=path
-filename:
20231109-174238.759| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:64456:20231109-174238.759:advertisement:2694:search=path
-filename:
20231109-174238.773| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:37972:20231109-174238.013:advertisement:2694:search=path
-filename:
20231109-174239.760| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:66920:20231109-174239.759:advertisement:2694:search=path
-filename:
20231109-174239.774| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:66926:20231109-174239.013:advertisement:2694:search=path
-filename:
20231109-174240.760| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:37130:20231109-174240.760:advertisement:2694:search=path
-filename:
20231109-174240.774| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:10215:20231109-174240.014:advertisement:2694:search=path
-filename:
20231109-174241.761| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:95623:20231109-174241.760:advertisement:2694:search=path
-filename:
20231109-174241.775| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:80390:20231109-174241.014:advertisement:2694:search=path
-filename:
20231109-174242.761| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:10385:20231109-174242.761:advertisement:2694:search=path
-filename:
20231109-174242.775| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:48413:20231109-174242.014:advertisement:2694:search=path
-filename:
20231109-174243.762| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:63190:20231109-174243.761:advertisement:2694:search=path
-filename:
20231109-174243.775| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:35824:20231109-174243.015:advertisement:2694:search=path
-filename:
20231109-174244.762| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:91091:20231109-174244.762:advertisement:2694:search=path
-filename:
20231109-174244.776| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:53188:20231109-174244.015:advertisement:2694:search=path
-filename:
20231109-174245.776| left IPv6 multicast group

+++ 1 node(s) discovered:
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, port: 2694, message type: advertisement, search: search=path-filename
+++
```

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :nodes
+++ Initiating discovery protocol...
20231109-174237.010| joined IPv6 multicast group /[[ff02:0:0:0:2:2694]:2694
20231109-174237.012| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:82080:20231109-174237.011:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174238.013| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:37972:20231109-174238.013:advertisement:2694:search=path
-filename:
20231109-174238.023| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:31167:20231109-174237.758:advertisement:2694:search=path
-filename:
20231109-174239.013| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:66926:20231109-174239.013:advertisement:2694:search=path
-filename:
20231109-174239.023| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:64456:20231109-174238.759:advertisement:2694:search=path
-filename:
20231109-174240.014| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:10215:20231109-174240.014:advertisement:2694:search=path
-filename:
20231109-174240.024| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:66920:20231109-174239.759:advertisement:2694:search=path
-filename:
20231109-174241.014| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80390:20231109-174241.014:advertisement:2694:search=path
-filename:
20231109-174241.024| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:37130:20231109-174240.760:advertisement:2694:search=path
-filename:
20231109-174242.015| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:48413:20231109-174242.014:advertisement:2694:search=path
-filename:
20231109-174242.024| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:95623:20231109-174241.760:advertisement:2694:search=path
-filename:
20231109-174243.015| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:35824:20231109-174243.015:advertisement:2694:search=path
-filename:
20231109-174243.025| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:10385:20231109-174242.761:advertisement:2694:search=path
-filename:
20231109-174244.015| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:53188:20231109-174244.015:advertisement:2694:search=path
-filename:
20231109-174244.025| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:63190:20231109-174243.761:advertisement:2694:search=path
-filename:
20231109-174245.016| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:77914:20231109-174245.016:advertisement:2694:search=path
-filename:
20231109-174245.026| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:91091:20231109-174244.762:advertisement:2694:search=path
-filename:
20231109-174246.016| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:93447:20231109-174246.016:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-174247.037| left IPv6 multicast group

+++ 1 node(s) discovered:
0 id: sb409@pc7-019-l.cs.st-andrews.ac.uk, port: 2694, message type: advertisement, search: search=path-filename
+++
```

Search

If the search protocol is initiated without initiating a discovery protocol, then this is automatically done. Then after the discovery protocol has occurred, the search protocol is then able to be initiated which allows users to search for either a file name or path. This is done by entering “:search” which displays the search capabilities by listing all the nodes that are able to provide the search functionality, along with whether each node is able to provide search for both a file name and path, or just a path. Any nodes that are unable to provide the search functionality are not displayed. If no nodes are able to provide this functionality, then search cannot take place. If there are nodes capable of searching, then the user is asked to enter the file name or path to search for, which causes the node to join the multicast group and for the search request to be sent. On the other hand, nodes that are part of the multicast group would have to enter the search command as well so that they are able to join the multicast group and receive this search request. This involves simply pressing the enter key without entering a file name or path, which means that the node only wants to receive search requests. Additionally, if other nodes also intend on sending search requests, this is also possible again due to the use of multi-threading. In this situation each node is simultaneously sending out search requests for a file name or path and receiving request from all the other nodes involved. After the communication has taken place, nodes that have initiated a search will receive a list of responses which is either a search result or a search error from each node.

A series of tests are included below to show demonstrate the operation of the search functionality:

- Initiating a search without first discovering for nodes.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :search
+++ no nodes discovered yet
+++ Initiating discovery protocol...
20231109-180326.397| joined IPv6 multicast group /[[ff02:0:0:0:0:2:2694]:2694
20231109-180326.400| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:25912:20231109-180326.398:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180327.400| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:36657:20231109-180327.400:advertisement:2694:search=path
-filename:
20231109-180327.411| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:42309:20231109-180326.818:advertisement:2694:search=path
-filename:
20231109-180328.401| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:57633:20231109-180328.400:advertisement:2694:search=path
-filename:
20231109-180328.411| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:28790:20231109-180327.819:advertisement:2694:search=path
-filename:
20231109-180329.401| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:94022:20231109-180329.401:advertisement:2694:search=path
-filename:
20231109-180329.411| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:56495:20231109-180328.820:advertisement:2694:search=path
-filename:
20231109-180330.402| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:39305:20231109-180330.401:advertisement:2694:search=path
-filename:
20231109-180330.412| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:38698:20231109-180329.820:advertisement:2694:search=path
-filename:
20231109-180331.402| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:21619:20231109-180331.402:advertisement:2694:search=path
-filename:
20231109-180331.412| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:31950:20231109-180330.821:advertisement:2694:search=path
-filename:
20231109-180332.403| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:26879:20231109-180332.402:advertisement:2694:search=path
-filename:
20231109-180332.413| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:19584:20231109-180331.821:advertisement:2694:search=path
-filename:
20231109-180333.403| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:97835:20231109-180333.403:advertisement:2694:search=path
-filename:
20231109-180333.413| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:35770:20231109-180332.821:advertisement:2694:search=path
-filename:
20231109-180334.404| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:42849:20231109-180334.403:advertisement:2694:search=path
-filename:
20231109-180334.413| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:99557:20231109-180333.822:advertisement:2694:search=path
-filename:
20231109-180335.404| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:38898:20231109-180335.404:advertisement:2694:search=path
-filename:
20231109-180335.414| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:12392:20231109-180334.822:advertisement:2694:search=path
-filename:
20231109-180336.414| left IPv6 multicast group

+++ 1 node(s) discovered:
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, port: 2694, message type: advertisement, search: search=path-filename
+++

+++ Search capabilities:
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, search: search=path-filename
+++

+++ Enter the filename or path to search
+++ Otherwise press ENTER to recieve search requests
```

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :search
+++ no nodes discovered yet
+++ Initiating discovery protocol...
20231109-180326.817| joined IPv6 multicast group /[ff02:0:0:0:0:2:2694]:2694
20231109-180326.819| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42309:20231109-180326.818:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180327.820| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:28790:20231109-180327.819:advertisement:2694:search=path
-filename:
20231109-180327.830| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:36657:20231109-180327.400:advertisement:2694:search=path
-filename:
20231109-180328.820| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:56495:20231109-180328.820:advertisement:2694:search=path
-filename:
20231109-180328.830| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:57633:20231109-180328.400:advertisement:2694:search=path
-filename:
20231109-180329.820| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:38698:20231109-180329.820:advertisement:2694:search=path
-filename:
20231109-180329.831| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:94022:20231109-180329.401:advertisement:2694:search=path
-filename:
20231109-180330.821| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:31950:20231109-180330.821:advertisement:2694:search=path
-filename:
20231109-180330.831| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:39305:20231109-180330.401:advertisement:2694:search=path
-filename:
20231109-180331.821| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:19584:20231109-180331.821:advertisement:2694:search=path
-filename:
20231109-180331.831| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:21619:20231109-180331.402:advertisement:2694:search=path
-filename:
20231109-180332.822| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:35770:20231109-180332.821:advertisement:2694:search=path
-filename:
20231109-180332.832| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:26879:20231109-180332.402:advertisement:2694:search=path
-filename:
20231109-180333.822| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:99557:20231109-180333.822:advertisement:2694:search=path
-filename:
20231109-180333.832| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:97835:20231109-180333.403:advertisement:2694:search=path
-filename:
20231109-180334.823| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:12392:20231109-180334.822:advertisement:2694:search=path
-filename:
20231109-180334.832| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:42849:20231109-180334.403:advertisement:2694:search=path
-filename:
20231109-180335.823| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:33796:20231109-180335.823:advertisement:2694:search=path
-filename:
20231109-180335.833| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:38898:20231109-180335.404:advertisement:2694:search=path
-filename:
20231109-180336.833| left IPv6 multicast group

+++ 1 node(s) discovered:
0 id: sb409@pc7-019-l.cs.st-andrews.ac.uk, port: 2694, message type: advertisement, search: search=path-filename
+++

+++ Search capabilities:
0 id: sb409@pc7-019-l.cs.st-andrews.ac.uk, search: search=path-filename
+++
+++ Enter the filename or path to search
+++ Otherwise press ENTER to receive search requests
```

- Initiating search when no nodes are available to provide the functionality.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :search
+++ no nodes discovered yet
+++ Initiating discovery protocol...
20231109-180943.873| joined IPv6 multicast group /[[ff02:0:0:0:2:2694]:2694
20231109-180943.875| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:85149:20231109-180943.873:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180944.876| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:66427:20231109-180944.875:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180945.877| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:63846:20231109-180945.876:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180946.878| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:67695:20231109-180946.877:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180947.879| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:34534:20231109-180947.878:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180948.880| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:63751:20231109-180948.879:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180949.881| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:28038:20231109-180949.881:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180950.882| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:89941:20231109-180950.882:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180951.883| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:67717:20231109-180951.883:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180952.885| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:95356:20231109-180952.884:advertisement:2694:search=path
-filename:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-180953.983| left IPv6 multicast group
+++ No available nodes
+++ search functionality unavailable
```

- Searching for a file when none of the nodes are capable of providing the search functionality.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :search
+++ search functionality unavailable
+++ discovered node(s) don't support search.

[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help']
```


- One node sending search requests.

```
+++ Search capabilities:
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, search: search=path-filename
+++
+++ Enter the filename or path to search
+++ Otherwise press ENTER to receive search requests
text1-1.txt
+++ Initiating search protocol
20231109-181140.633| joined IPv6 multicast group /[ff02:0:0:0:0:2:2694]:2694
20231109-181140.635| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181140.634:search-request:filename:text1-1.txt:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-181141.636| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181141.636:search-request:filename:text1-1.txt:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-181142.637| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181142.637:search-request:filename:text1-1.txt:
20231109-181142.655| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:58677:20231109-181141.938:search-result:sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:text1-1.txt:
20231109-181143.637| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181143.637:search-request:filename:text1-1.txt:
20231109-181143.656| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:95157:20231109-181142.946:search-result:sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:text1-1.txt:
20231109-181144.638| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181144.638:search-request:filename:text1-1.txt:
20231109-181144.656| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:21929:20231109-181143.951:search-result:sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:text1-1.txt:
20231109-181145.638| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181145.638:search-request:filename:text1-1.txt:
20231109-181145.657| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:76838:20231109-181144.954:search-result:sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:text1-1.txt:
20231109-181146.639| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181146.639:search-request:filename:text1-1.txt:
20231109-181146.657| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:88045:20231109-181145.960:search-result:sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:text1-1.txt:
20231109-181147.639| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181147.639:search-request:filename:text1-1.txt:
20231109-181147.658| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:70249:20231109-181146.963:search-result:sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:text1-1.txt:
20231109-181148.640| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181148.640:search-request:filename:text1-1.txt:
20231109-181148.658| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:91746:20231109-181147.966:search-result:sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:text1-1.txt:
20231109-181149.640| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:20231109-181149.640:search-request:filename:text1-1.txt:
20231109-181149.659| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:83729:20231109-181148.968:search-result:sb409@pc7-019-l.cs.st-andrews.ac.uk:80715:text1-1.txt:
20231109-181150.659| left IPv6 multicast group

+++ response(s):
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, message type: search-result, search string: text1-1.txt
+++
```

- Two nodes sending search requests simultaneously.

```
sb409@pc7-019-l -> java FileTreeBrowser

sb409@pc7-019-l -> java FileTree...  x  sb409@pc7-020-l -> java FileTree...  x  sb409@pc7-022-l -> java FileTree...  x  ▼

20231109-181441.477| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181441.477:search-request:filename:no_cha
rge-web.mp4:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-181442.479| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181442.479:search-request:filename:no_cha
rge-web.mp4:
20231109-181442.488| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181441.789:search-request:filename:ninja.
jpg:
20231109-181442.500| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:10719:20231109-181442.488:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181443.479| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181443.479:search-request:filename:no_cha
rge-web.mp4:
20231109-181443.500| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181442.790:search-request:filename:ninja.
jpg:
20231109-181443.504| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:29009:20231109-181443.500:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181444.480| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181444.479:search-request:filename:no_cha
rge-web.mp4:
20231109-181444.505| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:85299:20231109-181442.800:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:90085:no_charge-web.mp4:
20231109-181445.480| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181445.480:search-request:filename:no_cha
rge-web.mp4:
20231109-181445.505| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181443.790:search-request:filename:ninja.
jpg:
20231109-181445.509| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:66051:20231109-181445.505:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181446.481| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181446.480:search-request:filename:no_cha
rge-web.mp4:
20231109-181446.509| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181444.791:search-request:filename:ninja.
jpg:
20231109-181446.513| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:18547:20231109-181446.509:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181447.481| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181447.481:search-request:filename:no_cha
rge-web.mp4:
20231109-181447.513| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:79810:20231109-181444.814:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:90085:no_charge-web.mp4:
20231109-181448.481| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181448.481:search-request:filename:no_cha
rge-web.mp4:
20231109-181448.513| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181445.791:search-request:filename:ninja.
jpg:
20231109-181448.528| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:46136:20231109-181448.524:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181449.482| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181449.482:search-request:filename:no_cha
rge-web.mp4:
20231109-181449.528| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181446.792:search-request:filename:ninja.
jpg:
20231109-181449.532| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:21641:20231109-181449.528:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181450.482| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181450.482:search-request:filename:no_cha
rge-web.mp4:
20231109-181450.532| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:98574:20231109-181446.820:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:90085:no_charge-web.mp4:
20231109-181451.533| left IPv6 multicast group

+++ response(s):
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, message type: search-result, search string: no_charge-web.mp4
+++
```

```
sb409@pc7-020-l -> java FileTreeBrowser
ninja.jpg
+++ Initiating search protocol
20231109-181441.788| joined IPv6 multicast group /[[ff02:0:0:0:2:2694]:2694
20231109-181441.790| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181441.789:search-request:filename:ninja.
jpg:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-181442.790| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181442.790:search-request:filename:ninja.
jpg:
20231109-181442.800| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181442.479:search-request:filename:no_cha
rge-web.mp4:
20231109-181442.813| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:85299:20231109-181442.800:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:90085:no_charge-web.mp4:
20231109-181443.791| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181443.790:search-request:filename:ninja.
jpg:
20231109-181443.814| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:10719:20231109-181442.488:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181444.791| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181444.791:search-request:filename:ninja.
jpg:
20231109-181444.814| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181443.479:search-request:filename:no_cha
rge-web.mp4:
20231109-181444.819| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:79810:20231109-181444.814:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:90085:no_charge-web.mp4:
20231109-181445.791| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181445.791:search-request:filename:ninja.
jpg:
20231109-181445.820| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:29009:20231109-181443.500:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181446.792| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181446.792:search-request:filename:ninja.
jpg:
20231109-181446.820| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181444.479:search-request:filename:no_cha
rge-web.mp4:
20231109-181446.879| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:98574:20231109-181446.820:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:90085:no_charge-web.mp4:
20231109-181447.792| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181447.792:search-request:filename:ninja.
jpg:
20231109-181447.880| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181445.480:search-request:filename:no_cha
rge-web.mp4:
20231109-181447.884| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:74553:20231109-181447.880:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:90085:no_charge-web.mp4:
20231109-181448.793| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181448.793:search-request:filename:ninja.
jpg:
20231109-181448.884| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:66051:20231109-181445.505:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181449.793| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181449.793:search-request:filename:ninja.
jpg:
20231109-181449.884| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:90085:20231109-181446.480:search-request:filename:no_cha
rge-web.mp4:
20231109-181449.888| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80670:20231109-181449.884:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:90085:no_charge-web.mp4:
20231109-181450.794| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:42964:20231109-181450.793:search-request:filename:ninja.
jpg:
20231109-181450.889| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:18547:20231109-181446.509:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:42964:ninja.jpg:
20231109-181451.889| left IPv6 multicast group

+++ response(s):
0 id: sb409@pc7-019-l.cs.st-andrews.ac.uk, message type: search-result, search string: ninja.jpg
+++
```

- Three nodes requesting for a search simultaneously.

```
sb409@pc7-019-l -> java FileTree... × sb409@pc7-020-l -> java FileTree... × sb409@pc7-022-l -> java FileTree... × ▾
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-184743.888| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184743.887:search-request:filename:textl-
2.txt:
20231109-184743.897| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184743.183:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184743.912| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:96229:20231109-184743.897:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184744.888| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184744.888:search-request:filename:textl-
2.txt:
20231109-184744.912| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:21053:20231109-184743.191:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:72136:totem.jpg:
20231109-184745.889| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184745.888:search-request:filename:textl-
2.txt:
20231109-184745.912| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184743.507:search-request:filename:totem.
jpg:
20231109-184745.916| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:34857:20231109-184745.913:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:72136:totem.jpg:
20231109-184746.889| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184746.889:search-request:filename:textl-
2.txt:
20231109-184746.916| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:63234:20231109-184743.517:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:textl-2.txt:
20231109-184747.890| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184747.889:search-request:filename:textl-
2.txt:
20231109-184747.917| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184744.183:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184747.921| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:14797:20231109-184747.917:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184748.890| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184748.890:search-request:filename:textl-
2.txt:
20231109-184748.941| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:85325:20231109-184744.203:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:textl-2.txt:
20231109-184749.890| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184749.890:search-request:filename:textl-
2.txt:
20231109-184749.942| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184744.508:search-request:filename:totem.
jpg:
20231109-184749.945| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:48036:20231109-184749.942:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:72136:totem.jpg:
20231109-184750.891| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184750.891:search-request:filename:textl-
2.txt:
20231109-184750.946| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:86998:20231109-184744.524:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184751.891| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184751.891:search-request:filename:textl-
2.txt:
20231109-184751.946| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184745.184:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184751.950| tx-> sb409@pc7-019-l.cs.st-andrews.ac.uk:42484:20231109-184751.946:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184752.951| left IPv6 multicast group

+++ response(s):
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, message type: search-result, search string: textl-2.txt
1 id: sb409@pc7-022-l.cs.st-andrews.ac.uk, message type: search-result, search string: textl-2.txt

+++
```

```
sb409@pc7-019-l -> java FileTree...  ×  sb409@pc7-020-l -> java FileTree...  ×  sb409@pc7-022-l -> java FileTree...  ×  ▼
20231109-184743.507| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184743.507:search-request:filename:totem.
jpg:
20231109-184743.517| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184742.886:search-request:filename:textl1-
2.txt:
20231109-184743.523| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:63234:20231109-184743.517:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:textl1-2.txt:
20231109-184744.508| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184744.508:search-request:filename:totem.
jpg:
20231109-184744.524| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184743.183:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184744.530| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:86998:20231109-184744.524:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184745.508| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184745.508:search-request:filename:totem.
jpg:
20231109-184745.530| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:21053:20231109-184743.191:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:72136:totem.jpg:
20231109-184746.509| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184746.509:search-request:filename:totem.
jpg:
20231109-184746.530| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184743.887:search-request:filename:textl1-
2.txt:
20231109-184746.533| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:79266:20231109-184746.531:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:textl1-2.txt:
20231109-184747.509| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184747.509:search-request:filename:totem.
jpg:
20231109-184747.533| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:96229:20231109-184743.897:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184748.510| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184748.509:search-request:filename:totem.
jpg:
20231109-184748.533| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184744.183:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184748.537| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:27071:20231109-184748.533:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184749.510| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184749.510:search-request:filename:totem.
jpg:
20231109-184749.537| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:85325:20231109-184744.203:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:textl1-2.txt:
20231109-184750.510| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184750.510:search-request:filename:totem.
jpg:
20231109-184750.537| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184744.888:search-request:filename:textl1-
2.txt:
20231109-184750.539| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:31411:20231109-184750.537:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:textl1-2.txt:
20231109-184751.511| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184751.511:search-request:filename:totem.
jpg:
20231109-184751.539| ->rx sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184745.184:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184751.543| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:89696:20231109-184751.540:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184752.543| left IPv6 multicast group

+++ response(s):
0 id: sb409@pc7-022-l.cs.st-andrews.ac.uk, message type: search-result, search string: totem.jpg

+++
```



```
sb409@pc7-019-l -> java FileTree... × sb409@pc7-020-l -> java FileTree... × sb409@pc7-022-l -> java FileTree... × ▾
nd_strong-web.mp4:
20231109-184743.191| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184742.506:search-request:filename:totem.
jpg:
20231109-184743.202| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:21053:20231109-184743.191:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:72136:totem.jpg:
20231109-184744.184| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184744.183:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184744.203| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184742.886:search-request:filename:text1-
2.txt:
20231109-184744.207| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:85325:20231109-184744.203:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:text1-2.txt:
20231109-184745.185| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184745.184:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184745.208| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184743.507:search-request:filename:totem.
jpg:
20231109-184745.213| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:46135:20231109-184745.208:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:72136:totem.jpg:
20231109-184746.186| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184746.185:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184746.214| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:63234:20231109-184743.517:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:text1-2.txt:
20231109-184747.187| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184747.186:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184747.215| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184743.887:search-request:filename:text1-
2.txt:
20231109-184747.220| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:71041:20231109-184747.216:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:text1-2.txt:
20231109-184748.188| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184748.187:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184748.220| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:96229:20231109-184743.897:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184749.189| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184749.188:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184749.221| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:72136:20231109-184744.508:search-request:filename:totem.
jpg:
20231109-184749.227| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:65516:20231109-184749.222:search-result:sb409@pc7-020-l.
cs.st-andrews.ac.uk:72136:totem.jpg:
20231109-184750.190| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184750.189:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184750.228| ->rx sb409@pc7-020-l.cs.st-andrews.ac.uk:86998:20231109-184744.524:search-result:sb409@pc7-022-l.
cs.st-andrews.ac.uk:62613:good_and_strong-web.mp4:
20231109-184751.191| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:62613:20231109-184751.190:search-request:filename:good_a
nd_strong-web.mp4:
20231109-184751.229| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:99493:20231109-184744.888:search-request:filename:text1-
2.txt:
20231109-184751.233| tx-> sb409@pc7-022-l.cs.st-andrews.ac.uk:50703:20231109-184751.229:search-result:sb409@pc7-019-l.
cs.st-andrews.ac.uk:99493:text1-2.txt:
20231109-184752.234| left IPv6 multicast group

+++ response(s):
0 id: sb409@pc7-019-l.cs.st-andrews.ac.uk, message type: search-result, search string: good_and_strong-web.mp4
1 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, message type: search-result, search string: good_and_strong-web.mp4

+++
```

- Searching for a file name when available nodes only allow search on a path.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :search

+++ Search capabilities:
0 id: sb409@pc7-019-l.cs.st-andrews.ac.uk, search: search=path
+++
+++ Enter the filename or path to search
+++ Otherwise press ENTER to receive search requests
text2-1.txt
+++ Initiating search protocol
20231109-182200.055| joined IPv6 multicast group /[[ff02:0:0:0:0:2:2694]:2694
20231109-182200.056| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182200.055:search-request:filename:text2-1.txt:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-182201.056| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182201.056:search-request:filename:text2-1.txt:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-182202.056| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182202.056:search-request:filename:text2-1.txt:
20231109-182202.076| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:89249:20231109-182201.286:search-error:sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:
20231109-182203.057| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182203.057:search-request:filename:text2-1.txt:
20231109-182203.077| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:11931:20231109-182202.287:search-error:sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:
20231109-182204.057| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182204.057:search-request:filename:text2-1.txt:
20231109-182204.077| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:24579:20231109-182203.289:search-error:sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:
20231109-182205.058| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182205.058:search-request:filename:text2-1.txt:
20231109-182205.077| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:81082:20231109-182204.291:search-error:sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:
20231109-182206.058| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182206.058:search-request:filename:text2-1.txt:
20231109-182206.078| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:85089:20231109-182205.293:search-error:sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:
20231109-182207.059| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182207.059:search-request:filename:text2-1.txt:
20231109-182207.078| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:21742:20231109-182206.295:search-error:sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:
20231109-182208.059| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182208.059:search-request:filename:text2-1.txt:
20231109-182208.078| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:70610:20231109-182207.298:search-error:sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:
20231109-182209.060| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:20231109-182209.060:search-request:filename:text2-1.txt:
20231109-182209.079| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:21830:20231109-182208.300:search-error:sb409@pc7-020-l.cs.st-andrews.ac.uk:55783:
20231109-182210.079| left IPv6 multicast group
+++ file not found

[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] ^[x
```

- Searched file name or path not found.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :search
+++ Search capabilities:
0 id: sb409@pc7-019-l.cs.st-andrews.ac.uk, search: search=path-filename
+++
+++ Enter the filename or path to search
+++ Otherwise press ENTER to receive search requests
gfdshfdsgfsdg
+++ Initiating search protocol
20231109-181817.026| joined IPv6 multicast group /[[ff02:0:0:0:0:2:694]:2694
20231109-181817.027| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181817.027:search-request:filename:gfdshf
dsgfsdg:
MulticastEndpoint.rx(): timeout on receive - Receive timed out
20231109-181818.028| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181818.027:search-request:filename:gfdshf
dsgfsdg:
20231109-181818.038| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:39610:20231109-181817.545:search-error:sb409@pc7-020-l.c
s.st-andrews.ac.uk:80300:
20231109-181819.028| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181819.028:search-request:filename:gfdshf
dsgfsdg:
20231109-181819.038| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:79774:20231109-181818.562:search-error:sb409@pc7-020-l.c
s.st-andrews.ac.uk:80300:
20231109-181820.029| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181820.028:search-request:filename:gfdshf
dsgfsdg:
20231109-181820.038| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:95319:20231109-181819.566:search-error:sb409@pc7-020-l.c
s.st-andrews.ac.uk:80300:
20231109-181821.029| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181821.029:search-request:filename:gfdshf
dsgfsdg:
20231109-181821.039| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:74632:20231109-181820.575:search-error:sb409@pc7-020-l.c
s.st-andrews.ac.uk:80300:
20231109-181822.029| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181822.029:search-request:filename:gfdshf
dsgfsdg:
20231109-181822.039| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:17951:20231109-181821.591:search-error:sb409@pc7-020-l.c
s.st-andrews.ac.uk:80300:
20231109-181823.030| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181823.030:search-request:filename:gfdshf
dsgfsdg:
20231109-181823.039| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:88653:20231109-181822.674:search-error:sb409@pc7-020-l.c
s.st-andrews.ac.uk:80300:
20231109-181824.030| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181824.030:search-request:filename:gfdshf
dsgfsdg:
20231109-181824.040| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:26408:20231109-181823.679:search-error:sb409@pc7-020-l.c
s.st-andrews.ac.uk:80300:
20231109-181825.031| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181825.031:search-request:filename:gfdshf
dsgfsdg:
20231109-181825.040| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:88787:20231109-181824.683:search-error:sb409@pc7-020-l.c
s.st-andrews.ac.uk:80300:
20231109-181826.031| tx-> sb409@pc7-020-l.cs.st-andrews.ac.uk:80300:20231109-181826.031:search-request:filename:gfdshf
dsgfsdg:
20231109-181826.040| ->rx sb409@pc7-019-l.cs.st-andrews.ac.uk:94081:20231109-181825.703:search-error:sb409@pc7-020-l.c
s.st-andrews.ac.uk:80300:
20231109-181827.041| left IPv6 multicast group
+++ file not found
```


Download

The download functionality deviates from the protocol specification and so download messages aren't signalled within the multicast group. This decision has been made due to how my application has been designed thus far. All the relevant information for the download functionality to take place has already been stored in the program through the discovery and search protocols which have already occurred. The discovery protocol includes the address and port number of each node which is required for the TCP connection. And the search protocol includes information about whether a specified file is included in the distributed file space. The download functionality can therefore take place without having to design a separate protocol message, using the other two protocols messages as the foundation for this functionality. Otherwise, the signalling of download messages would be a direct copy of the code in the search function which means redundant code which is why I chose to implement it this way.

For the search functionality to occur, the user is first required to initiate a search for the file to download. Then after a response has been received, the user can enter the download command to start the download. Then the user is asked to choose between either initiating a client to download the file or initiating a server to upload the file. In this case, since the user is intending on downloading, the client is initiated. Following this, the user is asked to choose a node to download from which is based on the list of responses received through the search protocol. On the other hand, the node that has been chosen to download from would have to enter the download command as well. Then it would have to choose to initiate the server for transferring the file to the client. This establishes a TCP connection the node acting as the client and the node acting as the server. This functionality is therefore designed to be a one-to-one communication.

A series of tests have been included below to demonstrate the operation of the download functionality:

- Initiating download without first searching for the file.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
1
+++ Use :search to search for the file to download first
```

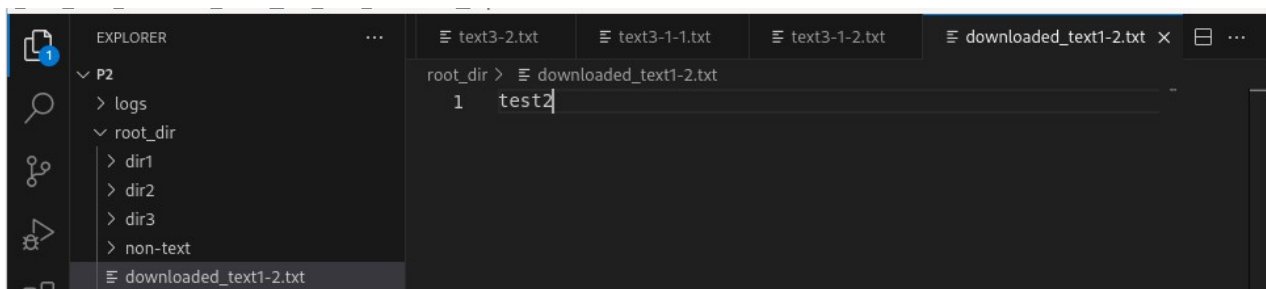
- Downloading a text file.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
1
+++ available downloads:
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, search string: text1-2.txt
1 id: sb409@pc7-022-l.cs.st-andrews.ac.uk, search string: text1-2.txt
+++
+++ Choose a node to download from
Enter the node number
0
+++ Enter the path to download to
root_dir
+++ hostname: pc7-020-l.cs.st-andrews.ac.uk
+++ IP address: 138.251.29.30
+++ port number: 2694
Connected to server
text1-2.txt
File downloaded successfully

[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help']
```

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
0
Server is listening on port 2694...
Client connected
transferring: /cs/home/sb409/Documents/Fourth_Year/CS4105/P2/root_dir/dir1/text1-2.txt
size: 0 bytes
File has been sent

[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help']
```



- Downloading an image.

```

[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
0
Server is listening on port 2694...
Client connected
transferring: /cs/home/sb409/Documents/Fourth_Year/CS4105/P2/root_dir/dir1/text1-2.txt
size: 0 bytes
File has been sent

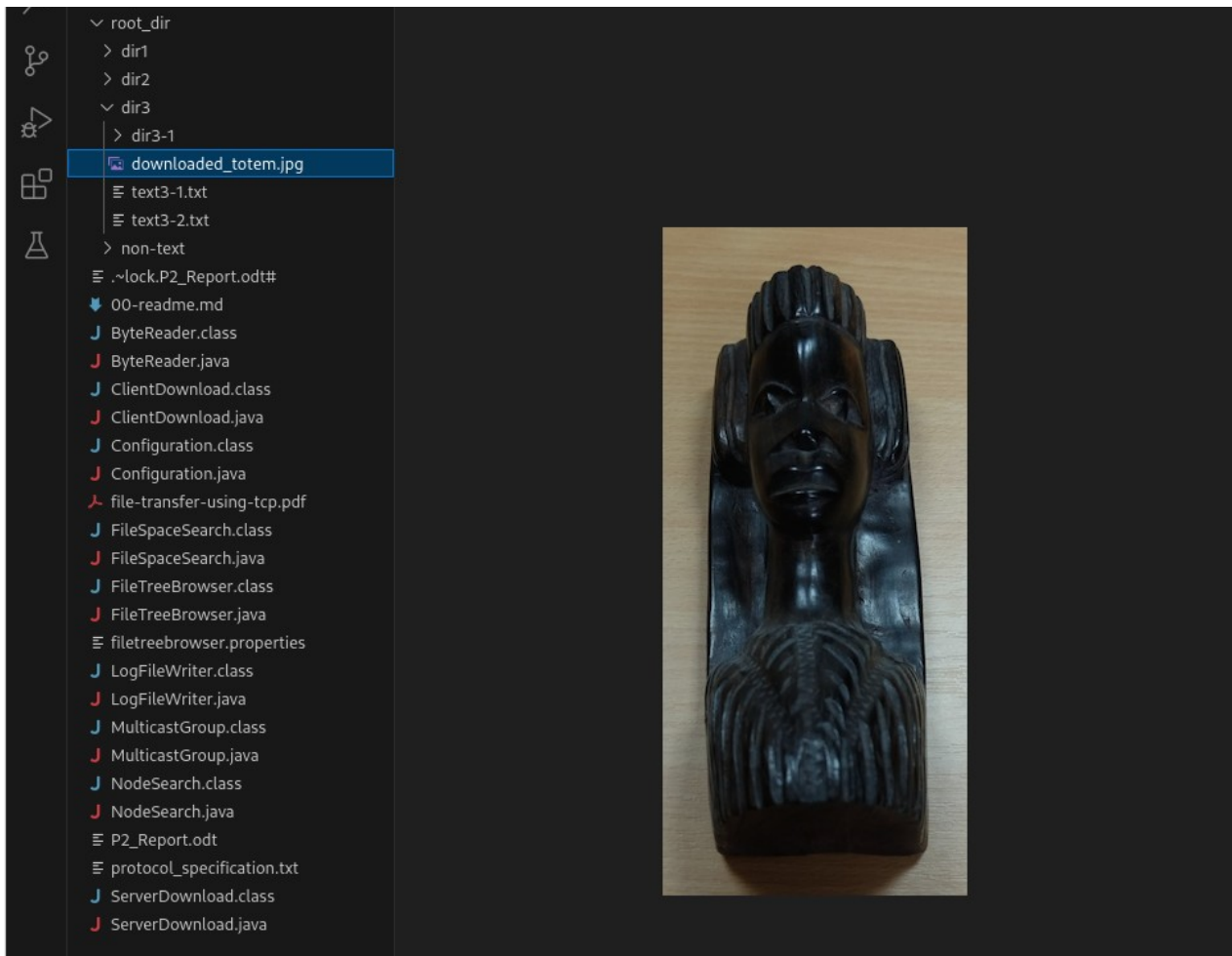
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
1
+++ available downloads:
0 id: sb409@pc7-022-l.cs.st-andrews.ac.uk, search string: totem.jpg
+++
+++ Choose a node to download from
Enter the node number
0
+++ Enter the path to download to
root_dir/dir3
+++ hostname: pc7-022-l.cs.st-andrews.ac.uk
+++ IP address: 138.251.29.32
+++ port number: 2694
Connected to server
totem.jpg
File downloaded successfully

```

```

[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
0
Server is listening on port 2694...
Client connected
transferring: /cs/home/sb409/Documents/Fourth_Year/CS4105/P2/root_dir/non-text/images/totem.jpg
size: 56120 bytes
File has been sent

```

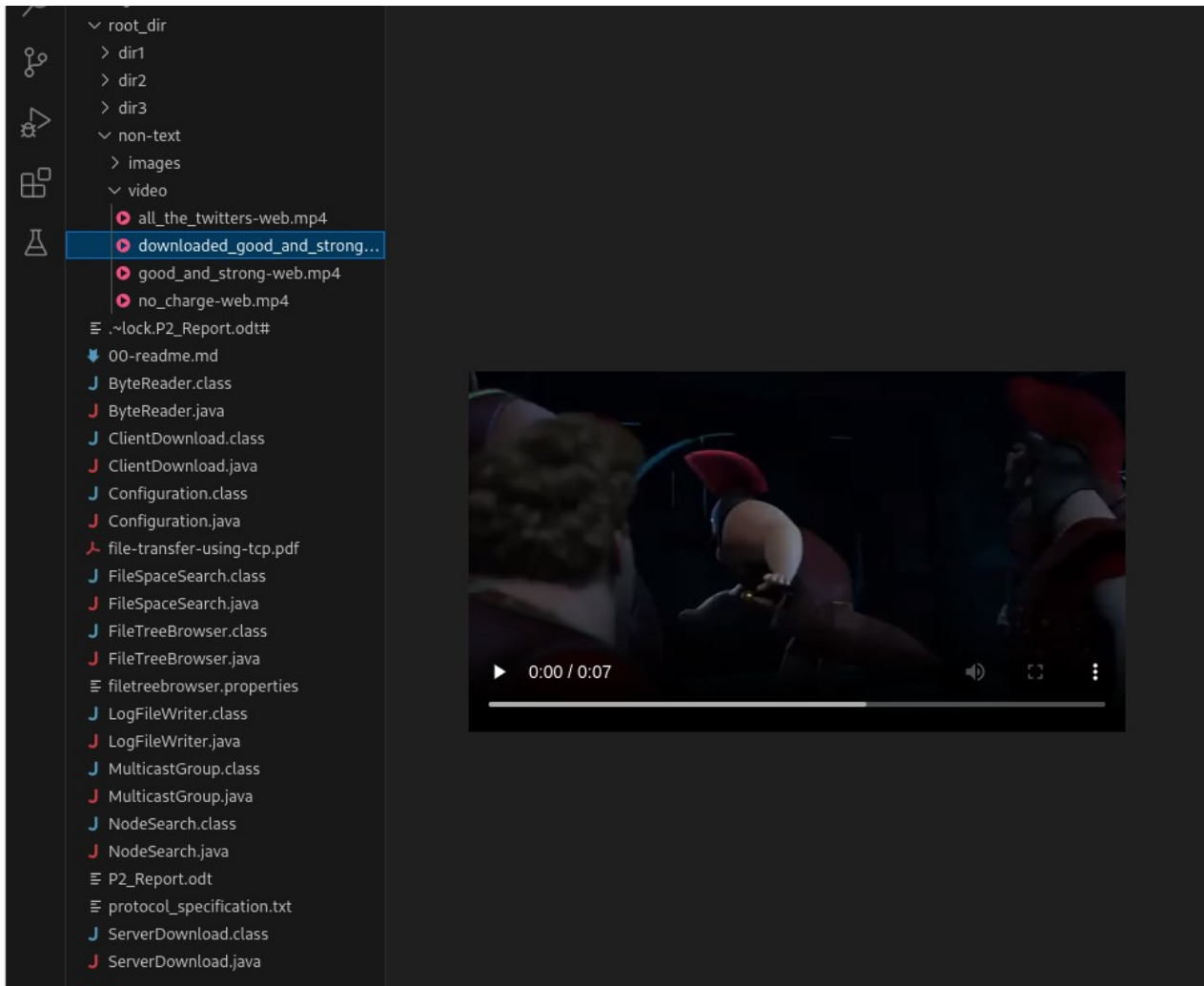


- Downloading a video.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
0
Server is listening on port 2694...
Client connected
transferring: /cs/home/sb409/Documents/Fourth_Year/CS4105/P2/root_dir/non-text/images/totem.jpg
size: 56120 bytes
File has been sent

[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
1
+++ available downloads:
0 id: sb409@pc7-019-l.cs.st-andrews.ac.uk, search string: good_and_strong-web.mp4
1 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, search string: good_and_strong-web.mp4
+++
+++ Choose a node to download from
Enter the node number
1
+++ Enter the path to download to
root_dir/non-text/video
+++ hostname: pc7-020-l.cs.st-andrews.ac.uk
+++ IP address: 138.251.29.30
+++ port number: 2694
Connected to server
good_and_strong-web.mp4
File downloaded successfully
```

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
0
Server is listening on port 2694...
Client connected
transferring: /cs/home/sb409/Documents/Fourth_Year/CS4105/P2/root_dir/non-text/video/good_and_strong-web.mp4
size: 319863 bytes
File has been sent
```



- Downloading a file to an invalid path.

```
[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
1

+++ available downloads:
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, search string: text1-2.txt
1 id: sb409@pc7-022-l.cs.st-andrews.ac.uk, search string: text1-2.txt

+++
+++ Choose a node to download from
Enter the node number
0
+++ Enter the path to download to
root_dir
+++ hostname: pc7-020-l.cs.st-andrews.ac.uk
+++ IP address: 138.251.29.30
+++ port number: 2694
Connected to server
text1-2.txt
File downloaded successfully

[filename | '.' | '..' | ':services' | ':nodes' | ':search' | ':download' | ':quit' | ':help'] :download
+++ Choose the functionality to perform:
0: Initiate server for file upload
1: Initiate client for file download
1

+++ available downloads:
0 id: sb409@pc7-020-l.cs.st-andrews.ac.uk, search string: text1-2.txt
1 id: sb409@pc7-022-l.cs.st-andrews.ac.uk, search string: text1-2.txt

+++
+++ Choose a node to download from
Enter the node number
1
+++ Enter the path to download to
asdfgfd
+++ hostname: pc7-022-l.cs.st-andrews.ac.uk
+++ IP address: 138.251.29.32
+++ port number: 2694
Client error: asdfgfd/downloaded_text1-2.txt (No such file or directory)
```

Critical Analysis

Since this application uses IPv6 multicast, one-to-many communication is used, making it an efficient way for nodes to provide functionality. All the nodes use the same multicast address so each node would only have to send a message once for it to be received by all the nodes. Additionally, it makes use of the existing LAN network infrastructure so modification of the existing hardware isn't required. For individual nodes to support this application, the only requirement is that each node needs to have a configuration file which is configured correctly for the control-plane protocol to operate. This means that it is relatively straightforward for nodes to be added to the distributed file-space. However, this only applies to the discovery and search functionality. One limitation of this implementation is that the download functionality is based on a one-to-one TCP communication between nodes and doesn't support concurrency, which doesn't scale well. Each node would have to wait in a queue to download a file which can mean which can be really inefficient when the number of nodes requesting a service is large. Another drawback with this control-plane design is that as more nodes are added to the network, the network traffic would increase rapidly since each node is sending and receiving messages to and from every other node.

Since the design of the control-plane is based on UDP, messages are transferred quickly since reliability isn't ensured. Multicast performs well for this application since as mentioned above, messages are received by every other node without the need to transfer it to every other node. Along with this, multiple requests are handled simultaneously. But again the download functionality doesn't perform is being limited by its design. Moreover, due to the potential traffic that comes with this design, the overall performance of the control-plane protocol can be impacted since it could lead to larger delays and potential loss. In addition, since this there is no reliability ensured, the messages aren't retransmitted which results in loss of service when the request messages aren't received.

The main drawback with this design is its lack of privacy and security. The protocol doesn't have an authentication mechanism to ensure that only authorized users can take part in the communication. Any node can join the multicast group as long as it is configured to use the right multicast address. This could result in unauthorised access to the file-space where a malicious user can make search and download requests and since these files aren't encrypted, it is entirely visible to anyone within the multicast group. There is also no data integrity since access control isn't provided feature to enforce restrictions on who can do what. Each node involved in the communication is required to include their id and port number as part of the header in the protocol messages. This is again not encrypted which means a third-party user can gain access to the such information. Lastly, malicious users can easily inject traffic into the network and a perform a DoS attack.