**Reliable Udp File Transfer(ruft)**

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# Targaryen Server and Martell Client(ruft\_server.bin and ruft\_client.bin)

**I.Header Design**

##Ruft Header##  
+--------------------------------+  
| Flags(16 bits) |AdvWin(16 bits)|  
+--------------------------------+  
| Acknowledgement No(32 bits) |  
+--------------------------------+  
| Sequence no(32 bits) |  
+--------------------------------+  
| Payload Length(32 bits) |  
+--------------------------------+  
| Payload |  
| |  
. .  
. .  
. .  
| |  
+--------------------------------+

This is the application header for a ruft packet.

**Fields**

* **Flags(16bits)-** This has some necessary flags:
  + **is\_ack(first bit):** set if the packet is an acknowledgment
  + **is\_data\_pkt(second bit):** set if this is data packet unset if control packet
  + **is\_last\_pkt(third bit):** set if this is the last packet in communication
* **Advertised Win(16 bits):** Designed to be used for window negotiation between receiver and sender but left unused as receiver and sender negotiate it offline.
* **Acknowledgement No(32 bits):** Acknowledgement no stating the byte received till now.
* **Sequence No(32 bits):** Sequence no indicating the starting byte of the transfer byte stream.
* **Payload Length(32 bits):** Payload length indicating the length of the payload expected. Max is hardcoded as 1280 bits(MSS).
* **Payload(Variable length):** Depending on payload length max hardcoded as 1280 bits(MSS).

**Note:** All packets transferred on wire are on Network Order it is converted to host order in the respective programs i.e application layer.

**II. Basic Protocol Packets exchange**

**Targaryen(ruft\_server) Martell(ruft\_client)**

**file\_rqst**



**reqst\_recvd**  **file\_size received**

**file\_seg transfer**  **ack sent back**



**multiple segments** 

**based on wnd\_size** 



**.**

**.**

**.**

 **cumulative ack sent**

Things supported

1. Flow control using sliding window negotiated offline
2. Duplicate Acknowledgements
3. Congestion Control phases :
   1. Slow Start
   2. Congestion Avoidance
4. Adaptive retransmission using
   1. Jacobson/Karels algorithm
5. On client side
   1. No drop behaviour
   2. Variable packet loss
   3. High latency communication

**III. Implementation Details**

1. **Flow Control**

This has been done using sliding window. The server decides the window s size seeing the state of the server. Based on that it sends all the segments present in the window and waits for the ack. If packets are lost then it retransmits accordingly after timeout. Once all the packets have been acked using cumulative ack from the server the server resets the window size based on the state of the server and perform the sending action again

1. **Duplicate Acknowledgements**

In case of out of order delivery Duplicate ACKs(3 count) is sent from the client side. Upon receiving this the server only transfers one data segment corresponding to the ack. After which the client replies back with cumulative ack.

The server on receiving duplicate acks moves to fast recovery and then after transmitting goes to Congestion avoidance by changing the cwnd and ss\_thres values. If it further encounters timeouts it switches to slow start.

1. **Congestion Control**
   1. **Slow Start**

The server starts on slow start and then moves to congestion avoidance based on the distinct no of acks it got during the window transfer. If it crosses the threshold then the server moves to congestion avoidance.

* 1. **Congestion Avoidance**

The server after moving to congestion avoidance increases the window size linearly compared to exponentially in slow start.

1. **Adaptive retransmission**

The server and client uses adaptive retransmission by dynamically calculating the timeout based on Jacobson/Karels algorithm.

/\*The Jacobson/Karels algo according to the book\*/

est\_rtt = (0.875)\*est\_rtt + (0.125)\*(rtt);

dev\_rtt = (0.75)\*dev\_rtt + (0.25)\*(abs(rtt-est\_rtt));

timeout = est\_rtt + 4\*dev\_rtt;

1. **Client side** 
   1. **No Drop Mode**

In this mode the client does not perform any drops on its own.

* 1. **Variable Packet Loss**

This is done by deciding a random packet to be dropped in the receiver window in client side using rand() function.

rd\_index = recv\_ctr + rand()%(rwnd\_seg - recv\_ctr);

The drop percentage per window is (1/(window size))\*100.

This is non configurable and is hardcoded.

* 1. **High Latency Communication**

This is done by introducing sleep using usleep for microseconds granularity. The default sleep introduced is 1000 microseconds for each packet received.

usleep(DELAY);

**IV. Statistics Collected**

**SMALL FILE(File Size: 6 bytes)**

*No Drop Mode*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_small.txt 0 1280

File Recieved

Time taken in micro secs: 1412

**SERVER**

Server State: SERVER WAIT

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 2 RX: 2

Slow Start Packets Stats:

TX: 2 RX: 1 TX%: 100 RX%: 50

Congestion Avoidance Packets Stats:

TX: 0 RX: 0 TX%: 0 RX%: 0

**VERIFY**

[sirdas@silo client]$ ls -l

-rw------- 1 sirdas students 6 Oct 18 20:12 file\_small.txt

[sirdas@silo client]$ ls -l ../file\_small.txt

-rw------- 1 sirdas students 6 Oct 11 13:17 ../file\_small.txt

*Variable Packet Loss*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_small.txt 1 1280

File Recieved

Time taken in micro secs: 1618

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 3 RX: 2

Slow Start Packets Stats:

TX: 3 RX: 1 TX%: 100 RX%: 50

Congestion Avoidance Packets Stats:

TX: 0 RX: 0 TX%: 0 RX%: 0

**VERIFY**

[sirdas@silo client]$ ls -l file\_small.txt

-rw------- 1 sirdas students 6 Oct 18 20:33 file\_small.txt

[sirdas@silo client]$ ls -l ../file\_small.txt

-rw------- 1 sirdas students 6 Oct 11 13:17 ../file\_small.txt

*High Latency Communication*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_small.txt 2 1280

File Recieved

Time taken in micro secs: 2177

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 3 RX: 2

Slow Start Packets Stats:

TX: 3 RX: 1 TX%: 100 RX%: 50

Congestion Avoidance Packets Stats:

TX: 0 RX: 0 TX%: 0 RX%: 0

**VERIFY**

[sirdas@silo client]$ ls -l ../file\_small.txt

-rw------- 1 sirdas students 6 Oct 11 13:17 ../file\_small.txt

[sirdas@silo client]$ ls -l file\_small.txt

-rw------- 1 sirdas students 6 Oct 18 20:34 file\_small.txt

**MED FILE(20110 bytes Approx 20.11 KB)**

*No Drop Mode*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_med.txt 0 5120

File Recieved

Time taken in secs: 1

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 25 RX: 7

Slow Start Packets Stats:

TX: 8 RX: 3 TX%: 32 RX%: 42

Congestion Avoidance Packets Stats:

TX: 17 RX: 3 TX%: 68 RX%: 42

**VERIFY**

[sirdas@silo client]$ ls -l file\_med.txt

-rw------- 1 sirdas students 20110 Oct 18 20:36 file\_med.txt

[sirdas@silo client]$ ls -l ../file\_med.txt

-rw------- 1 sirdas students 20110 Oct 7 22:11 ../file\_med.txt

*Variable Packet Loss*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_med.txt 1 5120

File Recieved

Time taken in micro secs: 28525

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: FAST RECOVERY

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 41 RX: 15

Slow Start Packets Stats:

TX: 22 RX: 8 TX%: 53 RX%: 53

Congestion Avoidance Packets Stats:

TX: 19 RX: 6 TX%: 46 RX%: 40

**VERIFY**

[sirdas@silo client]$ ls -l file\_med.txt

-rw------- 1 sirdas students 20110 Oct 18 20:40 file\_med.txt

[sirdas@silo client]$ ls -l ../file\_med.txt

-rw------- 1 sirdas students 20110 Oct 7 22:11 ../file\_med.txt

*High Latency Communication*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_med.txt 2 5120

File Recieved

Time taken in micro secs: 64373

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 25 RX: 7

Slow Start Packets Stats:

TX: 8 RX: 3 TX%: 32 RX%: 42

Congestion Avoidance Packets Stats:

TX: 17 RX: 3 TX%: 68 RX%: 42

**VERIFY**

[sirdas@silo client]$ ls -l file\_med.txt

-rw------- 1 sirdas students 20110 Oct 18 20:41 file\_med.txt

[sirdas@silo client]$ ls -l ../file\_med.txt

-rw------- 1 sirdas students 20110 Oct 7 22:11 ../file\_med.txt

**Medium Large TXT(File Size: 1009368 bytes Approx: 1MB )**

*No Drop Mode*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_med\_large.txt 0 12800

File Recieved

Time taken in micro secs: 280094

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

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Server State: CONGESTION AVOIDANCE

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Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: CONGESTION AVOIDANCE

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 815 RX: 83

Slow Start Packets Stats:

TX: 25 RX: 3 TX%: 3 RX%: 3

Congestion Avoidance Packets Stats:

TX: 790 RX: 79 TX%: 96 RX%: 95

**VERIFY**

[sirdas@silo client]$ ls -l file\_med\_large.txt

-rw------- 1 sirdas students 1009368 Oct 18 20:42 file\_med\_large.txt

[sirdas@silo client]$ ls -l ../file\_med\_large.txt

-rw------- 1 sirdas students 1009368 Oct 4 22:24 ../file\_med\_large.txt

***Changing the negotiated Window to 64000 bytes***

*Variable Packet Loss*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_med\_large.txt 1 5120

File Recieved

Time taken in secs: 5

**SERVER**

[sirdas@silo reliable\_udp\_file\_transfer]$ ./ruft\_server.bin 20010 5120

Server State: SERVER WAIT

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

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Server State: CONGESTION AVOIDANCE

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Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 3977 RX: 615

Slow Start Packets Stats:

TX: 2416 RX: 400 TX%: 60 RX%: 65

Congestion Avoidance Packets Stats:

TX: 1558 RX: 210 TX%: 39 RX%: 34

**VERIFY**

[sirdas@silo client]$ ls -l file\_med\_large.txt

-rw------- 1 sirdas students 1009368 Oct 18 20:48 file\_med\_large.txt

[sirdas@silo client]$ ls -l ../file\_med\_large.txt

-rw------- 1 sirdas students 1009368 Oct 4 22:24 ../file\_med\_large.txt

*High Latency Communication*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_med\_large.txt 2 12800

File Recieved

Time taken in secs: 3

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

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Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 3841 RX: 137

Slow Start Packets Stats:

TX: 2817 RX: 109 TX%: 73 RX%: 79

Congestion Avoidance Packets Stats:

TX: 1022 RX: 27 TX%: 26 RX%: 19

**VERIFY**

[sirdas@silo client]$ ls -l file\_med\_large.txt

-rw------- 1 sirdas students 1009368 Oct 18 20:50 file\_med\_large.txt

[sirdas@silo client]$ ls -l ../file\_med\_large.txt

-rw------- 1 sirdas students 1009368 Oct 4 22:24 ../file\_med\_large.txt

**LARGE PACKET TXT(file size: 5348511 bytes Approx: 5.3MB)**

*No Drop Mode*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_large.txt 0 5120

File Recieved

Time taken in secs: 3

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: FAST RECOVERY

Server State: CONGESTION AVOIDANCE

Server State: FAST RECOVERY

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 8270 RX: 501

Slow Start Packets Stats:

TX: 4088 RX: 402 TX%: 49 RX%: 80

Congestion Avoidance Packets Stats:

TX: 4182 RX: 98 TX%: 50 RX%: 19

**VERIFY**

[sirdas@silo client]$ ls -l file\_large.txt

-rw------- 1 sirdas students 5348511 Oct 18 21:30 file\_large.txt

[sirdas@silo client]$ ls -l ../file\_large.txt

-rw------- 1 sirdas students 5348511 Oct 11 13:11 ../file\_large.txt

*Variable Packet Loss*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_large.txt 1 5120

File Recieved

Time taken in secs: 33

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

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Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 27913 RX: 616

Slow Start Packets Stats:

TX: 23715 RX: 490 TX%: 84 RX%: 79

Congestion Avoidance Packets Stats:

TX: 4195 RX: 117 TX%: 15 RX%: 18

**VERIFY**

[sirdas@silo client]$ ls -l file\_large.txt

-rw------- 1 sirdas students 5348511 Oct 18 21:39 file\_large.txt

[sirdas@silo client]$ ls -l ../file\_large.txt

-rw------- 1 sirdas students 5348511 Oct 11 13:11 ../file\_large.txt

*High Latency Communication*

**CLIENT**

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_large.txt 2 5120

File Recieved

Time taken in secs: 200

**SERVER**

Server State: PROCESS REQUEST

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: CONGESTION AVOIDANCE

Server State: FAST RECOVERY

Server State: CONGESTION AVOIDANCE

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Server State: SLOW START

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Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: FAST RECOVERY

Server State: CONGESTION AVOIDANCE

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Server State: FAST RECOVERY

Server State: CONGESTION AVOIDANCE

Server State: SLOW START

Server State: CONGESTION AVOIDANCE

Server State: FILE SENT

File Sent

Server State: SERVER WAIT

Total Packets Stats:

TX: 72408 RX: 5214

Slow Start Packets Stats:

TX: 58545 RX: 4299 TX%: 80 RX%: 82

Congestion Avoidance Packets Stats:

TX: 13772 RX: 710 TX%: 19 RX%: 13

**VERIFY**

[sirdas@silo client]$ ls -l file\_large.txt

-rw------- 1 sirdas students 5348511 Oct 18 21:39 file\_large.txt

[sirdas@silo client]$ ls -l ../file\_large.txt

-rw------- 1 sirdas students 5348511 Oct 11 13:11 ../file\_large.txt

***Varying the window size for 5MB file transfer***

*For window size 5120 bytes*

With high Latency file is transferred in 200 secs

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_large.txt 2 5120

File Recieved

Time taken in secs: 200

*For window size 64000*

[sirdas@silo client]$ ./ruft\_client.bin localhost 20010 file\_large.txt 2 64000

File Recieved

Time taken in secs: 53

====================================END=======================================