SYNCX

Outline

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- Empirical Analysis: Comparison with State of the Art Technique
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- Future Research

Problem Statement

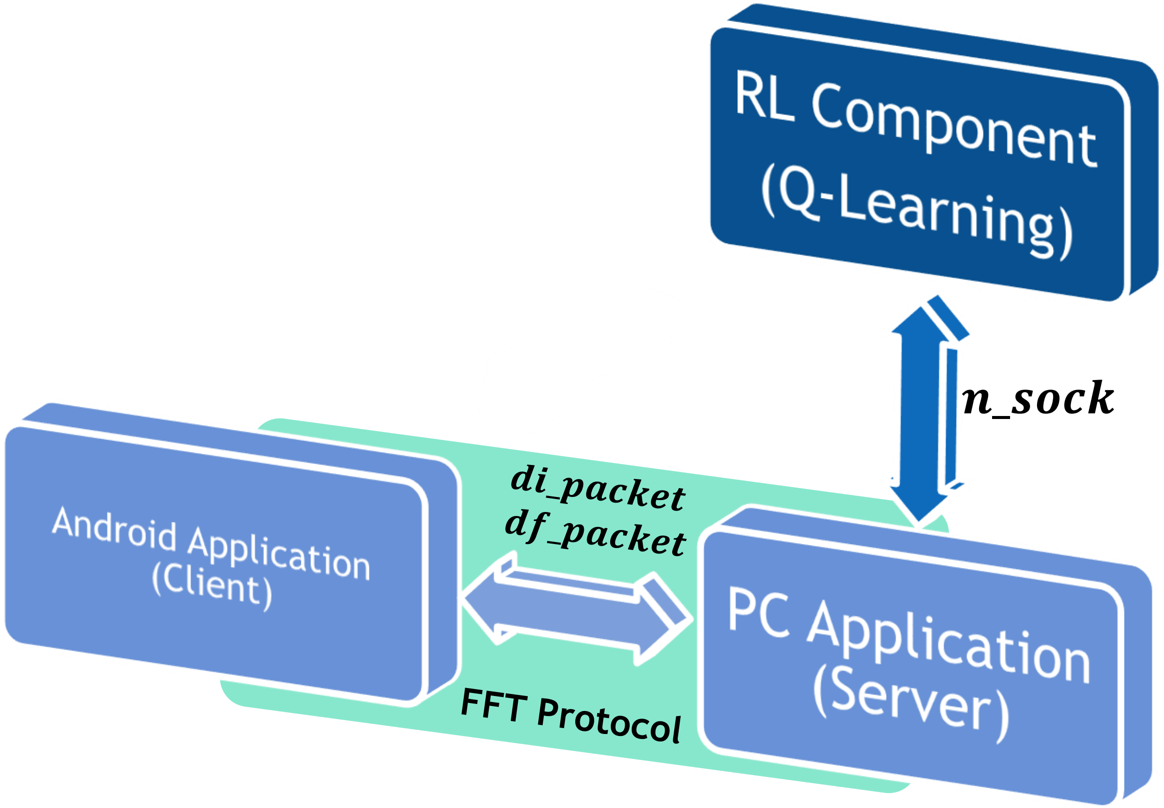
Optimizing the file transfer throughput between two end systems using Reinforcement Learning and a customized network protocol

Most of the existing file sharing software's like "***ShareIt***" and "***Xender Web***" don't provide the optimal speed for transfer using parallel sockets (depending on system resources) because of the dynamically changing resources and standardization of file transfer protocols.

Approach

- Since **FTP** doesn't support multiple sockets to transfer a single file, we designed our own underlying protocol (***FFT***) to transfer files between two end systems using **TCP** sockets. Our protocol supports multiple sockets for file transfer.
- Our approach was to implement RL as a managing element. We built a RL model to dynamically learn the optimal TCP sockets to transfer a payload. This allowed us to utilize maximum available system resources.
- An Android application and a corresponding Server End on PC to transfer files interchangeably employing the ***FFT*** protocol with optimal number of sockets.

Implementation



Client End

Native Android Application built using **AndroidStudio** – JAVA.

- The Application receives the optimal sockets for transfer after interaction with the server end through a permanent connection.
- It splits the payload into chunks equal to the number of sockets and sends them over a reliable link to the server application to which it is connected.
- The application is built as a native interface with minimum computational overhead.
- The server end records the transfer information that is used further to improve the RL model.

The FFT Protocol

- Same as **FTP** (File Transfer Protocol), there is a permanent **TCP** connection between the server and client, which is used to send the data-exchange information($\boldsymbol{di\_packet}$).
- The sending entity will first exchange the file information – file name, file size over a non-permanent connection.
- After exchanging the file information, the sending entity starts sending the file by truncating it into $\boldsymbol{n}$-different chunks and send all the chunks parallely using multiple sockets.
- The number $\boldsymbol{n}$ is determined by our RL algorithm running on the server (PC Application).

FFT Protocol

Client End: di_packet

Fields	Size(in bytes)	Description
is_request	1	• 1 – When a sender is asking receiver to send a file, the packet is called $\boldsymbol{di\_request}$ packet. • 0 – When receiver is granting permission to sender, the packet is called $\boldsymbol{di\_response}$ packet.
name_size	4	Length of the name of the file
name	*name_size*	Name of the file(in byte utf-8 encoding)
file_size	8	Size of file in bytes
id	4	Unique Identifier for a single file transaction
n_sock	4	Value currently not set

FFT Protocol

Server End : di_packet

Fields	Size(in bytes)	Description
is_request	1	• 1 – When a sender is asking receiver to send a file, the packet is called $\boldsymbol{di\_request}$ packet. • 0 – When receiver is granting permission to sender, the packet is called $\boldsymbol{di\_response}$ packet.
name_size	4	Length of the name of the file
name	*name_size*	Name of the file(in byte utf-8 encoding)
file_size	8	Size of file in bytes
id	4	Unique Identifier for a single file transaction
n_sock	4	Optimal number of sockets as determined by server

FFT Protocol

- When a sender(Server/Client) wants to send a file, it needs to send a $\boldsymbol{di\_packet}$ to the receiver with $\boldsymbol{is\_request}$ set as 1 and receives a $\boldsymbol{di\_packet}$ with $\boldsymbol{is\_request}$ set as 0.
- The $\boldsymbol{n\_sock}$ field value is decided by the server. In case the server wants to send a file, the value of $\boldsymbol{n\_sock}$ is already set for both $\boldsymbol{di\_request}$ and $\boldsymbol{di\_response}$ packet as determined by the RL model.
- However, on the other hand, if the client wants to send a file, then the value of $\boldsymbol{n\_sock}$ is randomly selected for the $\boldsymbol{di\_request\ packet}$. The random value is discarded by the server and $\boldsymbol{di\_response\ packet}$ contains the optimal value for $\boldsymbol{n\_sock}$.
- Server cannot initialize connection itself so if server wants to send a file then it will send $\boldsymbol{di\_request}$ packet the client and after sending $\boldsymbol{di\_response}$ packet client will also initialize $\boldsymbol{n\_sock}$ parallel connection to the server and on each connection it will send empty $\boldsymbol{df}$ header packet($\boldsymbol{df\_packet}$ with no payload) then server send $\boldsymbol{df\_packet}$ to client with payload.

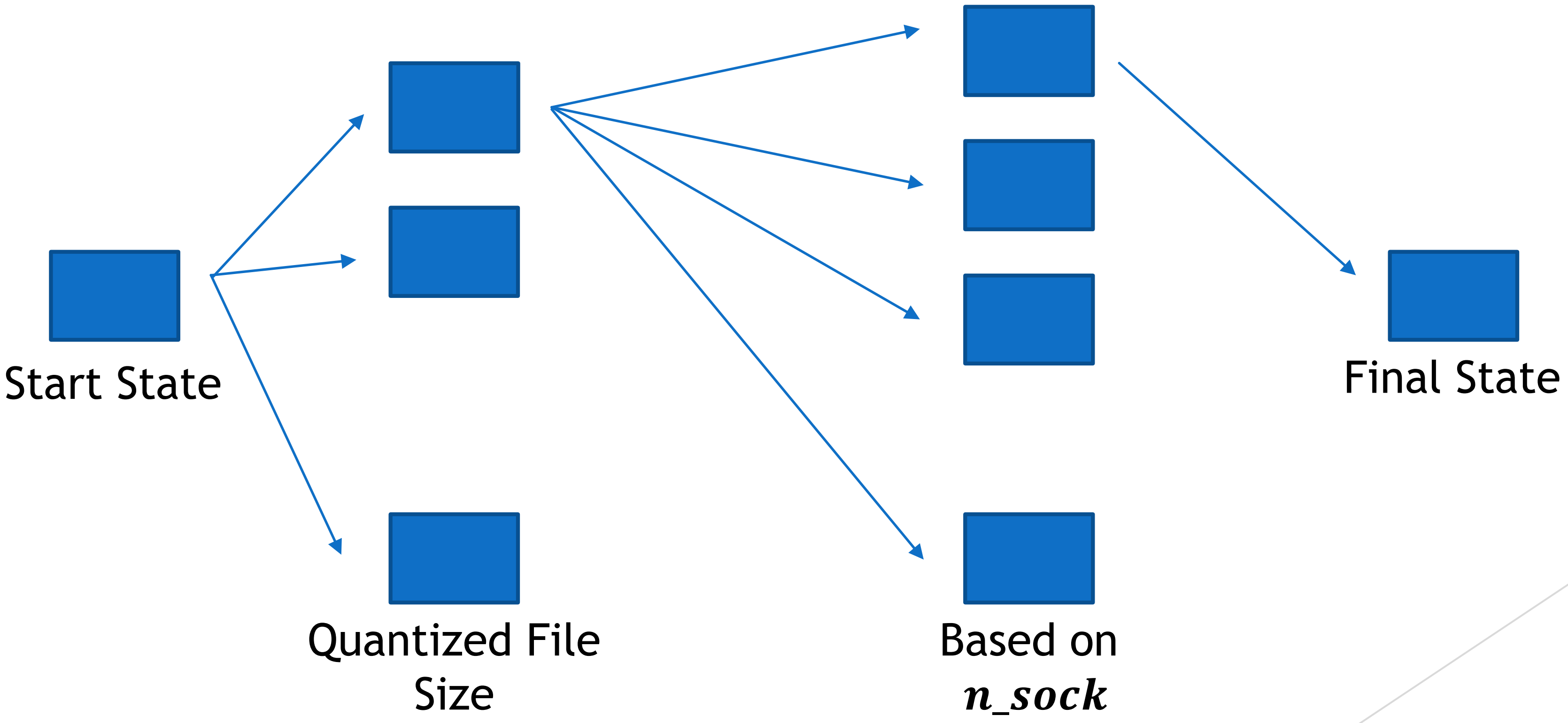
FFT Protocol : df_packet

Fields	Size(in bytes)	Description
data_id	4	Unique Identifier for a single file transaction
starting_point	8	Offset from the beginning of the file
data_size	8	Size of the payload
data	data_size	Payload

Reinforcement Learning

For the reinforcement learning model, we have used **Q-value** algorithm to determine the value of n_sock for a given file size.

The MDP of the problem is given below:



Reinforcement Learning

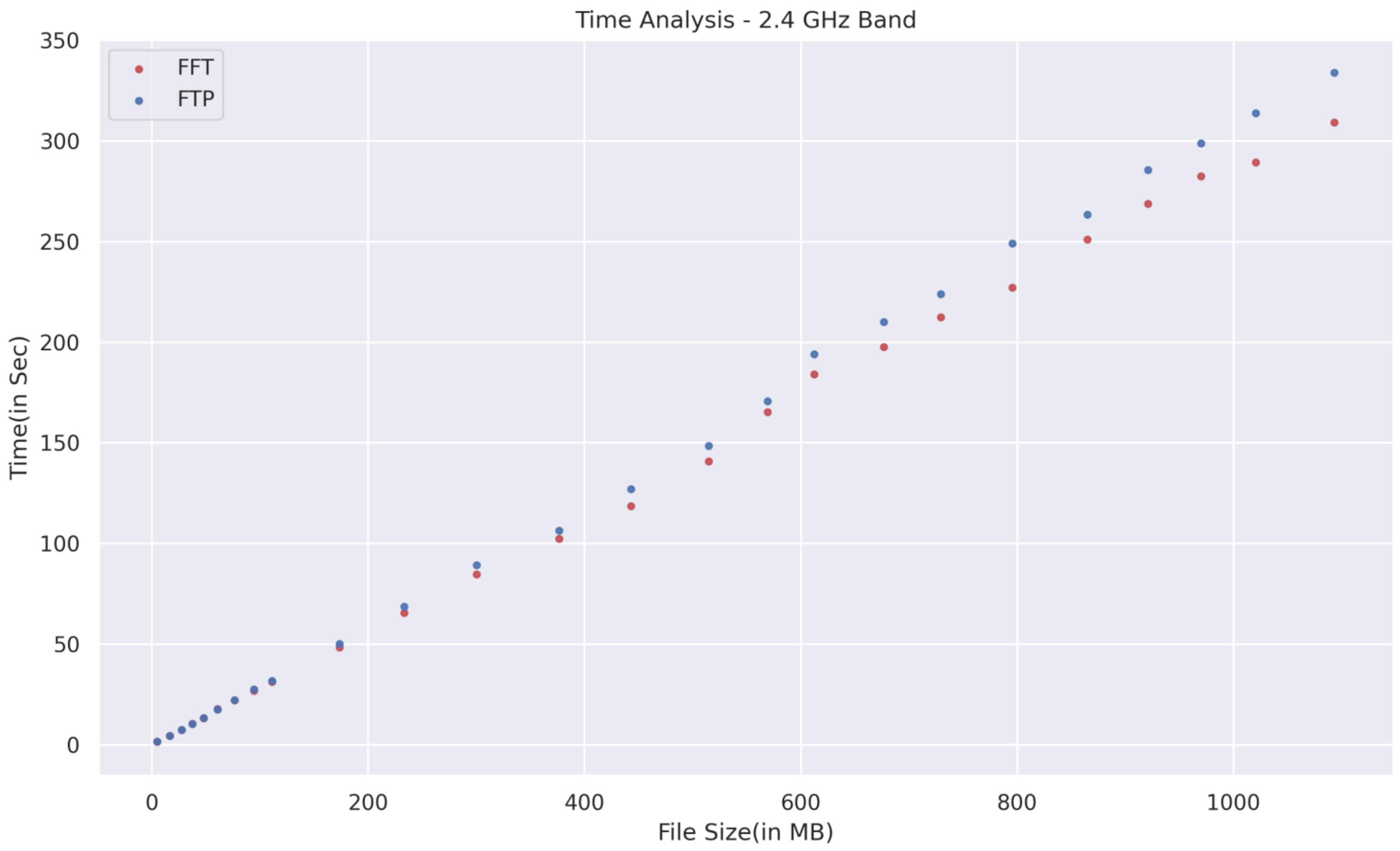
- For construction of discrete states from file sizes, we quantize the file size into **10** states, having linear interval of **20**MB, for size **0** to **200**MB. For file sizes **200**MB to **1**GB, **10** states are chosen such that they follow a geometric progression.

- Initially, we had also chosen an exploration rate of **0.99** and an exploration decay rate of **0.99**. After every iteration, the exploration rate was decreased.

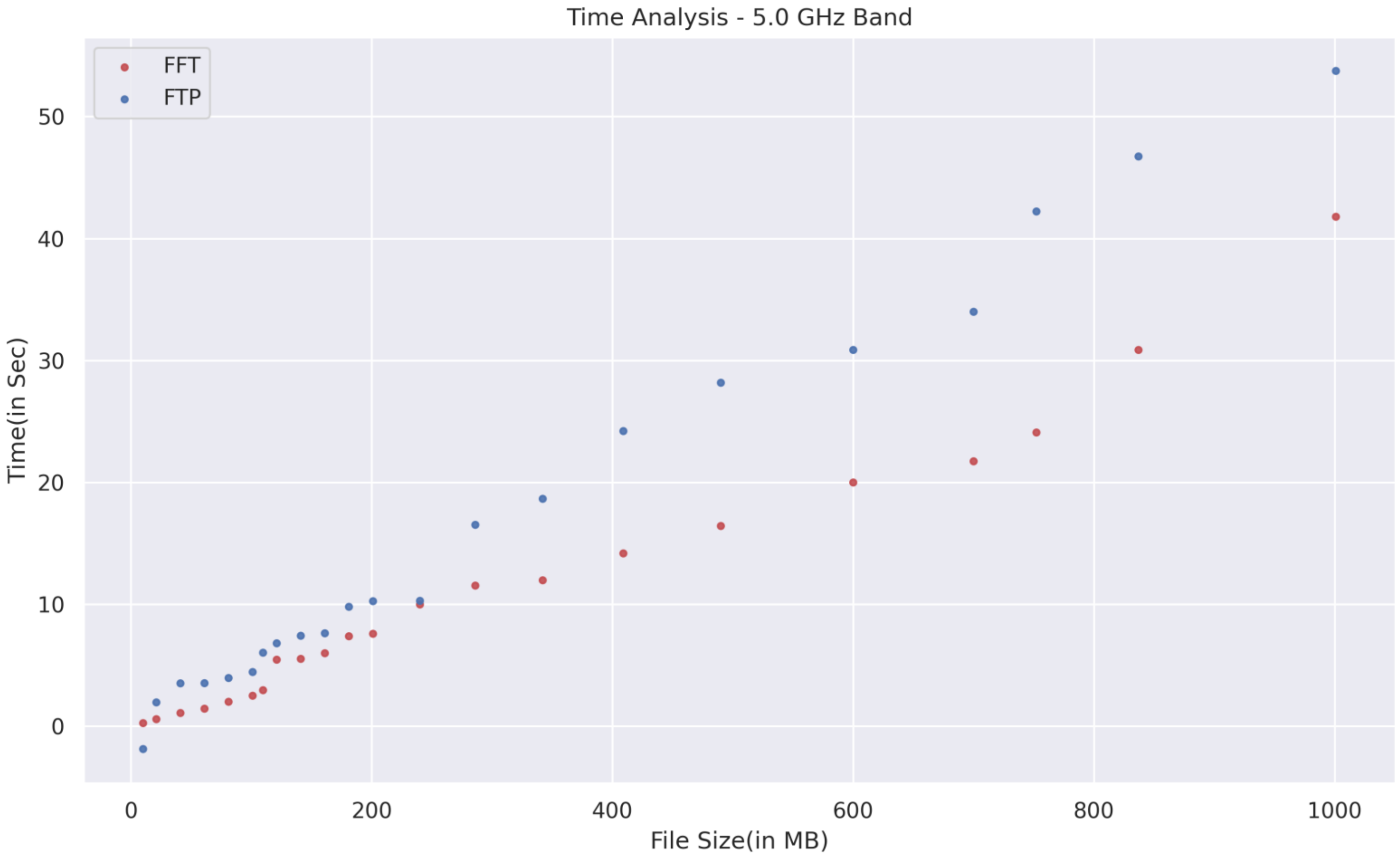
Reinforcement Learning

For abstraction, the Reinforcement Learning model had implemented 2 functions, ***predict*** and ***learn***. The '***predict***' function takes the input as file size, perform the corresponding *state transition* and return the $\boldsymbol{n\_sock}$ value. Later, the learn function would the reward for the action(dependent on the bandwidth that was obtained) and would make the Q-value updation.

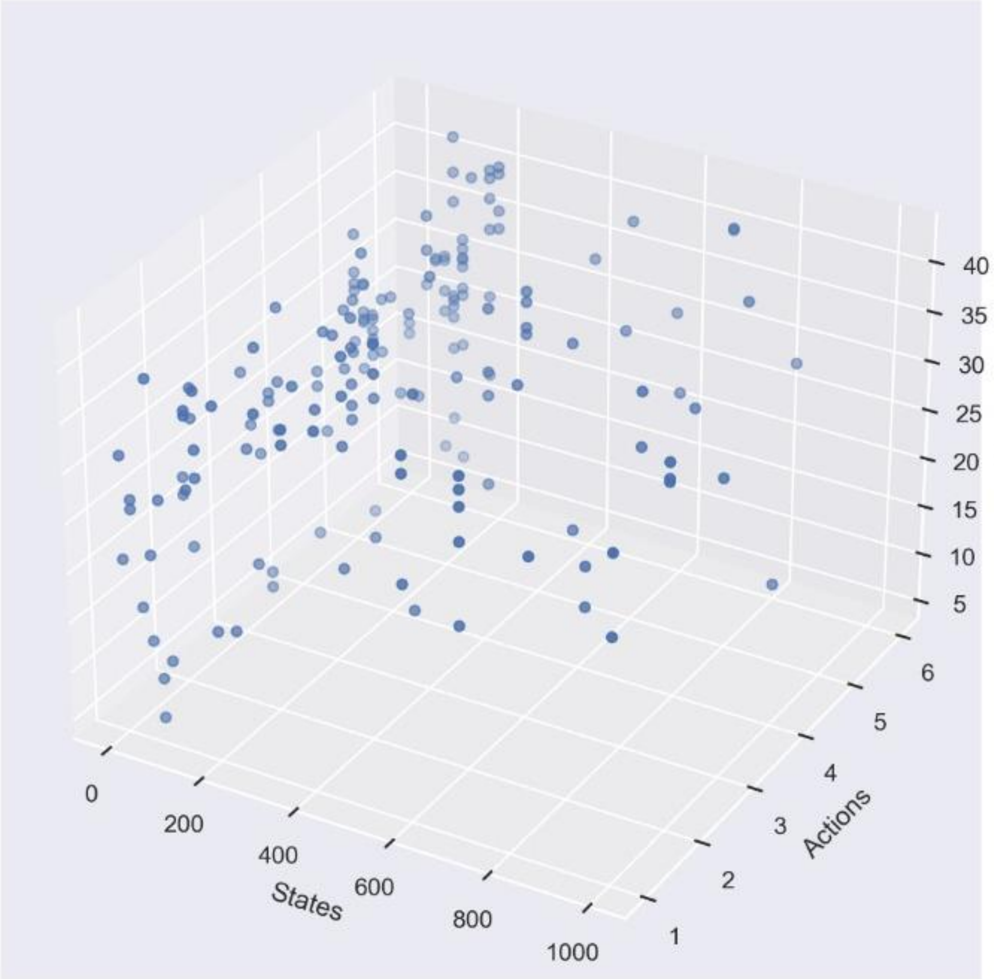
Empirical Analysis : Time



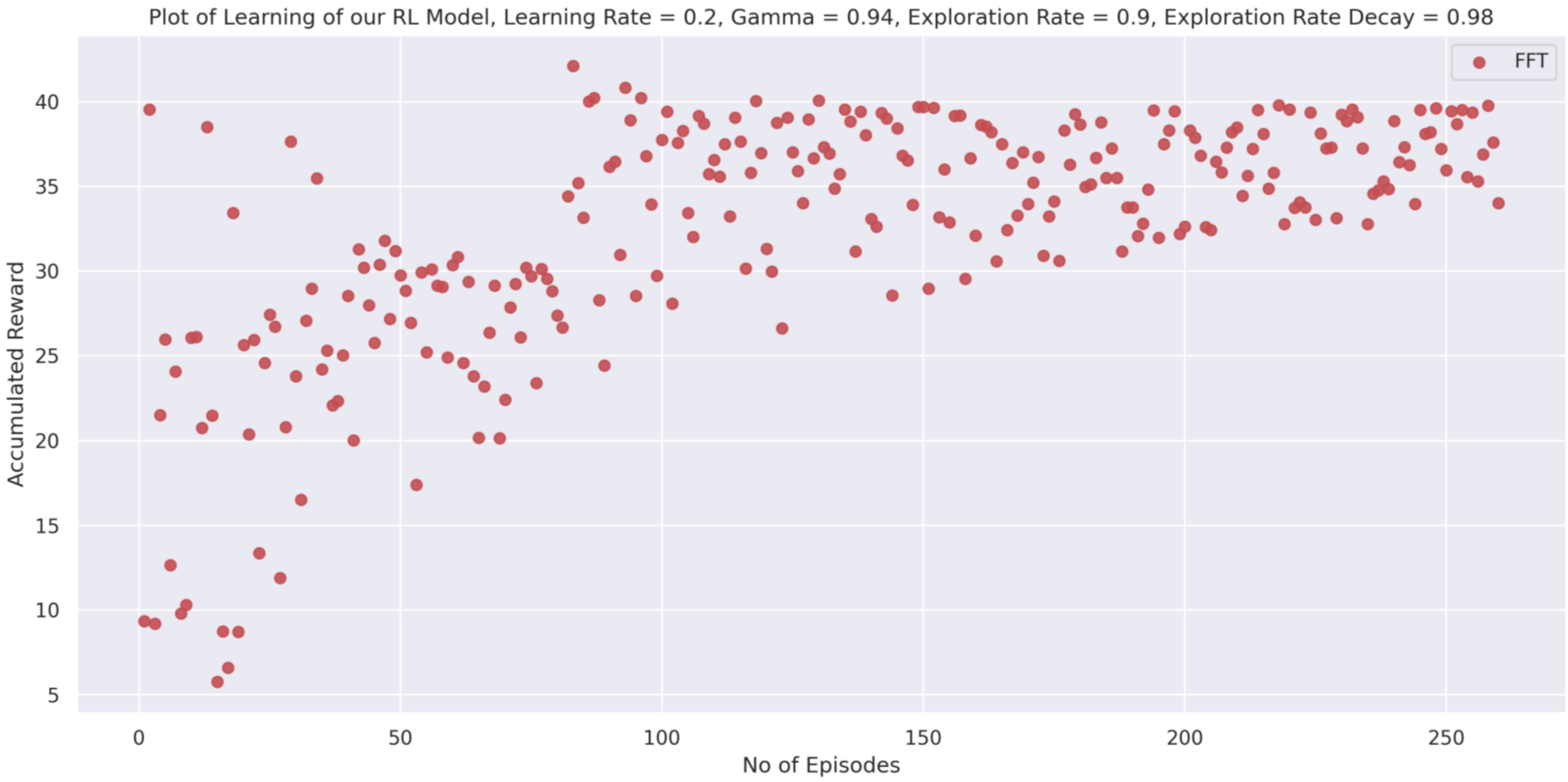
Empirical Analysis : Time



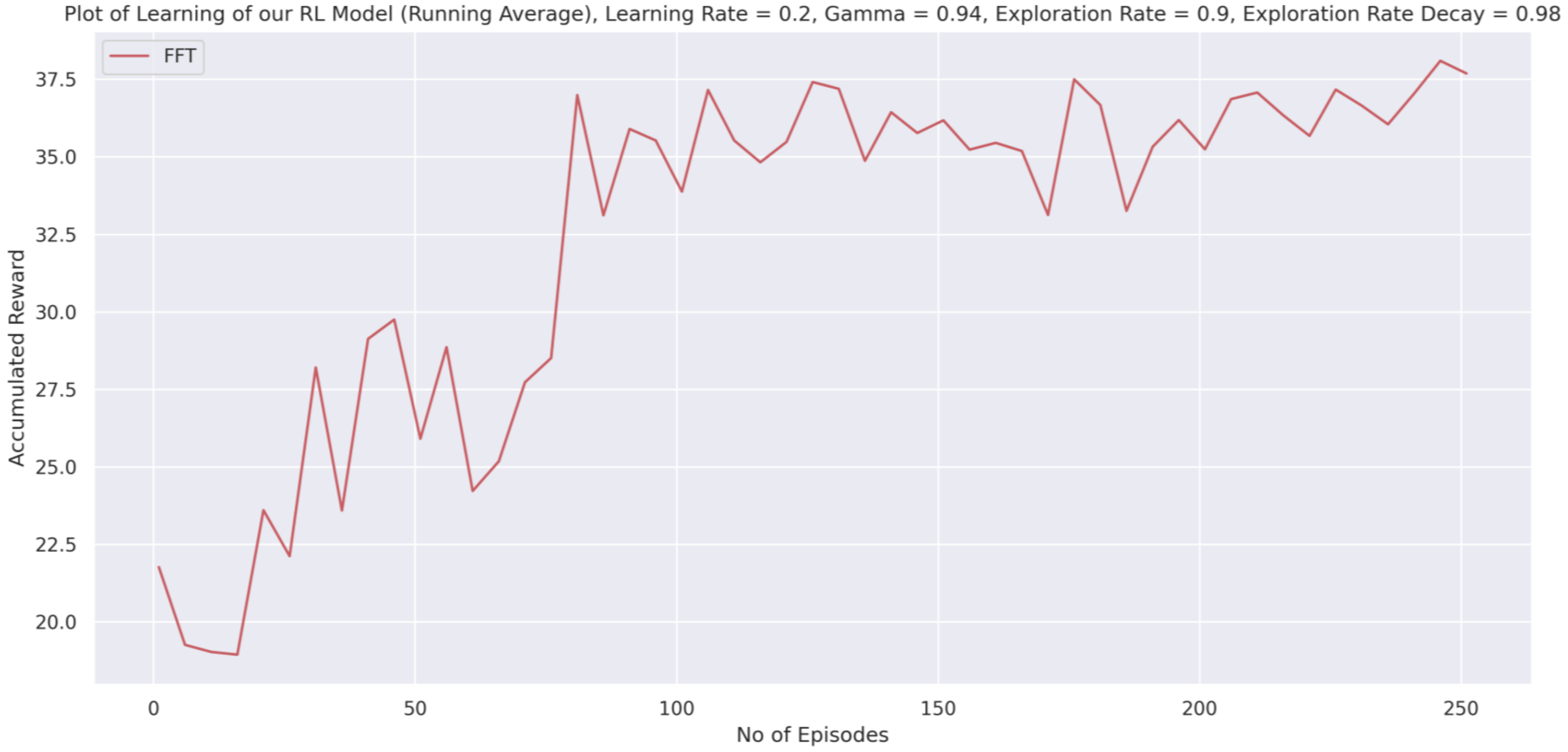
Empirical Analysis: Rewards v/s State Action Pair



Empirical Analysis: Learning



Empirical Analysis: Learning



Future Research & Scope of Improvement

- We can include additional parameters in our MDP, which take into account the network strength, battery status etc.
- Raw Sockets implementation instead of TCP which will ensure a better control over file transfer.
- Quantization of file size into states can be more fine grained if large no. of examples can be found. Also, the Q-table maintenance can be centralized and to have optimal starting values across servers.
- Logging options to improve the performance of the model further, including a centralized computational unit which receives the transaction logs of all users.

TIMELINE

FFT Protocol Design
& Implementation

Mobile Application
Development (Client End)

Using RL to
improve the overall throughput + Testing

11 Days	14 Days	12 Days	6 Days	23 Days

PC Application
Development (Server End)

Using the state-of-art techniques
to achieve seamless file transfer

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Android Client Application Development

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Protocol and Server Application Development

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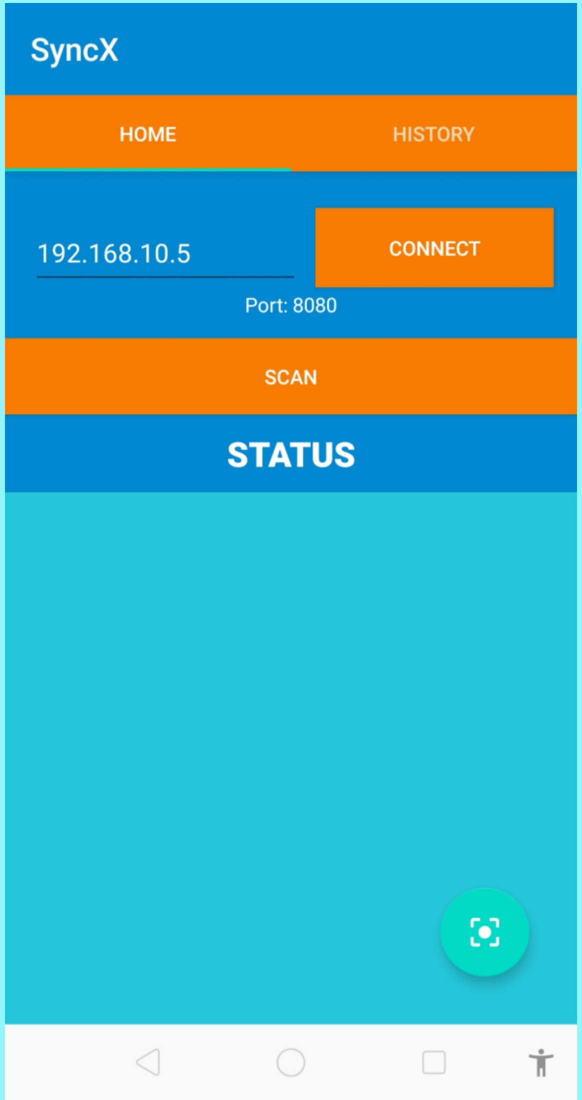
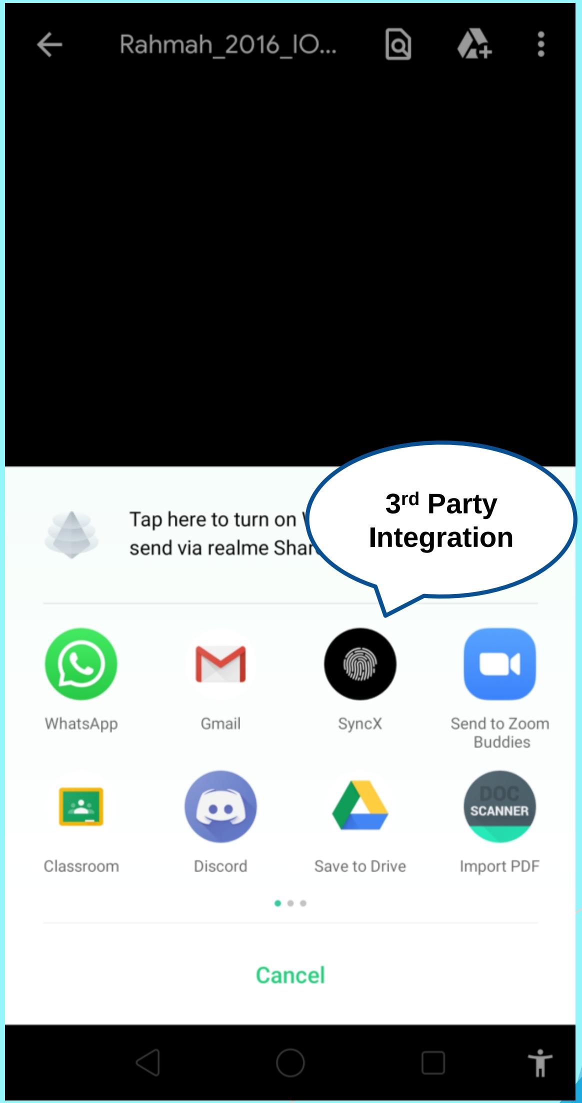
Reinforcement Learning Model Development

**The protocol design was discussed and worked upon by the whole team.*

GALLERY


SyncX


SyncX
HOME
HISTORY
192.168.10.5
CONNECT
Port: 8080
SCAN
STATUS


Rahmah_2016_IO...
Tap here to turn on
send via realme Shar
3rd Party Integration
WhatsApp
Gmail
SyncX
Send to Zoom Buddies
Classroom
Discord
Save to Drive
Import PDF
Cancel

THANK YOU

QUESTIONS?