University of Sussex

Implementation of Multipath-TCP in Network Simulator-3

Morteza Kheirkhah

Informatics Departments

University of Sussex

UK

What is Multipath-TCP (MPTCP)?

- Transport protocol that sends a stream of data via multiple paths.
- It preserves all TCP's semantics, e.g., connection oriented, flow control, congestion control and reliable data delivery.
- It is fair to competing TCP flows in a bottleneck link.
- It uses available network capacity more efficiently than TCP.
- It can be robust in case of network failure.

MPTCP Implementations available in ns3

University of Sussex

✧ **Linux kernel via ns-3-dce**

- Hard to modify the core implementation inside the Linux.

✧ **MPTCP in ns-3.6**

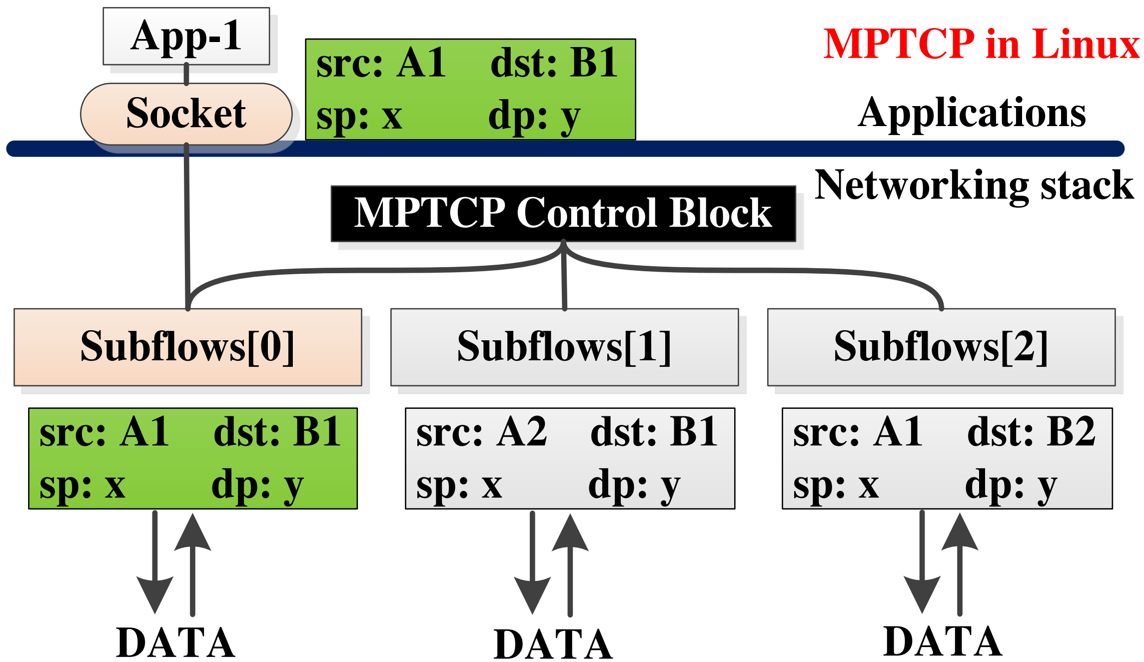
- Never merged with any stable version of ns-3 and became obsolete after TCP was rewritten in ns-3.8.
- A client can only connect to a server (no forking mechanism).
- No parallel execution of TCP and MPTCP in a node.
- Many other simplifications (e.g., TCP timeout behavior or TCP state transitions).

Advantages of our implementation of MPTCP in ns3

University of Sussex

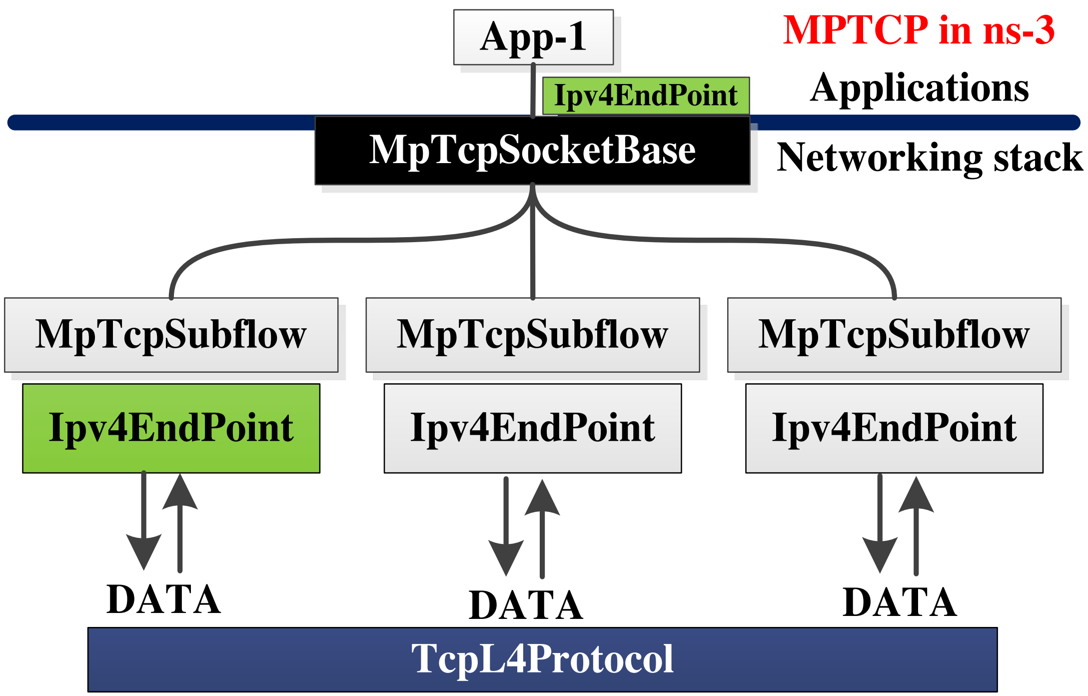
- Conforming to the RFC 6824 (TCP extension for Multipath Operation with Multiple Addresses).
- Multiple MPTCP clients can connect to a MPTCP server.
- Parallel execution of TCP and MPTCP in a node.
- Multiple subflows can be established via different ports.
- Existing TCP functionality in ns-3 is not changed at all.

Architecture of MPTCP in Linux



- Each MPTCP connection starts with master subflow, the only subflow presented to the application.
- Each MPTCP connection can have several subflows, each of which operates as regular TCP.

Our Architecture of MPTCP in ns3



Our Architecture of MPTCP in ns3

University of Sussex

MpTcpSocketBase.

- It mimics MPTCP control block and exports the socket API to ns-3 applications.
- It performs data scheduling, path management, packet reordering, congestion control and loss recovery for all subflows.
- It is a subclass of TcpSocketBase class and handled by smart pointer.

MpTcpSubflow.

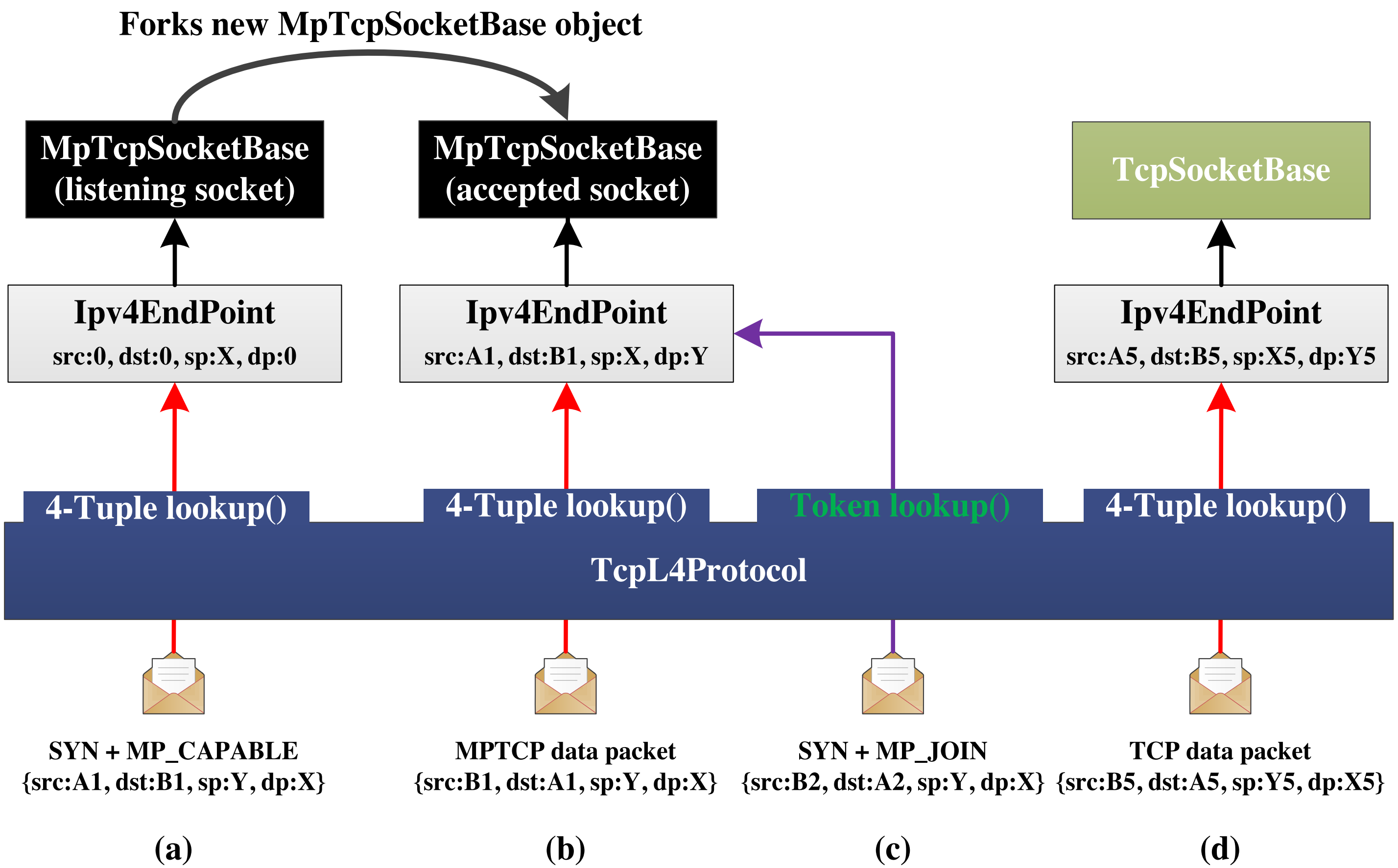
- It represents an MPTCP subflow and is a subclass of the Object class.

TcpL4Protocol.

- An interface between the transport and network layers.
- We have changed this class so that MPTCP connections can be handled, without disrupting any existing TCP functionality.

Functional decomposition of TcpL4Protocol

University of Sussex



Functional decomposition of TcpL4Protocol

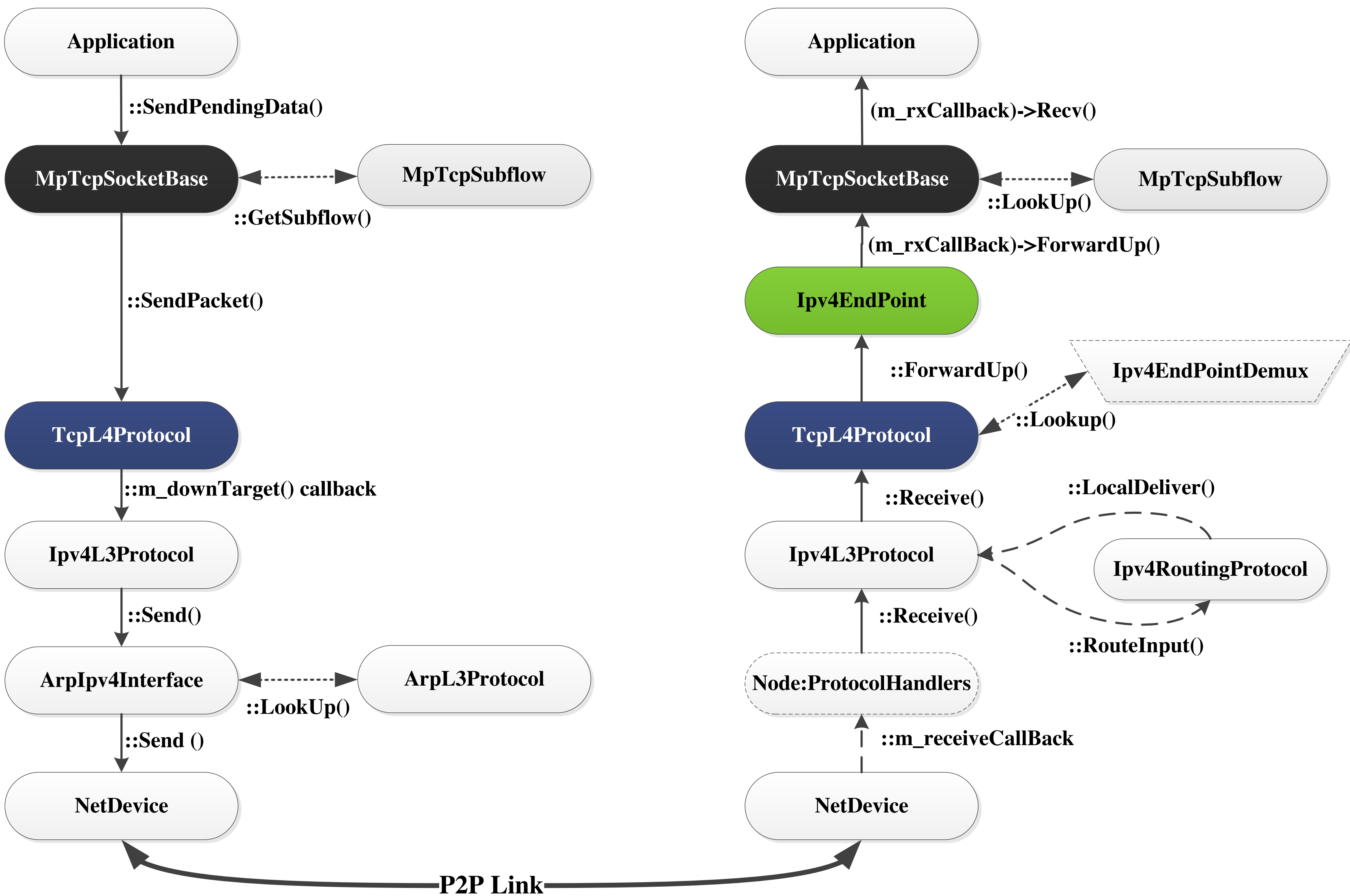
(a) Requests for new MPTCP connections are resolved using the TCP header's four-tuple and forwarded to the listening MpTcpSocketBase object.

(b) Request for MPTCP data exchange, per each established subflow, is resolved using the TCP header's four-tuple.

(c) Requests for new subflow are resolved using the token, provided in MP_JOIN option, and forwarded to the respective MpTcpSocketBase.

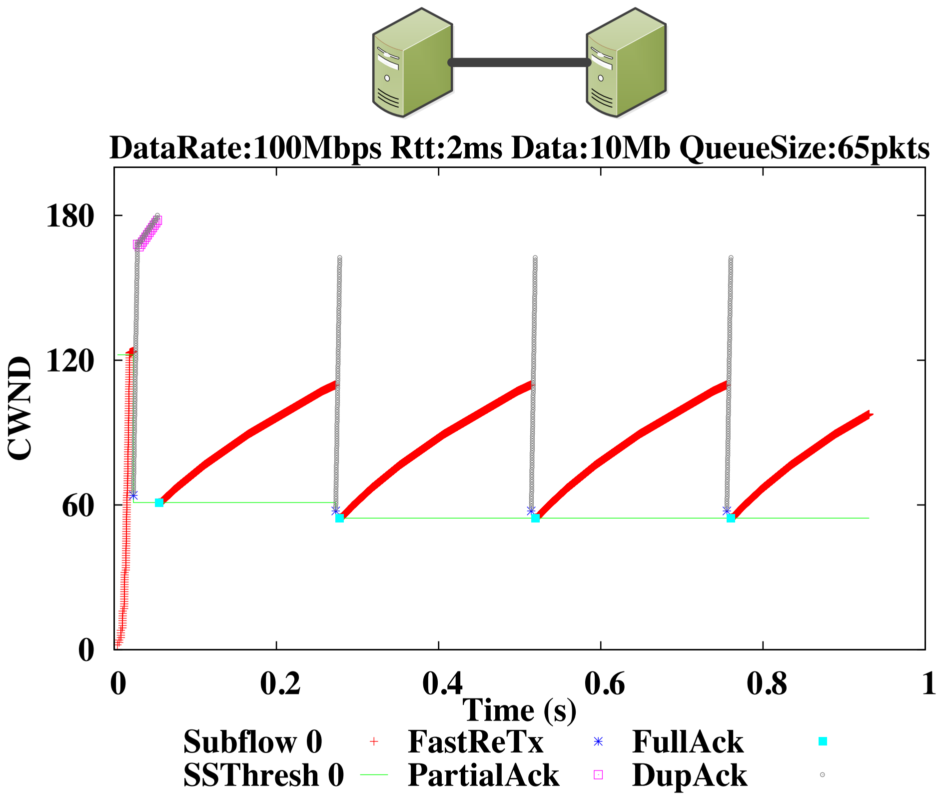
(d) All Requests regarding TCP operations are resolved using the four-tuple.

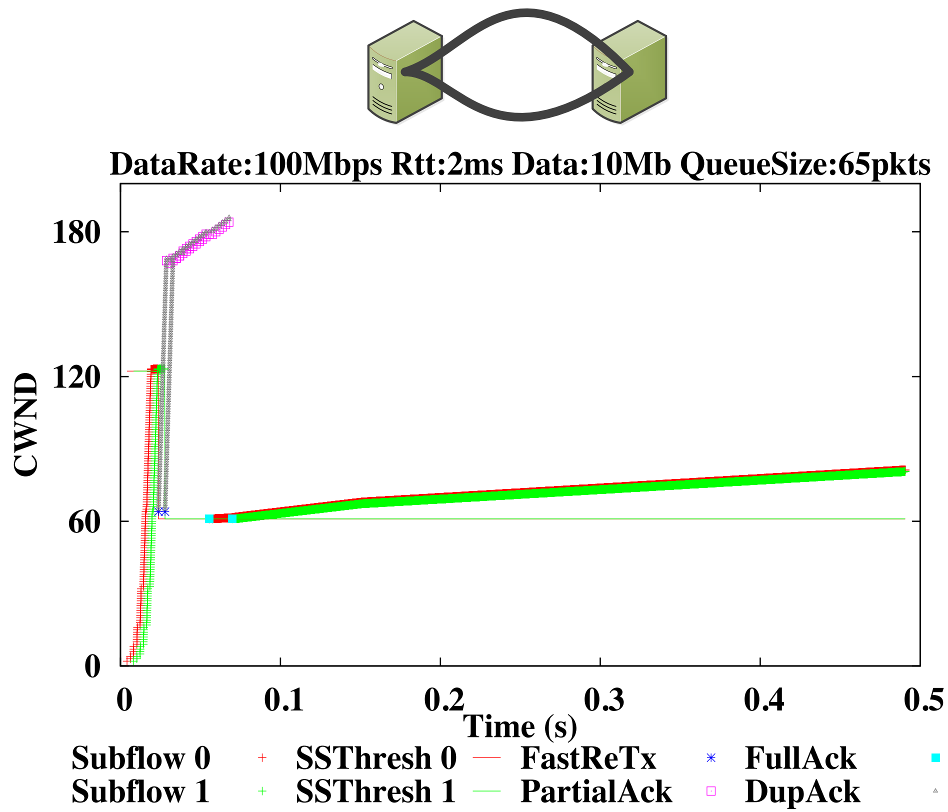
Steps in sending a packet



Simple simulations

University of Sussex





MPTCP with single subflow.

It behaves exactly the same as TCP in ns-3.

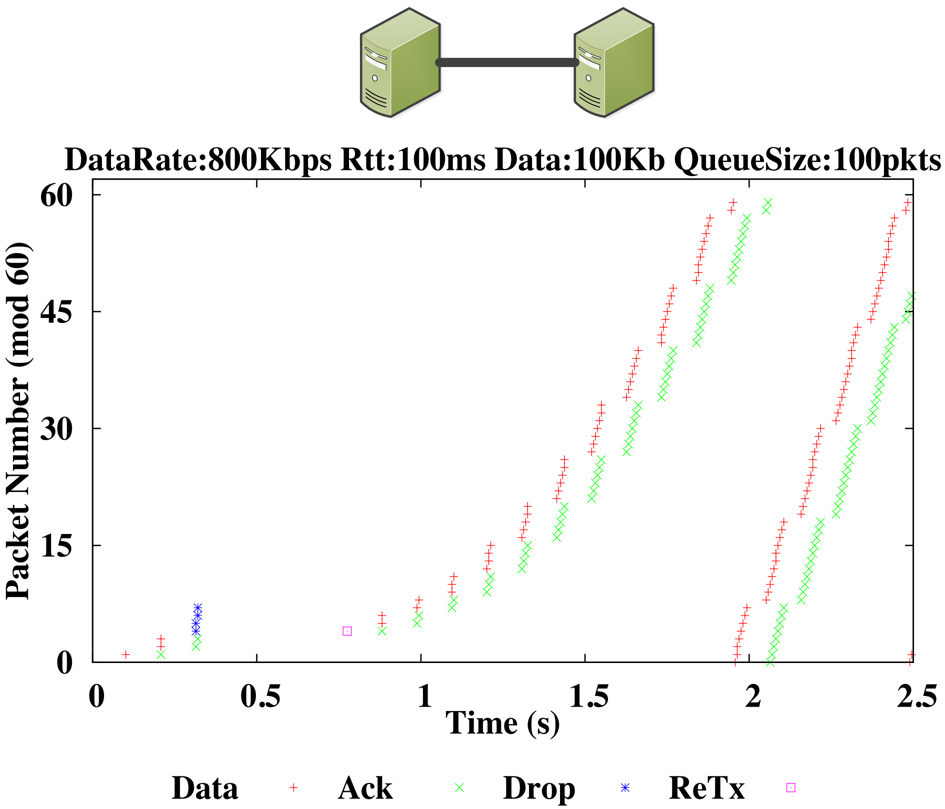
MSS is 536 bytes in all of our results.

MPTCP with two subflows via two p2p links.

It becomes less aggressive than regular TCP after a packet drop.

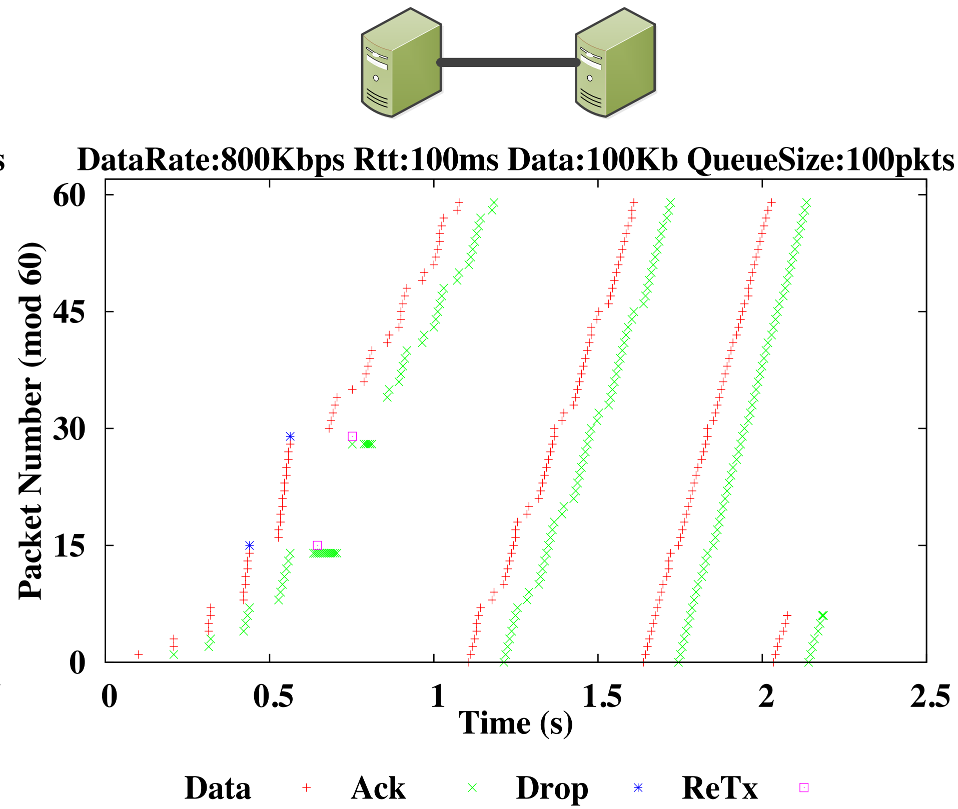
Simple simulations continue

University of Sussex



MPTCP with single flow and four packet drops (entire window).

It shows the behavior of TCP NewReno timeout algorithm.



MPTCP with single flow and two packet drops.

It shows the TCP NewReno loss recovery algorithm.

Further information

University of Sussex

- More information visit my personal homepage or ns3 wiki page:
  - http://www.uclmail.net/users/m.kheirkhah/
  - http://www.nsnam.org/wiki/Current_Development

Thank you!