Predictable Multi-Path TCP extension

draft-qian-mptcp-predict-00

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Predictability

- Predictable nodes are involved in emerging networks
  - They are different, for their inherent (thus predictable) location information.
  - ➢Some are **at fixed locations**: ground base stations;
  - ➢Some are **keep moving** at expectable speed on their pre-defined orbits or routines on earth, on ocean or in the space: LEO satellites, GEO satellites, aviation aircrafts, ships and so on.
- These characteristics mean that the relative positions between them are predictable and furthermore, the state of the network links between them are predictable.

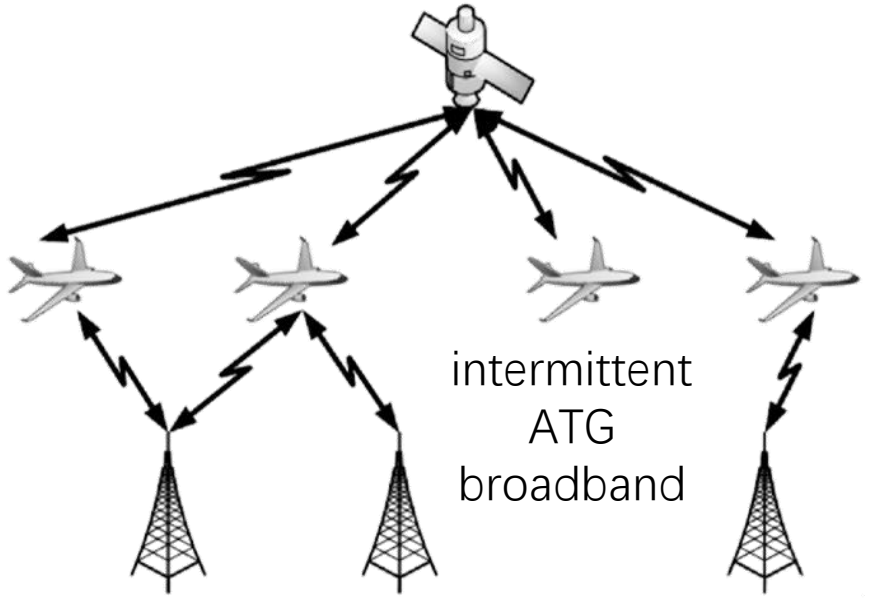
Predictable Information

- For link handover, predictable information include the time handover happens, link bandwidth and end-to-end delay changes after handover and so on.

- For on-off switching, predictable information include the time link disconnection and reconnection happens, link bandwidth and end-to-end delay when link reconnects and so on.

An example: Scheduler Utilizing Prediction Information

- Aviation aircrafts connecting to Internet with MPTCP, where ATG Broadband and Satellite Communications are simultaneously available.
- However, the complicated topography (like mountains and lakes) leads to the discontinuity of ATG Broadband, and therefore defeats the quality of aircraft network service.



Modification to Scheduler: How to utilize Prediction Information

- The default scheduling principle of MPTCP scheduler is “min-RTT” principle.
- The modified version is called “MPTCP-P”, which introduces prediction information to calculate a modified round trip time called “RTT-P”.
- The prediction information that MPTCP-P requests include
  - a) the time when the next disconnection of the ATG link happens,
  - b) the time when the next reconnection of the ATG link happens
  - they are respectively denoted as time_down and time_up.

Modification to Scheduler: How to utilize Prediction Information

- The RTT calculated by default method of TCP is denoted as RTT_Orignal.
- When the ATG link of the aircraft is connected (i.e. time_now < time_down):

$$RTT\text{-}P = RTT\_Orignal;$$

- When the ATG link of the aircraft is disconnected (i.e. time_down < time_now < time_up):

$$RTT\text{-}P = RTT\_Orignal + time\_up - time\_now;$$

- MPTCP-P schedules packets in “min-RTT-P” principle.

Enhancement

- Based on timers, it takes time for original MPTCP to find link disconnected or reconnected and then accordingly schedule packets to different paths.
- With prediction information about link on-off switching, MPTCP-P could
  - a) reduce the packets to be allocated to a path and cancel timers for the packets sent through a path when the predictable link of the path is going to disconnect.
  - b) allocate packets to a reconnecting path at the moment it gets reconnected according to the prediction information.

More

- Corresponding extension for path management
  - Some path In order to keep the temporarily disconnected subflow valid (in case it is in a quite long disconnected period), it might be necessary to
    - a) set it into backup mode
    - b) inform the other end the link on-off state through newly extended MPTCP option.
    - What's more, some extension to TCP might be needed to keep the corresponding paths valid.

- Encourage the community to find more ways to utilize the prediction information for **the emerging Predictable Network Nodes.**

THANKS

Comments & Questions

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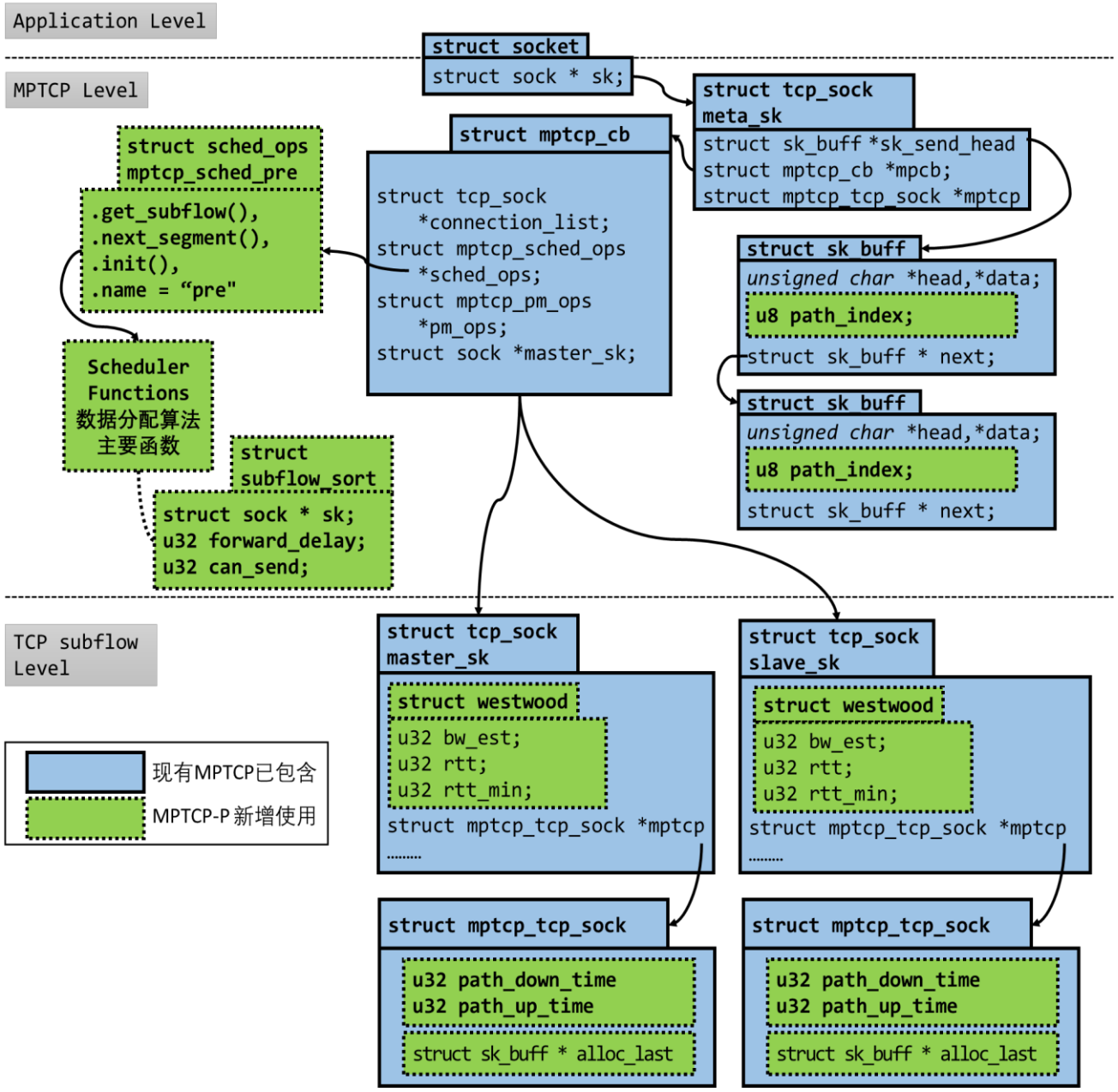
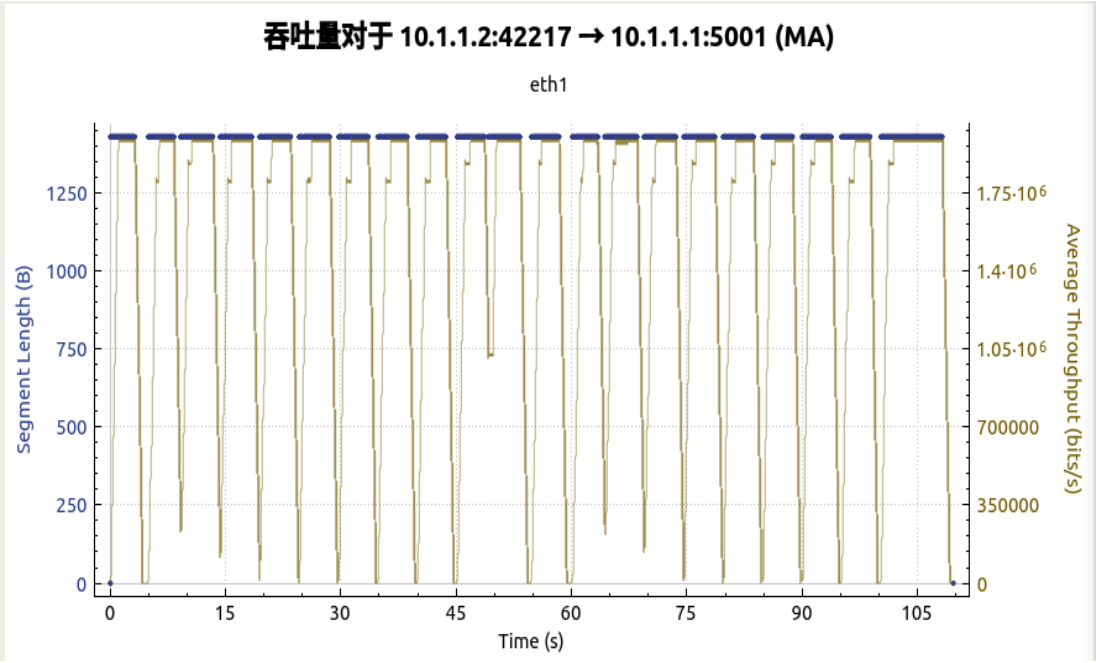
BACKUP

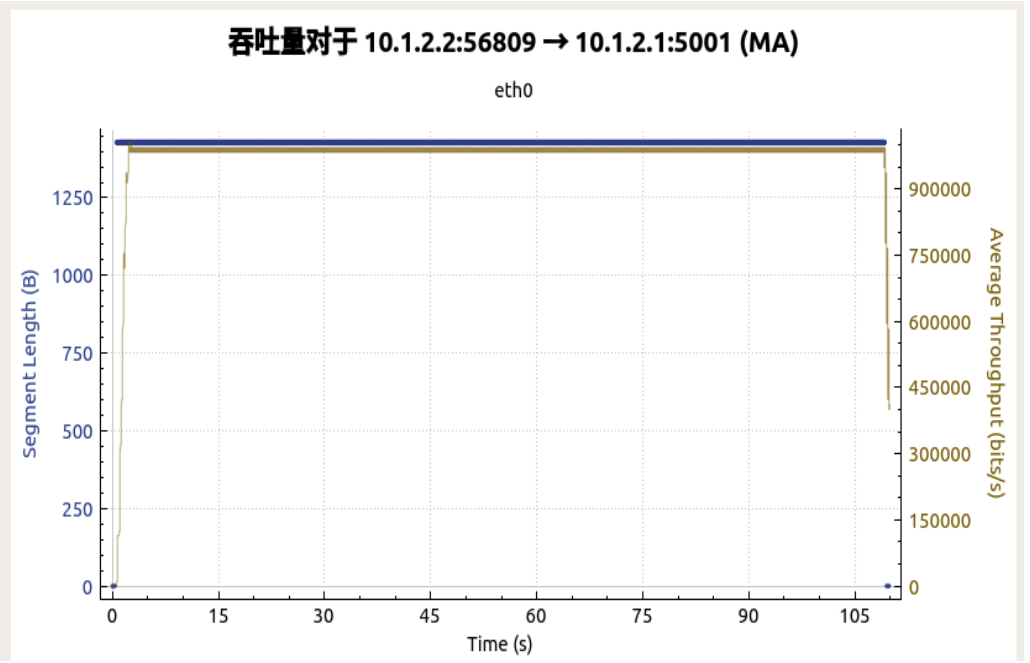
Implementation of MPTCP-P in Linux Kernel



Throughput of different paths in MPTCP-P

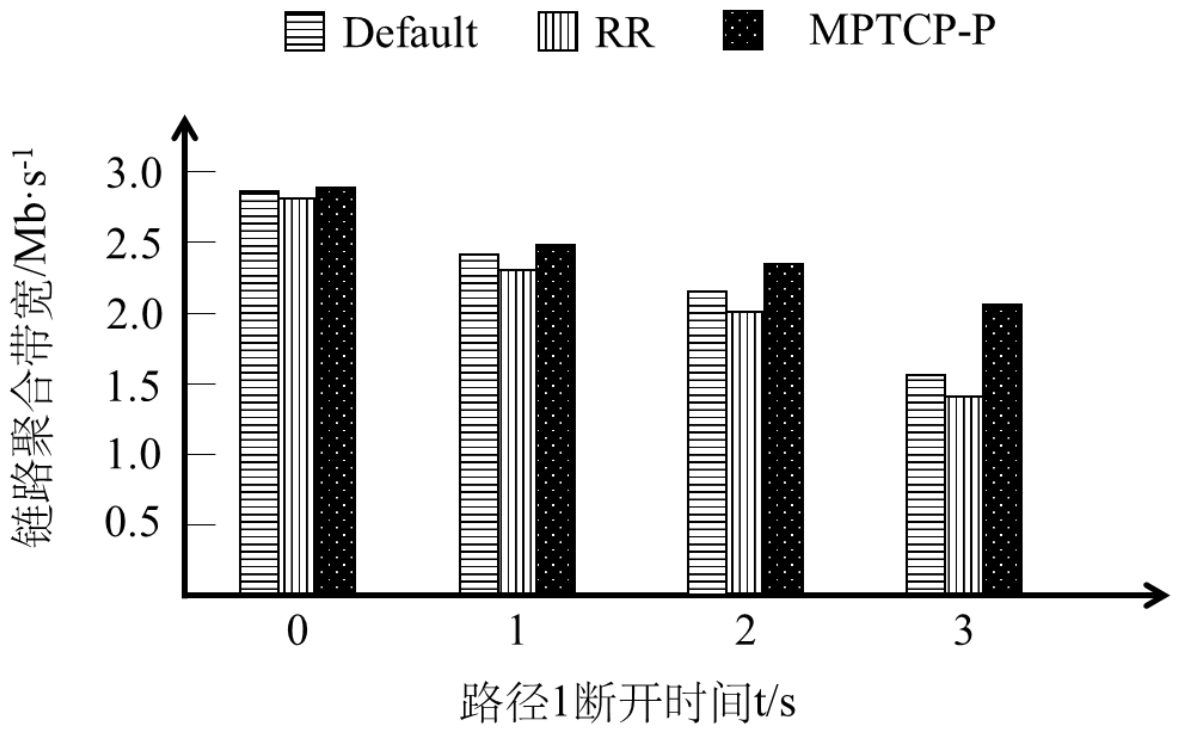


Intermittent path (ATG)



Steady path (GEO satellite)

Throughput Comparison
with different schedulers



Motivation

- **Multiple paths almost always exist** in integrated networks that integrate different systems (especially the systems that continually move), **so suitable!**
- However, link handover and link on-off switching happen frequently in such scenarios, which are likely to decrease MPTCP.(see more in the draft section 3)
- **Contradiction**: Predictable information do exist in these scenarios **v.s.** MPTCP not being able to obtain and utilize them.