Does the End-User Really have benefits from using Multipath Transport?

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Motivation

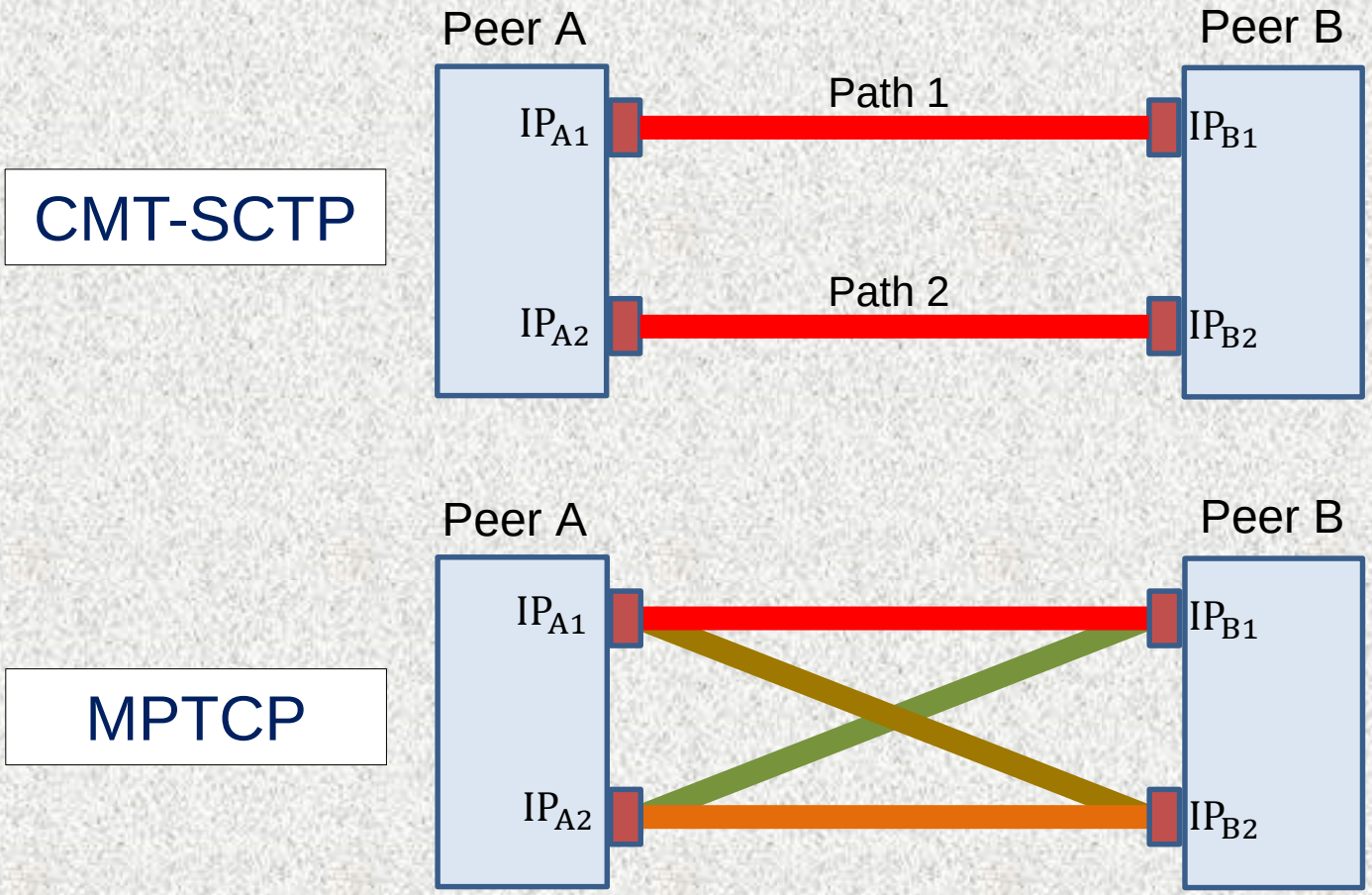
- Why do the users want to use multipath protocols
  - .
  - .
  - .
  - Seek to maximize throughput over all available paths
    (While remaining fair to other transport flows)

- Is it possible to reach this goal?
  - Technical point of view
  - Design point of view

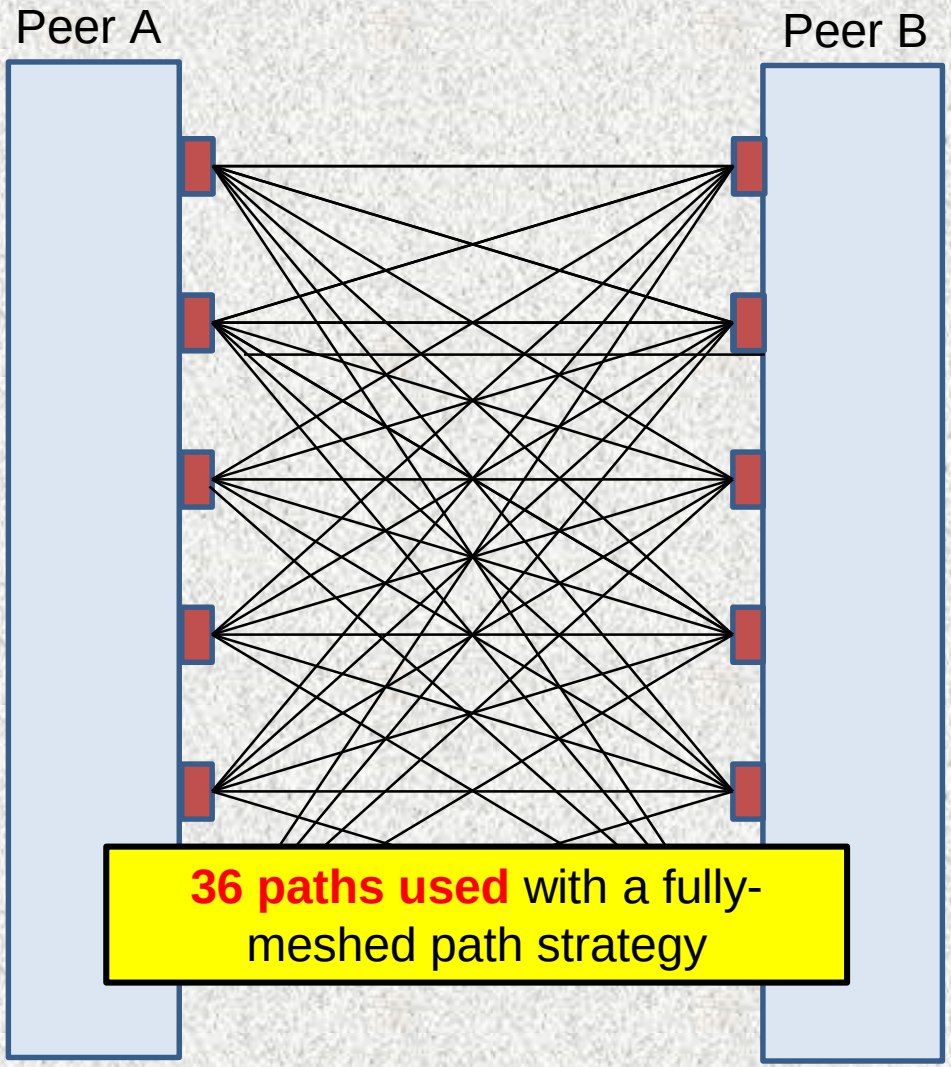
Current state of multipath protocols

- Very good results in controlled environments
- Good results under realistic conditions but still a lot of open issues
  - Path management

Current state of multipath protocols
Path management



Current state of multipath protocols
Path management



Current state of multipath protocols
Current State

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- Very good results in controlled environments
- Good results under realistic conditions but still a lot of issues with
  - Path management
  - Buffer management
  - Retransmission strategies
  - .
  - .
  - .
  - But also design Issues
    - Fairness

Design Issues
Fairness

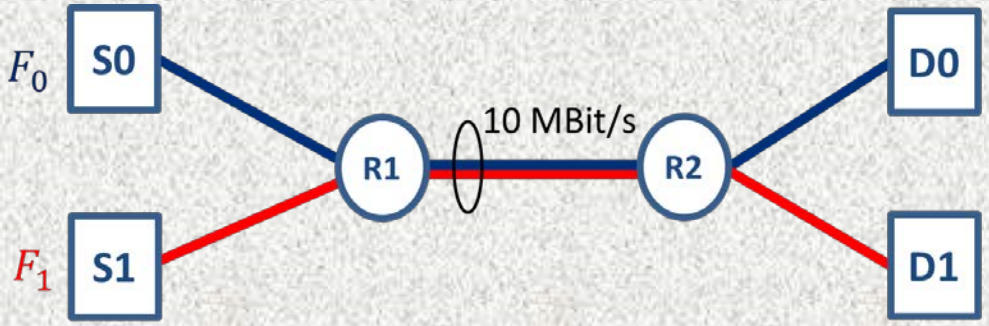
- Fairness goal:
  - Fair allocation of resources among participants
- However:
  - Multiple confusions and contradictions
    - For singlepath
    - With multipath: more confusing

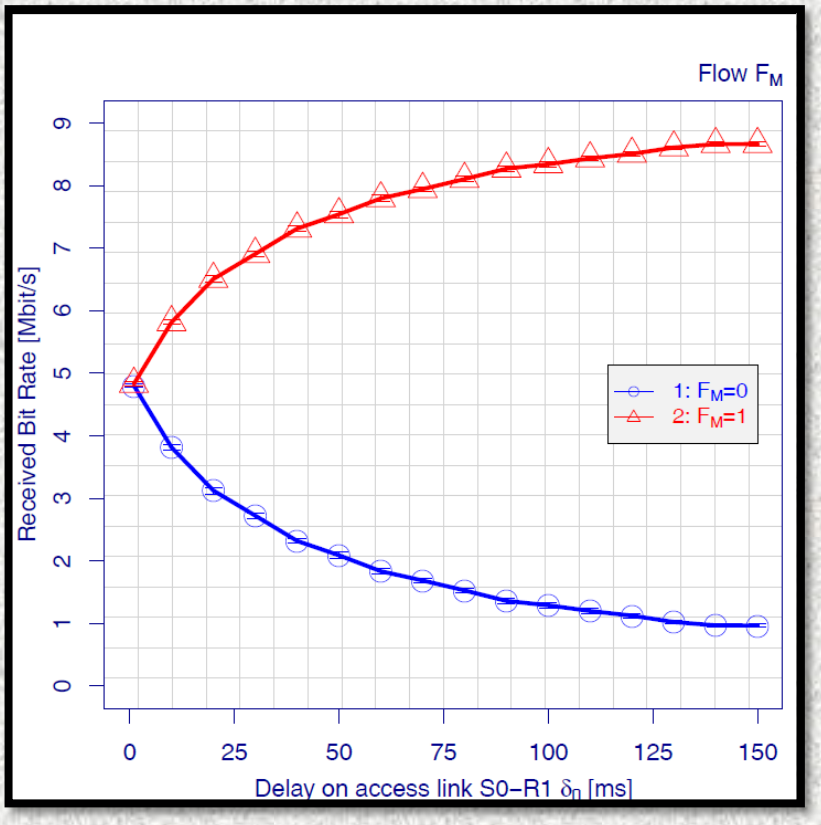
Design Issues
Fairness

- Terminology
  - It is considered as ‘fair’ not to push away TCP flows.
    - TCP friendliness: the common definition of fairness
  - RFC 2309 :
    - A "TCP-compatible“ flow behaves under congestion like a flow produced by a conformant TCP.
    - A TCP-compatible flow is responsive to congestion notification, and in steady-state it uses no more bandwidth than a conformant TCP running under comparable conditions (drop rate, RTT, MTU, etc.)

Design Issues
Fairness

- "Under comparable conditions"?





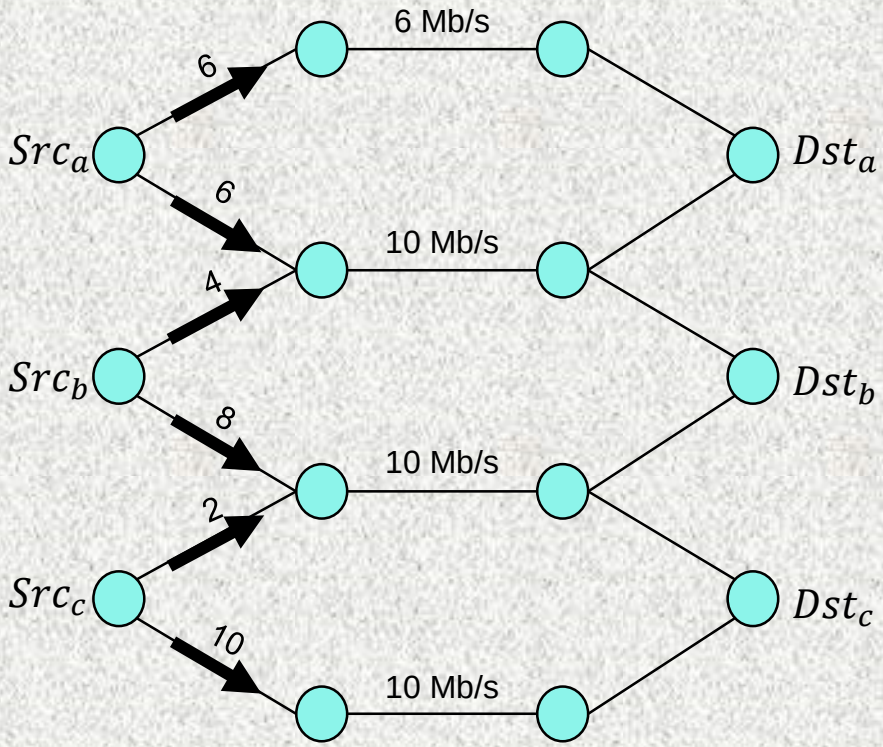
Design Issues
Fairness

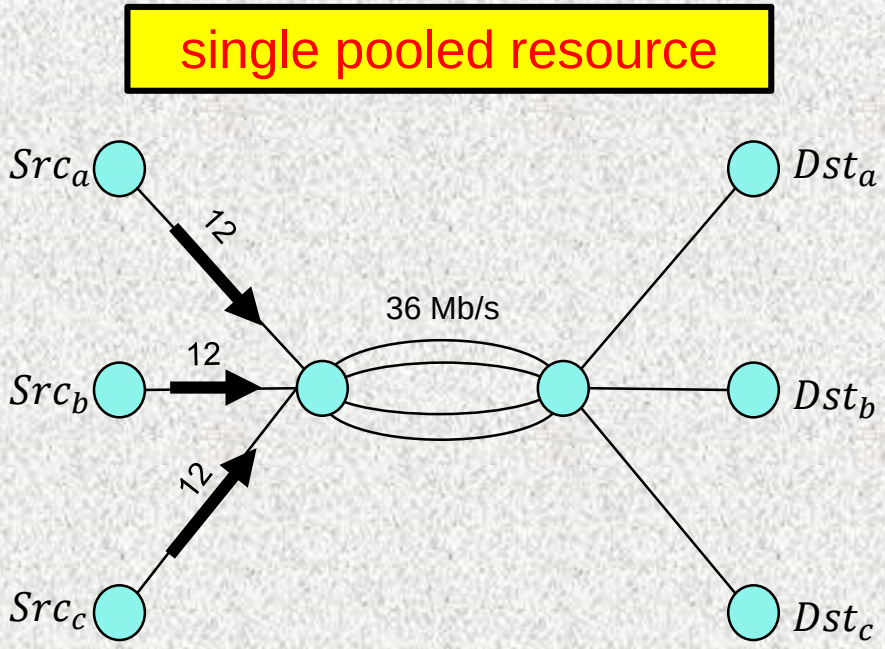
- Fairness goal:
  - Fair allocation resources between participants
    - For singlepath

    - For Multipath

Design Issues
Fairness

- How current multipath congestion Controls (CC) are designed (LIA, OLIA, RP-V2)
  - Based on resource pooling





Design Issues
Fairness

- How current multipath CCs are designed
  - LIA, OLIA, RP-V2 ← Participant ➔ Flow, Resource ➔ Network
  - Other approaches:
    - Dynamic Window Coupling ← Participant ➔ Flow, Resource ➔ Bottleneck
    - Independent CC ← Participant ➔ Subflow, Resource ➔ Bottleneck

Design Issues
Fairness

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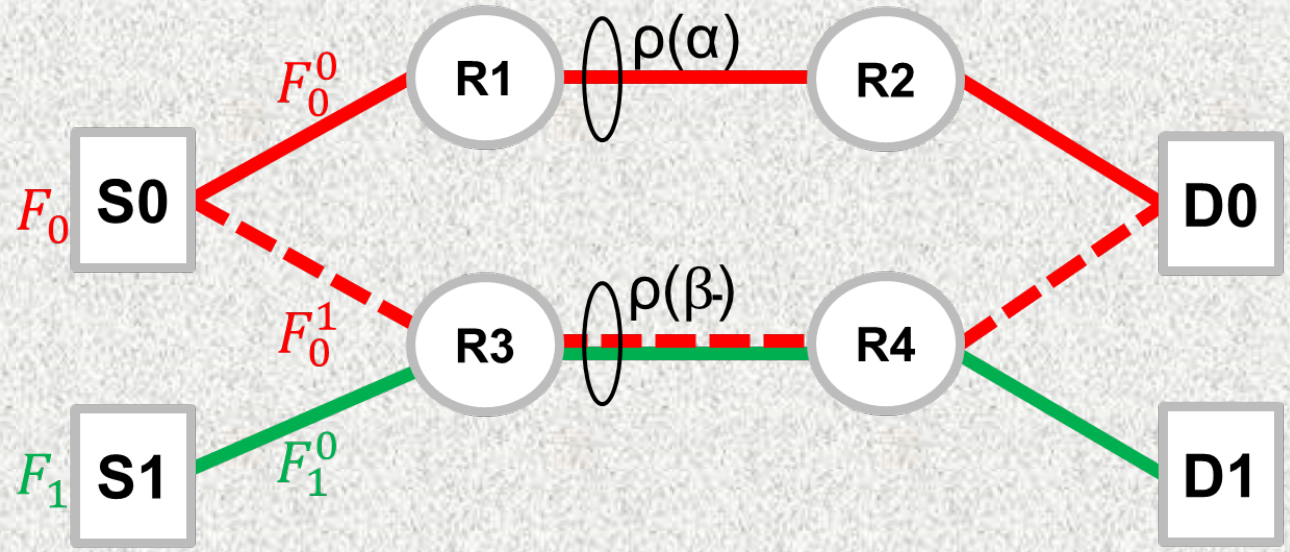
Multipath Fairness Definitions

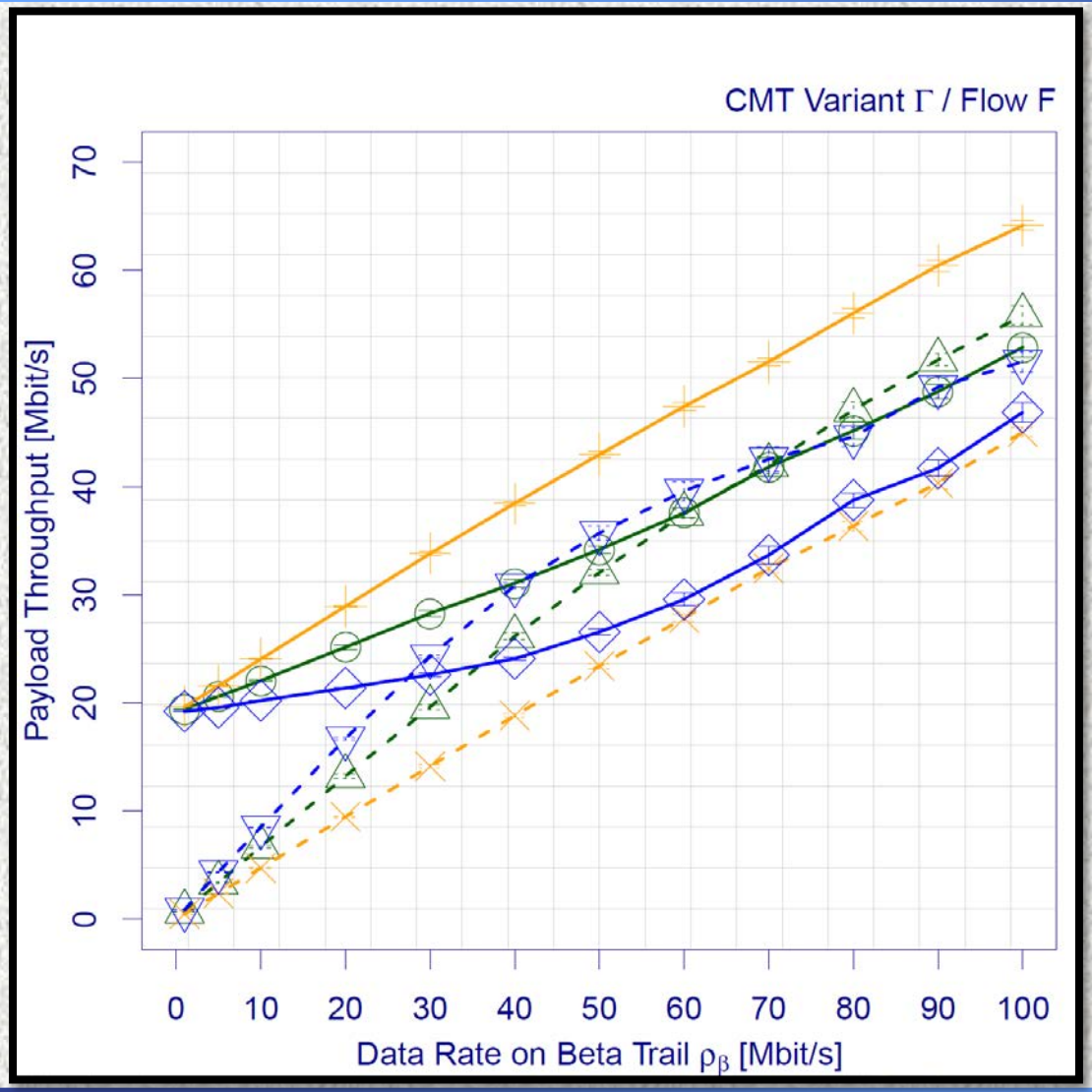
- Link-Centric Sub-Flow Fairness
  - Based on the number of the sub-flows on a link l
  - $\rho(l)/m$ for each of the m sub-flows
- Link-Centric Flow Fairness
  - For n different flows sharing a link l
    - $\rho(l)/n$ for each of the n flows
- Network-Centric Flow Fairness
  - The whole network is considered

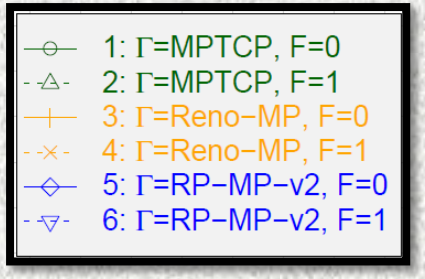
Are the protocols able to reach the fairness goals

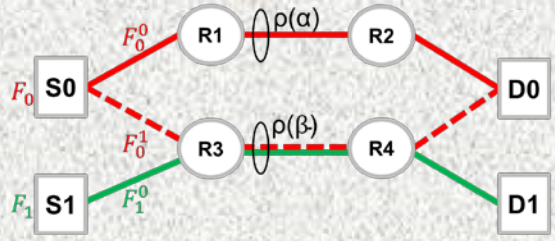


$\rho(\alpha) = 20\ \text{Mbit/s}$

Are the protocols able to reach the fairness goals







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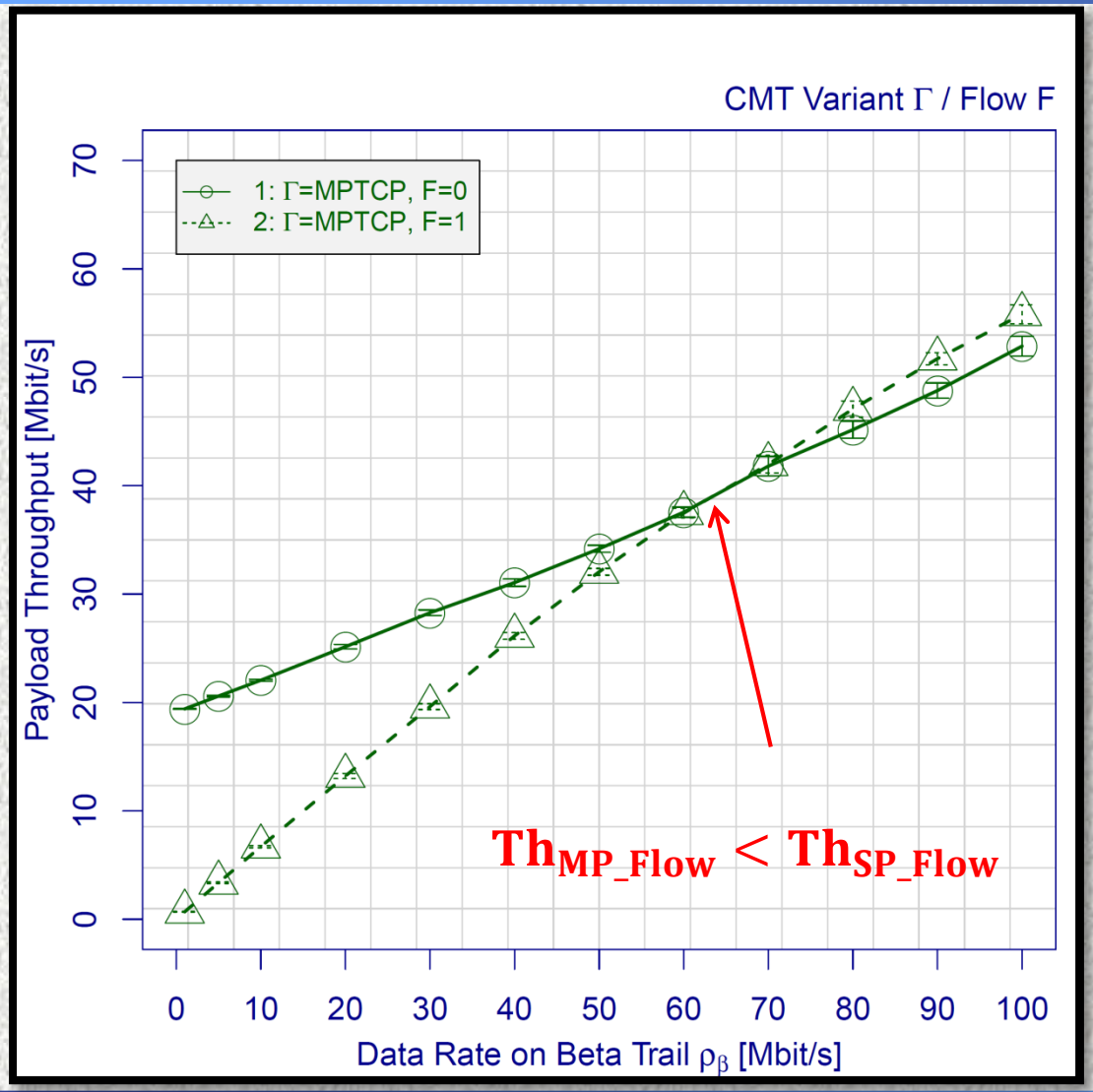

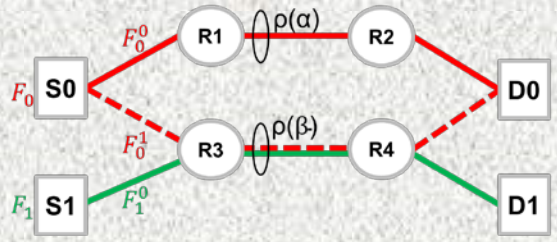

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Are the protocols able to reach the fairness goals

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- Until now:
  - Dominating single-path transfer
    - With singlepath: The ratio of flows to subflow: 1:1
- With Multipath
  - The old flow fairness has been adapted to multipath
  - We are still using flow fairness but:
    - The ratio of flows to subflow: 1:x
  - No relationship between the brought-in resources and the final allocation
    - Disadvantage for Multi-Path flows

Design point of view

Technical issues

Conclusion

- Is that what currently considered as fair (even for singlepath) really fair?
- Are we currently moving from a singlepath dominated network to a multipath dominated network?
- Multiple design alternatives
  - What should be considered as a participant
    - Flow
    - Subflow
  - What should be considered as a resource
    - Bottleneck
    - Network
- Is Coupled CC the right way to do it?