Multipath TCP Protocol Design

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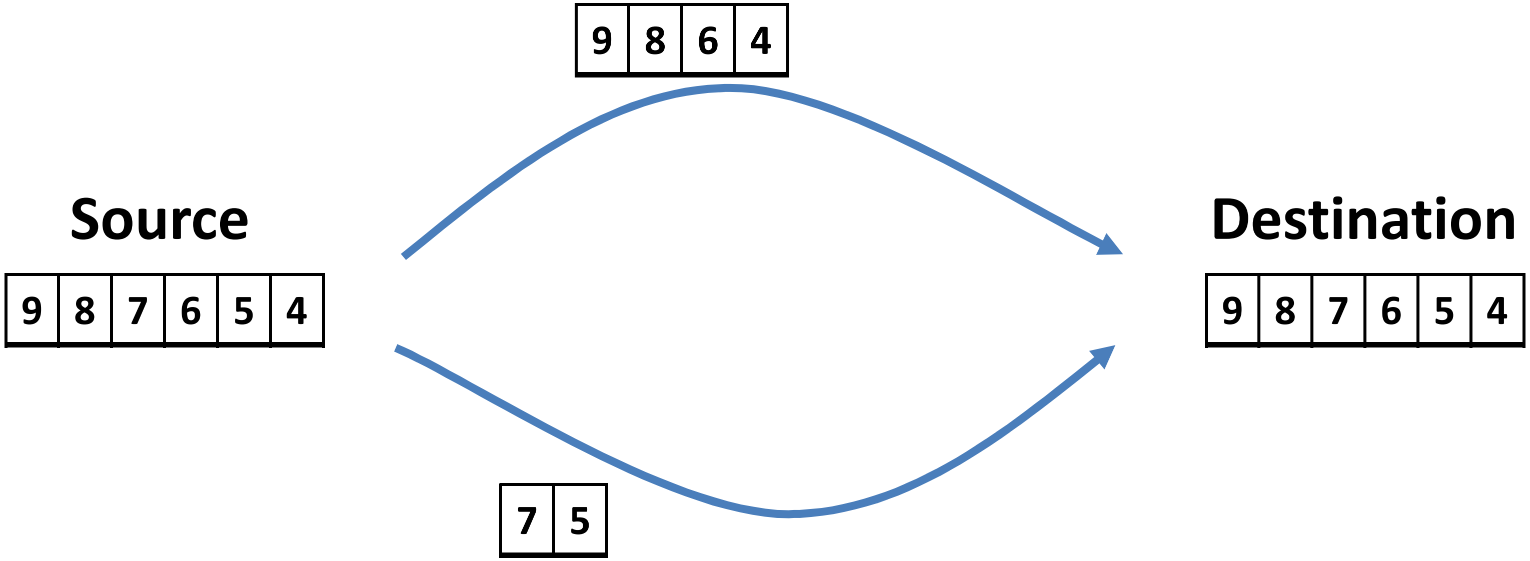
Scope

- *To build TCP modifications to support multipath operation*
- We have more than one implementation already, but this presentation is about the details needed to be solved in any implementation – for WG evolution

Usage and Design Considerations



9 8 6 4

Source

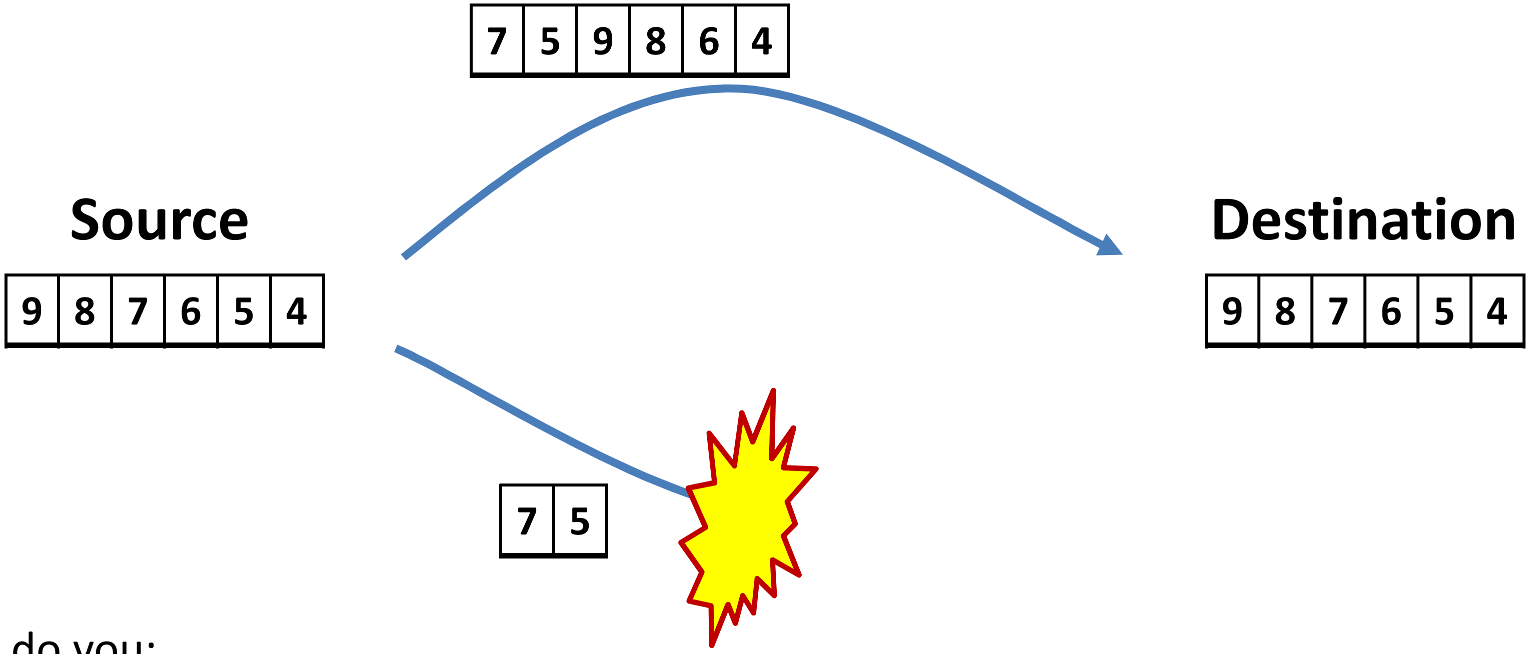
9 8 7 6 5 4

Destination

9 8 7 6 5 4

7 5

Usage and Design Considerations



7 5 9 8 6 4

Source

9 8 7 6 5 4

Destination

9 8 7 6 5 4

7 5

How do you:

- Discover paths and create subflows?
- Do sequence numbering to identify and reorder data to the application?
- Deal with changes in semantics and implementation, e.g. sequence numbering and SYN/FIN flags?
- Handle flow control and receive buffer depletion?
- Schedule appropriately?

Scenarios

- Bulk client/server transfers (e.g. HTTP/FTP)
- Short transactions (e.g. HTTP)
- Peer-to-peer transfers
- Interactive services (e.g. SSH, IM)
- Streaming services (NB buffered vs live)

- Where to deploy multipath TCP to give benefit?

Compatibility Goals

- Deployability is the key driver
- Performance should, in the worst case, be no worse than regular TCP over the best path
- It should appear compatible with regular TCP to unaware boxes on the wire
  - It should be able to seamlessly operate with legacy middleboxes (particularly NATs)

API Compatibility

- It should appear as regular TCP to applications
  - It provides the same service model: byte-oriented, in-order stream delivery
  - No mandatory API changes
- Essentially: is standard TCP, but with the potential to use multiple paths

Scheduling

- A scheduler decides how to distribute application data across available paths
- The scheduler also handles retransmissions, which may be over alternative paths
- Congestion coupling will be the subject of the next presentation
  - Goal: maximised throughput
- Other scheduling logic, e.g.
  - Goal: increased resilience and failover
  - Dependencies on path properties, e.g. cost, b/w

Signalling

If signalling is required (e.g. addresses, sequence numbering), how to do this?

- In the payload?
  - A chunking mechanism (using types) would be very clearly an application-layer rather than a transport-layer solution
- As TCP options?
  - Currently preferred in the draft solutions
  - Existing extension mechanism
  - Limited space so keep signalling to a minimum

Sequence Space

Shared or separate sequence spaces?

- Single sequence space, across all paths
  - Simply send each TCP segment on one of the available paths
- Create a data sequence space, leaving the individual subflow TCP sequence spaces untouched
  - Both ends aware of multiple TCP connections: clear distinction between paths and data.

Two Proposals

We have two example proposals for locating functionality, for different usage scenarios:

- *“One-ended”*
- *“Two-ended”*

- Both appropriately schedule packets over multiple paths
- These are implemented examples – but not the only way to solve the problem!

One-Ended MPTCP

draft-van-beijnum-1e-mp-tcp

- Multihomed hosts with PI addressing can distribute packets across multiple links
- Only sender needs to be modified
- One source, one destination address
- Need to recover per-path acknowledgements from SACK
- Do per-path congestion control

Two-ended MPTCP

draft-ford-mptcp-multiaddressed

- Start with single TCP “subflow”
- Initiate additional subflows
  - Which have different source/destination address pairs
  - Use identifier to merge with existing subflow
- Can be done from a hosts additional interfaces, or signalled to the other endpoint
  - To get around NATs/firewalls
  - Can also allow simultaneous IPv6/4 usage

Two-ended MPTCP: Details

- To middleboxes, subflows look like regular TCP sessions (with extra options)
  - Operate independently regarding FIN etc
- Two sequence spaces:
  - Data-level sequence number in TCP option for reassembly
  - Each subflow maintains its own TCP-level sequencing

Security

- We want a *no worse than TCP* security
  - And quite possibly a migration path to improve
- One-ended is basically TCP as it stands
- Two-ended solution must consider similar issues to mobility/shim6
- Need to avoid redirection attacks when adding and removing subflows

Summary

- For more information:

  http://trac.tools.ietf.org/area/tsv/trac/wiki/MultipathTcp

- See current proposals:
  - draft-ford-mptcp-multiaddressed-01
  - draft-van-beijnum-1e-mp-tcp-00
  - Design space discussion document