Multipath TCP: Goals and Background

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Not your grandfather's Internet…

- Once upon a time the Internet did email, ftp, and telnet.
  - And it fell over due to congestion.
- TCP congestion control has kept the Internet running every since.
  - Matches load to available capacity on short timescales.
  - On long timescales, needs an external feedback loop to reduce the arrival rate of new connections.

Today

- Very high demands for reliability.
  - Higher than the reliability rate of the network components themselves.
- Demanding applications becoming prevalent.
  - VoIP, IPTV, Games.

Unpredictability

- Can't predict failures.
- Can't predict flash crowds.
- Can't predict DDoS attacks.

- Still need to provide very high reliability service for demanding applications.

Robustness

- General solution to providing robustness:
  - Redundancy

- In the Internet:
  - Routing around failures (rather slow).
  - Multihoming (rather crude).
  - Traffic engineering via routing to cope with the above.
  - DPI and traffic shaping when TE can't cope.

Unpredictability of Wireless

- Wireless links becoming ubiquitous at the network edge.
- Fading, interference, etc make provision of reliable service much harder.

- Many wireless devices do have multiple radios.
  - Can't currently use these effectively to provide redundancy.

Mobility

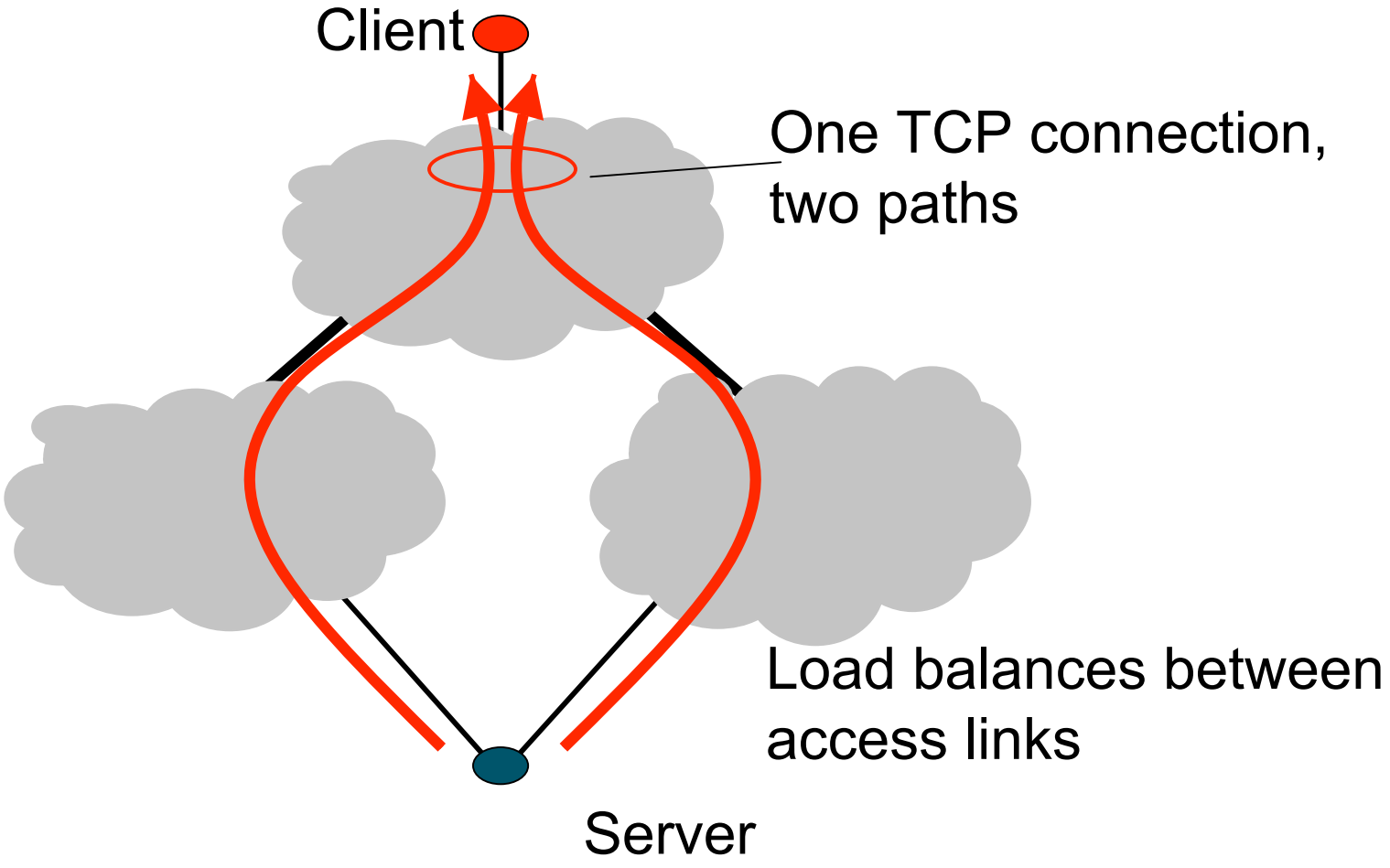
- Imagine a phone with 3G and WiFi, moving around a campus.
  - Would like to use 3G as semi-reliable baseline service, supplimented by WiFi when available, and switching between WiFi APs as they come and go.

- Current Internet protocols not designed around such agile network connectivity.

Multipath Transport: The Basic Idea

- Stop hiding multi-homing!
- Make the different network downlinks available to the transport protocol (eg, give them different addresses).
- Establish more than one path between the same pair of endpoints for the same connection.
- Use congestion control to determine which traffic goes down each of the paths.

Scenarios: Multi-homed server



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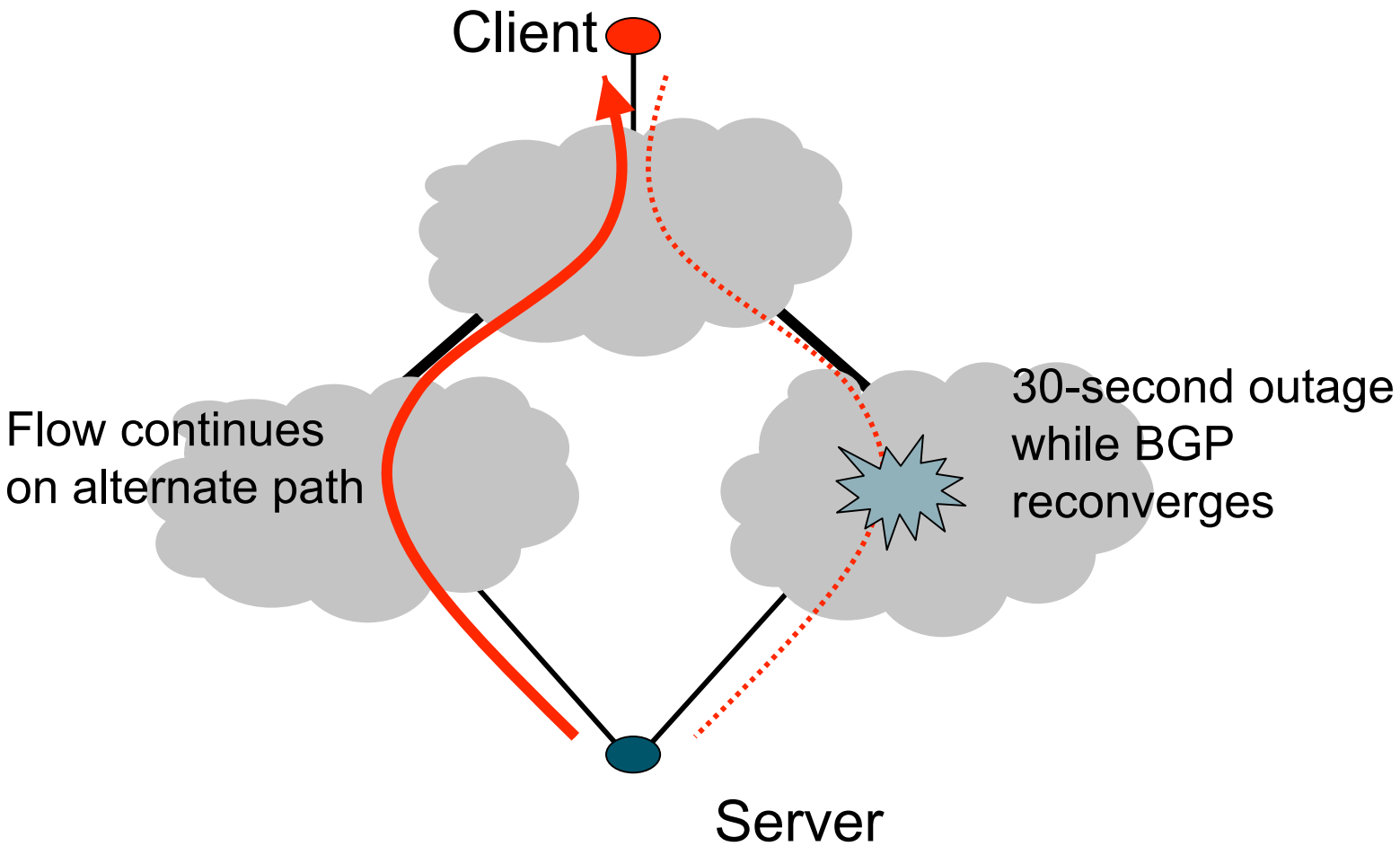

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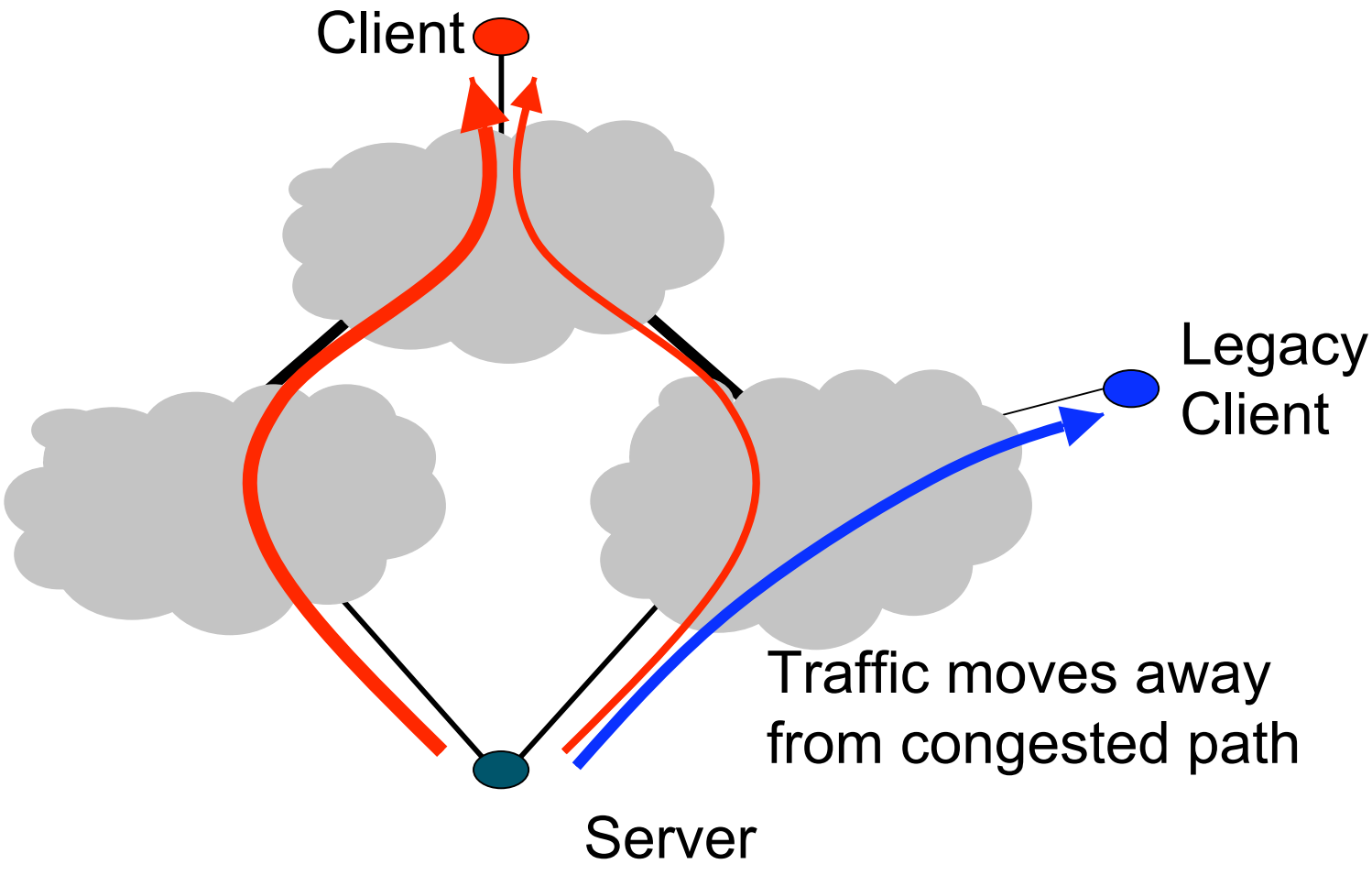
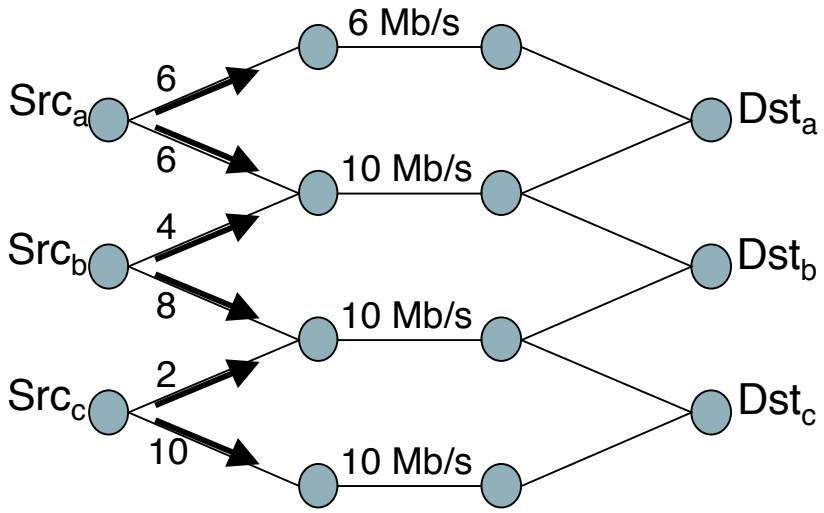


Resource Pooling

Network's resources behave like a **single pooled resource**.

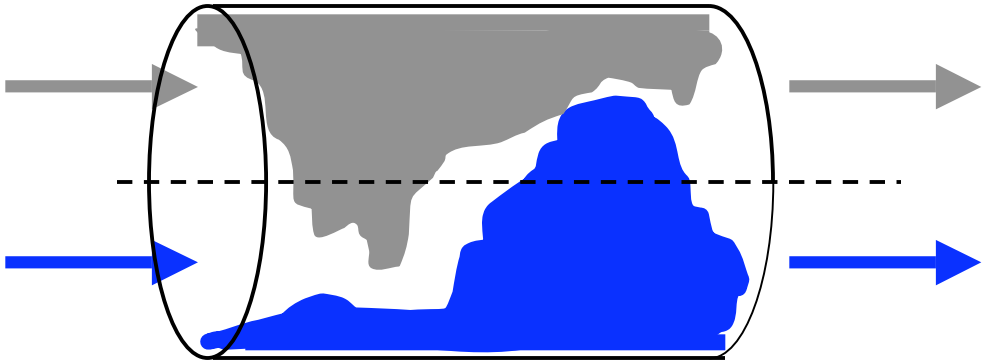
- Aim is to increase reliability, flexibility and efficiency.
- Method is to build mechanisms for shifting load between the various parts of the network.



Resource Pooling is not new…

Computer communication is bursty, so a virtual circuit-based model with rate allocations gives poor utilization.

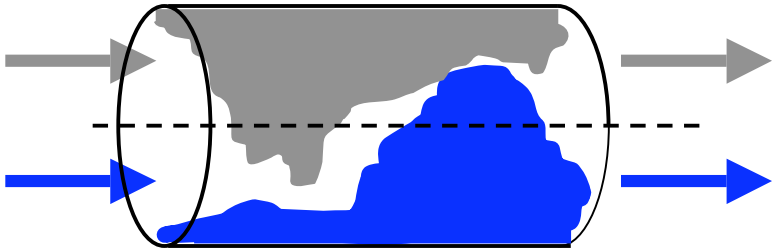
- A packet-switched network pools the capacity of a single link.
  - Goal: high utilization
- Router queues pool capacity from one time interval to the next
  - Goal: high utilization, robustness to arrival patterns



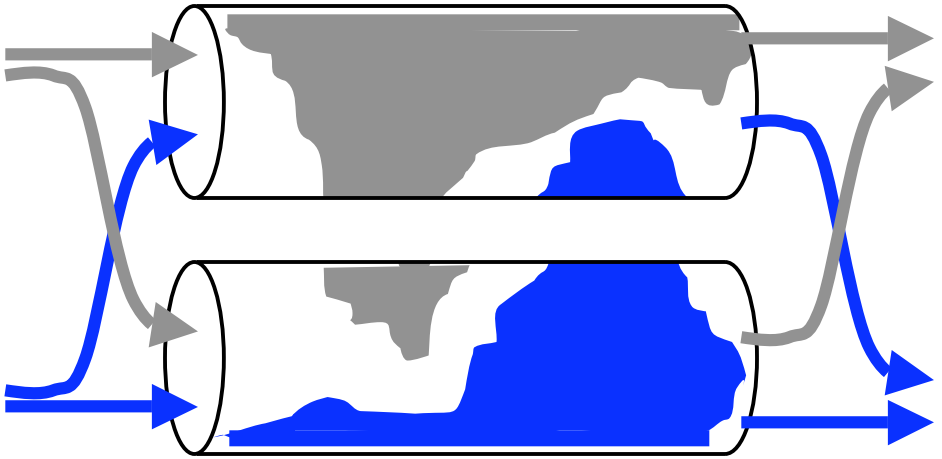
Multipath transport

- Multipath transport allows multiple links to be treated as a single pooled resource.
- Traffic moves away from congested links.
- Larger bursts can be accommodated.

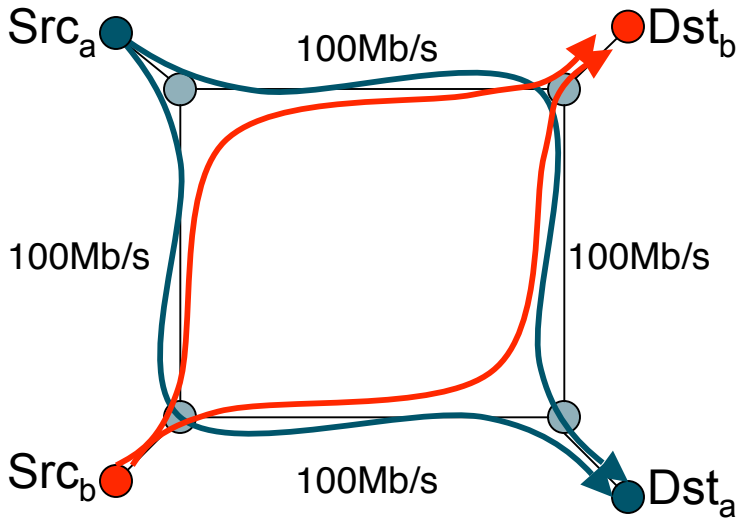
ARPAnet resource pooling:

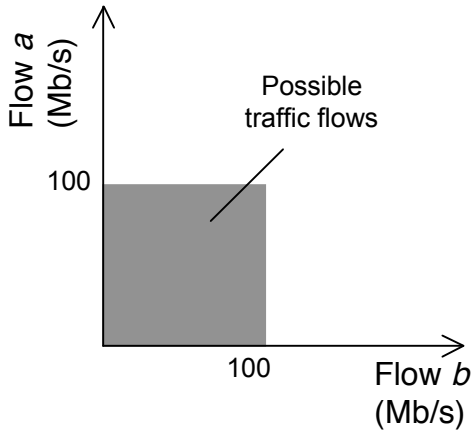


Multipath resource pooling:

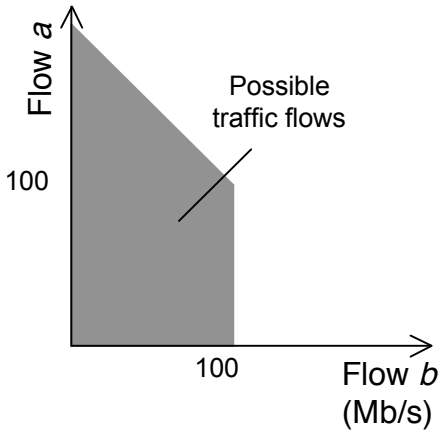


Resource pooling allows a wider range of traffic matrices

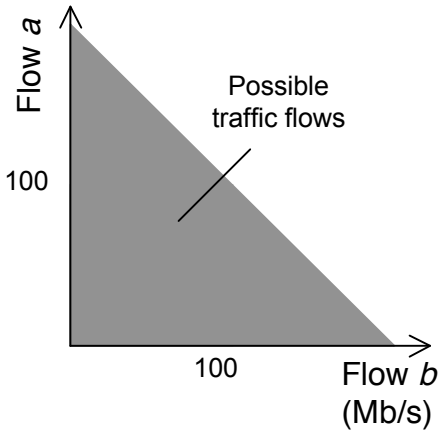




No multi-path flows

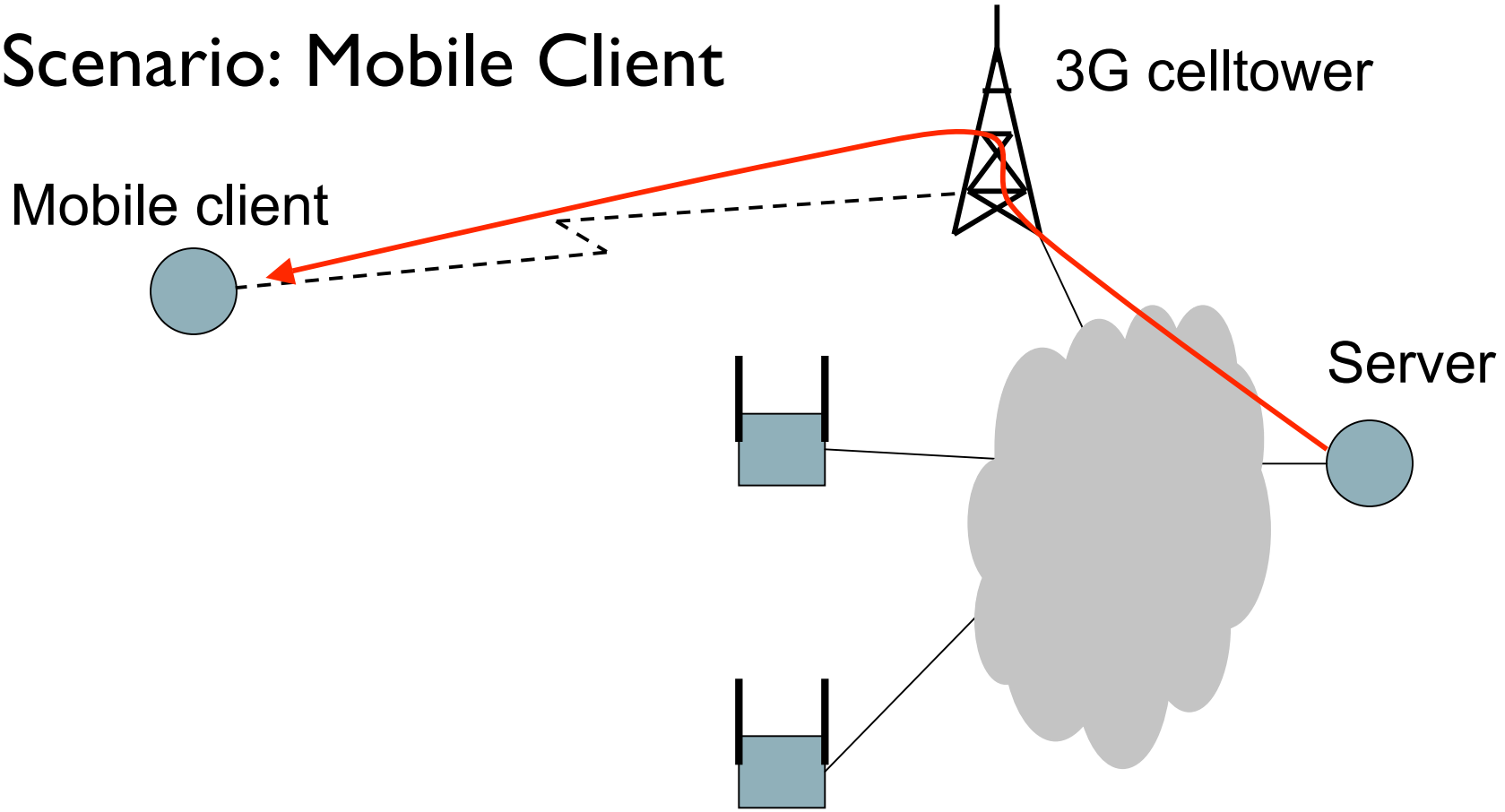


Only flow *a* is multi-path.



Both flows are multi-path

Scenario: Mobile Client



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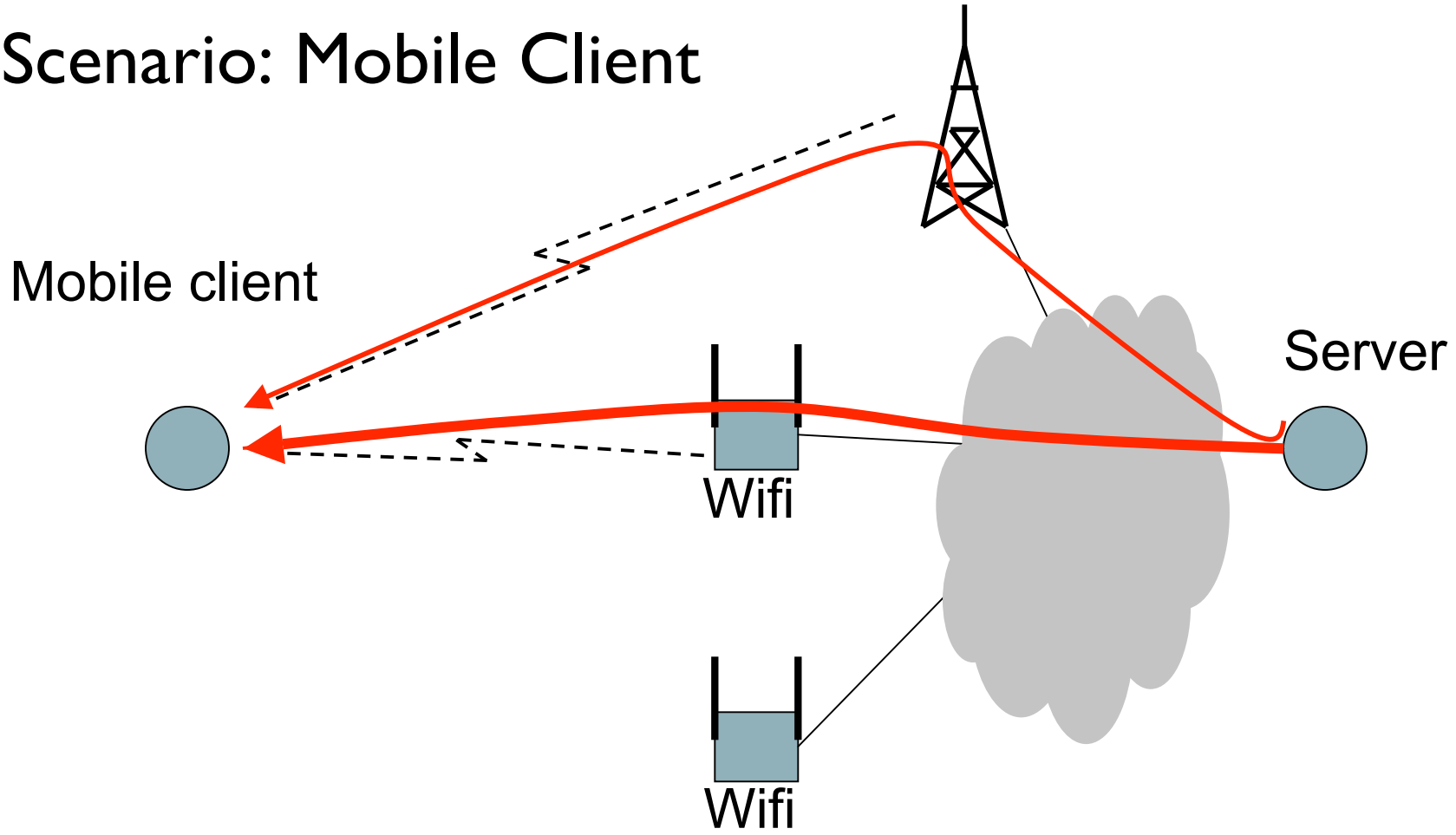

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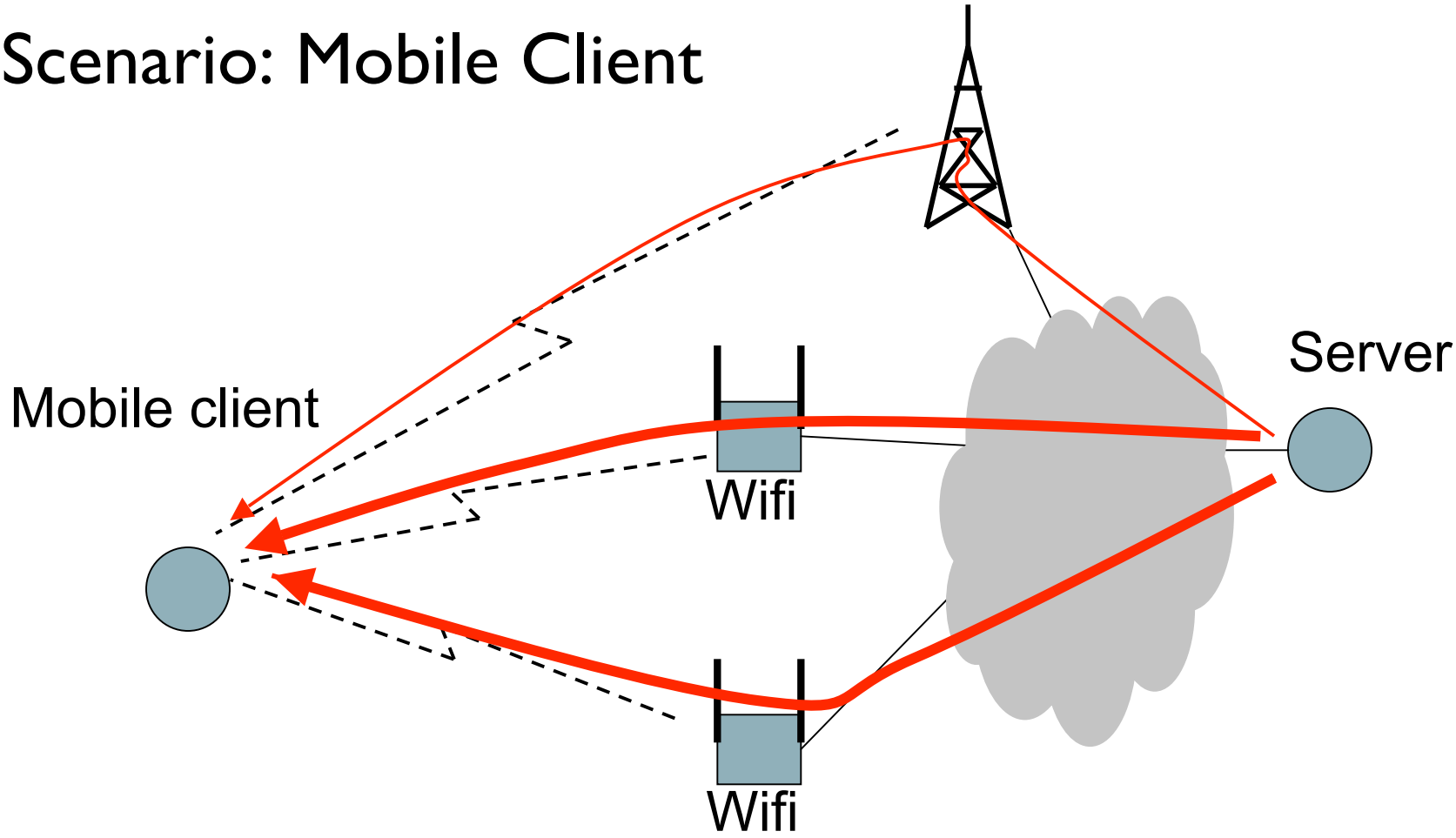

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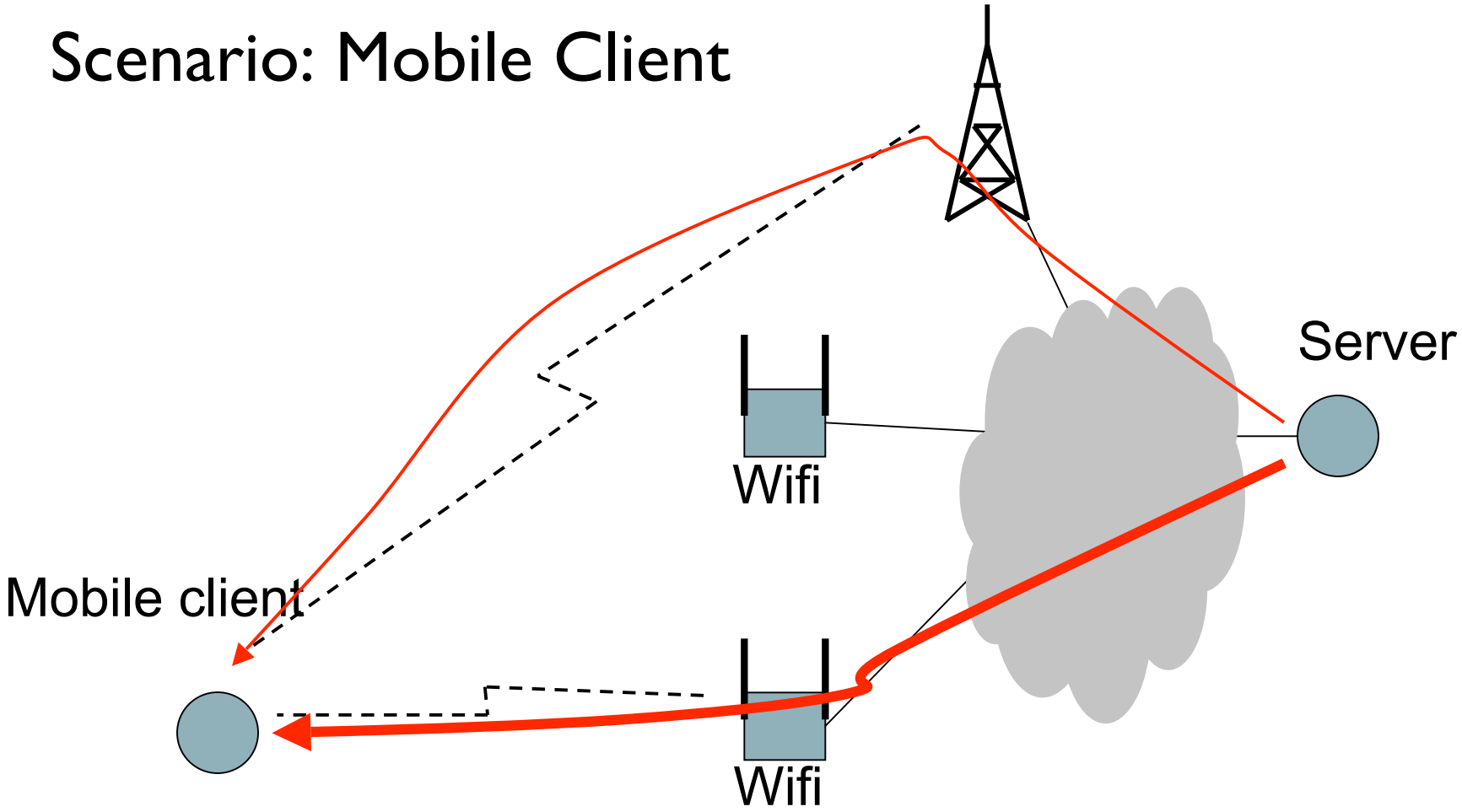

Multipath Transport

- Multipath transport protocols seem to be key to making the Internet more robust and more responsive to congestion.
  - Inherent redundancy.
  - Move congestion, not just spread it out over more time.
- React on timescales not possible in routing.
  - May offload work from routing?

Multipath TCP

- TCP is ubiquitous.
- Assertion:
  - Can add multipath capability to TCP fairly easily.
  - Improve behavior of existing applications.

Why *in* TCP, not *over* it?

- Can't we just do this over TCP?
  - BitTorrent gets many of the benefits while running over TCP.
  - Multi-server HTTP would do the same for multihomed servers.

Why in TCP?

- Only get the full congestion benefits when you link the congestion response of the subflows to move traffic away from congestion.
- Leverage TCP handshake to bootstrap subflows quickly.
- Want it to work for all existing TCP applications.

Other transport protocols?

- SCTP
  - Already has the protocol mechanism, just needs to implement the new congestion control mechanisms.
- DCCP
  - Would be easy to add, if there was demand.
- UDP
  - No single approach.
  - No handshake; maybe an application library?

Multipath TCP

- Has been proposed several times over the years (originally by Huitema?).
- We now understand that multipath TCP, if done appropriately, can go a long way towards solving network-wide traffic engineering problems.
- We're starting to understand the consequences of not solving the issue in a general way.

Next Presentations

- Alan Ford
  - Multipath TCP Protocol Design
- Costin Raiciu
  - Multipath Congestion Control