Proposal for Fast Subflow Creation

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From "Every Millisecond Counts: Tuning Multipath TCP for Interactive Applications on Smartphones", tech. report.

http://hdl.handle.net/2078.1/185717

Why do we propose this?

Current implementations (e.g., Linux one) opens subflows on all available interfaces upon connection establishment

→ Great for bandwidth aggregation

But *Make-Before-Break* is sometimes useless

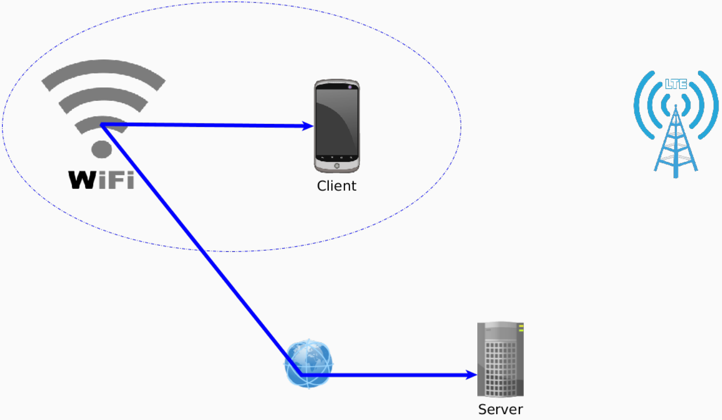
- Connection finished before establishment of additional subflows
- Application not requiring lot of capacity
  - But rather low latency...
  - ...and seamless network handover

Useless subflows waste network/energy resources

The Smartphone Usecase

Typically wants to remain on the WiFi if good

- Only create cellular subflows if bad/no WiFi
  - Or if traffic actually requires large bandwidth



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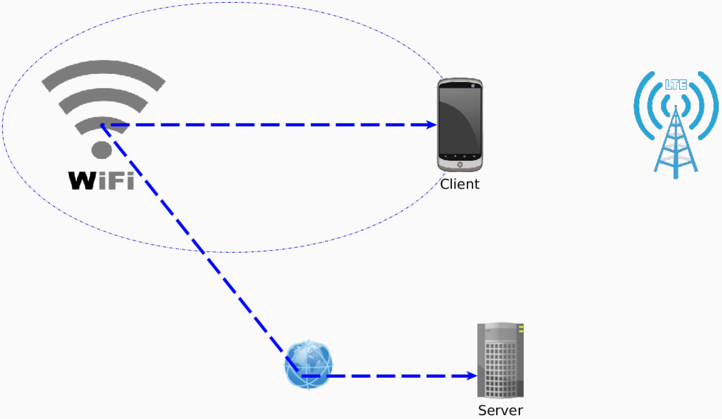

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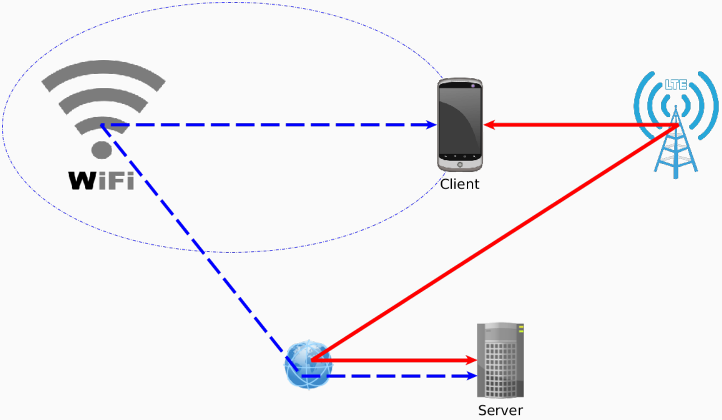

Proposing a *Break-Before-Make* Approach

We propose three mechanisms for the smartphone usecase

- "Global Scheduling": server following client's choices
- "Multipath TCP Oracle": detecting bad performing subflows
- **"Immediate Reinjections": fast subflow creation**

Only discussing the last one here, as it affects interoperability

Limiting Handover Delay

The backup (cellular) path creation is delayed

- Nice from a energy consumption point of view...
- ...but incurs larger app perceived latency in mobility cases
  - Reactive approach: need to detect first bad network

Furthermore, additional Multipath TCP path creation takes time...

Towards Fast Establishment of Additional Subflows

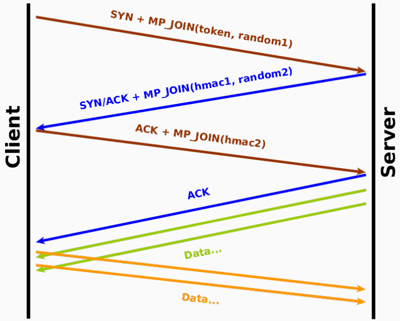

Figure 1: Normal JOIN.

Towards Fast Establishment of Additional Subflows

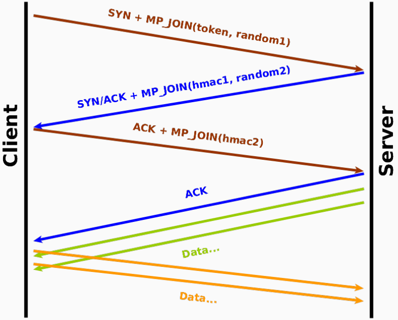

Figure 1: Normal `JOIN`.

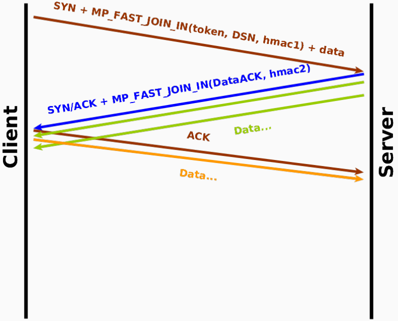

Figure 2: Fast `JOIN` with data.

Quantifying Latency Gains (Request/Response – Mininet Setup)

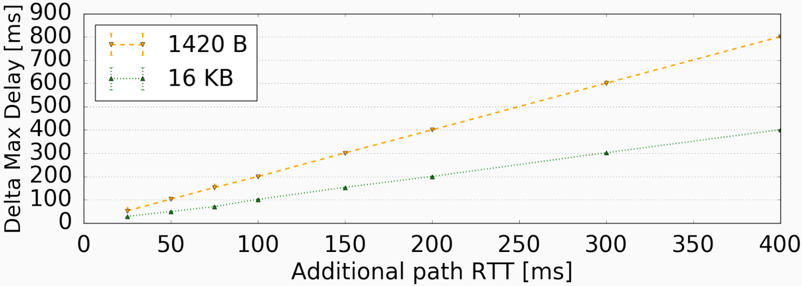

Figure 3: Latency gain between Fast and Normal Joins depending on the request size.

- Saving at least 1 RTT
- Saving 2 RTTs if request size $<$ MSS

Defining New Multipath TCP Options

Two new proposed options

- FAST_JOIN_OUT
  - When the client has data to send
- FAST_JOIN_IN
  - When the client has no data to send
    - But knows that main path(s) failed
    - And the server might still have data to send (e.g., middle of bulk download)

FAST_JOIN_OUT Option Format – Initial SYN

```
                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---------------+---------------+-------+-+-+-+-+---------------+
|     Kind      |    Length     |Subtype|rsv|E|B|   Address ID  |
+---------------+---------------+-------+-+-+-+-+---------------+
|                  Receiver's Token (4 bytes)                   |
+---------------------------------------------------------------+
|   Data sequence number (4 or 6 bytes, depending on flags)     |
+---------------------------------------------------------------+
|               Sender's Truncated HMAC (4 bytes)               |
+-------------------------------+-------------------------------+
| Data-Level Length (2 bytes)   |
+-------------------------------+
```

With $HMAC_{CS}(DSN, token)$

`FAST_JOIN_OUT` Option Format – SYN/ACK

```
                     1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---------------+---------------+-------+-+-+-+-+---------------+
|     Kind      |    Length     |Subtype|rsv|E|B|  Address ID   |
+---------------+---------------+-------+-+-+-+-+---------------+
|                                                               |
|             Sender's Truncated HMAC (8 bytes)                 |
|                                                               |
+---------------------------------------------------------------+
|         Data ACK (4 or 8 bytes, depending on flags)           |
+---------------------------------------------------------------+
```

With $HMAC_{SC}(DataACK, DSN)$

FAST_JOIN_IN Option Format – Initial SYN

```
                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---------------+---------------+-------+-+-+-+-+---------------+
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+---------------+---------------+-------+-+-+-+-+---------------+
|                   Receiver's Token (4 bytes)                  |
+---------------------------------------------------------------+
|          Data ACK (4 or 8 bytes, depending on flags)          |
+---------------------------------------------------------------+
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+---------------------------------------------------------------+
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+---------------------------------------------------------------+
```

With $HMAC_{SC}(DSN, DataACK)$

Possible Security Considerations

- Shortened HMAC size
  - Try to save as much TCP option space as possible
- SYN replay attacks
  - Prevent more than 1 subflow creation with a given DSN/Data ACK
  - Limit number of fast created subflows per connection

To Summarize

Tuning Multipath TCP for smartphone

- Cellular subflow consumes radio resources
- Only use cellular when needed

Applying changes at MPTCP design to suit this usecase

- Implemented in Linux MPTCP v0.91
- And in Nexus 5 (with Android 6.0.1)

→ Interest in writing a draft about this?

Thanks for your attention!

Feel free to ask questions or provide feedback ☺