



Multipath Transports at Apple

Siri

Goal

- Minimize latency
- Reduce network errors

Traffic & Environment

- Thin bi-directional stream
- Frequently used in mobile scenarios

Siri

Path Management

- Immediate TCP sub-flows on both Wi-Fi and Cell
 - Enables immediate use of a path
 - Provides initial RTT measurements

Scheduling

- "Interactive Mode" [1]
- Continuous evaluation of path characteristics (RTT & packet-loss)
- Per-packet scheduling on most optimal path
 - RTT-based with threshold
 - Adapts if retransmission timeout is too large
 - Loss-based on retransmission timeout

Siri

QUIC Requirements

- Continuous measurement of path quality
- Ability to rapidly switch between paths
 - Wireless quality changes drastically in short time-frames
 - E.g., lossy low-latency Wi-Fi combined with high-latency cellular

Apple Music

Goal

- Reduce playback stalls
- Reduce stall duration

Traffic & Environment

- Uni-directional bulk-data transfer (entire song)
- Playback buffer "hides" most networking issues

Apple Music

Path Management

- Enable cellular subflow only when really necessary
 - Keeps cellular data usage at strict minimum

Scheduling

- Schedule aggressively on both paths [1]
 - Resource Pooling to aggregate path capacities
 - When cellular is brought up, we need data as fast as possible to avoid the stall

Apple Music

QUIC Requirements

- Deliver data as fast as possible to the client
- Minimize cellular data usage