Voice-activated applications and Multipath TCP: A good match?

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Voice-assistants in thriving
Use cases

- Voice-based command
- Search & Query
- Connected cars
- Customer support
- Path guide
Cloud-based voice recognition

Stream of voice

Text-based answer
Network requirements

• High availability
• Low latency
• Energy awareness

-> TCP is limited to a single path/interface
-> MPTCP has been deployed for Siri on iOS since 2013
MPTCP for voice-activation traffic

Questions:

• What are the benefits of using MPTCP for voice-activated traffic?
• What are the factors that impact the performance?
MONROE platform

Platform for measurements in operational MBB networks

Coverage in Norway, Sweden, Spain, Italy
- Stationary nodes
- Mobile nodes: on buses, trucks and trains

Connectivity
- 2 cellular interfaces
- or 1 cellular and 1 WiFi. But not many have accessible WiFi's.
Measurement Design

- Test Server(s)
- MONROE Node
- MONROE Node
- MONROE Node
- MONROE Node

MONROE Experiment Scheduler Server
Technical challenge

De-facto MPTCP implementation is in kernel space

But: MONROE nodes require the experiments to be run inside Docker containers – userland!
Solution: Linux Kernel Library

LKL packs kernel networking stack in a userland library

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https://github.com/lkl/linux
MPTCP stack in user-space

- We merged LKL with MPTCP stack [1]
- The LKL-MPTCP library is put inside the Docker image
- Simulated app uses the transport stack of this library instead of the host

[1] https://github.com/hoang-tranviet/mptcp/tree/lkl_4.13-mptcp_v0.93_API
Set-up & Configuration

• 28 stationary nodes
• 44 mobile nodes
• Each node has 2 cellular interfaces
• Server in Belgium (another in Japan, not presented here)
• For each test: 5 runs from every node to server
Siri traffic pattern & Emulation

**Client**
- TCP+TLS handshaking
- Voice samples
- HTTP Continue
- Voice samples
- Final Response
- Voice samples
- Final Response

**Server**
1. Start test
2. Create test connection
3. Send burst
4. Timeout?
   - Yes
   - Wait ~300 ms
5. Burst count > 9 ?
   - Yes
   - Wait 4s
   - No
   - Yes
6. Close connection

**User-perceived Delay**
- Next user interaction
RESULTS
TCP VS. MPTCP
Stationary Nodes

MPTCP is better

Short tail
MPTCP reduces delay by switching path when default interface has bad signal
Mobile Nodes

MPTCP reduces tail, but not the median

Much longer tail
Mobile Nodes

![Graph showing request-response delay vs. RSSI of primary interface (dBm) for TCP and MPTCP Default]
RESULTS
DIFFERENT MPTCP CONFIGURATIONS
Multipath TCP: packet scheduling

• **Default scheduler:**
  Select the subflow having Lowest RTT

• **Server-heuristic scheduler[1]:**
  Select the subflow on which server received the latest segment from client

[1] Quentin De Coninck and Olivier Bonaventure. Tuning Multipath TCP for Interactive Applications on Smartphones. IFIP Networking 2018
Siri servers send Intermediate Response (HTTP Continue) regularly.

What if there is no Intermediate Response (No-IR)?
Stationary Nodes

No clear difference between default scheduler and server scheduler

without Inter-Response, delay is worse
Stationary Nodes
Mobile Nodes

Server scheduler gives lowest delay, esp. the tail

without Inter-Response, delay is worse, again
Conclusion

- LKL enables experiments requiring customized network stack without changing kernel
- MPTCP generally gives lower delays
- Server-heuristic scheduler is a bit better than default scheduler
- Intermediate Responses play the important role of active probe for the server
Any Question

• Source code:
  LKL-MPTCP stack:  
  https://github.com/hoang-tranviet/mptcp/tree/lkl_4.13-mptcp_v0.93_API
  Simulated program:  https://github.com/hoang-tranviet/iperf-siri
  Client Docker script:  https://github.com/hoang-tranviet/lkl-docker-monroe

• Dataset:  https://www.info.ucl.ac.be/~tranviet/monroe-voice-dataset.zip

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Japan server – mobile nodes

![Graph showing CDF of request-response delay](image)
Japan server – mobile nodes
Japan server - stationary nodes
Japan server - stationary nodes