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

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Voice-assistants in thriving

Apple Siri
2011

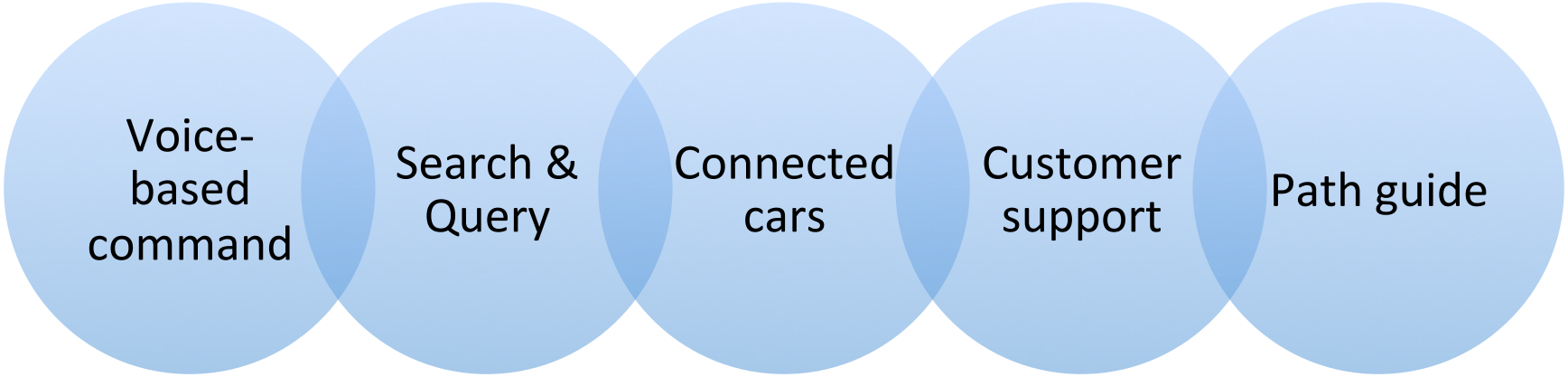
Google Now
2012

Microsoft Cortana
2013

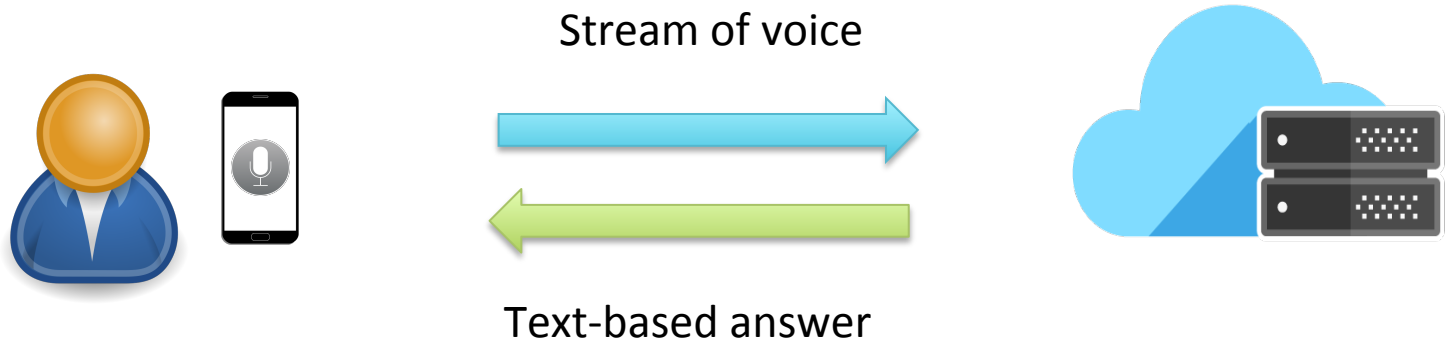
Amazon Alexa
2014

Google Assistant
2016

Use cases


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

Cloud-based voice recognition



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

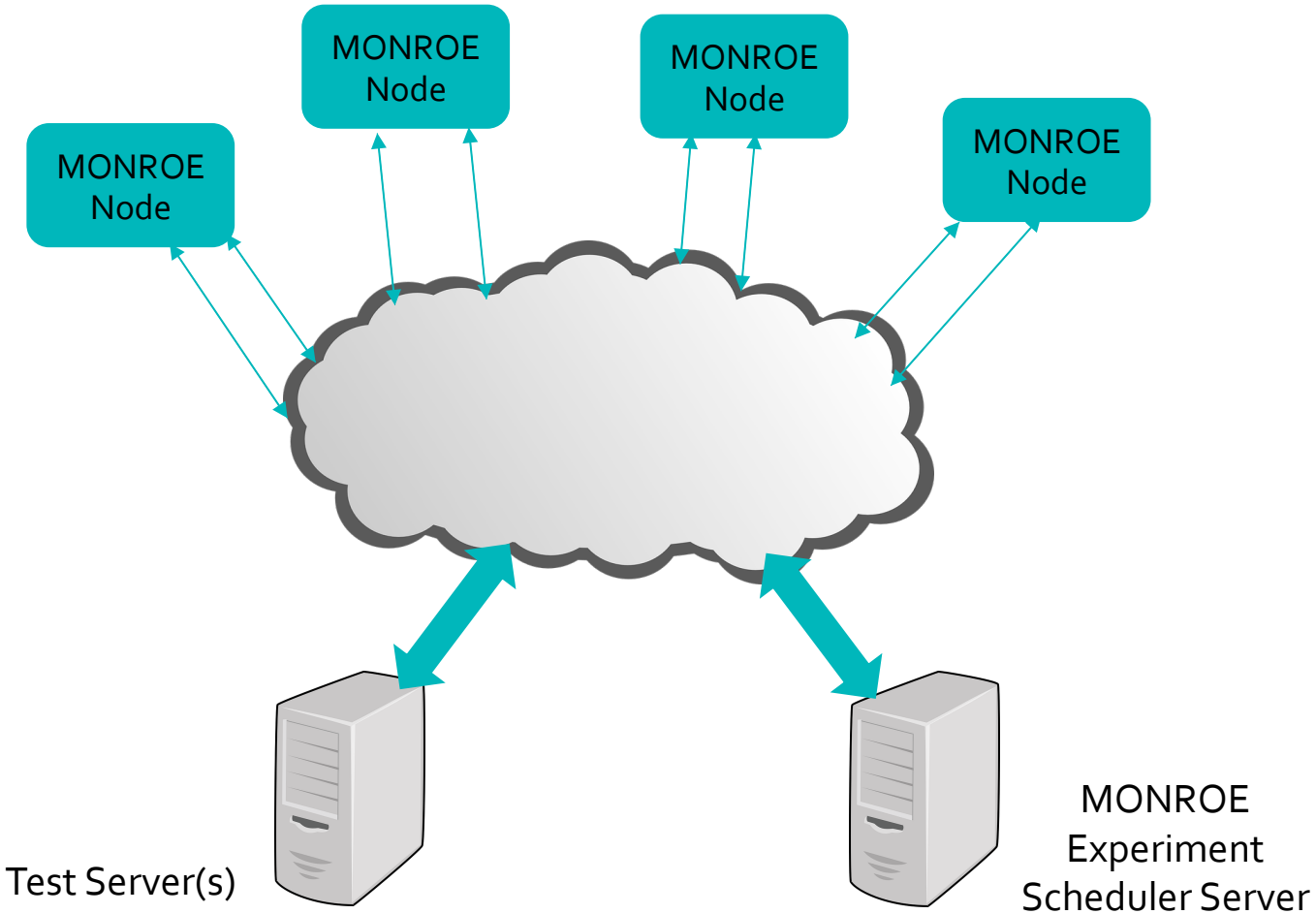
Coverage in Norway, Sweden, Spain, Italy

- Stationary nodes
- Mobile nodes: on buses, trucks and trains

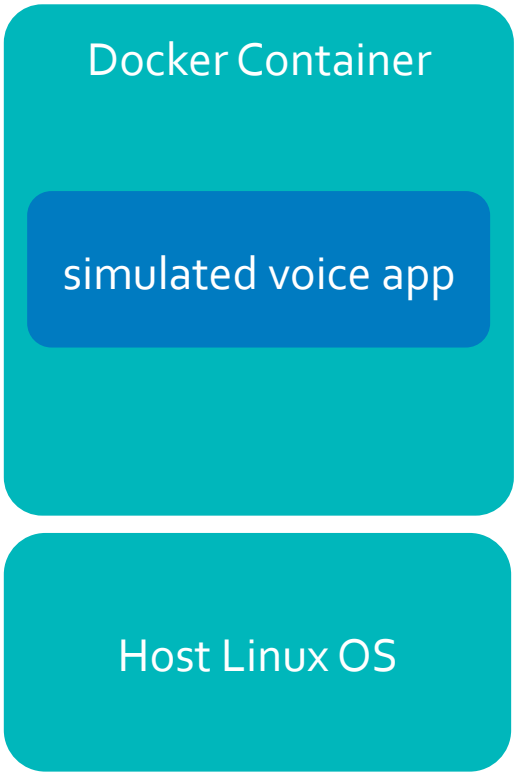
Connectivity

- 2 cellular interfaces
- or 1 cellular and 1 WiFi. But not many have accessible WiFis.

Measurement Design



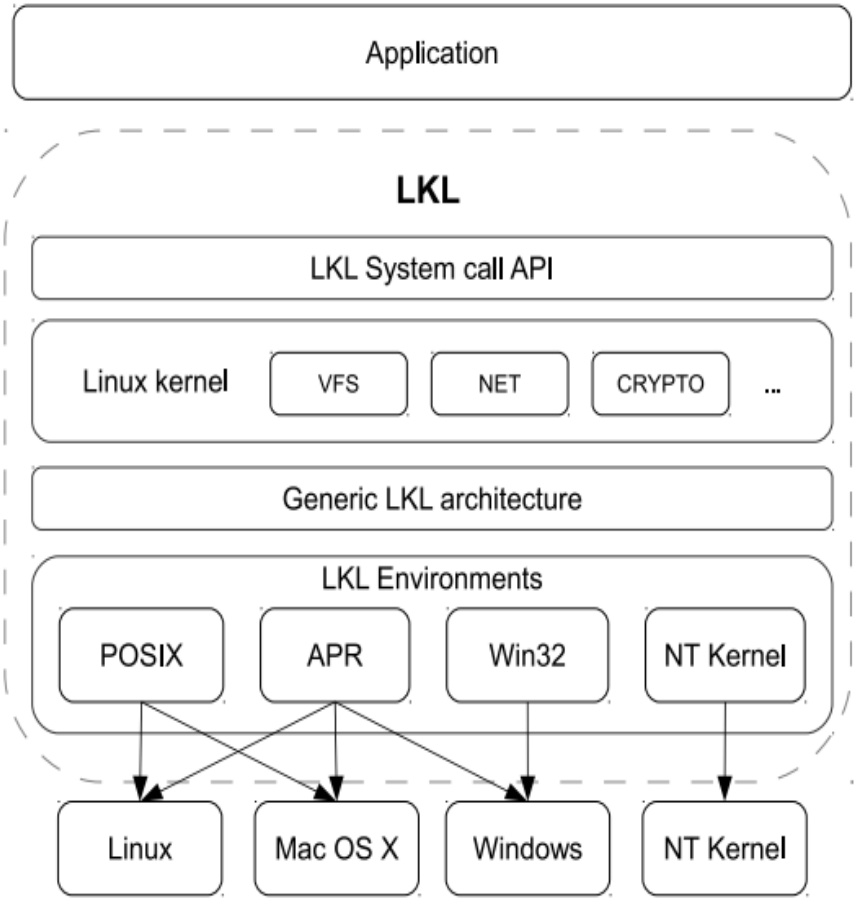
Technical challenge



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

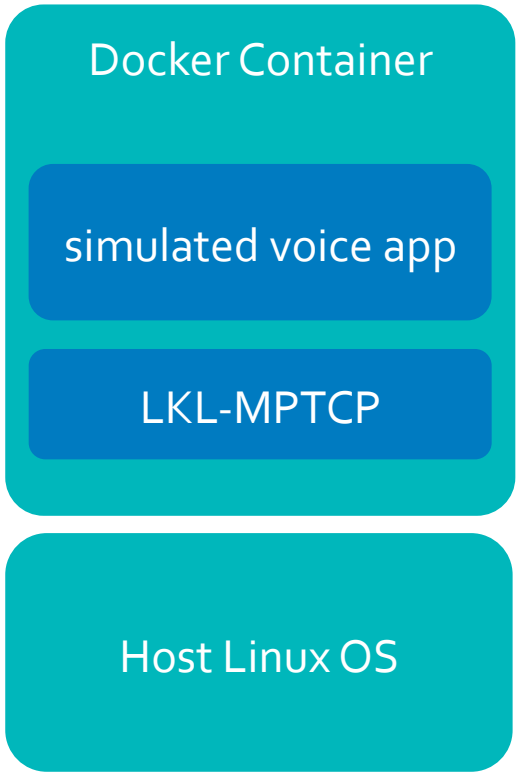


LKL packs kernel networking stack in a userland library

Authors: Octavian Purdila
Hajime Tazaki

https://github.com/lkl/linux

MPTCP stack in user-space



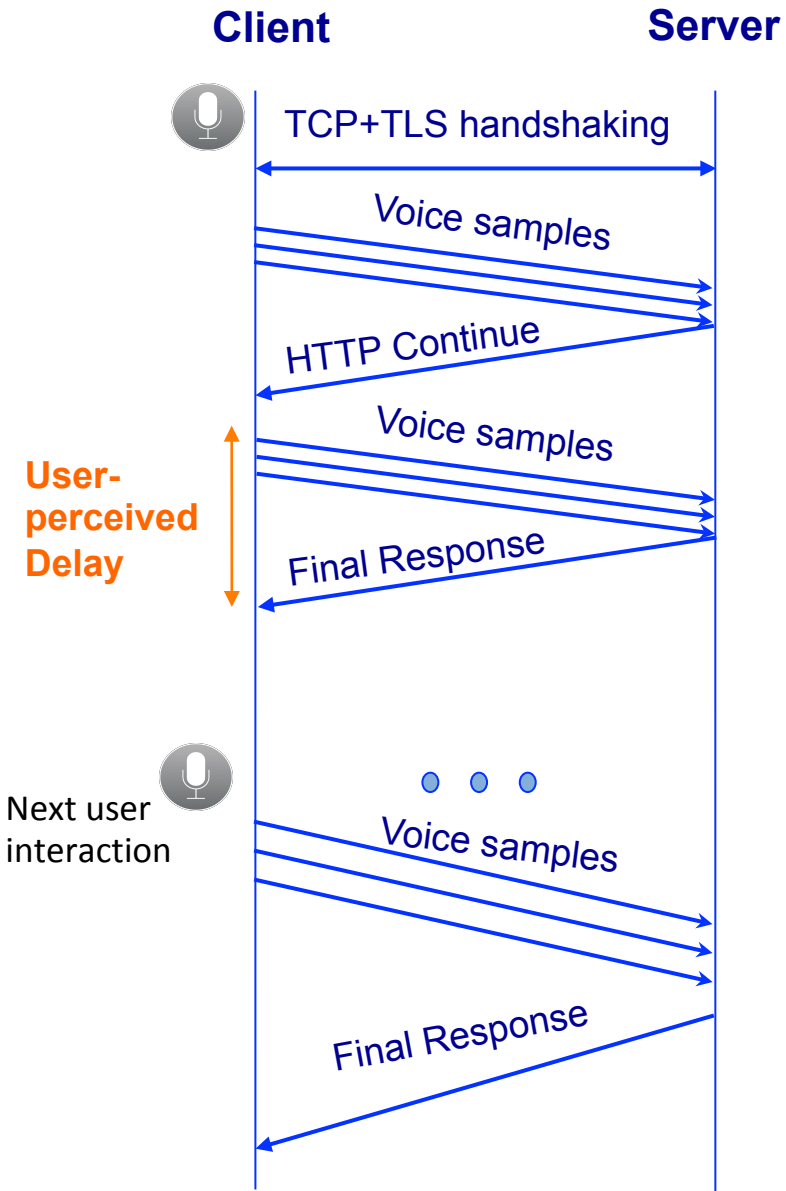
- We merged LKL with MPTCP stack [1]
- The LKL-MPTCP library is put inside the Docker image
- Simulated app uses the transport stack of this library instead of the host

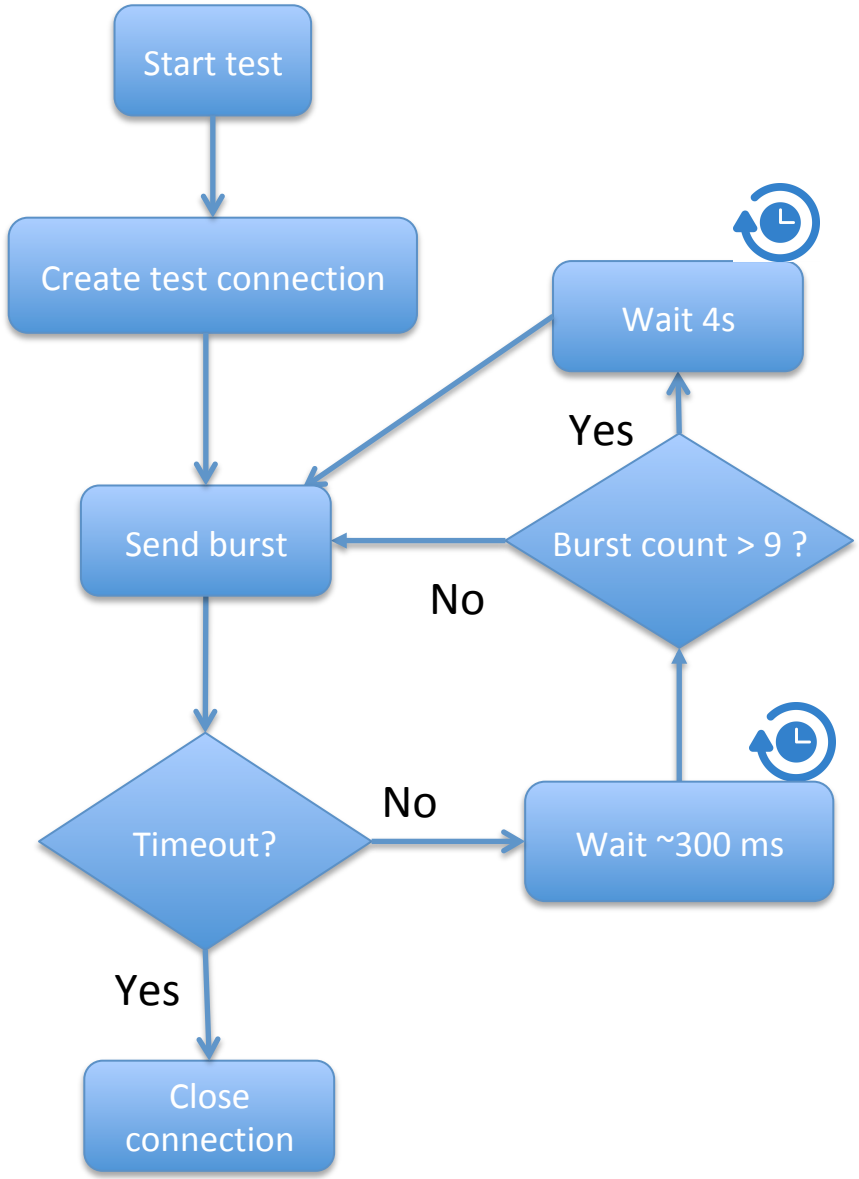
[1] https://github.com/hoang-tranviet/mptcp/tree/lkl_4.13-mptcp_v0.93_API

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

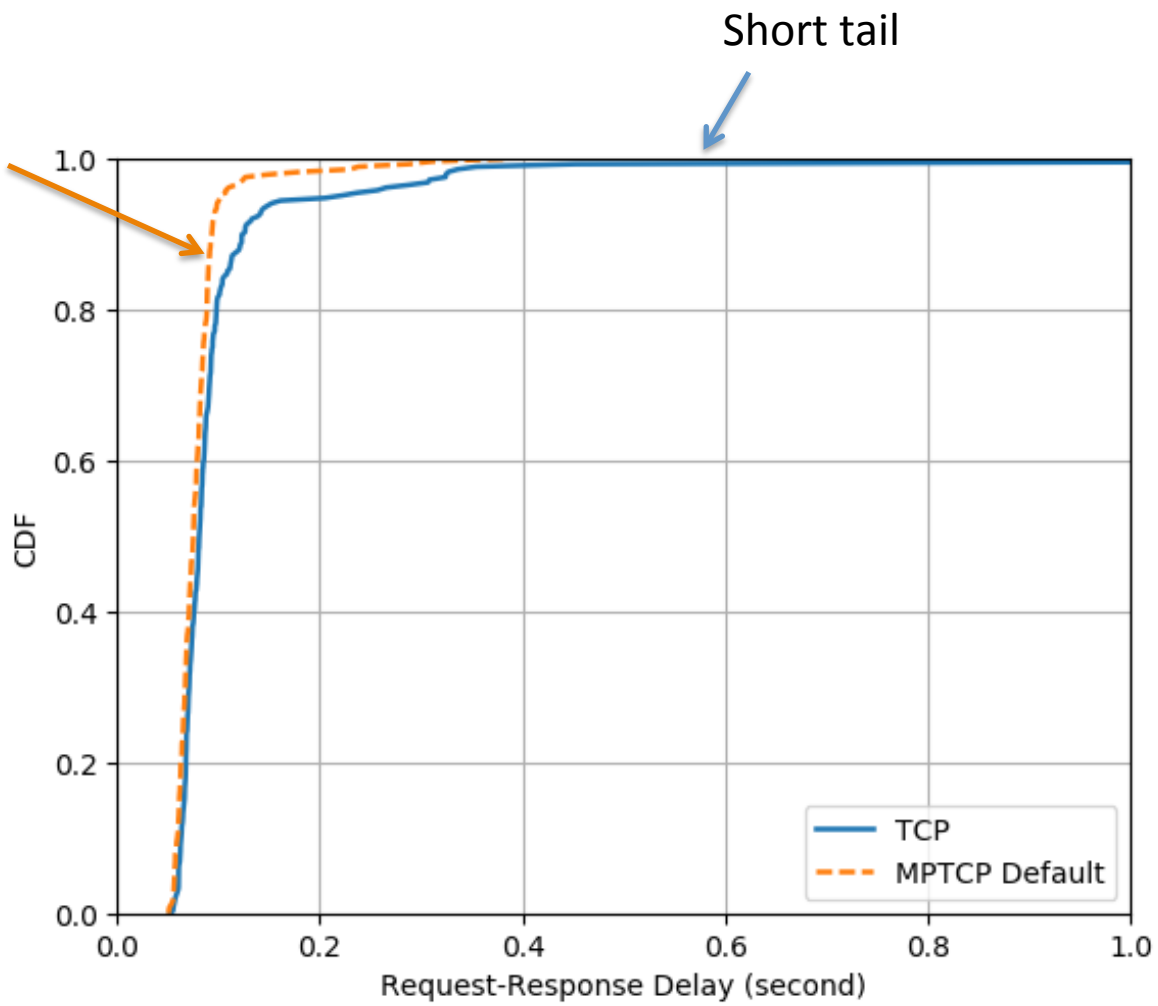




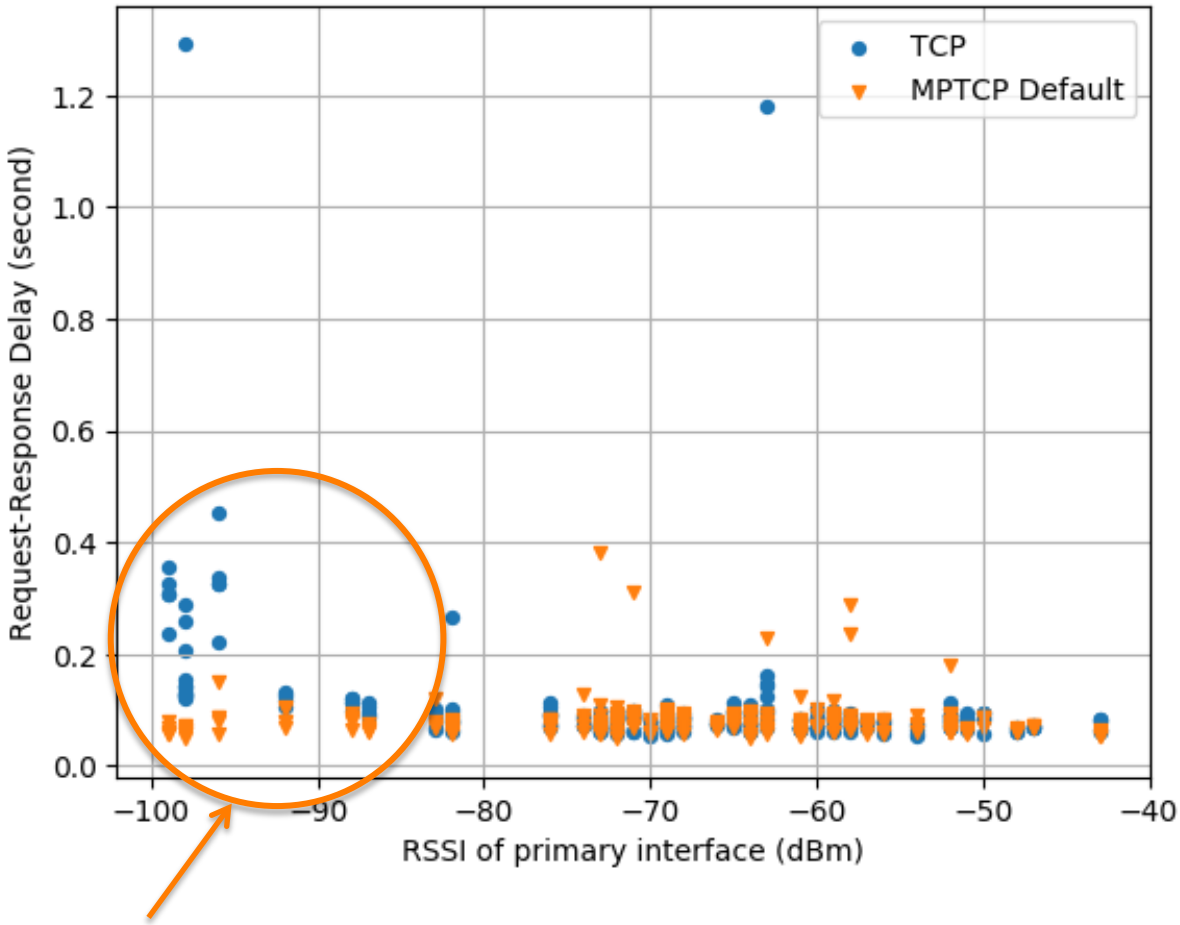
RESULTS
TCP VS. MPTCP

Stationary Nodes

MPTCP is better

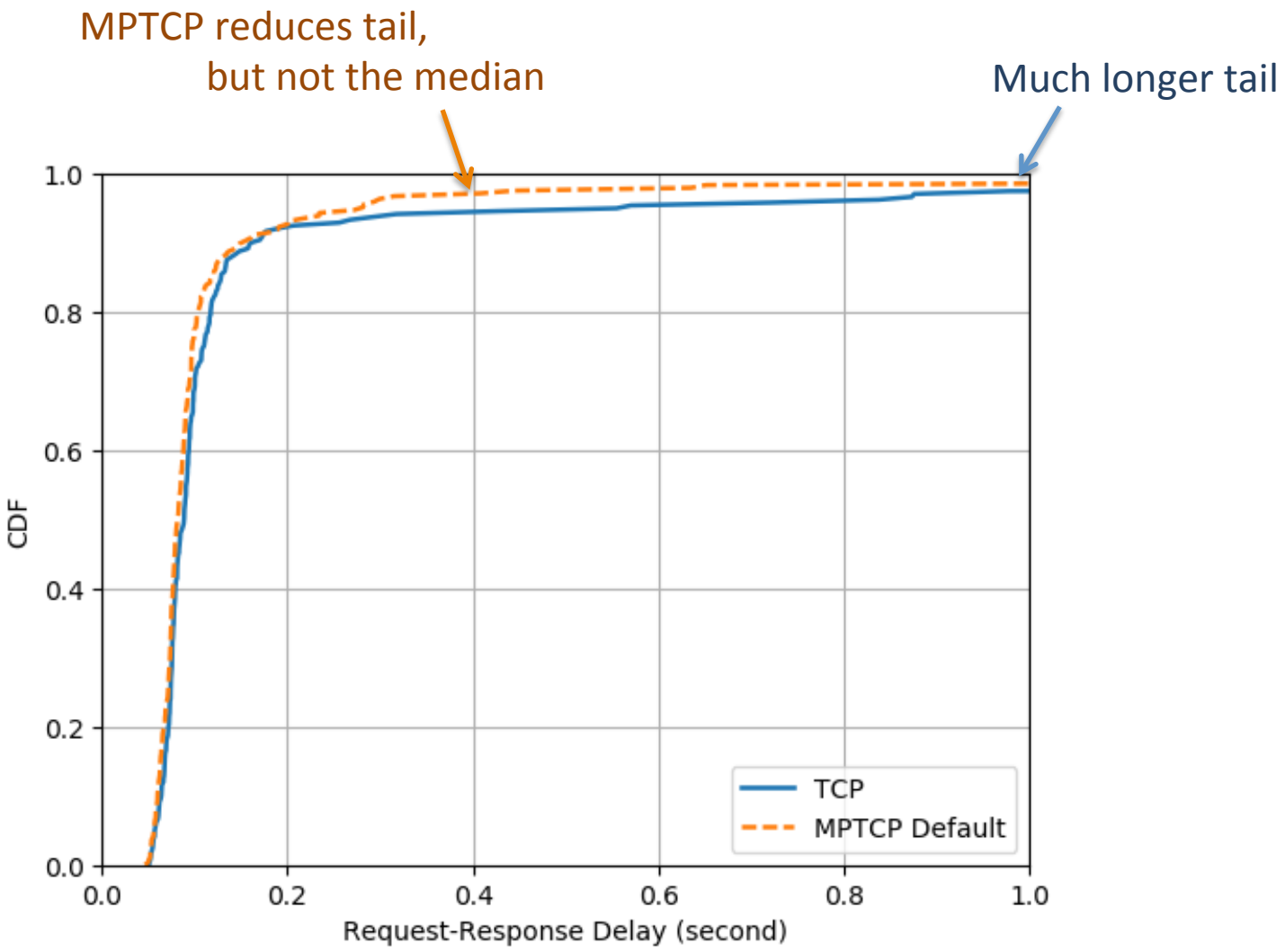


Delay vs. Signal strength (Stationary Nodes)

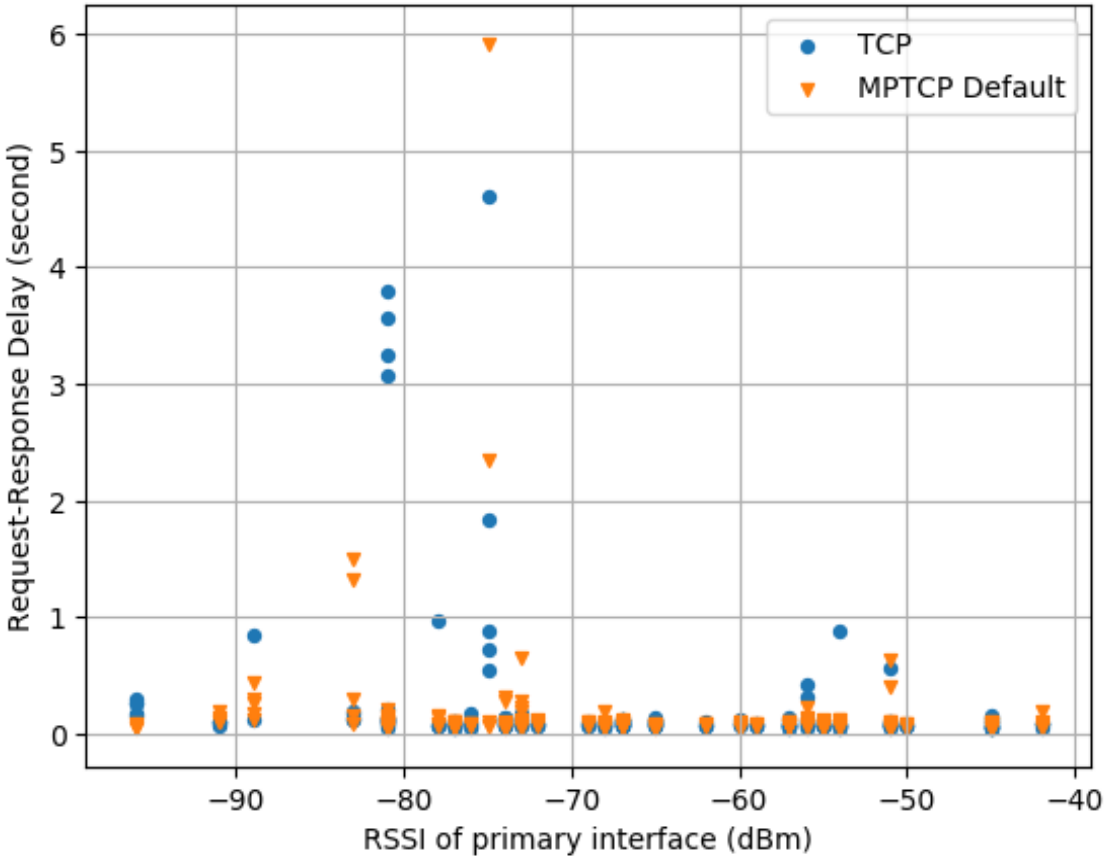


MPTCP reduces delay by switching path when default interface has bad signal

Mobile Nodes



Mobile Nodes



RESULTS
DIFFERENT MPTCP CONFIGURATIONS

Multipath TCP: packet scheduling

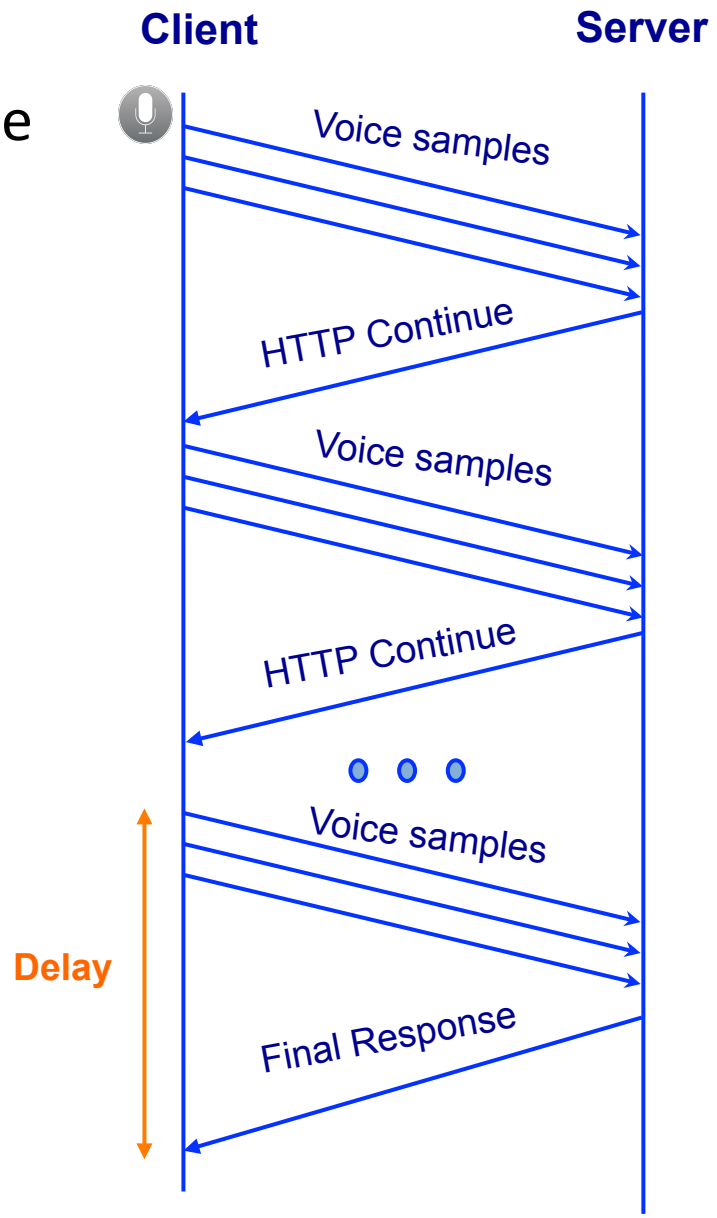
- **Default scheduler**:
  Select the subflow having Lowest RTT

- **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

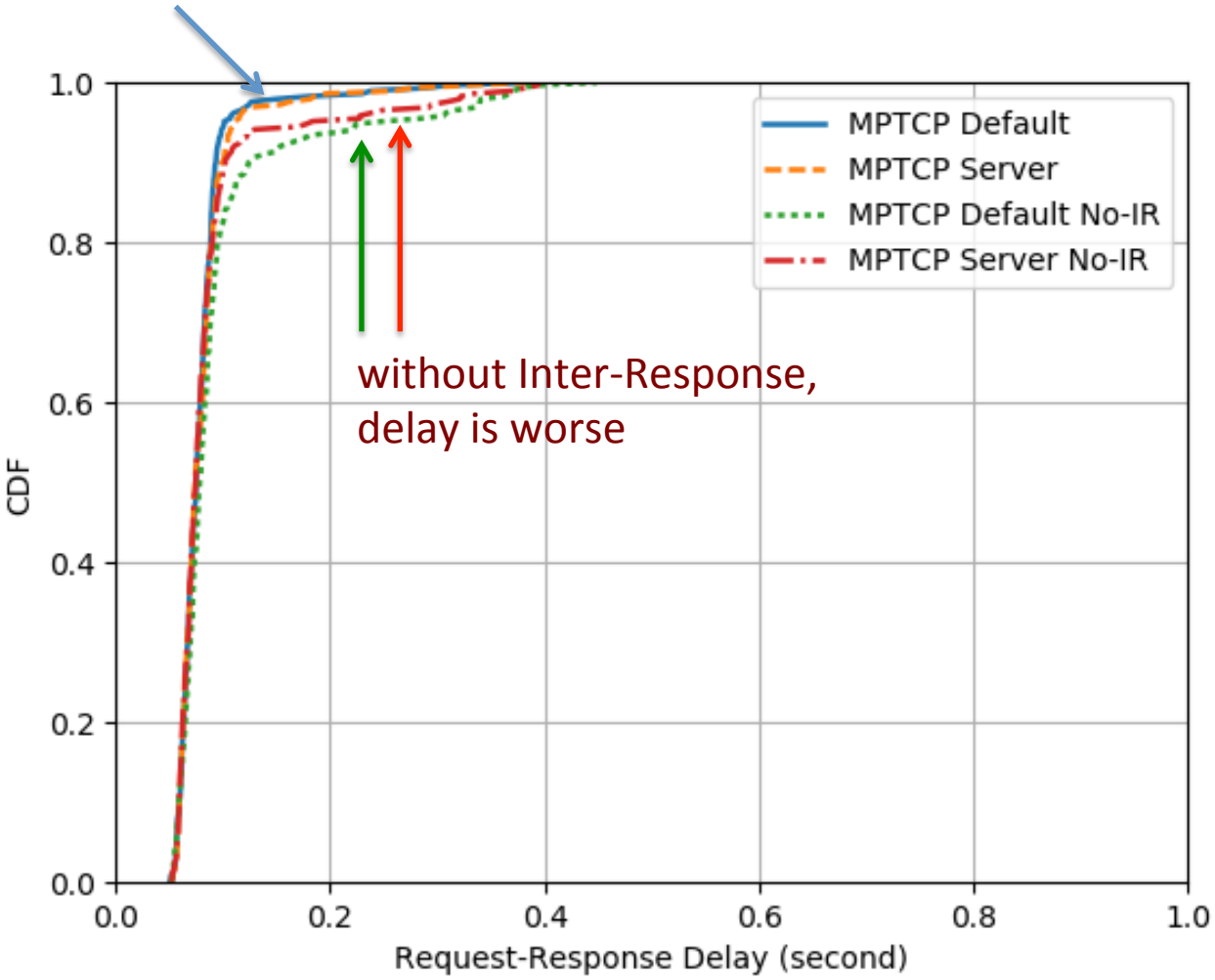
Siri servers send Intermediate Response (HTTP Continue) regularly.

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

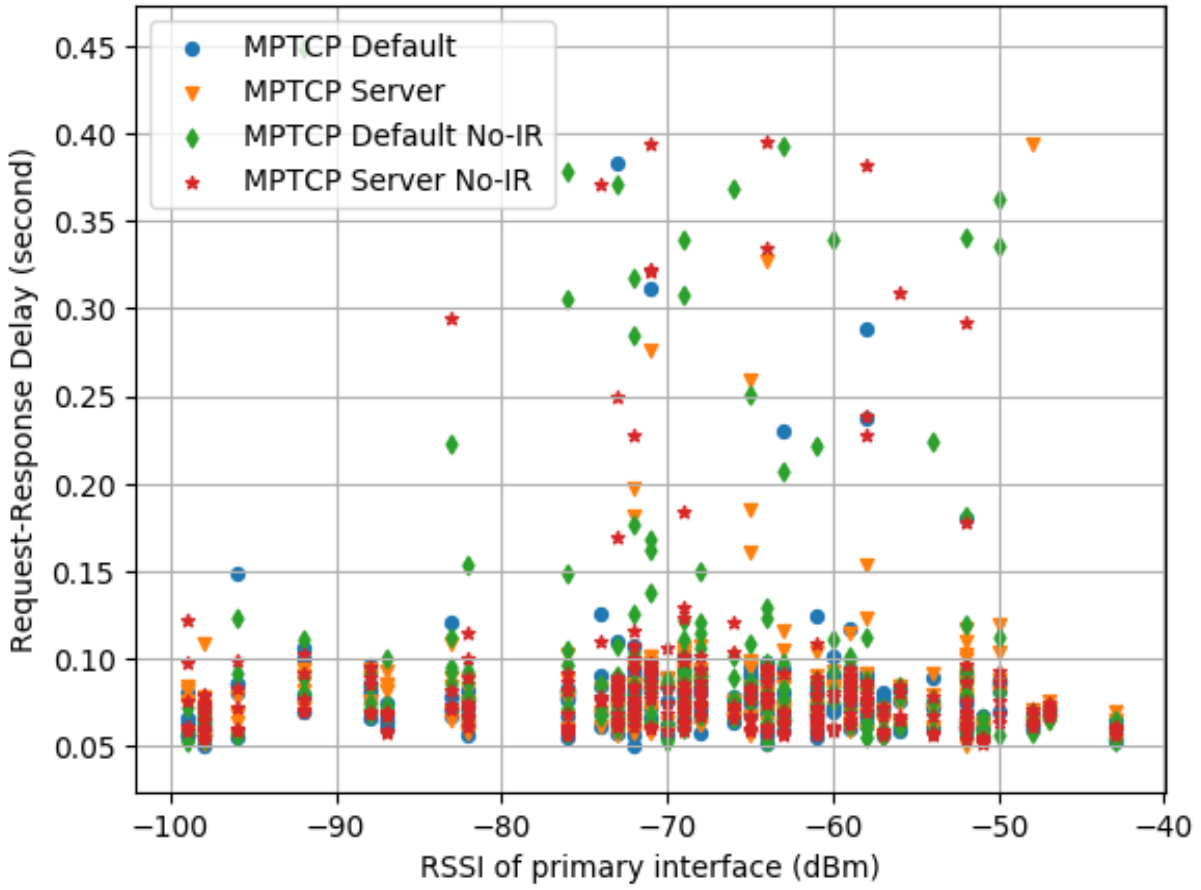


Stationary Nodes

No clear difference between
default scheduler and server scheduler

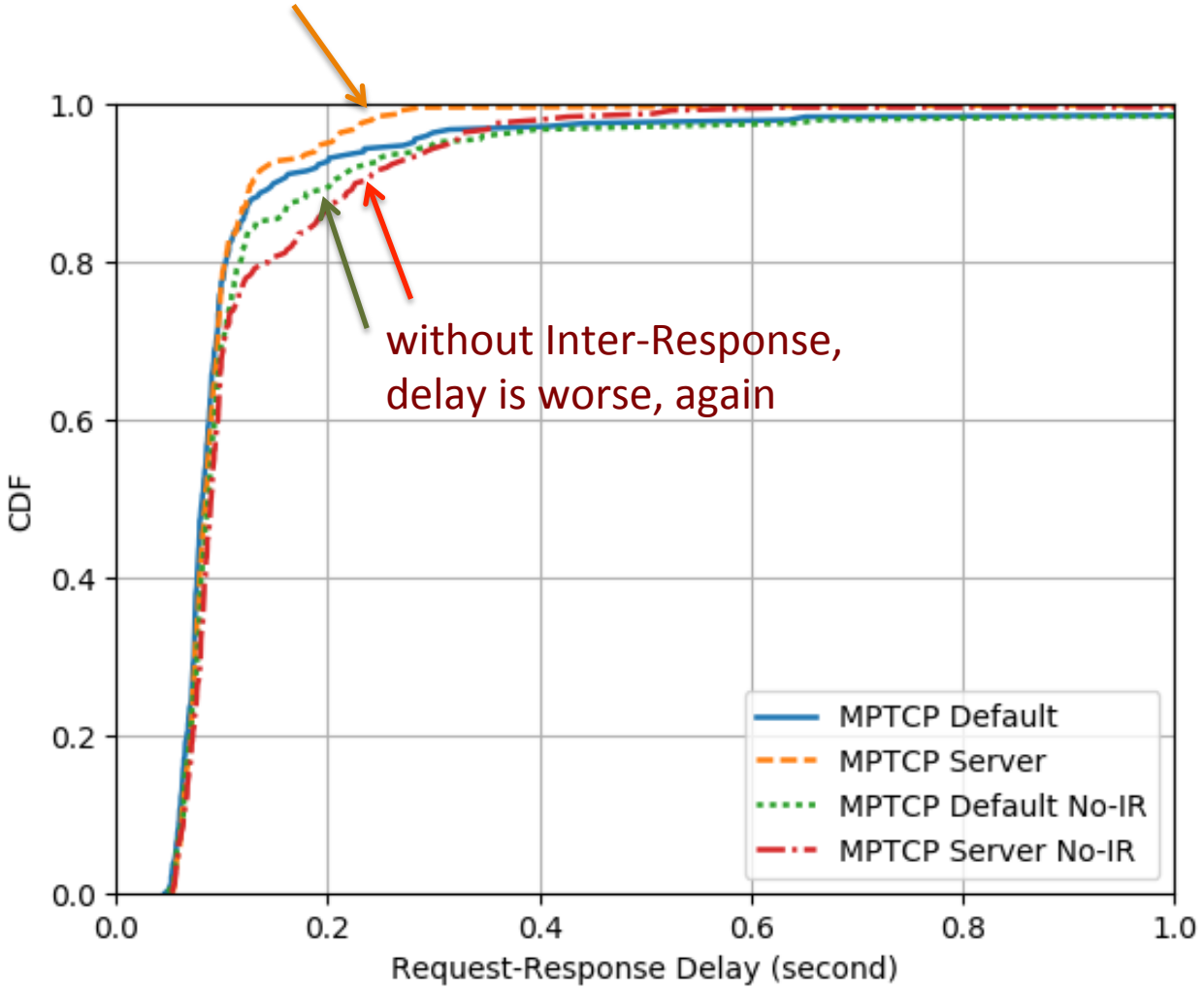


Stationary Nodes



Mobile Nodes

Server scheduler gives lowest delay, esp. the tail



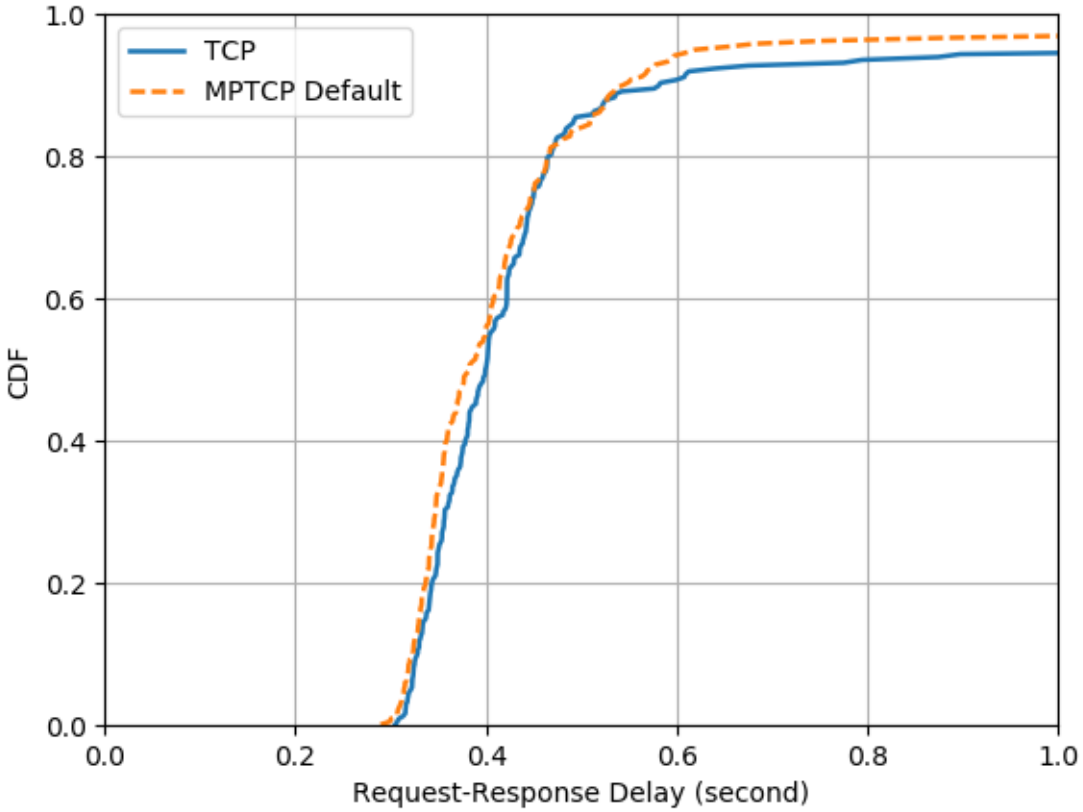
Conclusion

- 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

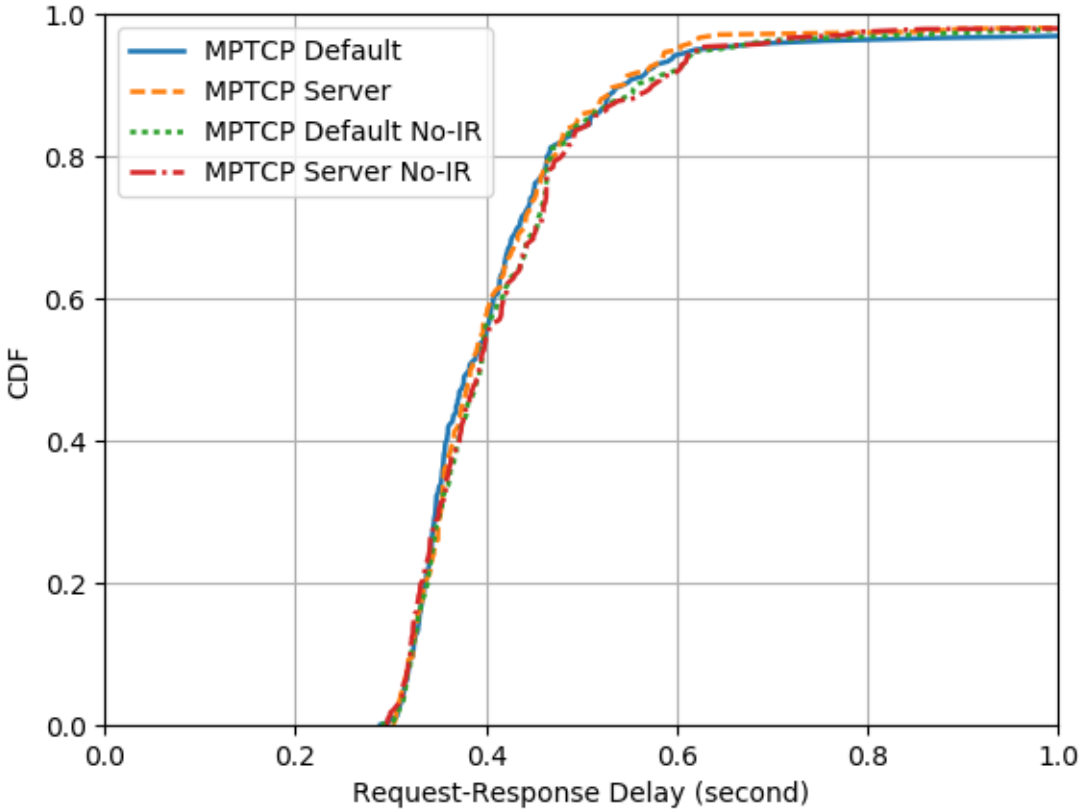
Any Question

- 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
- Contact: hoang.tran@uclouvain.be

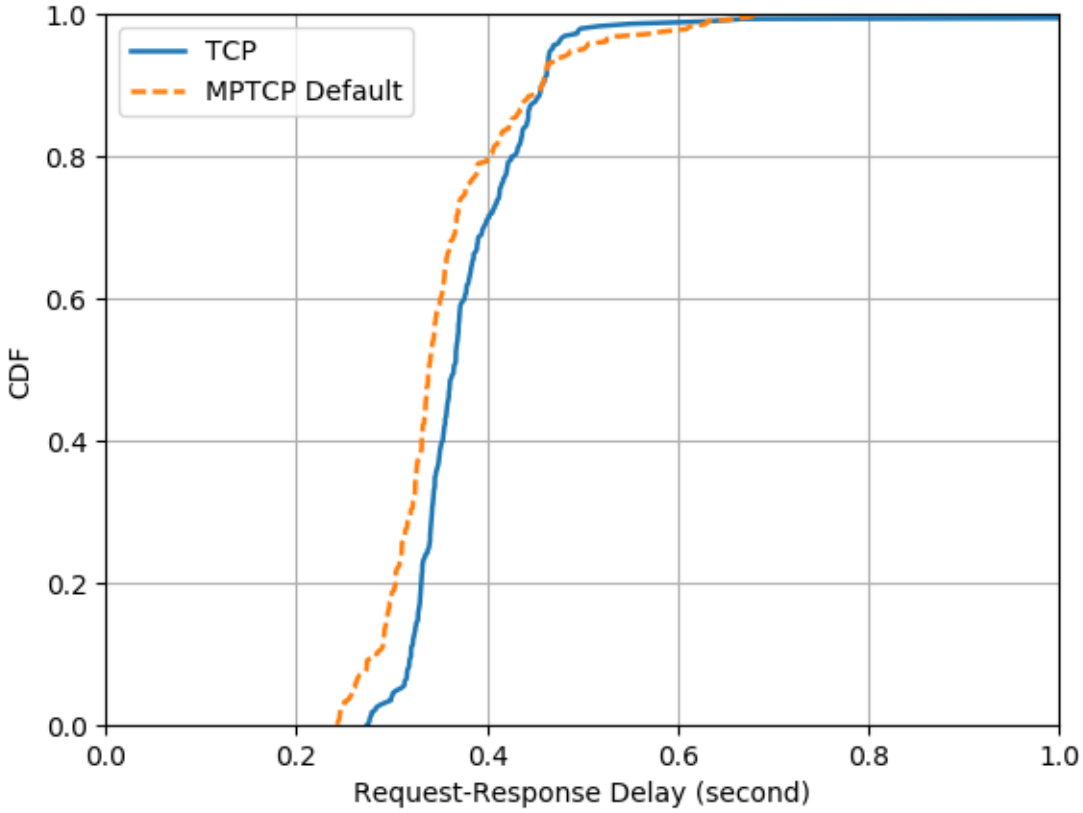
Japan server – mobile nodes



Japan server – mobile nodes



Japan server - stationary nodes



Japan server - stationary nodes