Enabling Multi-device Collaboration Using Distributed Mobile Multipath

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EECS 589 Midterm

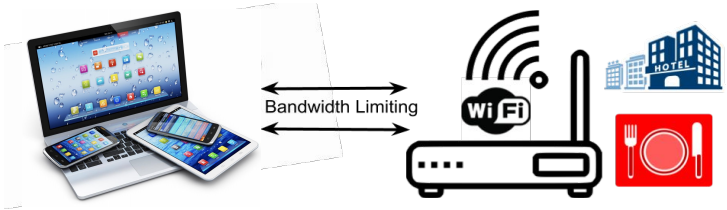
Blooming of mobile devices

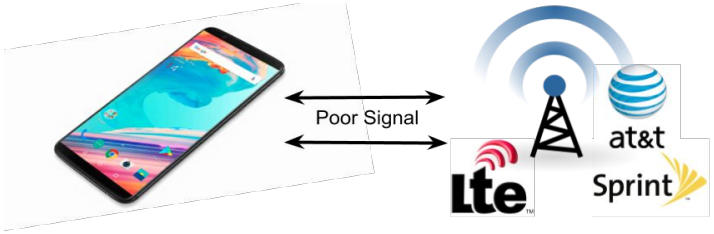
People routinely carry **more than one** smart devices like smartphones, laptops and smartwatches.

How is the performance?

Bad User QoS

- Public places like hotels and restaurants always limit ordinary users' **Wi-Fi bandwidth**.
- **LTE service fluctuates a lot** due to locations and time variations.





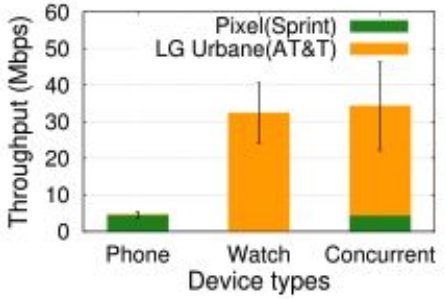
Preliminary Experiments

Conduct throughput and latency using different device sets:

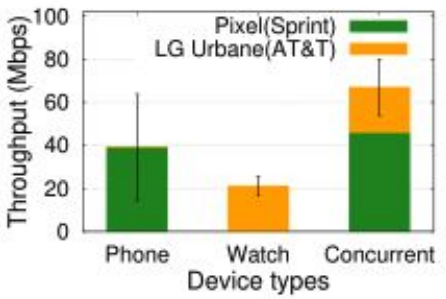
1) phone only;
2) watch only;
3) phone and watch concurrently.

Observation :

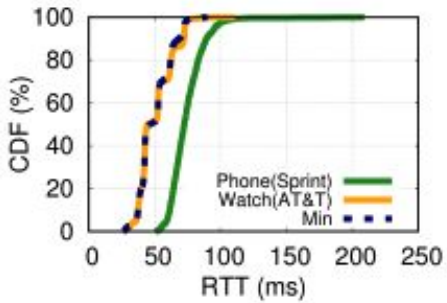
Neither of the carriers can consistently outperform the other at all places.



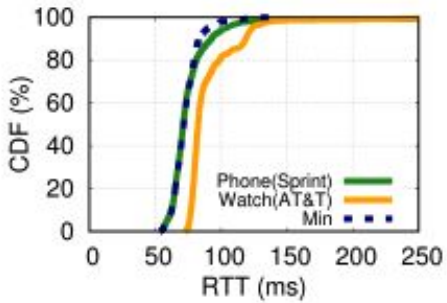
(a) Throughput at office



(b) Throughput at residence



(c) Latency at office

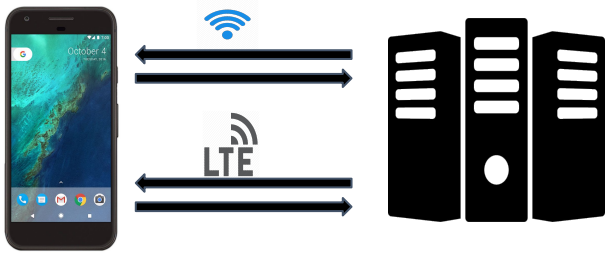


(d) Latency at residence

Preliminary Experiments

Can we leverage device-to-device collaborations to enhance network performance?

MPTCP is Not Enough

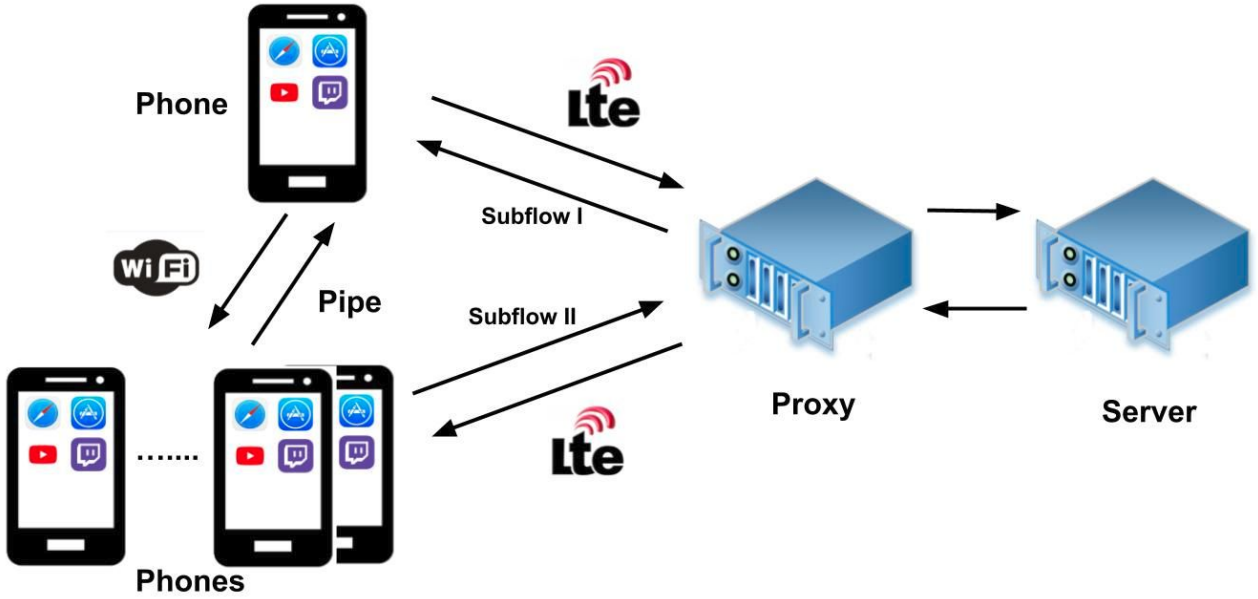


Multipath TCP [1] is the de facto multi-path solution that enables simultaneous use of multiple network paths (a.k.a.subflows).

Interfaces reside on different mobile hosts, directly applying MPTCP is difficult.

[1]Alan Ford, Costin Raiciu, Mark Handley, and Olivier Bonaventure. 2013.
TCP extensions for multipath operation with multiple addresses.Technical Report

Distributed Mobile Multipath (DMM)

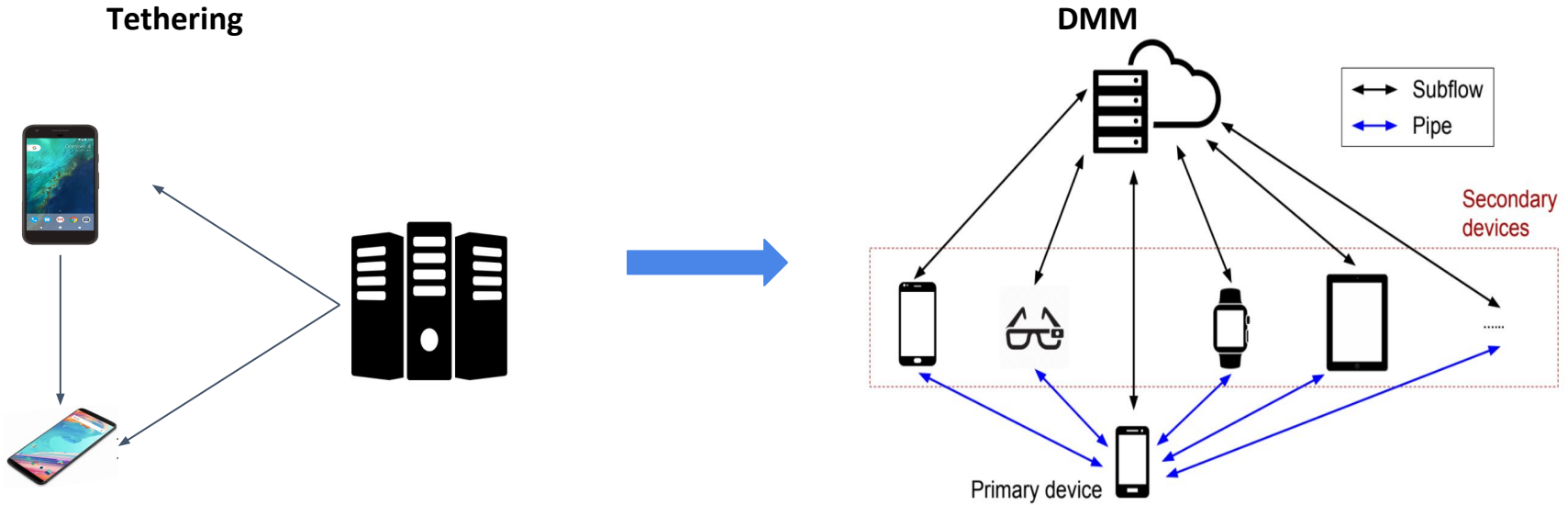


Why not Tether?

- Tethering is limited by 2 devices collaboration.
- Tethering suffers from low bandwidth utilization.
- Tethering hinders management on the second device.

Why not Tether?

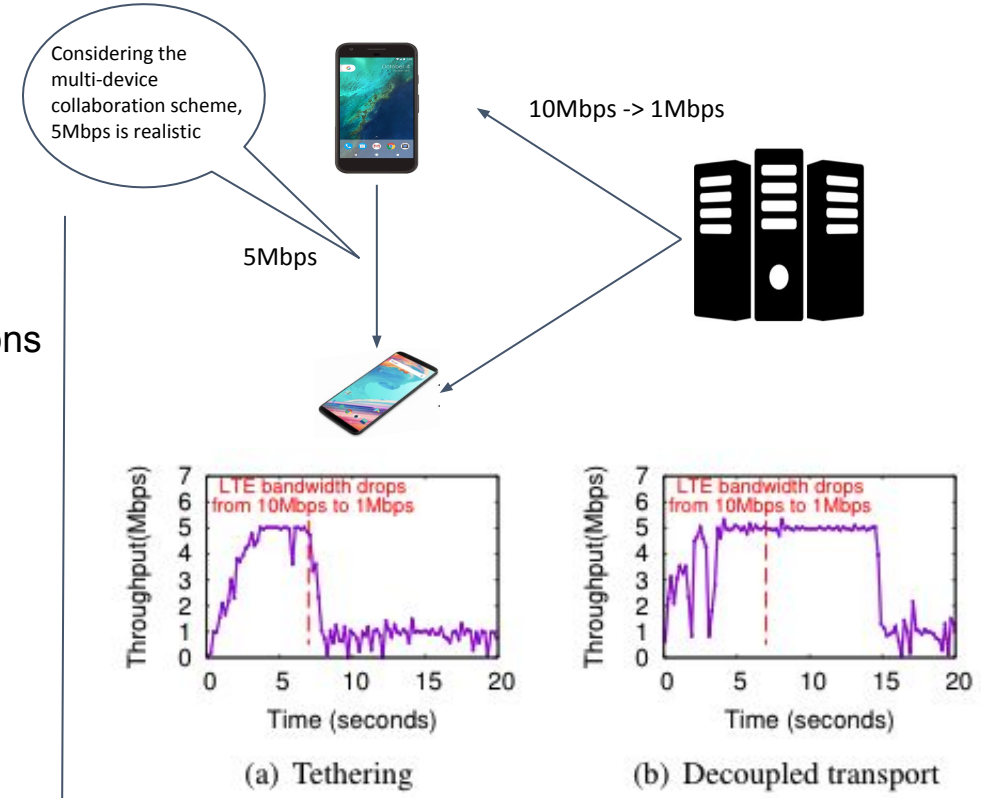
- Experiments on high-end smartphones shows tethering is limited by 2-device collaboration



Why not Tether?

- **Tethering[1,2] suffers from low bandwidth utilization**
  - ❖ Under changing network conditions
  - ❖ Under bandwidth asymmetry

- Tethering's blind packet forwarding at Layer 3 hinders various policies and transport-layer enhancements.



[1] Lim, Yeon-sup, et al. "Design, implementation, and evaluation of energy-aware multi-path TCP." Proceedings of the 11th ACM Conference on Emerging Networking Experiments and Technologies. ACM, 2015.

[2] Nicutar, Cătălin, Dragoş Niculescu, and Costin Raiciu. "Using cooperation for low power low latency cellular connectivity." Proceedings of the 10th ACM International on Conference on emerging Networking Experiments and Technologies. ACM, 2014.

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➔ Tethering approach use a static configuration, **DMM instead allows the pipe dynamically select based on network conditions.**

➔ When connection is lost, tethering approach will lose all state information, **DMM instead can maintain the transport-layer states (e.g. buffered packets).**

[1] Lim, Yeon-sup, et al. "Design, implementation, and evaluation of energy-aware multi-path TCP." Proceedings of the 11th ACM Conference on Emerging Networking Experiments and Technologies. ACM, 2015.
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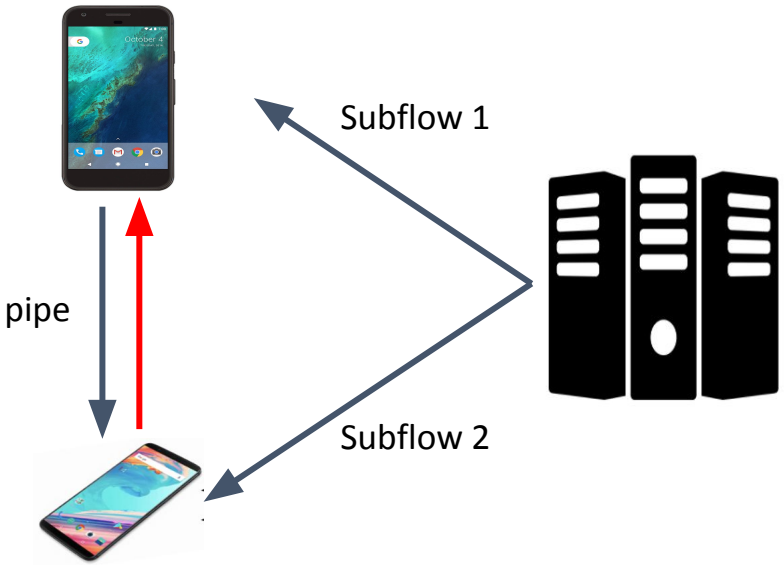
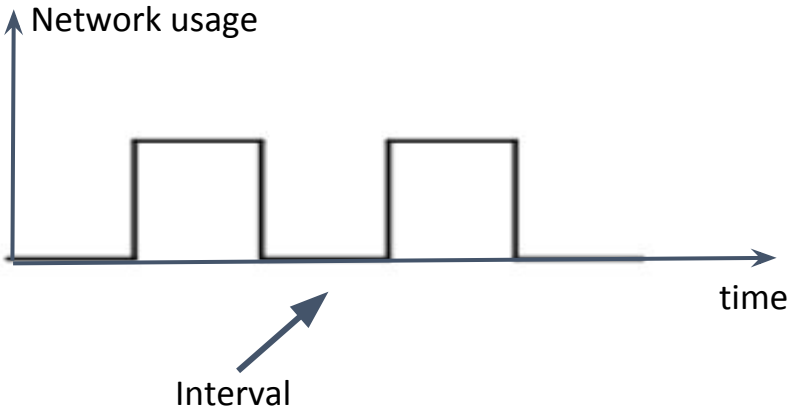
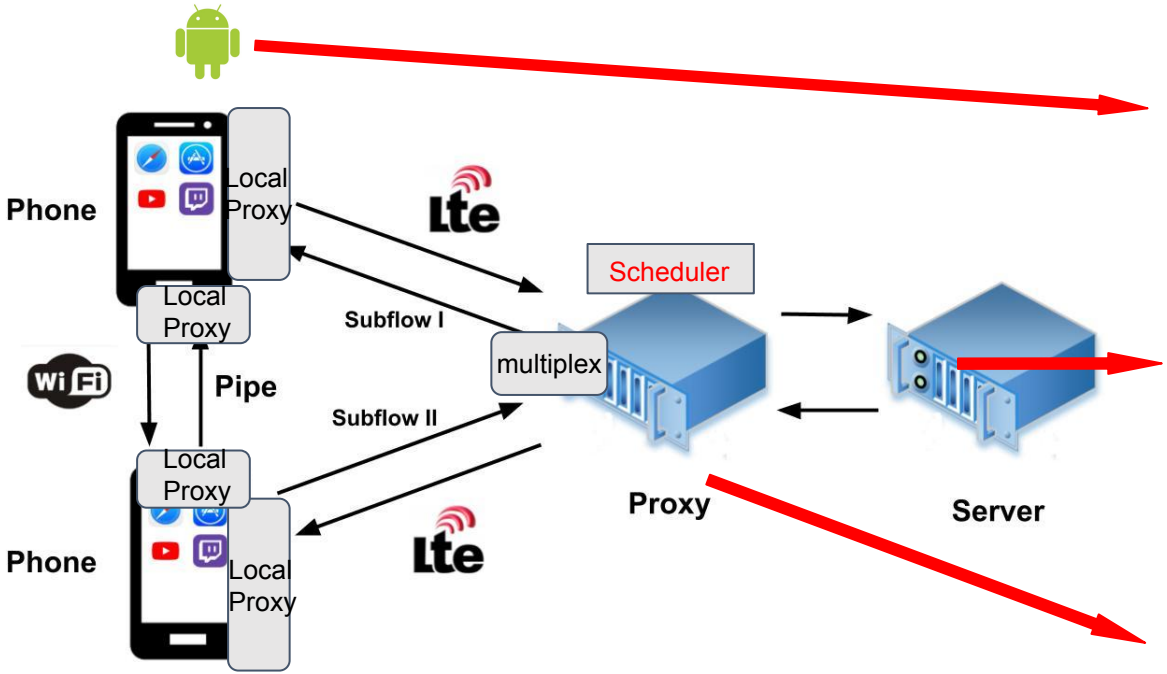
Dual Mode Pipe Management



- Both devices can be primary devices
- In web browsing and video streaming traffic, each request will have interval time
- Leverage smart scheduler to stagger the traffic



Current Progress



In the design and test phase, we implement a client App for bulk transferring.

In the design and test phase, we implement a server for above client.

Since most commercial servers do not support multipath network, we have to implement a proxy to make the whole system transparent to server.

How will we evaluate our solution?

- Basic Functionality
  - *Throughput for both delay-tolerant and delay-sensitive traffic.*
- Performance Improvement
  - *Synthetic traffic: bulk transfer, constant bitrate traffic.*
  - *Real Apps: web browsing, video streaming, and livecast.*
- Micro-benchmarks
  - *Different working modes.*
- Overhead
  - *Energy consumption.*