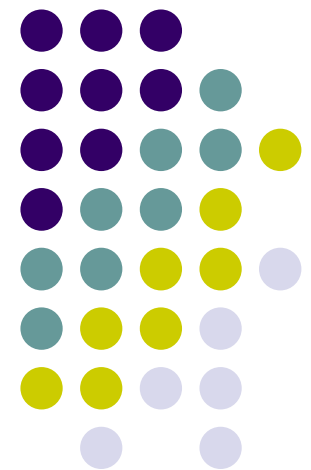# CS 525M Mobile and Ubiquitous Computing
Making use of all networks around us:
a case study in android

Emmanuel Agu

Best Selling Phone in 2012

- Multiple wireless interfaces
  - 3G/4G cellular
  - WiFi
  - Bluetooth
- Mobile device just picks one network interface
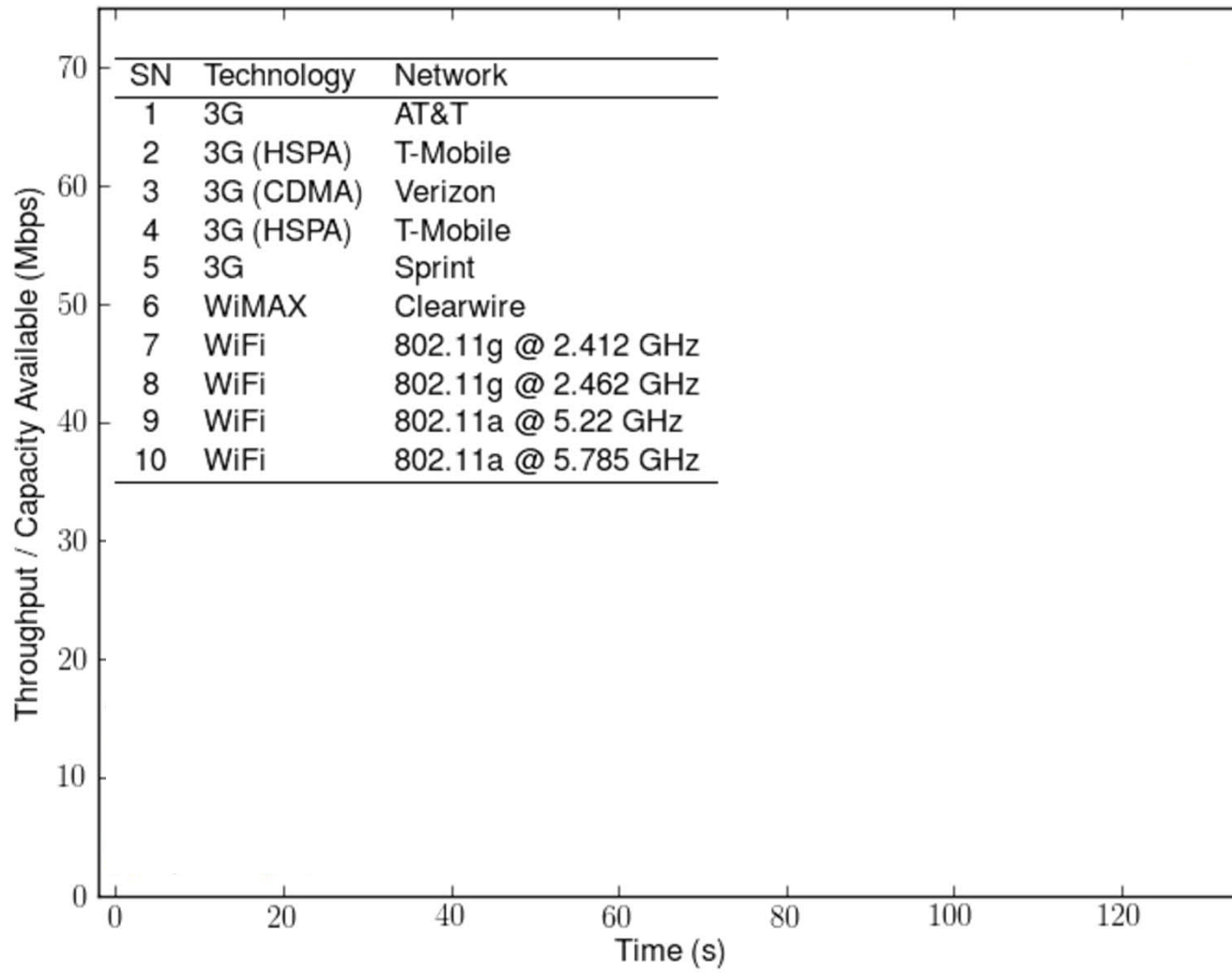- Choice may not be most cost/energy efficient
- Cannot combine interfaces

Samsung Galaxy S3

2G, 3G UMTS/HSPA+, LTE

WiFi, Bluetooth

How much bandwidth can we get?

SN	Technology	Network
1	3G	AT&T
2	3G (HSPA)	T-Mobile
3	3G (CDMA)	Verizon
4	3G (HSPA)	T-Mobile
5	3G	Sprint
6	WiMAX	Clearwire
7	WiFi	802.11g @ 2.412 GHz
8	WiFi	802.11g @ 2.462 GHz
9	WiFi	802.11a @ 5.22 GHz
10	WiFi	802.11a @ 5.785 GHz

Throughput / Capacity Available (Mbps) vs Time (s)

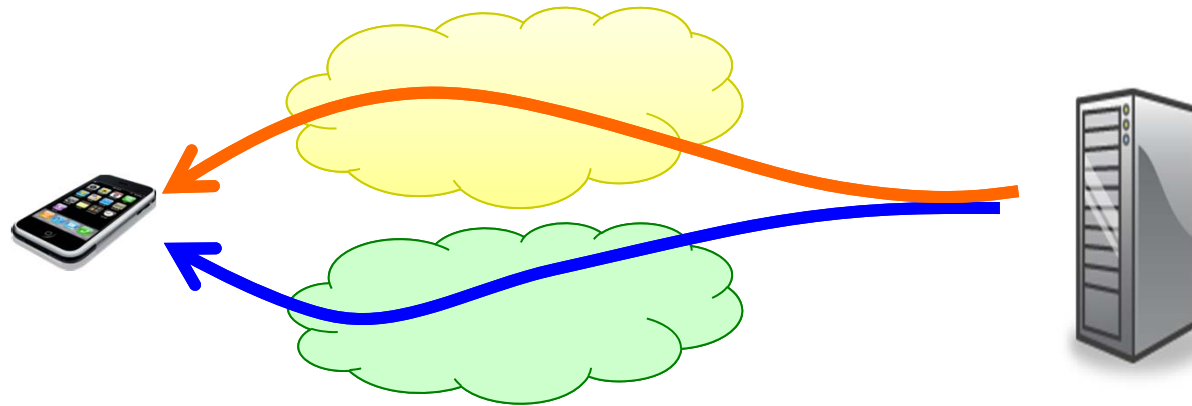# Why should we use multiple networks?

- Higher data rate for end user
- Uninterrupted connectivity
- Better energy efficiency
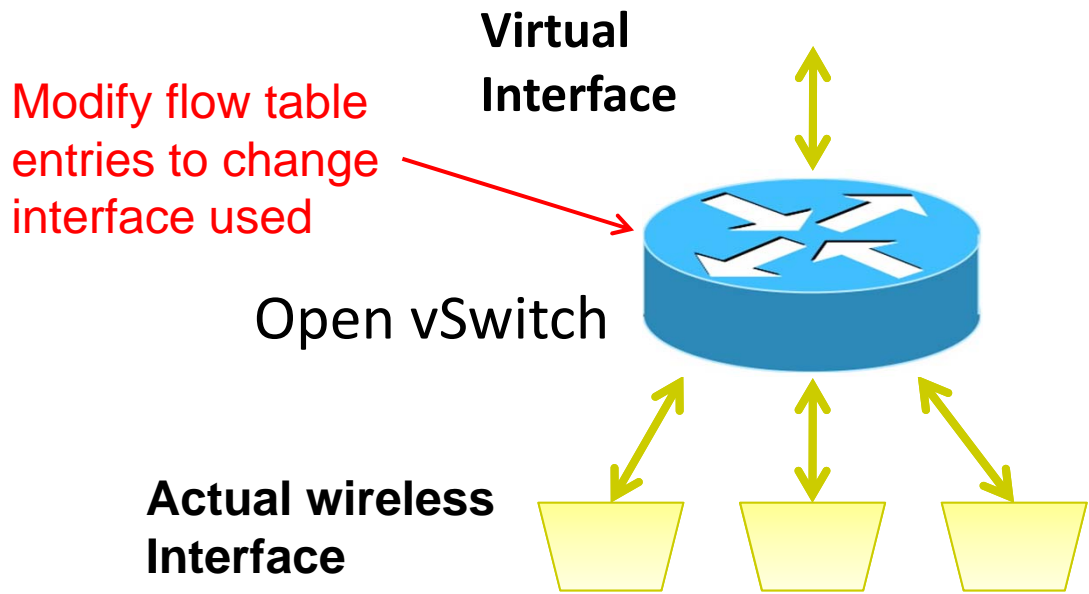- Lower cost
- Less packet loss
- Lower delay

Main Technical Challenge

- Once TCP flow is set up, cannot migrate from one network interface to another (e.g. WiFi to bluetooth)
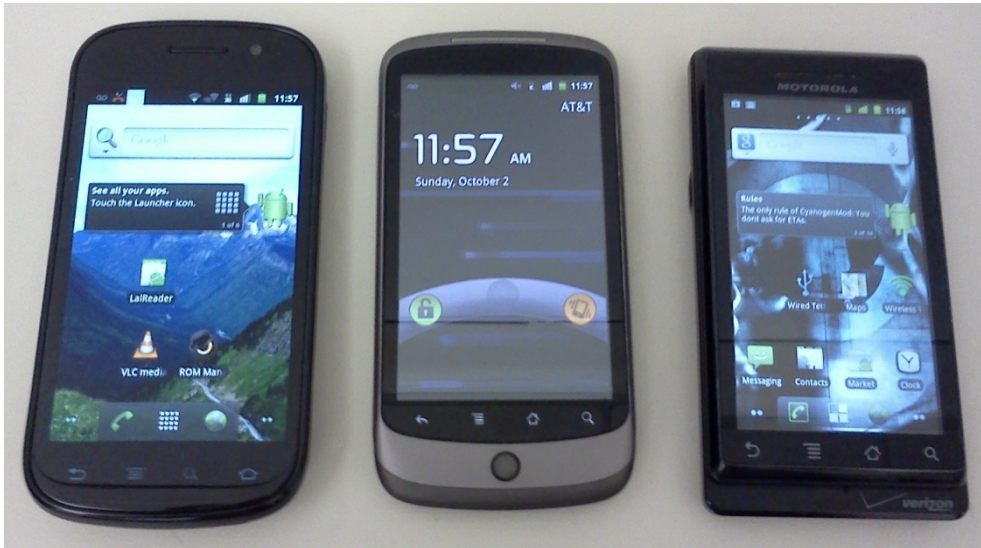
Proposed Solution

Android Applications

Android

Control Plane

Virtual Interface

Modify flow table entries to change interface used

Open vSwitch

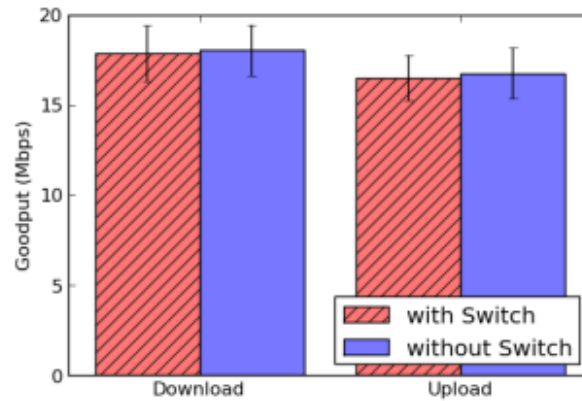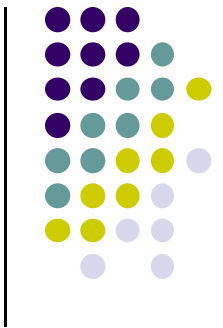**Actual wireless Interface**

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Experimental Setup

- Configured 3 smartphones, different hardware, cellular network providers, WiMax

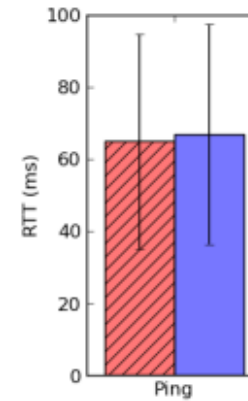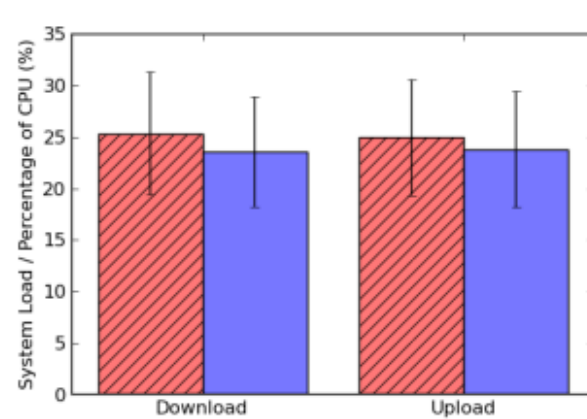- Laptop for testing up to 10 simultaneous connections

Results

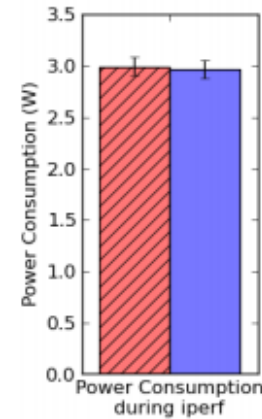- Overhead of switching (minimal)

(a) Throughput benchmark

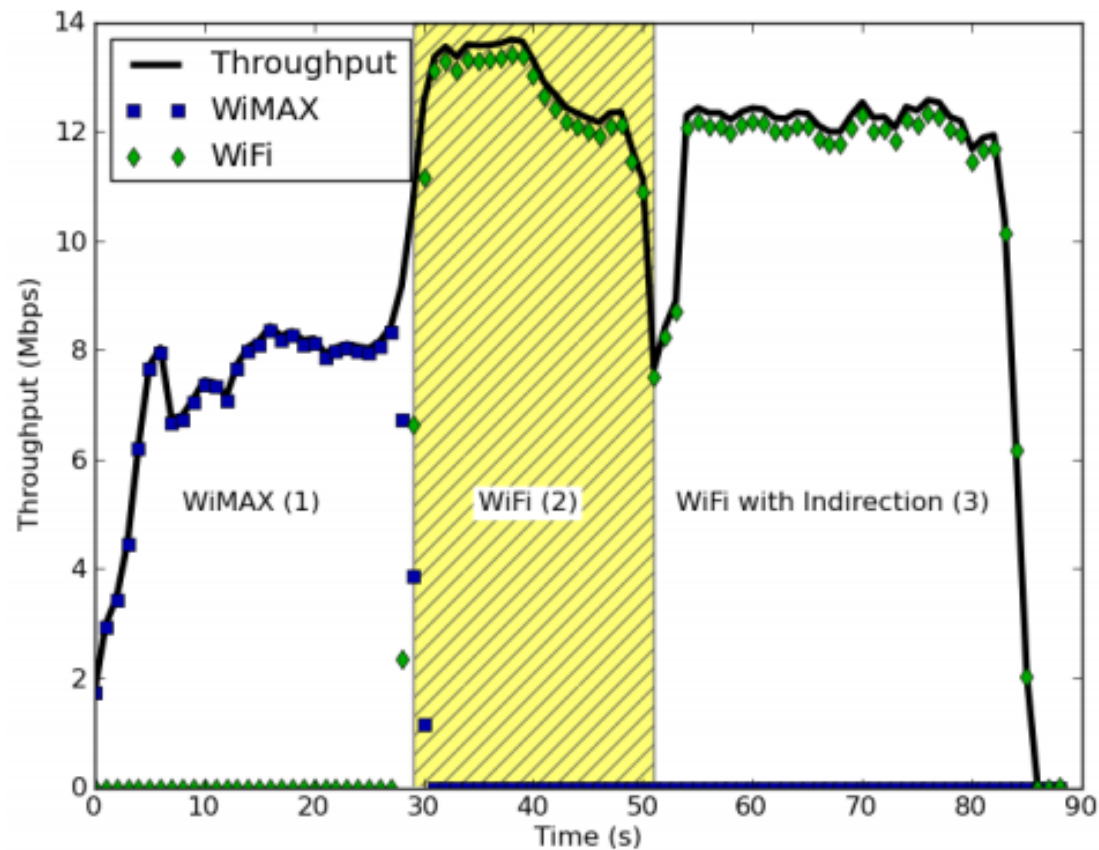(b) RTT benchmark

(c) System Load benchmark
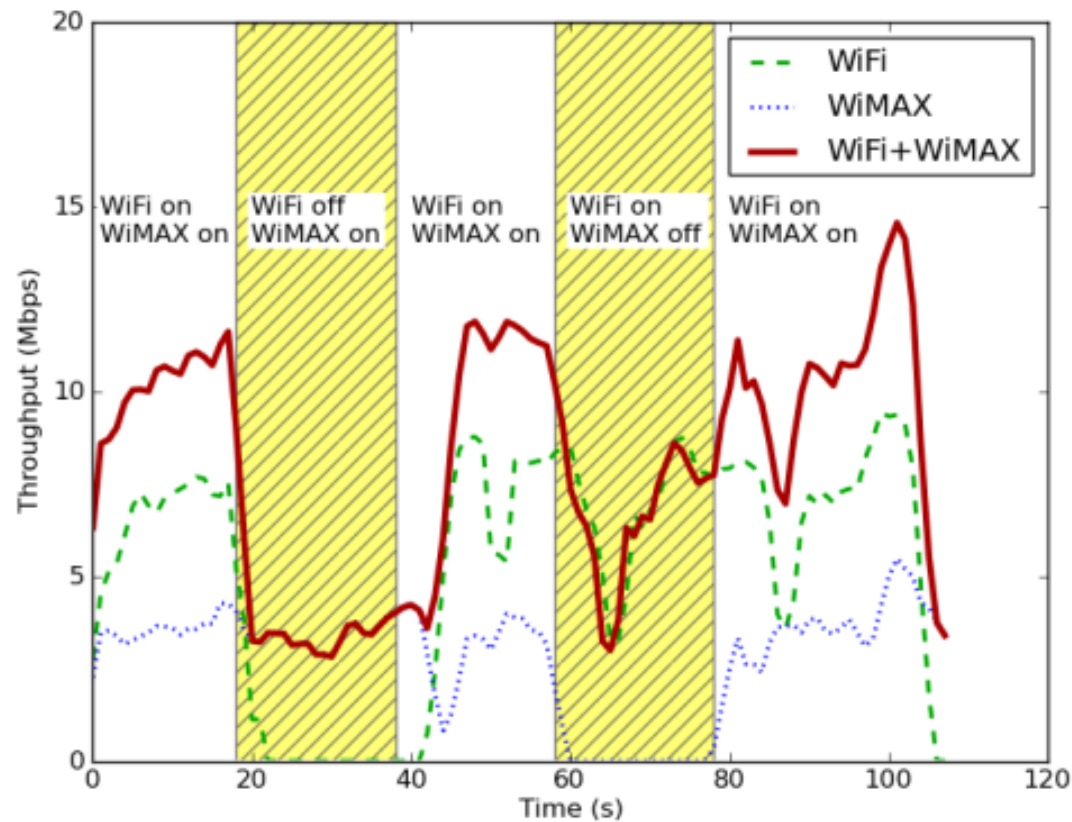
(d) Power benchmark

Results

- Throughput when switching networks during http transfer
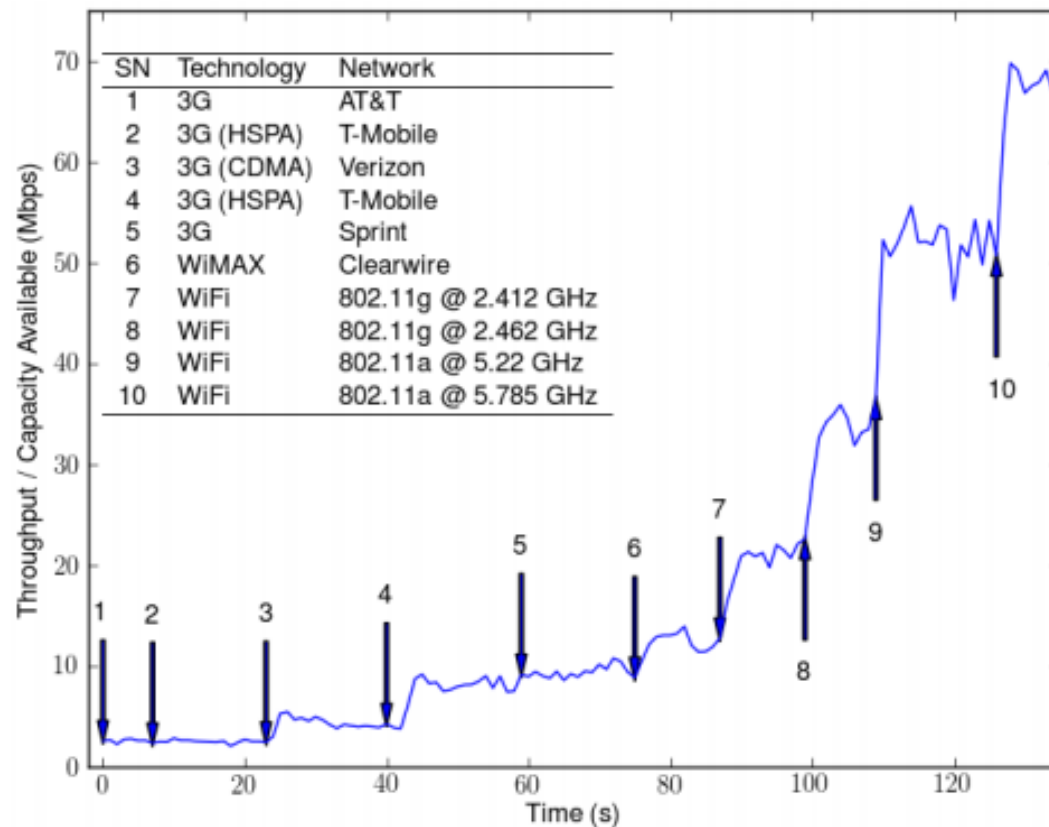
Results

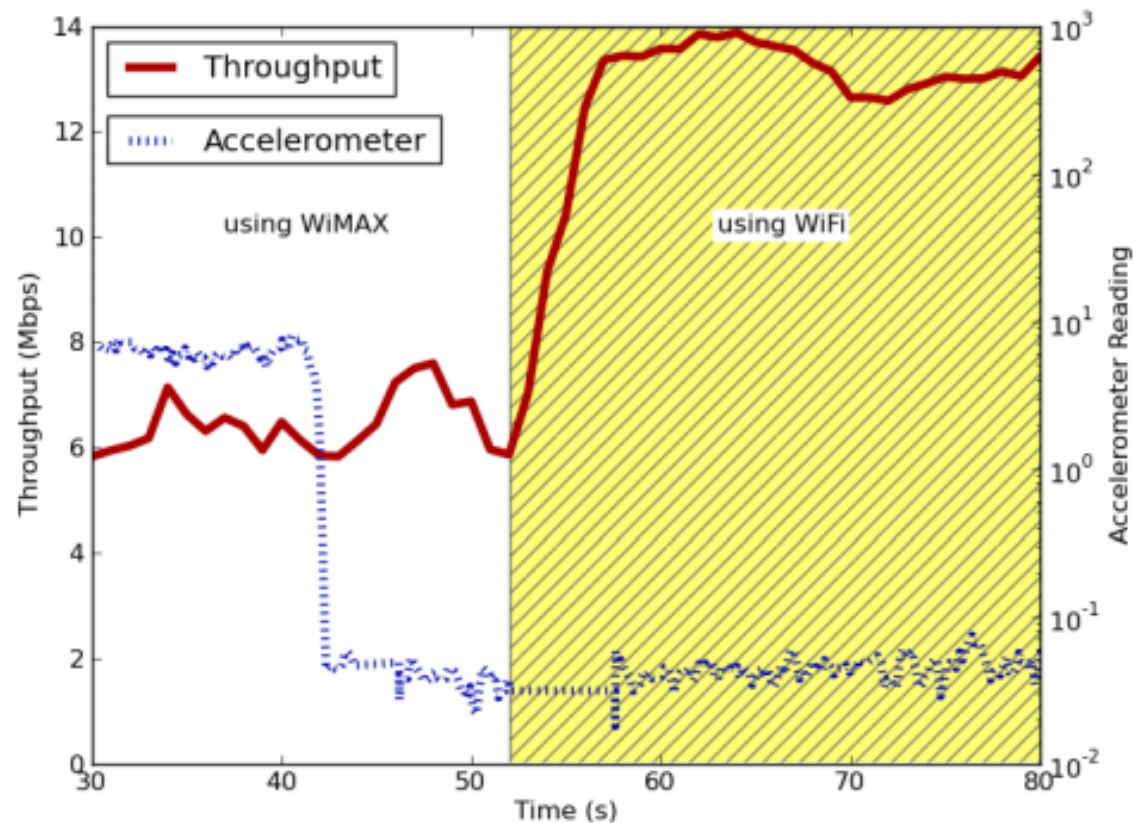- Throughput when switching 2 networks on/off during 100MB file transfer

Results

- Throughput when stitching up to 10 networks on laptop
(4 wireless technologies, 6 commercial providers)

Results

- Throughput when switching from WiMax to WiFi when device stops moving (accelerometer to detect motion)

Related Work

- Multipath Transport Protocols (e.g. TCP migrate)
  - Allow TCP flow migration without breaking connection

- Wireless network performance optimizations
  - E.g. using geolocation or user-specified information

- Multi-SIM (multi-provider) phones in foreign countries (e.g. India)

- FatVP: aggregates bandwidth from multiple neighboring APs

Conclusions

- Their prototype achieved

  1. Handover an ongoing TCP connection without re-establishing state

  2. Stitch multiple interfaces together for higher throughput

  3. Dynamically choose interfaces to minimize loss, delay, power consumption or usage charges

- Demonstrated refactored client network stack can achieve goals without changing fixed infrastructure

References

- Making use of all the networks around us: a case study in android. Kok-Kiong Yap, Te-Yuan Huang, Masayoshi Kobayashi, Yiannis Yiakoumis, Nick McKeown, Sachin Katti, and Guru Parulkar. 2012. In *Proceedings of the 2012 ACM SIGCOMM workshop on Cellular networks: operations, challenges, and future design* (CellNet '12). ACM, New York, NY, USA, 19-24.