Augmenting Mobile 3G Using WiFi

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Demand for mobile access growing

www.totaltele.com

Mobile data traffic growth 10 times faster than fixed over next five years – Nokia Siemens

By Nick Wood , Total Telecom, in Paris
Monday 07 September 2009

Network providers need to establish closer relationship with end -users to enable operators to optimise customer experience.

http://www.readwriteweb.com

Mobile Web's Explosive Growth

Written by Sarah Perez / October 29, 2009 7:15 AM / 10 Comments

Mobile ad firm AdMob has re
industry has seen in their lat
this morning. Believe it or no

900 million mobile broadband subscriptions today. Projected to increase to 4 billion by 2013

www.3gamericas.org

Mobile demand is projected to far exceed capacity

www.rysavy.com

Current spectrum	409.5 MHz
Unallocated spectrum (including whitespaces)	230 MHz
Projected demand by 2016	**800 MHz – 1000 MHz**

www.nytimes.com

Customers Angered as iPhones Overload AT&T

By JENNA WORTHAM
Published: September 2, 2009

Slim and sleek as it is, the iPhone is really the Hummer of cellphones.

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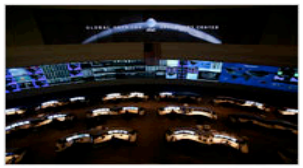

Michael Appleton for The New York Times

AT&T monitors its network from its operations center in Bedminster, N.J.
More Photos »

Multimedia

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AT&T Races to Expand the Network

It's a data guzzler. Owners use them like minicomputers, which they are, and use them a lot. Not only do iPhone owners download applications, stream music and videos and browse the Web at higher rates than the average smartphone user, but the average iPhone owner can also use 10 times the network capacity used by the average smartphone user.

"They don't even realize how much data they're using," said Gene Munster, a senior securities analyst with Piper Jaffray.

The result is dropped calls, spotty service, delayed text and voice messages and glacial download speeds as AT&T's cellular network strains to meet the demand. Another result is outraged customers.

Cellphone owners using other carriers may gloat now, but the problems of AT&T and the iPhone portend their future. Other networks could be stressed as well as more sophisticated phones encouraging such intense use become popular, analysts say.

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www.nytimes.com

"In light of the limited natural resource of spectrum, we have to look at the ways of conserving spectrum" -- Mark Siegel (AT&T)

Reducing cellular spectrum usage is key!

How can we reduce spectrum usage?

1. Behavioral

blogs.chron.com

December 10, 2009

AT&T wants to 'educate' you about data usage

Any time a business announces that it needs to "educate" its customers about their behavior, you'd best check your wallet, because someone's going to be reaching for it.

2. Economic

www.usatoday.com

New AT&T smartphone users won't get one-price Net

Updated 1h 36m ago | Comments 76 | Recommend 8 E-mail | Save | Print | Reprints & Permissions | RSS

By David Lieberman, USA TODAY

Share

AT&T, wireless provider for Apple's iPhone, on Monday will become the first major mobile

Yahoo! Buzz

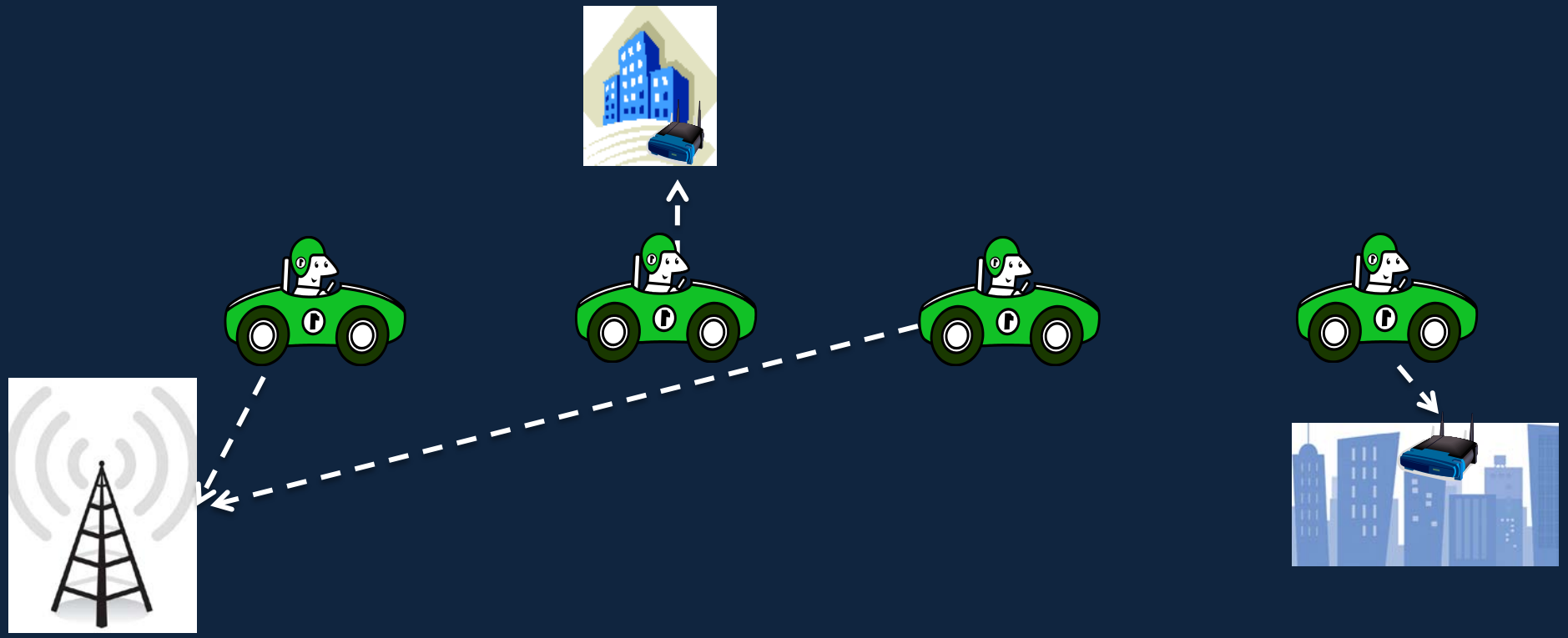
3. Technical

Augmenting Mobile 3G using WiFi

Offload data to WiFi when possible

We look at vehicular mobility

Offloading 3G data to WiFi



1. How much 3G data can be offloaded to WiFi?
2. Can the offload be performed without affecting apps?

Contributions

Measurement : Joint study of 3G and WiFi connectivity to study if WiFi can usefully augment 3G.

- Conducted across three cities

Protocol design: Wiffler, a system to offload data to WiFi with respect to application constraints

- Deployed on 20 vehicles

Measurement set up

Vehicular nodes with 3G and WiFi (802.11b) radios

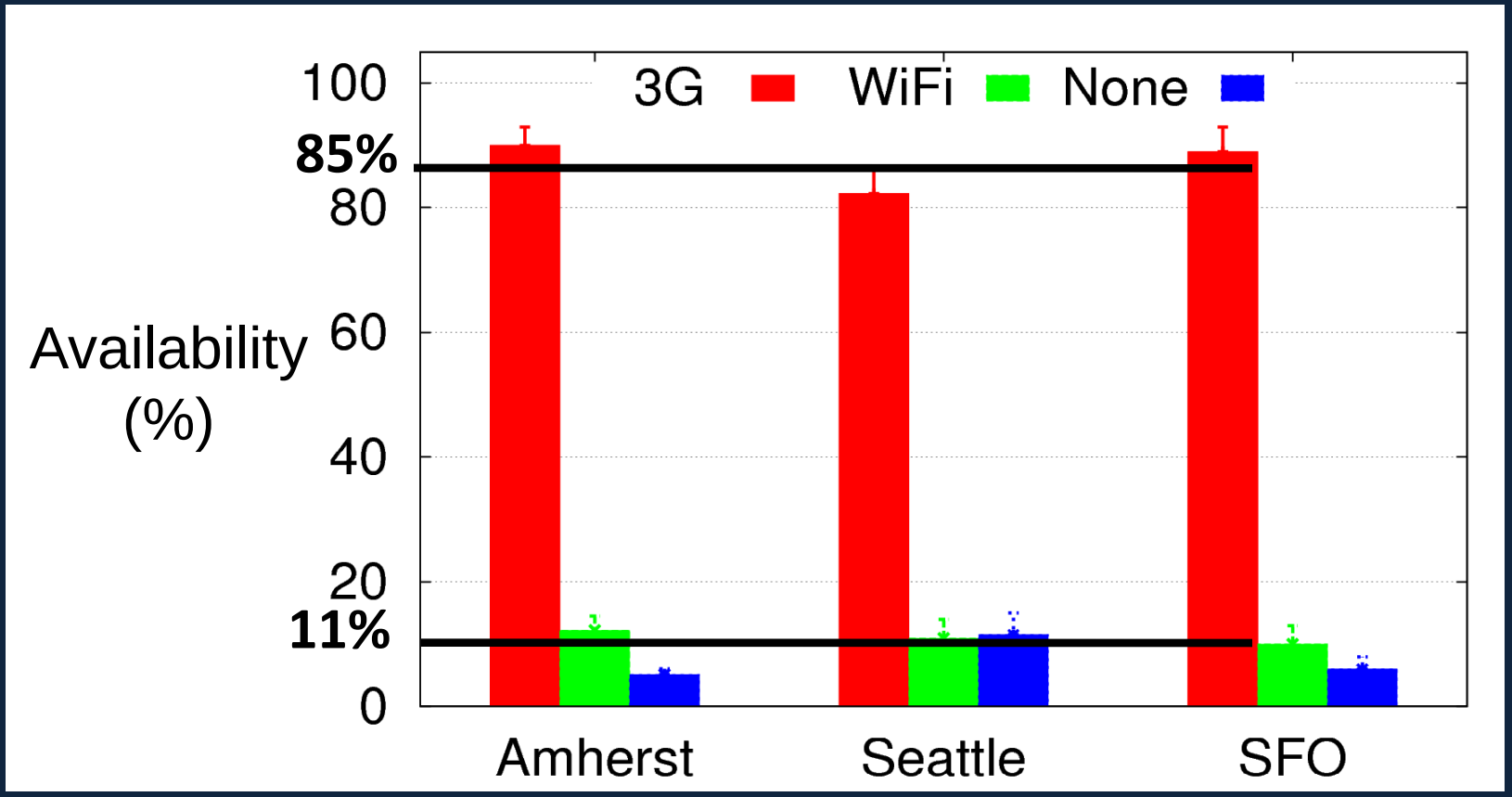
Software simultaneously sends data on 3G and WiFi

Measurement conducted in 3 cities: **Amherst: 20 buses, Seattle: 1 car, SFO: 1 car**

Collected more than 3000 hours of data for over 10 days

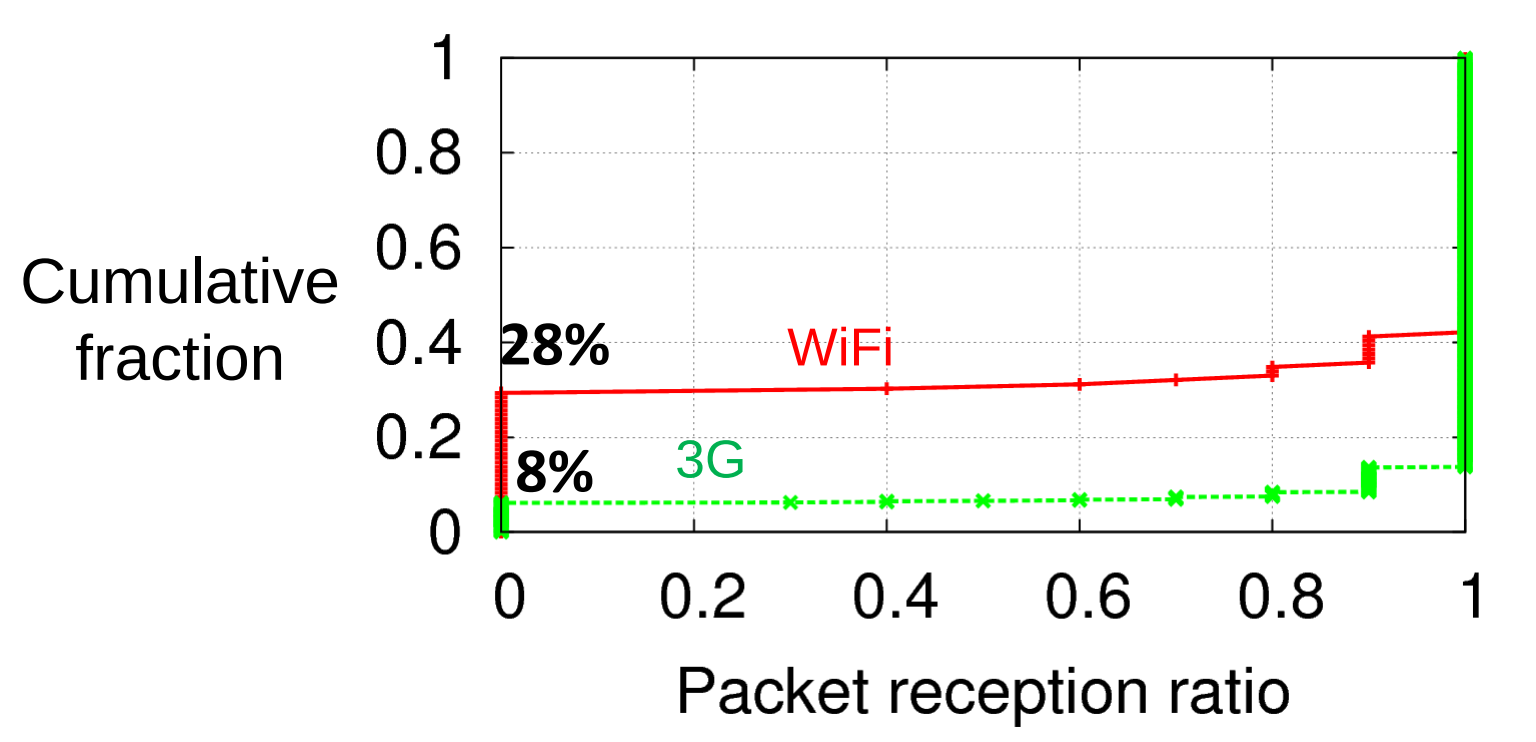
Open WiFi availability is low

Availability = # seconds when at least one packet recvd / total # seconds



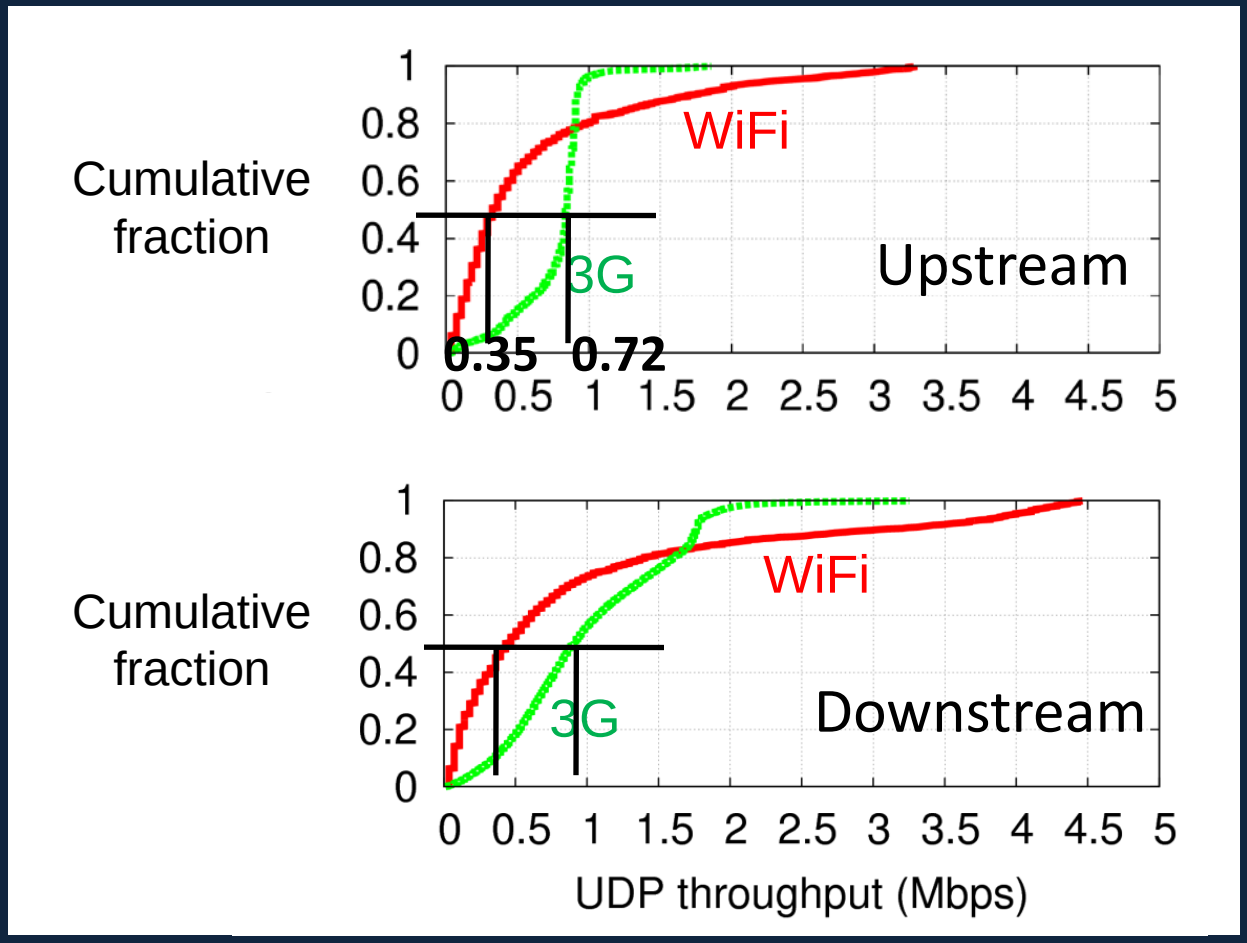
WiFi loss rate is higher

Loss rate = Number of packets lost per second out of 10 packets sent



WiFi (802.11b) throughput is lower

Throughput = Total data received per second



Implications of measurement study

Straightforward design: use WiFi when available

- Offloads only ~11% of the data
- Can hurt application performance because of higher loss rate and lower throughput

Key ideas in Wiffler

Using WiFi only when available not effective

- Exploit app delay tolerance and wait to offload on WiFi
- Use **prediction-based offloading** to wait only if 3G savings

Using WiFi whenever available can affect applications

- **Fast switch** to 3G when WiFi performance is poor

Prediction-based offloading

D = Delay tolerance threshold (seconds)

S = Remaining data to be sent

At each second,

1. If (*WiFi available*), send data on WiFi

2. Else,

   If ($W < S$), send data on 3G; Else wait for WiFi.

Predicted WiFi capacity in next D seconds

Predicting WiFi capacity

Simple history-based prediction of # of APs, using last N encounters

- future AP encounters depend on recent past

WiFi capacity = (expected # of APs) X (capacity per AP)

The simple prediction yields low prediction errors both in Amherst and Seattle

Sophisticated prediction using mobility prediction + AP location database does not significantly improve performance

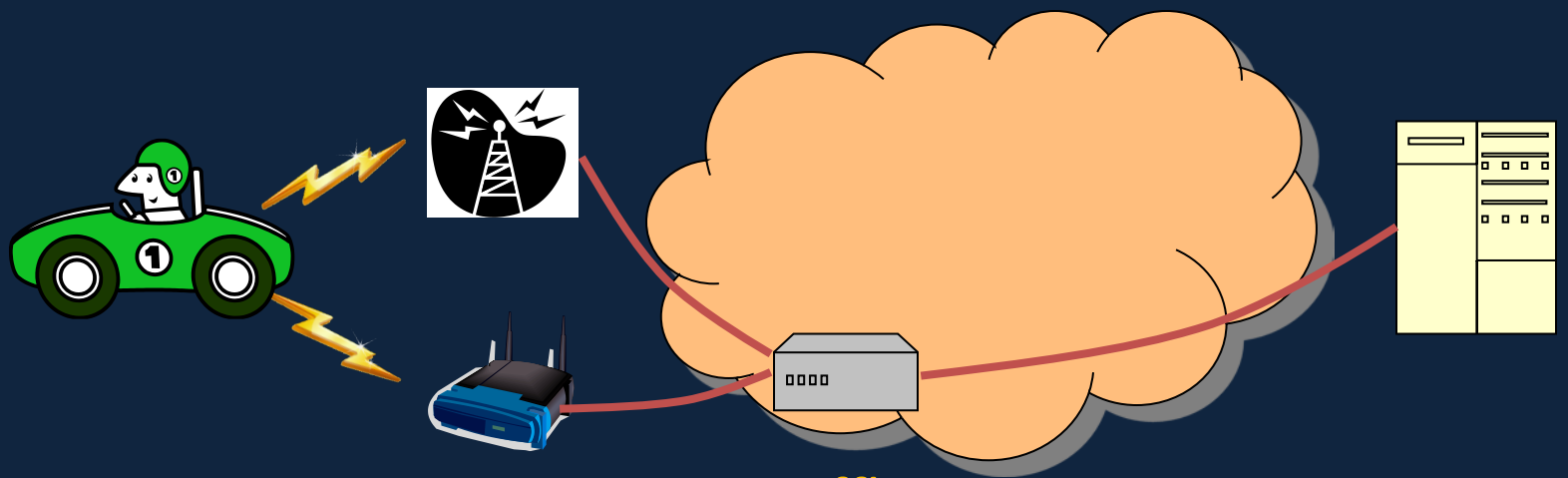
Fast switching to 3G

1. If no WiFi link-layer acknowledgment within 50ms
   - Send data on 3G

2. Else, continue sending on WiFi

Motivation: WiFi link layer retransmissions causes delay and WiFi losses are bursty

Wiffler Implementation



Offloading both in upstream and downstream.

Fast switching only in upstream

- implemented using a low level signaling mechanism

Evaluation

Deployment on 20 vehicular nodes

Trace-driven simulations

Deployment results

	Data offloaded to WiFi
Wiffler's prediction-based offloading	30%
WiFi when available	10%

File transfer size: 5MB; Delay tolerance: 60 secs;
Inter-transfer gap: random with mean 100 secs

	% time good voice quality
Wiffler's fast switching	68%
WiFi when available (no switching)	42%

VoIP-like traffic: 20-byte packet every 20 ms

Trace-driven evaluation

Yields results comparable to deployment

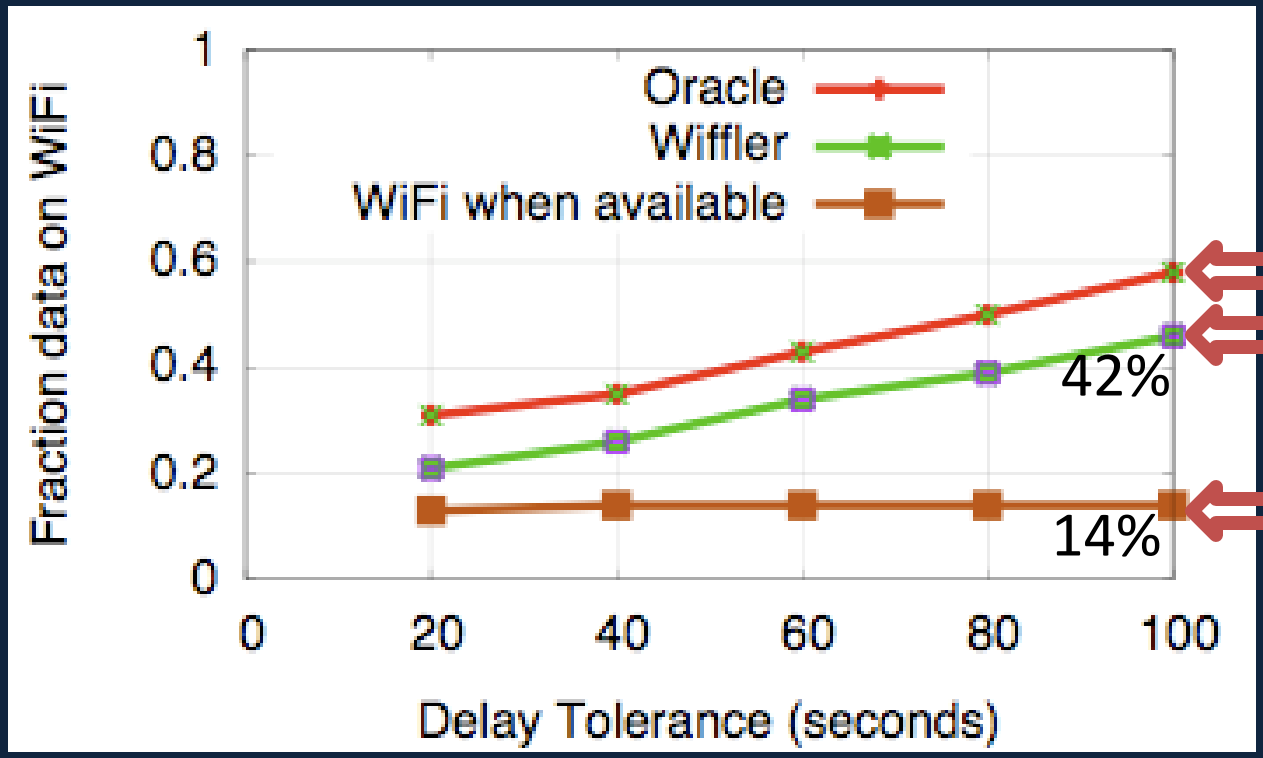
Vary workload, AP density, delay tolerance, switching threshold

Alternate strategies to prediction-based offloading:

- Wifi when available
- Oracle (Impractical): Perfect prediction with future knowledge

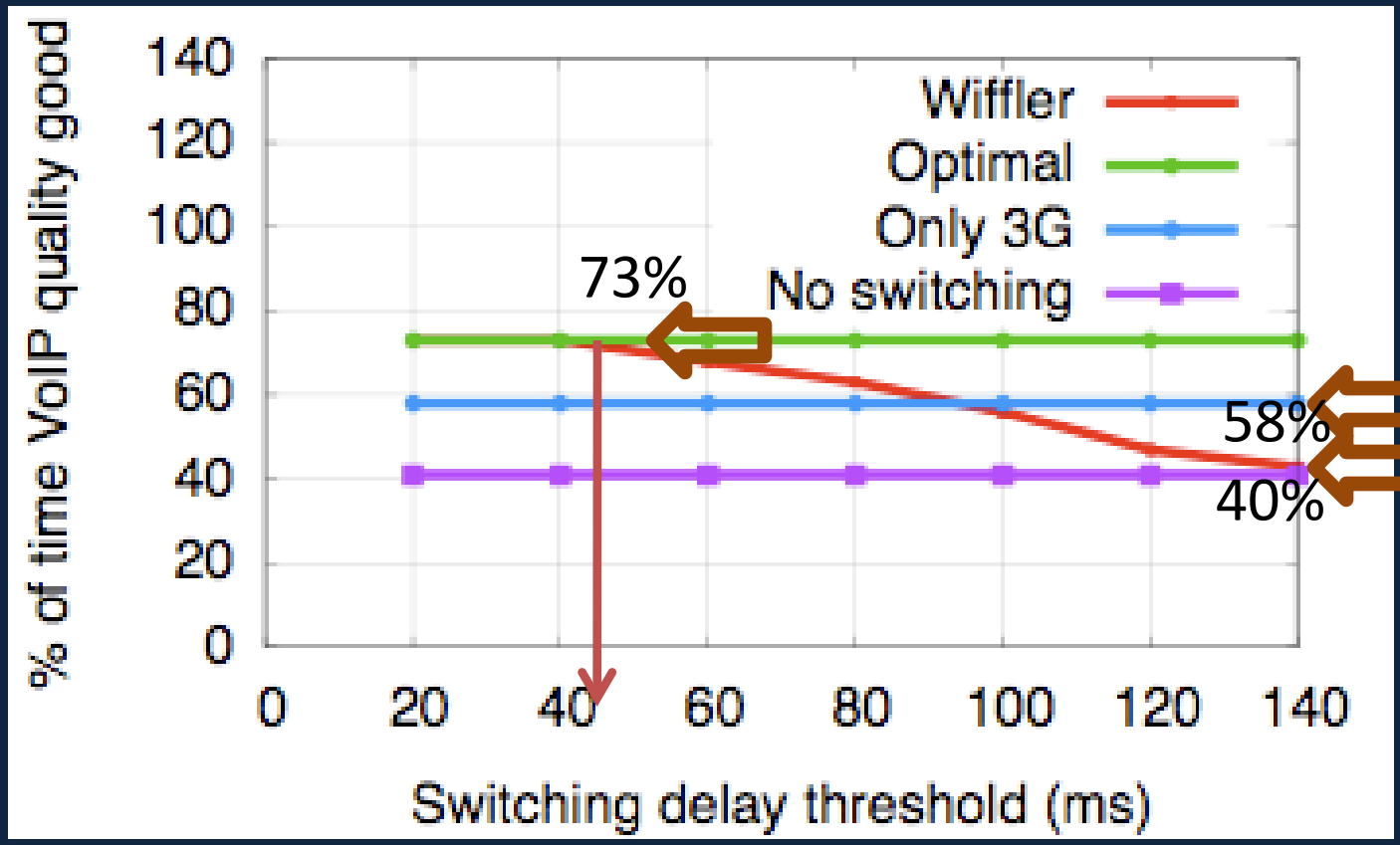
Wiffler increases data offloaded to WiFi

Workload: Web traces obtained from commuters



Wiffler increased app delay by 10 seconds over oracle.

Fast switching improves performance of delay/loss sensitive applications



30% of data was offloaded to WiFi, for 40 ms switching threshold

Future work

Reduce energy cost of searching for usable WiFi

Predict what a user will access and prefetch over WiFi

Conclusions

Augmenting 3G with WiFi can reduce pressure on cellular spectrum

Measurement in 3 cities: Low availability and poor performance of WiFi

Wiffler: Prediction-based offloading and fast switching to tackle these challenges

To be presented at MobiSys 2010

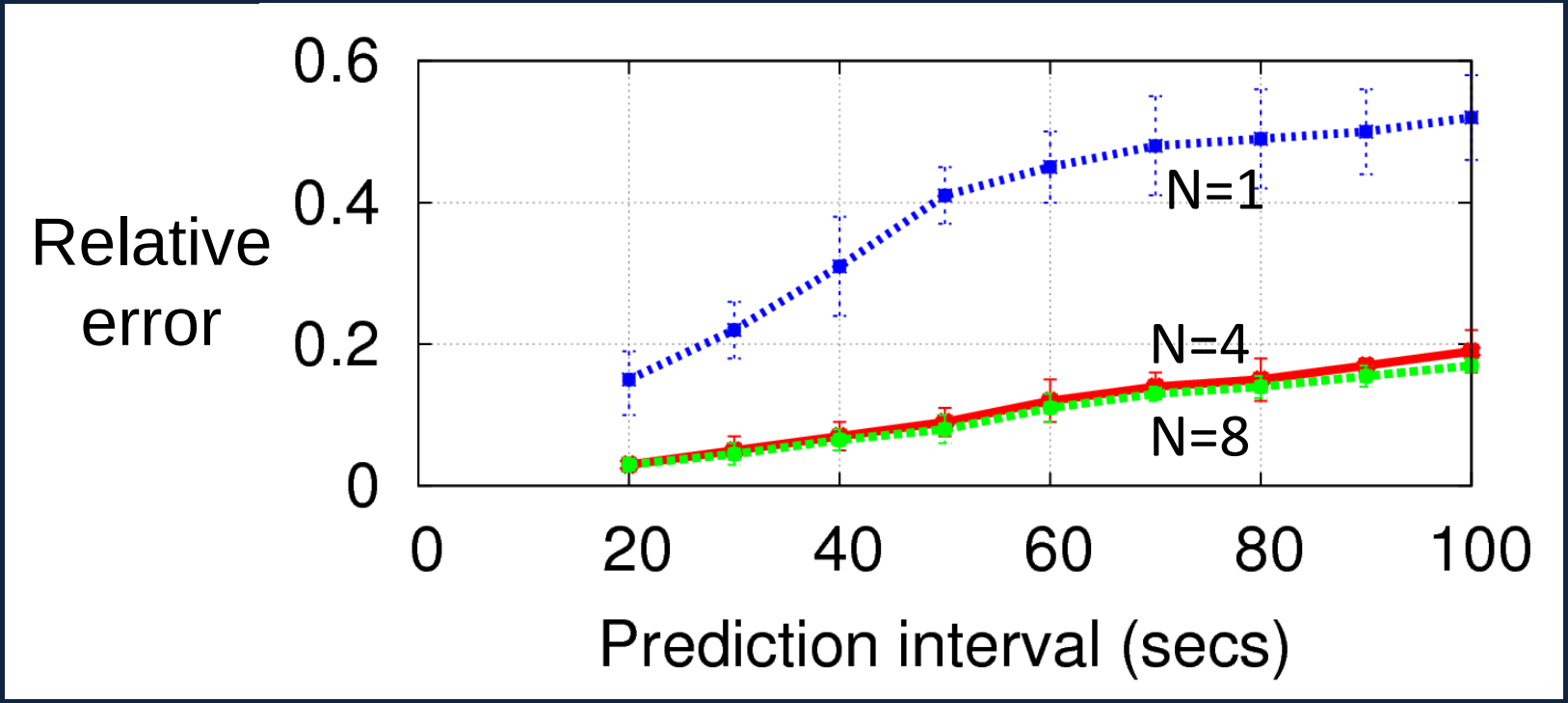
Prediction-based offloading

Delay data transfers only if that reduces 3G usage

Transfer requirements: S bytes by D seconds

- W = Predicted WiFi capacity over future D seconds
- Send data on 3G only when ($W < S \cdot c$)
- Send data on WiFi whenever available

Error in predicting # of APs



Fast switching improves performance of demanding applications