eecs589

ADVANCED COMPUTER NETWORKS

Fukuda, K., Asai, H., and Nagami, K., "Tracking the Evolution and Diversity in Network Usage of Smartphones," *Proc. of ACM IMC '15*, pp. 253-266, 2015

WiFi Offloading around Tokyo Area

Given a choice of WiFi and cellular data, how would user choose?

Cellular providers would prefer users offload traffic to WiFi networks

Three sets of user-side measurements, each lasting 15 days, in 2013, 2014, and 2015

Test-users recruited by a market analysis company

Measurements done by Android and iOS app $\Rightarrow$ study targeted only these two Android phones and iPhones

Recruited Platforms and Users

year	duration	#And	#iOS	#total	%LTE
2013	07 Mar - 22 Mar	948	807	1755	25%
2014	28 Feb - 22 Mar	887	789	1676	70%
2015	25 Feb - 25 Mar	835	781	1616	80%

Occupation	Percentage		
	2013	2014	2015
government worker	2.1	3.4	2.4
office worker	20.0	20.1	23.6
engineer	16.7	14.7	16.6
worker (other)	12.8	13.7	13.2
professional	2.4	2.0	2.8
self-owned business	6.1	6.7	5.6
part timer	9.0	10.1	10.6
housewife	15.0	14.2	13.3
student	9.6	8.3	2.7
other	6.3	6.8	7.1

Traffic Growth

Daily download traffic volume per user and annual growth rate

median	2013	2014	2015	AGR
All	57.9	90.3	126.5	48%
Cell	19.5	27.6	35.6	35%
WiFi	9.2	24.3	50.7	134%
mean	2013	2014	2015	AGR
All	102.9	179.9	239.5	53%
Cell	42.2	58.5	71.5	30%
WiFi	60.7	121.5	168.1	66%

Daily Traffic Volume by Type

2015

CDF axis: 0 to 1
Cellular TX, WiFi RX, WiFi TX, Cellular RX

Cell: 1.4% bw capped

WiFi: 20% no data usage

Cell: 8% no data usage

All: TX/RX bw asymmetry

Daily traffic volume [MB]

WiFi Offloading

Mixed users: 55% above diagonal, more opportunities for WiFi offloading

2015

WiFi intensive users (8%): avoid cellular fees

WiFi [MB] vs Cellular [MB]

Cellular intensive users: no available WiFi
(35% in '13 to 22% in '15)
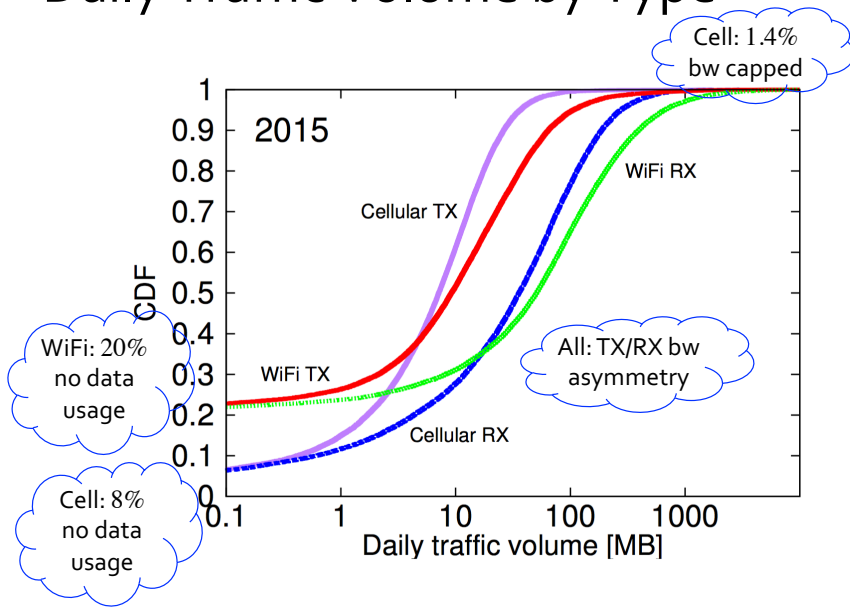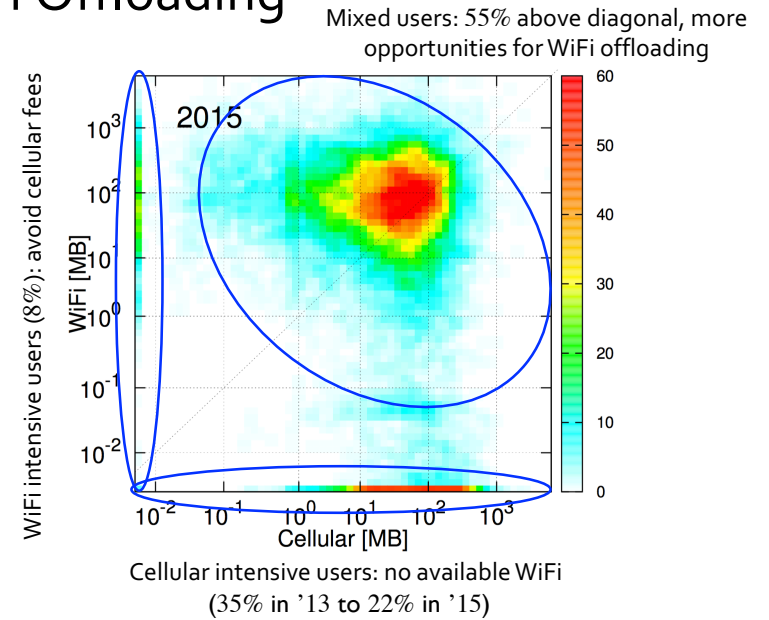
WiFi Offloading

Percentage of smartphone traffic and users offloaded to WiFi, for heavy and light users

(a) WiFi-traffic ratio (2013)
(b) WiFi-traffic ratio (2015)
(a) WiFi-user ratio (2013)
(b) WiFi-user ratio (2015)
heavy / light
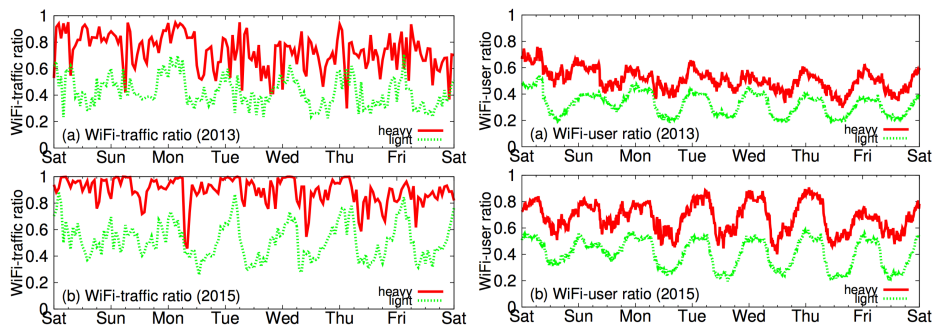
When WiFi Offloading Happens

WiFi used at home 10 pm to 6 am
Cellular usage peaks at 8 am, noon, 7-9 pm
Similarly for public WiFi

Cellular TX
Cellular RX
WiFi TX
WiFi RX

(e) public 2015

Traffic volume [Mbps]

28 Sat 01 Sun 02 Mon 03 Tue 04 Wed 05 Thu 06 Fri 07 Sat

Date (Mar. 2015, JST)
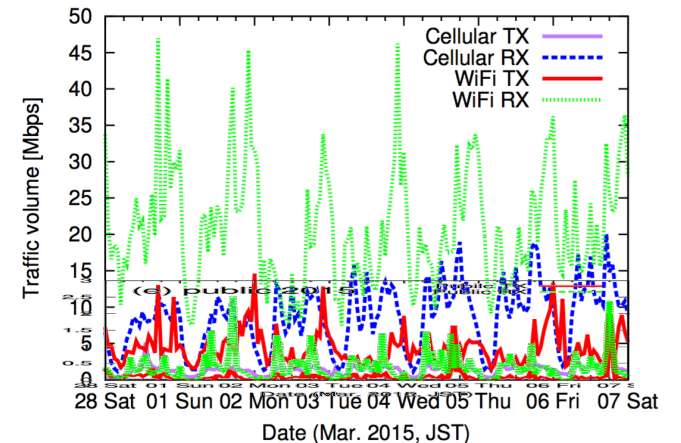
More Public WiFi's

| ESSIDs per day	HPO	2013	2014	2015
1	100	54.7%	52.6%	46.4%
	010	3.0%	2.4%	2.4%
	001	10.5%	9.4%	9.2%
2	110	8.2%	10.0%	9.0%
	101	10.7%	12.9%	16.5%
	011	1.4%	1.3%	1.7%
	020	0.6%	0.3%	0.3%
	002	1.5%	1.8%	2.4%
3	102	1.8%	2.0%	2.7%
	120	1.9%	1.4%	1.4%
	111	2.2%	2.3%	3.4%
	012	0.3%	0.4%	0.6%
	021	0.4%	0.2%	0.3%
	003	0.3%	0.4%	0.5%
4+	—	—	2.3%	2.5%

still mostly at home …

… but more public also

and more options:
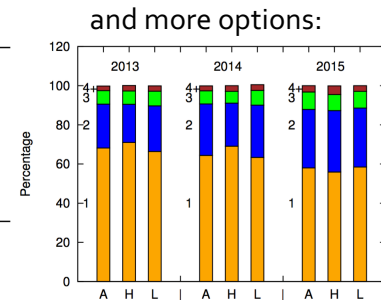
Quality of WiFi

Better channel allocations
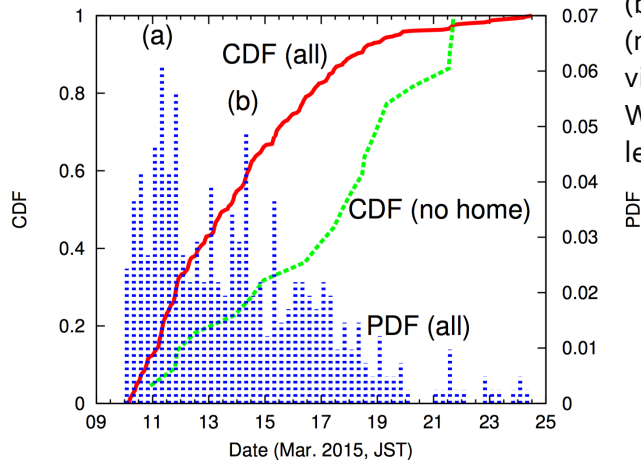(5-channel interval reduces interference)

but public WiFi not as good yet
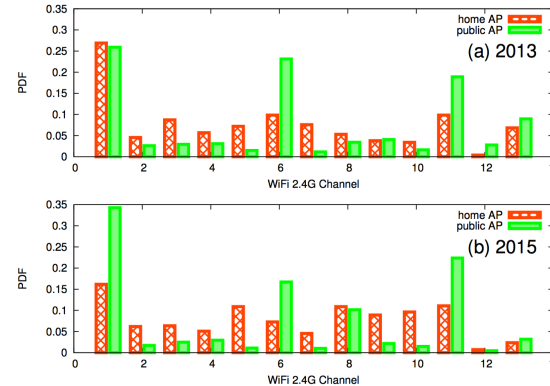
Suggestion: providers share AP to reduce interference

-79 dBm ⇒ 10% TCP retransmission probability
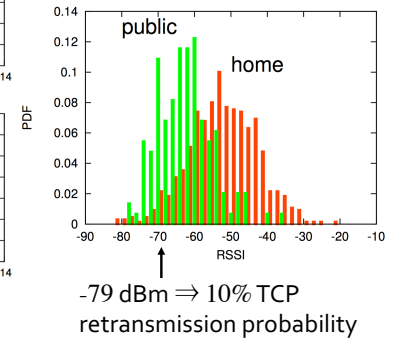
Application Enforced WiFi

Software (iOS) update release

(a) 1-2 days after
(b) weekend after
(no home): update via public or office WiFi ⇒ delay may lead to vulnerability

Why Not Use More WiFi? Survey

Reason	home			office			public		
	13	14	15	13	14	15	13	14	15
No available APs	33	34	40	46	49	52	25	24	23
Difficult to set up	32	27	21	16	15	11	31	31	25
No configuration	48	35	32	33	25	22	43	31	29
Battery drain	18	14	15	16	9	7	25	18	13
Failed	5	6	8	7	7	7	9	8	11
Security issue	NA	6	14	NA	9	14	NA	15	35
LTE is enough	NA	25	21	NA	12	10	NA	22	23
Other	6	5	5	12	10	10	9	5	4

Difficult to set up: use SIM authentication instead
Security issue: high for public WiFi
LTE is enough: no incentive
Battery drain: surprisingly low
No configuration: ???

How Generalizable?

To other parts of Japan
To other metropolis outside Japan
To other non-metropolis areas