

Pierdomenico Fiadino

The Telecommunications Research Center Vienna (ftw.)

Vivisecting WhatsApp in Cellular Networks

Servers, Flows, and Quality of Experience

fiadino@ftw.at

<http://userver.ftw.at/~fiadino>



WhatsApp

overview

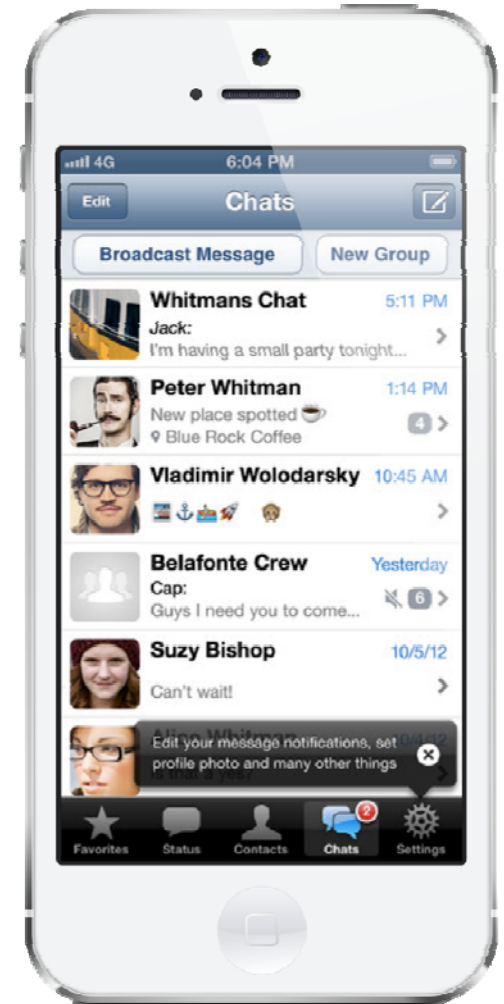
Hard facts:

- 64 billion messages per day
 - 700 million photos
 - 100 million videos
- 500 million of daily active users
- Company with the quickest growing user base in history
- Acquired by Facebook for 19 billion \$
 - Each user is worth 40\$



Operators need to investigate it because:

- It is taking over (or already has...) the SMS/MMS market
- They need to learn how to track its usage
- They need to understand its impact on their networks



Outline

1. Characterization of WhatsApp through hybrid measurements

- Traffic captures in lab with standard tools
- Large-scale passive traces (mobile national network)
- Large-scale active measures (RIPE Atlas)

2. Quality of Experience remarks

- Build a QoE model with user tests
- Apply model on passive traces

3. WhatsApp global outage overview

- Characterization
- Social media impact



Outline

1. Characterization of WhatsApp through hybrid measurements

- Traffic captures in lab with standard tools
- Large-scale passive traces (mobile national network)
- Large-scale active measures (RIPE Atlas)

2. Quality of Experience remarks

- Build a QoE model with user tests
- Apply model on passive traces

3. WhatsApp global outage overview

- Characterization
- Social media impact



Reverse engineering Whatsapp naming scheme..ftw

Hybrid measurements

Creating
Communication
Technologies



Testbed:

- Traffic (chat and media exchange) actively generated at end devices (Android and iOS)
- Passively captured at a gateway (**Wireshark**)
- Focus on DNS requests

Findings:

- Whatsapp used custom XMPP protocol
- Media exchange via HTTPS servers
- One persistent SSL connection to XMPP servers while the app is running
- Dedicated TLS connections to HTTPS servers for each media transfer

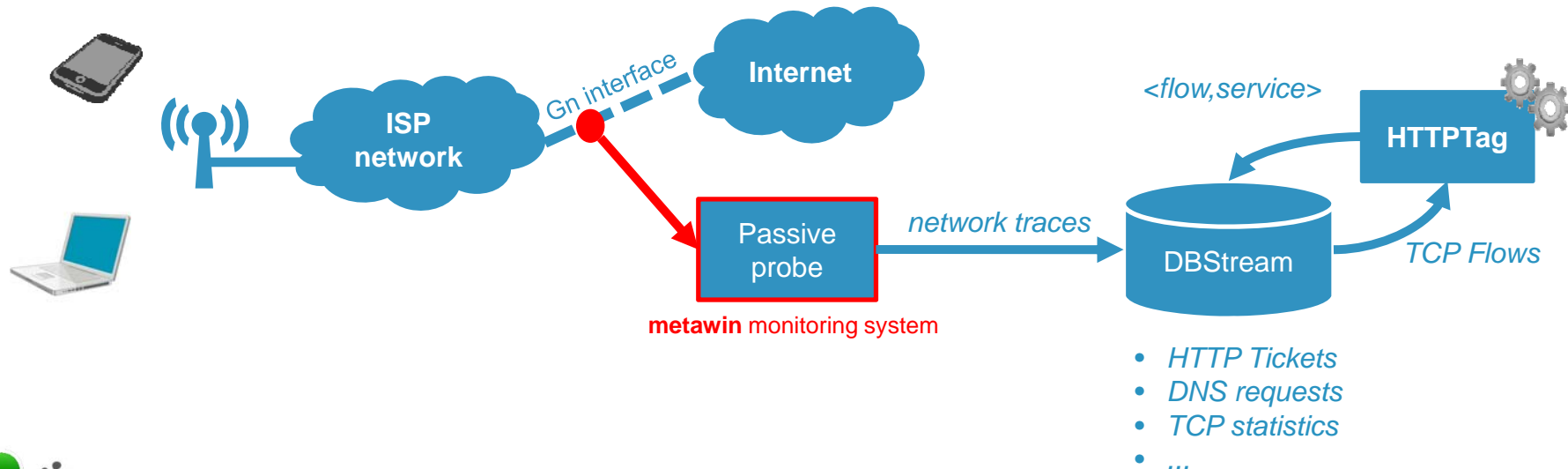
Servers naming scheme [`*.whatsapp.net`]:

3rd lvl domain	prot. (port)	type
cX, eX, dX	XMPP(5222,443)	chat & control
mmiXYZ, mmsXYZ	HTTPS (443)	media (photo,audio)
mmvXYZ	HTTPS (443)	media (video)

Passive probes

network architecture

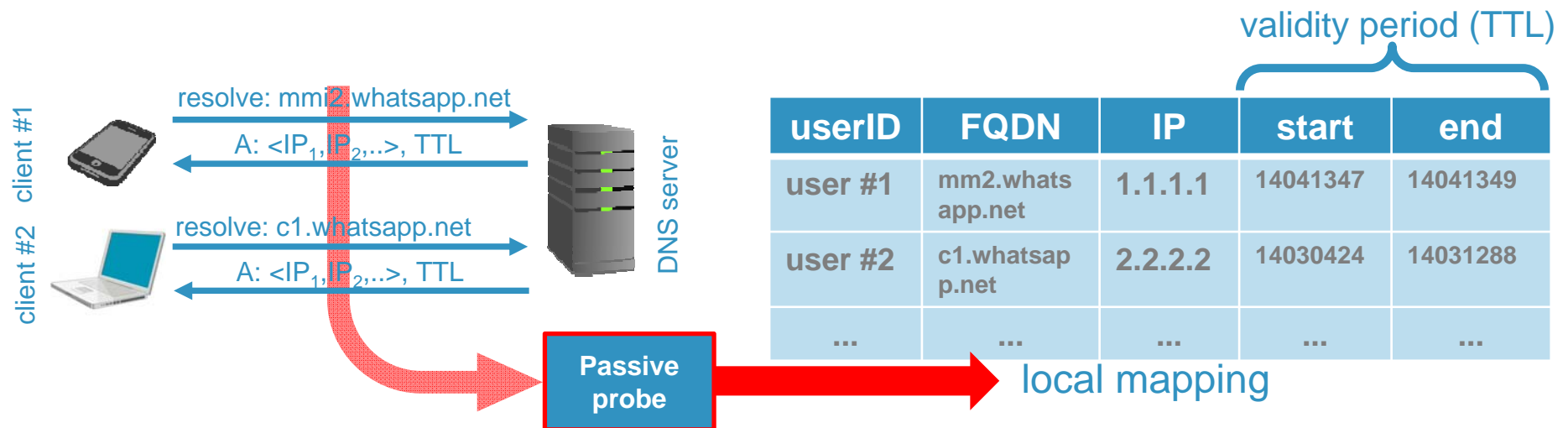
- ❑ Capture network traces at the core of an operational 3G/4G network (~5 millions of users)
- ❑ Dataset: 1 month long (February 2014)
- ❑ Classify flows: only consider Whatsapp-related traffic (details on classification techniques -> next slide)



Classification of TCP flows

Collect DNS requests from passive traces

- Idea: use **passively collected DNS** requests to dynamically map *<services,serverIPs>*

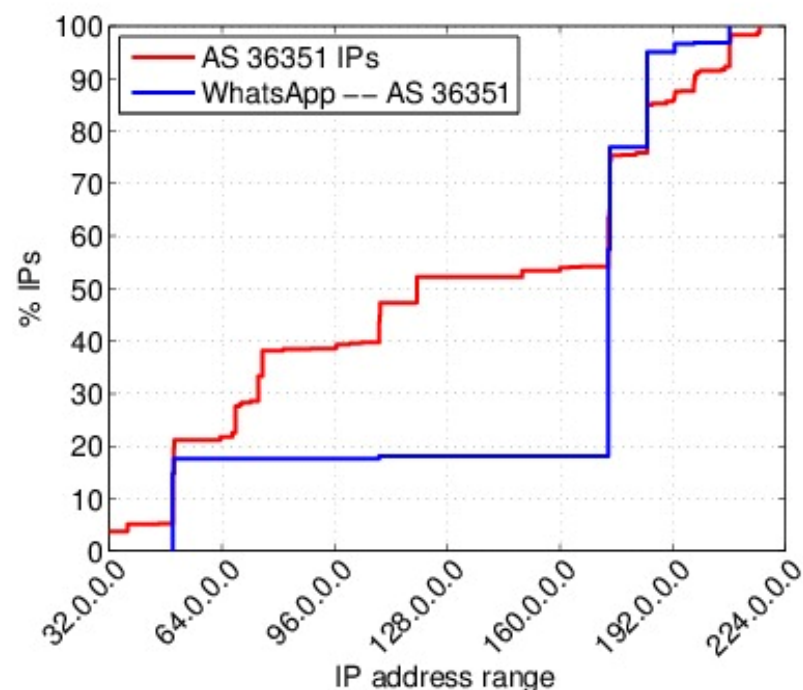


- Every subsequent flow between a *<user>* and a *<server_ip>* in the validity period *[validity_start:validity_end]* are assigned to *<FQDN>*
- The Fully Qualified Domain Names (FQDN) are assigned to service with usual pattern matching



Revealing Hosting Infrastructure

Through large-scale passive measurements



- 386 IP addresses used by Whatsapp (chat and media)
- All in AS36351 (Softlayer)

SOFTLAYER®
an IBM Company

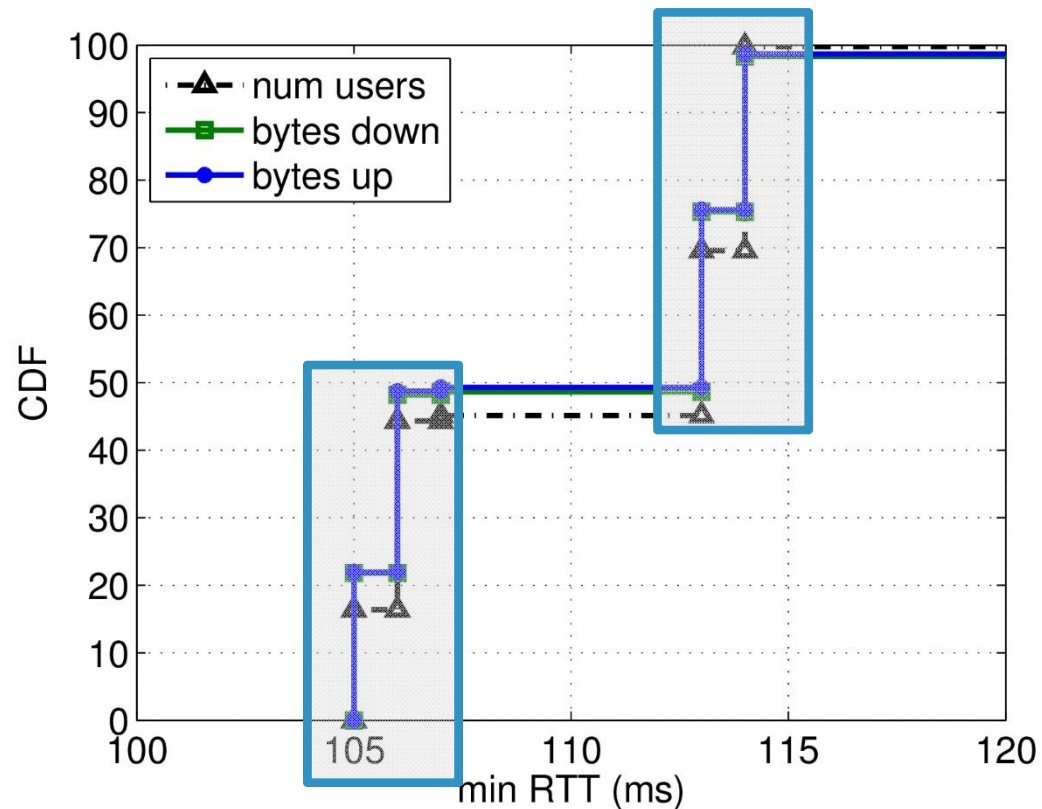
Service/AS	#IPs	# /24	# /16	# /8
WhatsApp	386	51	30	24
SoftLayer (AS36351)	1364480	5330	106	42



Revealing Hosting Infrastructure

Through large-scale passive measurements

Localization of servers through RTT measurements



~400 IP addresses in Softlayer AS

Two big steps in RTT distribution at:

- 106ms
- 114ms

Localized by MAXMIND in:

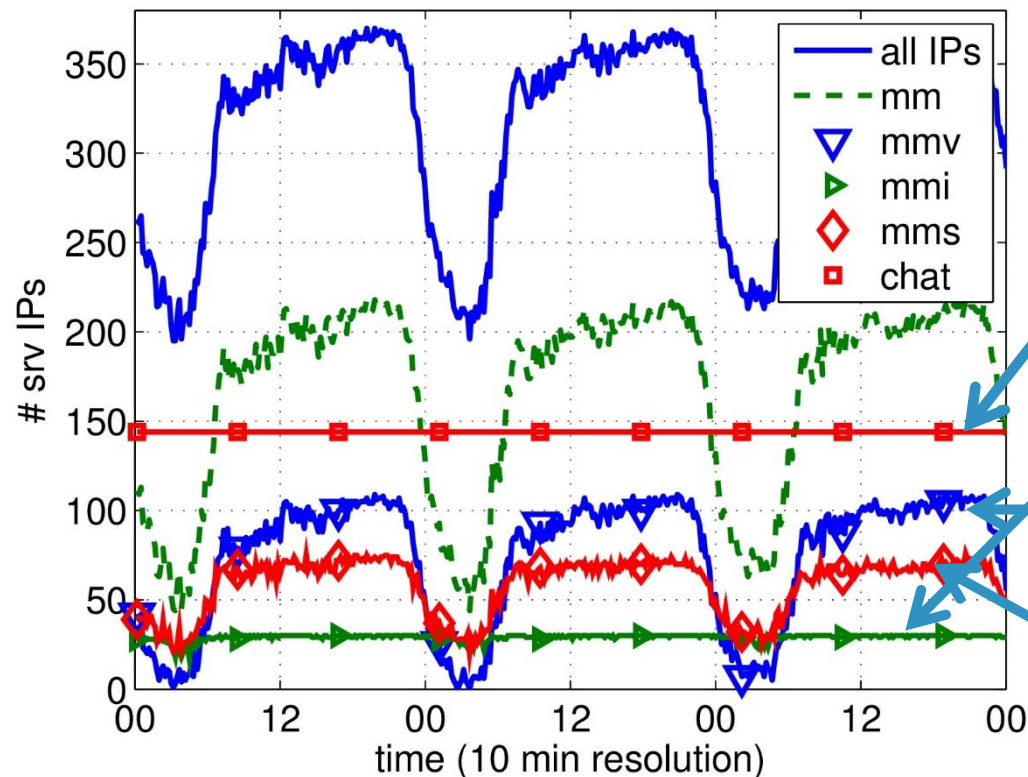
- Houston
- Dallas



Revealing Hosting Infrastructure

Through large-scale passive measurements

Active IPs



Chat servers

150 IPs *"always on"*

Images exch. servers

25 IPs *"always on"*

Video exchange servers

Up to 100 IPs at peak hours

Audio exchange servers

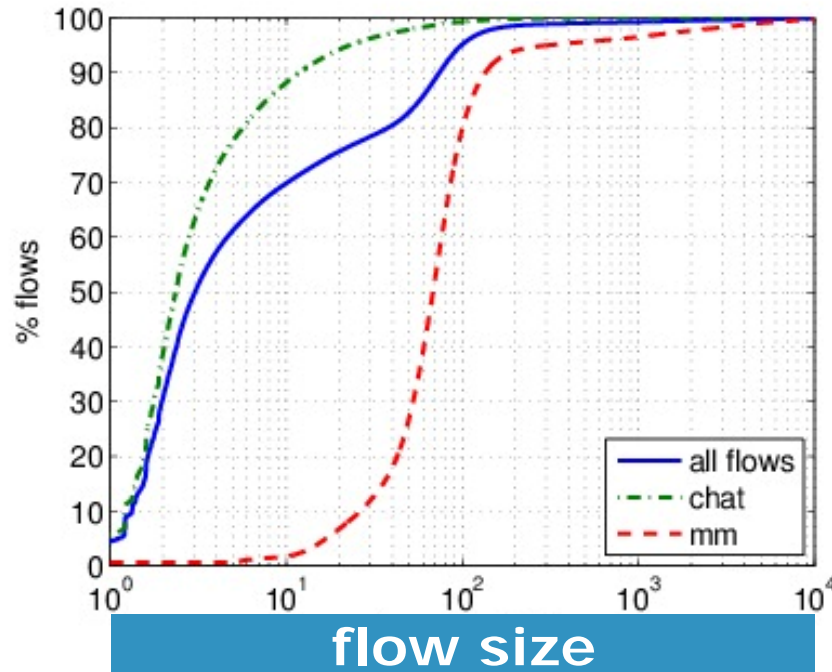
Up to 75 IPs at peak hours



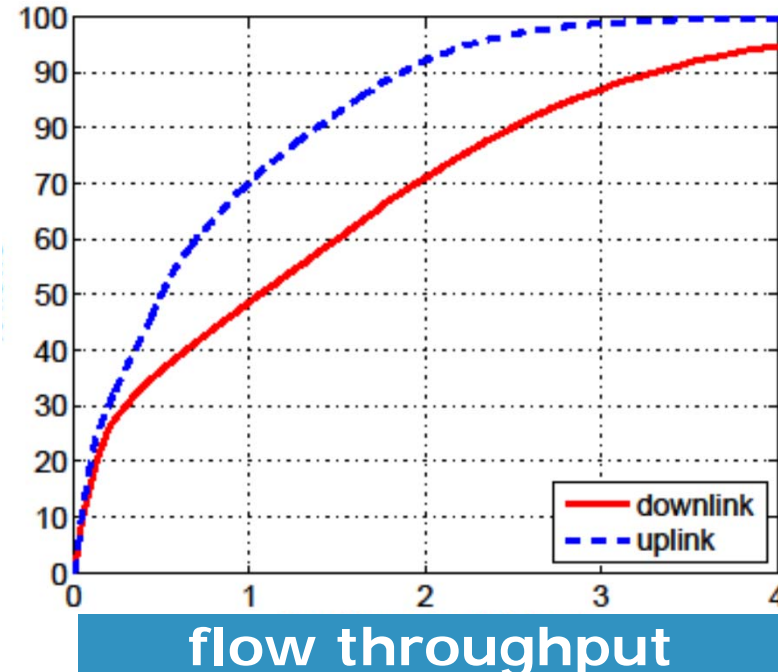
At least 200 IP addresses active at any time

Whatsapp traffic characteristics

flow size and throughput



- Smaller chat/control flows and heavier mm flows
- 90% of chat flows < 10KB
- 50% of mm flows > 70KB

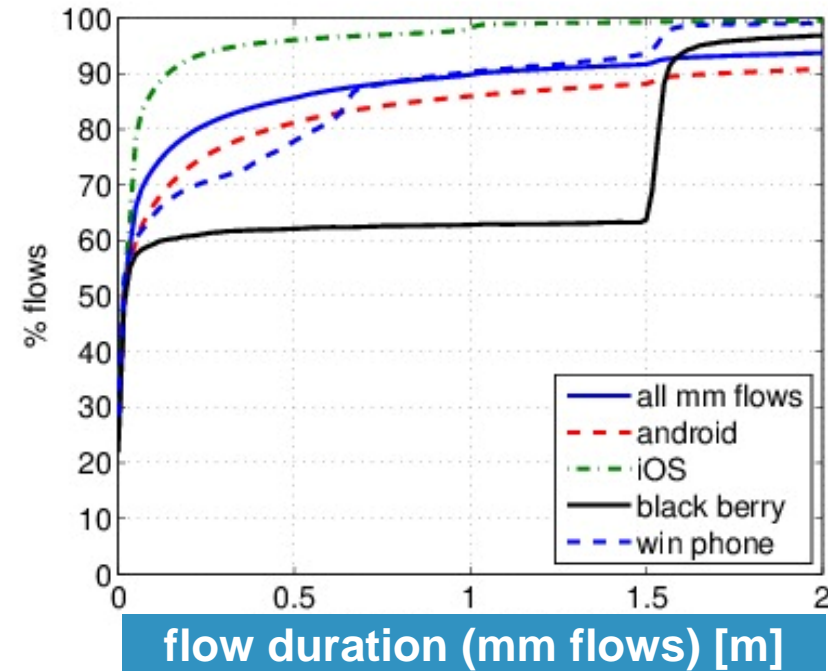
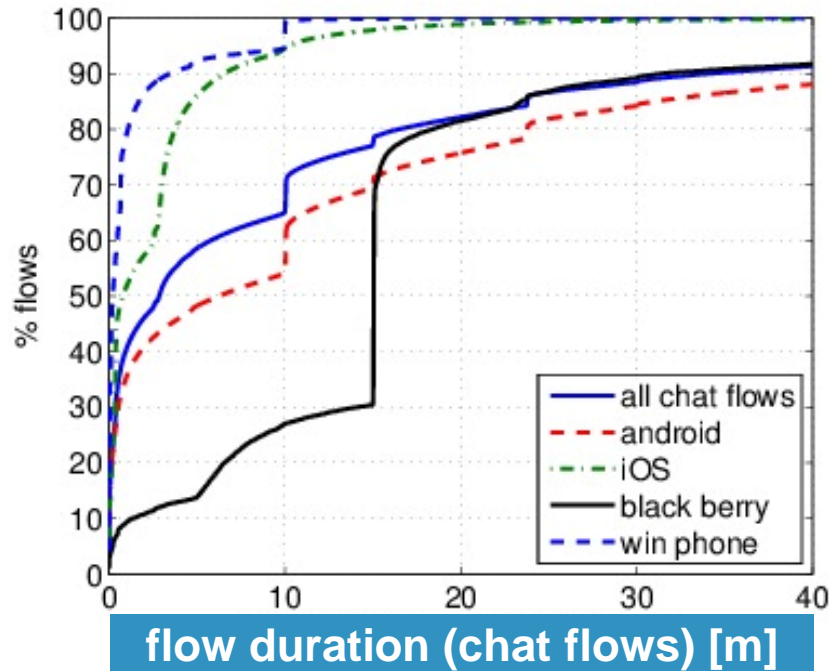


- Only bigger flows (>1MB) considered
- Up to 1.5Mbps in downlink
- Up to 800Kbps in uplink



Whatsapp traffic characteristics

flow duration with OS breakdown



Timeouts:

- Android: 10/15/25 min
- iOS: 3 min
- Blackberry: 15 min
- Windows Phone: 10 min

Timeouts:

- Blackberry: 90 sec



Flow characteristics depend on terminal operating system

RIPE Atlas infrastructure

for geo-distributed active measurements

- **RIPE NCC**: Regional Internet Registry for Europe (equivalent of ARIN for North America)
 - **RIPE Atlas**: a large measurement network composed of geographically distributed active probe used to measure connectability and reachability
-



Hosting infrastructure „stability“

Geographical distributed active measurements



- My UDM (User Defined Measurement): **600 probes world-wide resolve Whatsapp hostnames** (`{mmX | dX}.whatsapp.net`)
- Result: same set of IP addresses

Previous conclusions for
WhatsApp hosting infrastructure
are still valid from other VPs



Outline

1. Characterization of WhatsApp through hybrid measurements

- Traffic captures in lab with standard tools
- Large-scale passive traces (mobile national network)
- Large-scale active measures (RIPE Atlas)

2. Quality of Experience remarks

- Build a QoE model with user tests
- Apply model on passive traces

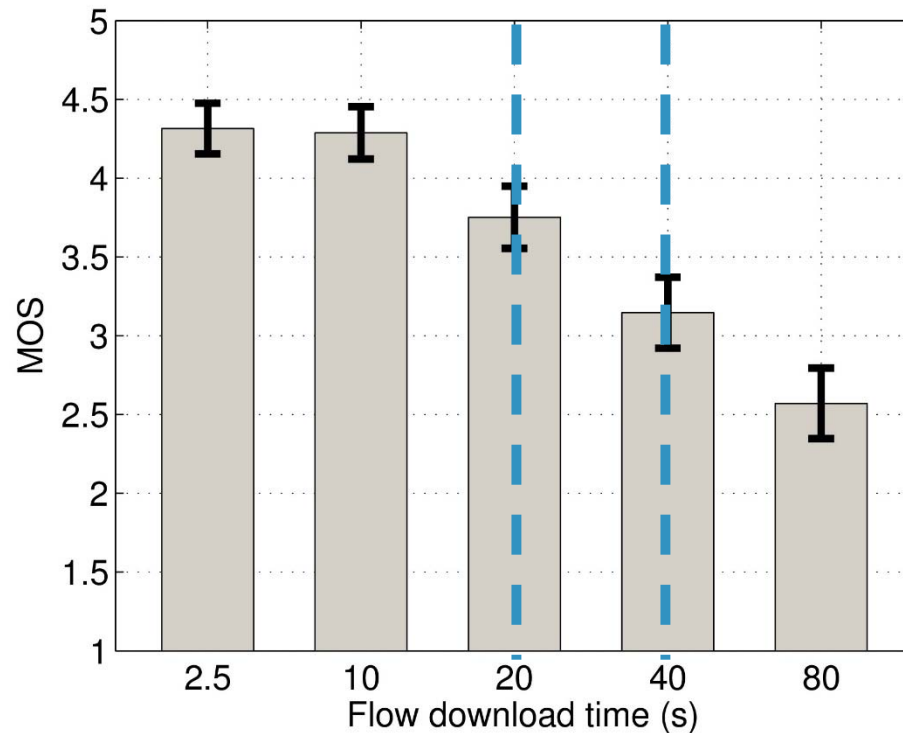
3. WhatsApp global outage overview

- Characterization
- Social media impact



Quality of Experience (QoE)

Measuring Mean Opinion Score (MOS) through user tests



Measurement campaign:

- 50 participants
- 45/50 male/female
- 60/40 students/employees
- 23 average age

Experiment:

- Media file transfer (5MB)
- Emulation of different network conditions (change transfer time)

Mean Opinion Score (MOS):

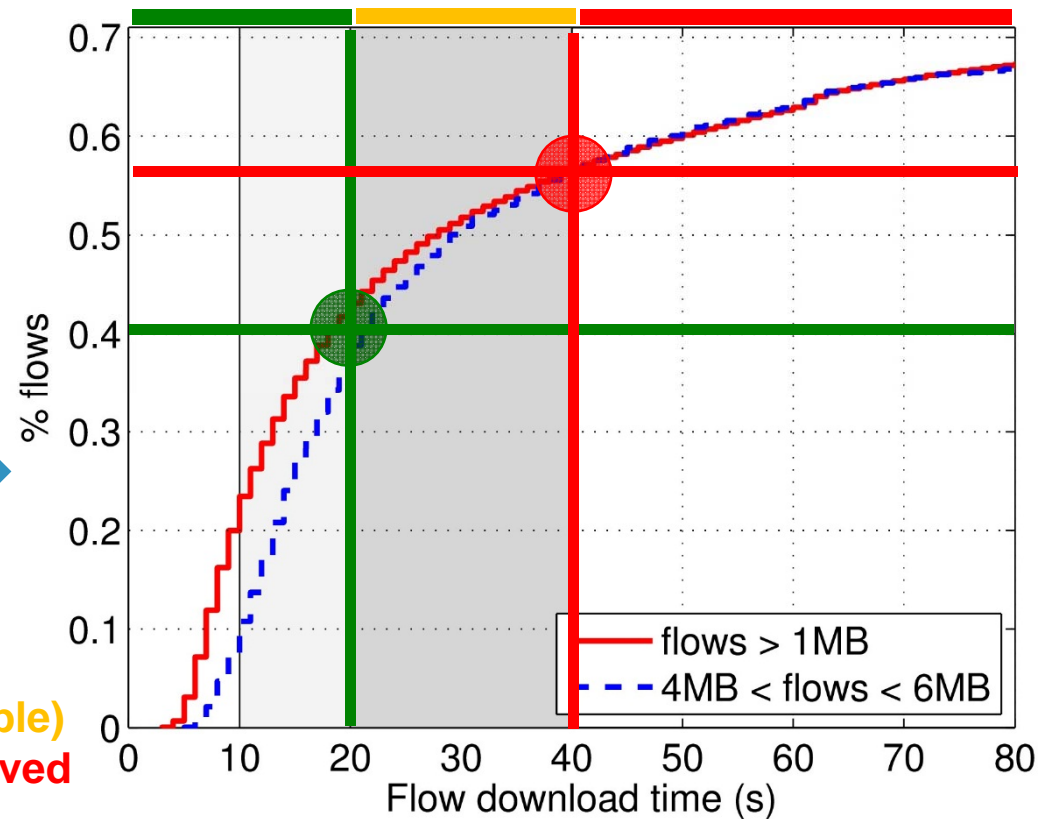
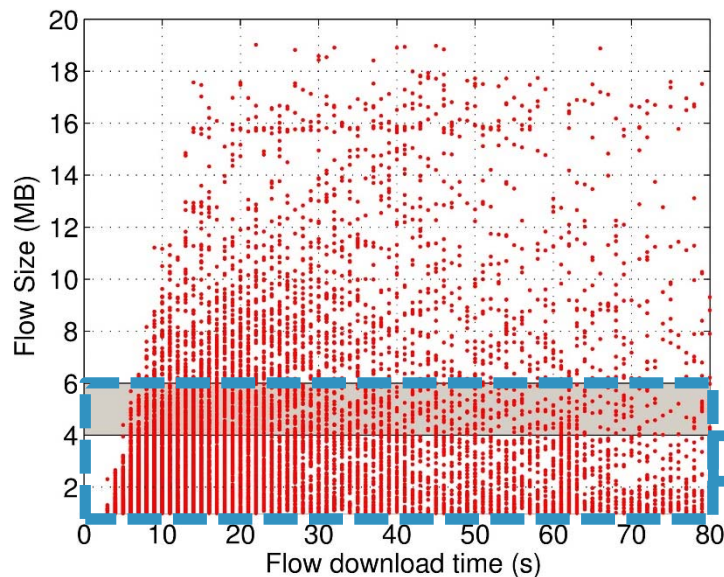
- From 1 (very bad) to 5 (excellent)

- Users tolerate transfers of up to 20 seconds with good experience
- Threshold of 40 seconds discriminates good and bad experience
- The score is independent of the flow size



Quality of Experience (QoE) in the large scale measurements

- User tests: 5MB transfers, <20s good, >40s bad (previous slide)
- Assumption: flow size is not taken into account
- Apply same model on large scale network traces



- **40% flows last less than 20s (good)**
- **60% flows last less than 40s (acceptable)**
- **35% flows are badly/very badly perceived**



Outline

1. Characterization of WhatsApp through hybrid measurements

- Traffic captures in lab with standard tools
- Large-scale passive traces (mobile national network)
- Large-scale active measures (RIPE Atlas)

2. Quality of Experience remarks

- Build a QoE model with user tests
- Apply model on passive traces

3. WhatsApp global outage overview

- Characterization
- Social media impact



The big 5-hours outage (Feb. 22nd, 2014) press reaction

BUSINESS INSIDER Tech Finance Politics Strategy Life Entertainment All

TECH More: Facebook WhatsApp

WhatsApp Returns To Normal After 5-Hour Outage

STEVE KOVACH | FEB. 22, 2014, 5:22 PM | 9,026 | 7

Facebook LINKEDIN TWITTER

Messaging service WhatsApp went down for several hours on Saturday, but the company announced it would acquire the company in a \$19 billion deal.

WhatsApp has more than 450 million users, but it's likely the outage was a big announcement. The app has already skyrocketed to new heights.

The company caught the issue early on and tweeted that it was working on the problem.

WhatsApp Status
@wa_status

sorry we currently exper

CNBC Enter Symbols GO Enter Keywords GO

HOME U.S. NEWS MARKETS INVESTING TECH SMALL BUSINESS VIDEO SHOWS WATCH LIVE PRO REGISTER SIGN IN

TECHNOLOGY

WhatsApp says it's back up after extended outage

Saturday, 22 Feb 2014 | 5:50 PM ET

<re/code>

WhatsApp Status

Great color! BTW you gotta hear this audio note:

Oh you can tap and hold message to get more options!

Oh yeah, I knew that

Image Source: WhatsApp

Days after Facebook said it would acquire messaging service, the company experienced a service outage for several hours.

REUTERS EDITION: U.S. SIGN IN REGISTER Search News & Quotes

HOME BUSINESS MARKETS WORLD POLITICS TECH OPINION BREAKINGVIEWS MONEY LIFE PICTURES VIDEO

Facebook's big buy, WhatsApp messaging app, back up after outage

BY ROS KRASNY AND CHRISTINE STEBBINS
WASHINGTON Sat Feb 22, 2014 6:28pm EST

7 COMMENTS | Tweet | 117 | Share | 29 | f | Share this | 8+1 | 29 | Email | Print

A WhatsApp App logo is seen behind a Samsung Galaxy S4 phone that is logged on to Facebook in the central Bosnian town of Zenica, February 20, 2014.
CREDIT: REUTERS/DADO RUVIC

MOST POPULAR

- 1 Rebels declare victory in east Ukraine self-rule vote VIDEO
- 2 Boko Haram offers to swap kidnapped Nigerian girls for prisoners VIDEO
- 3 Exclusive: Air traffic system failure caused by computer memory shortage
- 4 How 'Big Corn' lost the ethanol battle to Philadelphia refiners
- 5 North Korea denies spy drones, labels South's president a 'prostitute'

Follow Reuters

Facebook Twitter RSS YouTube

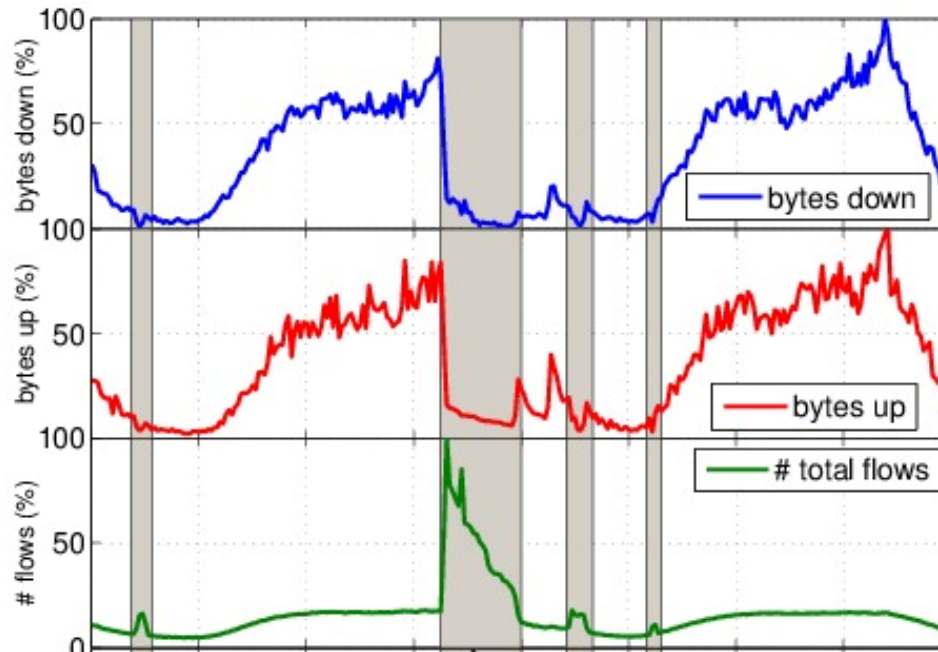
RECOMMENDED VIDEO

Helicopter-truck hybrid takes to the air

Flight MH370: 'objects spotted'



The big outage (Feb. 22nd, 2014) as seen from passive measurements and social feeds



drop in volume down
(with small residual traffic)

drop in volume up
(with small residual traffic)

ramp-up on flow counts
(SYN/RST exchange)

1. Residual traffic during outage
2. Number of flow increase
3. Clear social media reactions



Conclusions

1. Characterization of WhatsApp

- **Hybrid methodology for service characterization**
- **Revealed *.whatsapp.net server naming scheme**
- **Centralized infrastructure by Softlayer in Texas**
- **75% of volume for media transfers (36% is video)**



2. Quality of Experience remarks

- **Downlink throughput up to 1.5Mbps, but...**
- **40% of flows could suffer of bad user experience**

3. WhatsApp global outage overview

- **Servers still reachable, fail at app layer**
- **Strong social media impact (🐦 correlation)**

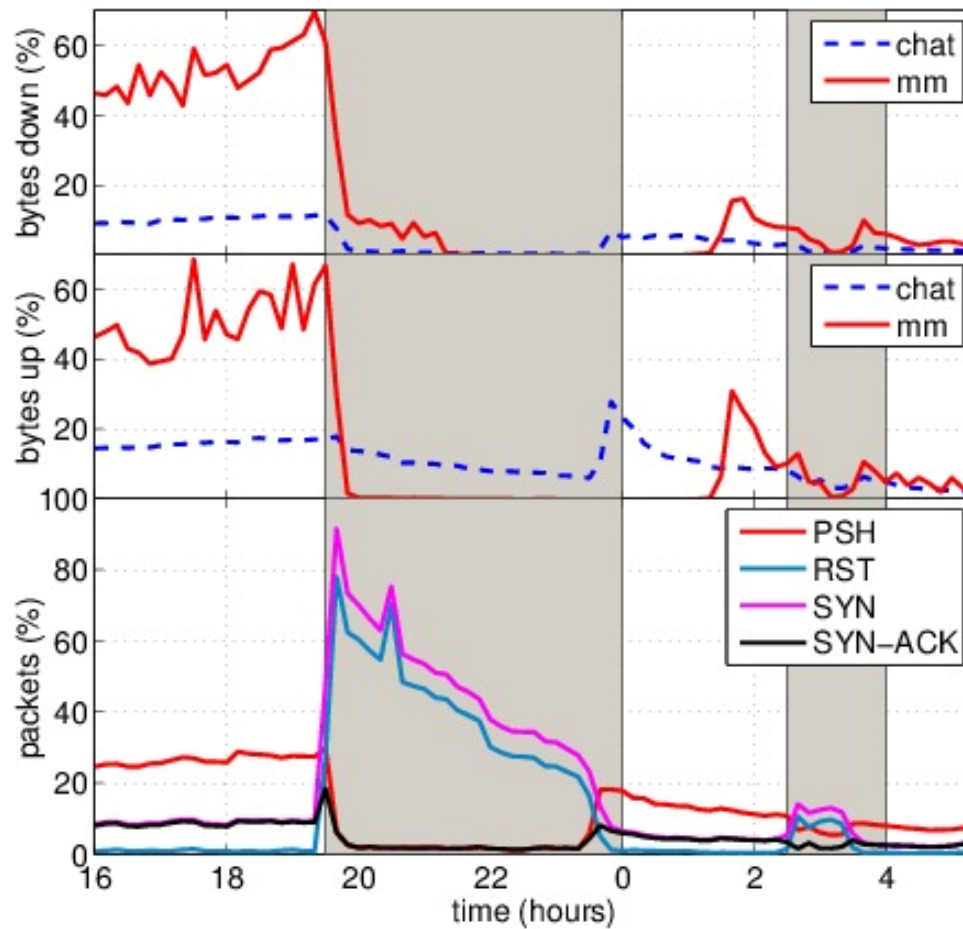


thank you for you attention!



Pierdomenico Fiadino
Telecommunications Research Center of Vienna (FTW)
<*fiadino@ftw.at*>

The big outage (Feb. 22nd, 2014) as seen from passive measurements and social feeds



residual volume down (mm)

residual volume up (chat)

TCP flags counters

