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Conclusion

# Multipath TCP with real Smartphone applications

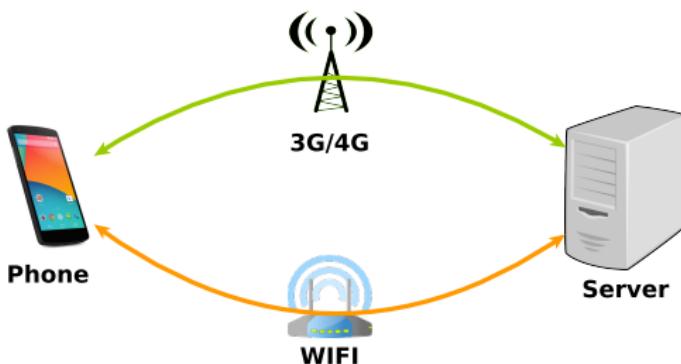
Matthieu BAERTS   Quentin DE CONINCK

INGI

June 19<sup>th</sup>, 2015



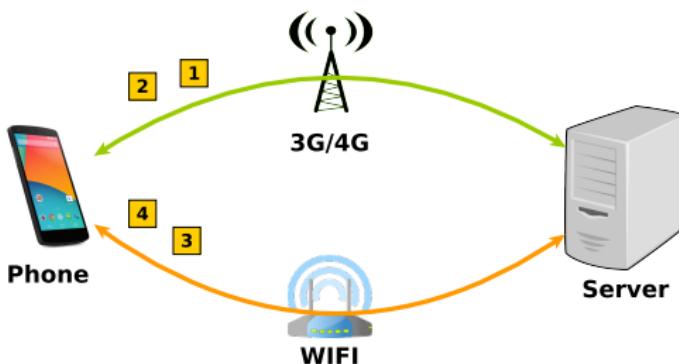
# Multipath TCP on smartphones: overview



## Pros

- Two interfaces: let's use them!
- Mobility (handovers)

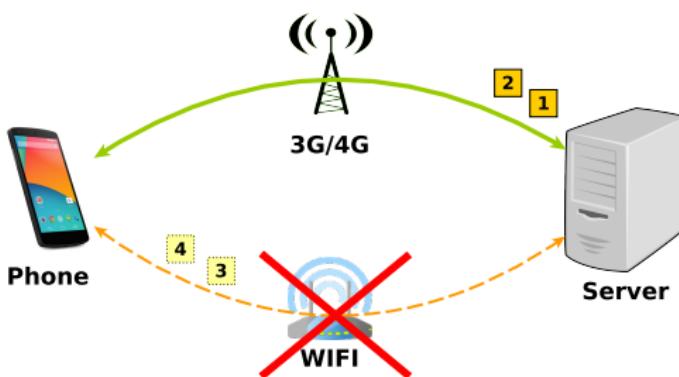
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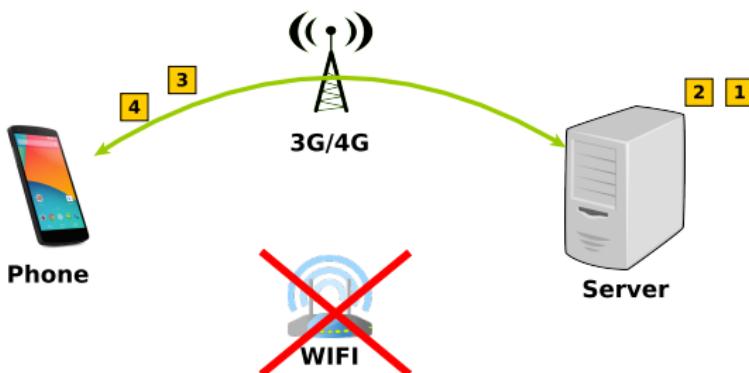
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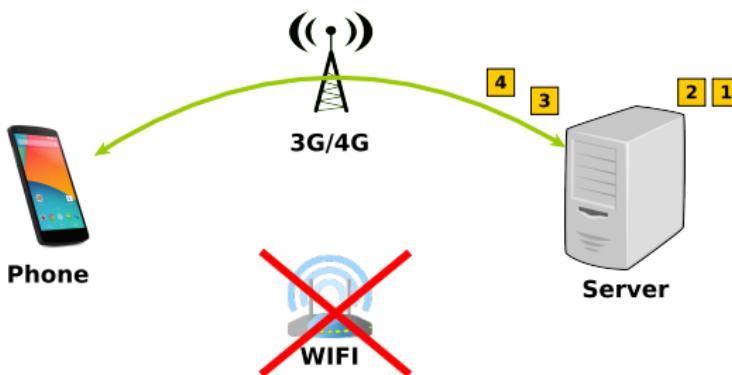
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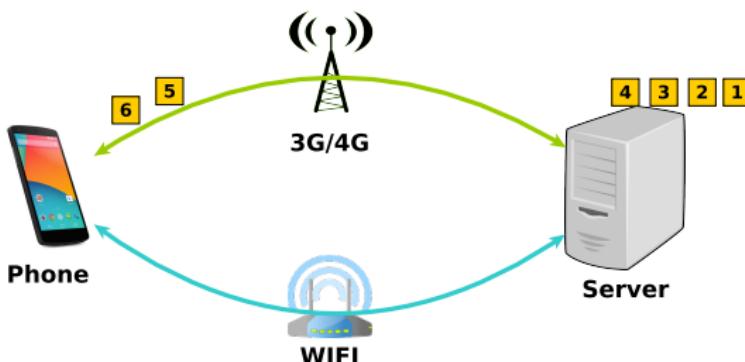
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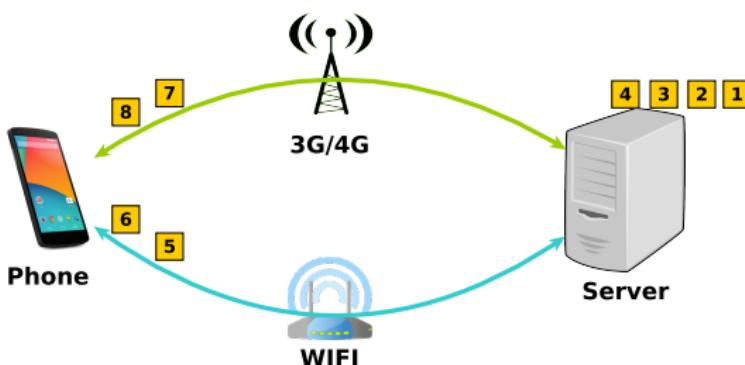
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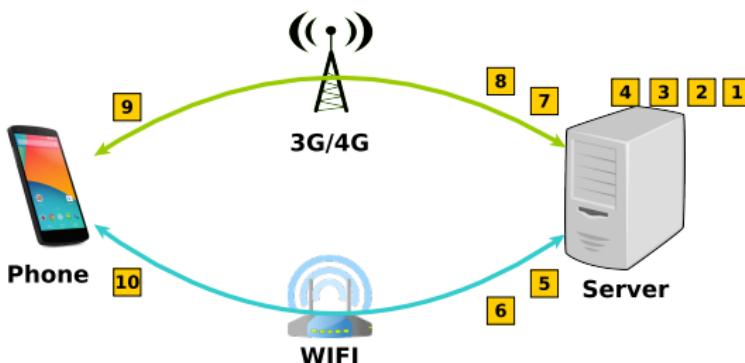
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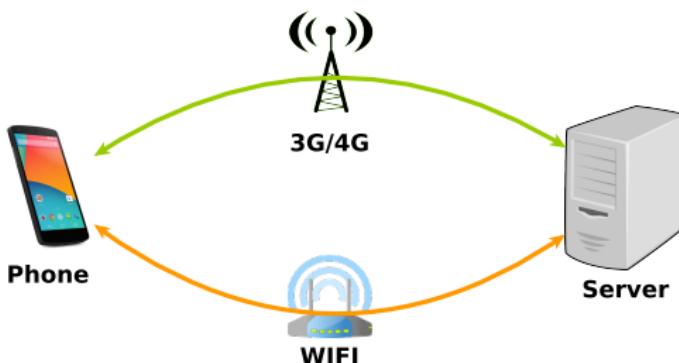
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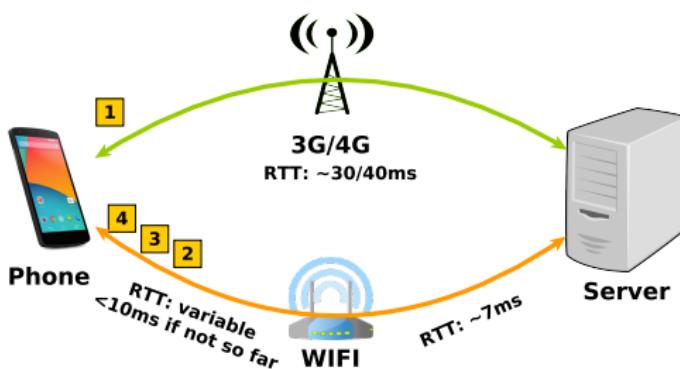
# Multipath TCP on smartphones: overview



## Challenges

- Major changes on end-hosts required
- Heterogeneous paths

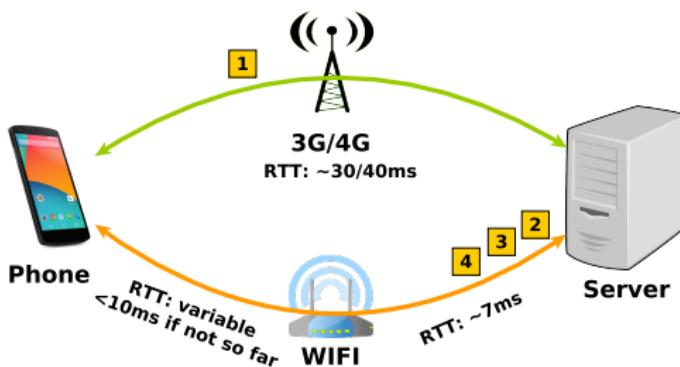
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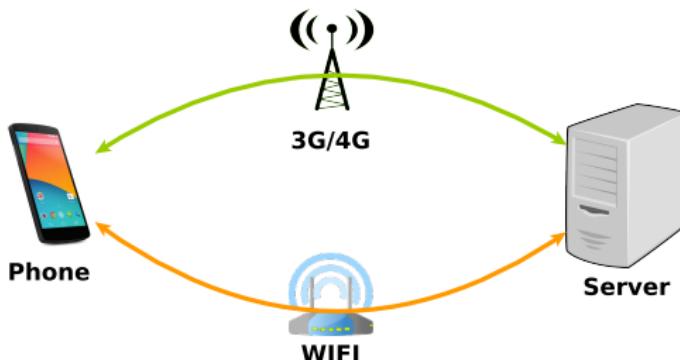
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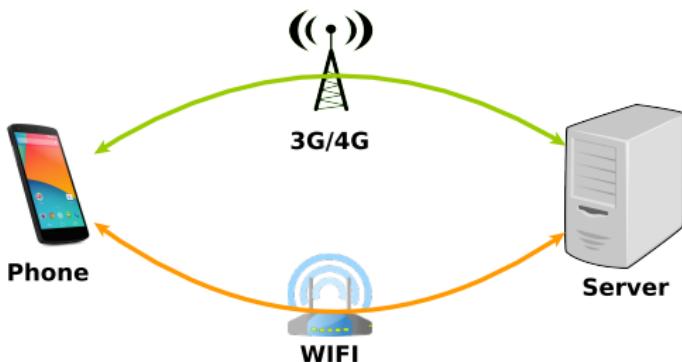
# Multipath TCP on smartphones: components



## Subflows

One Multipath TCP connection, multiple TCP subflows

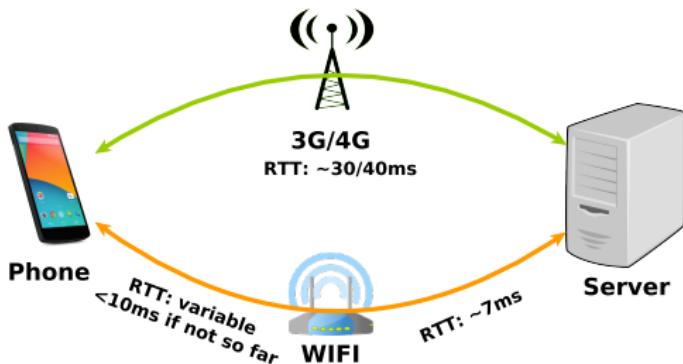
# Multipath TCP on smartphones: components



## Path manager

Management of subflows (Full-Mesh)

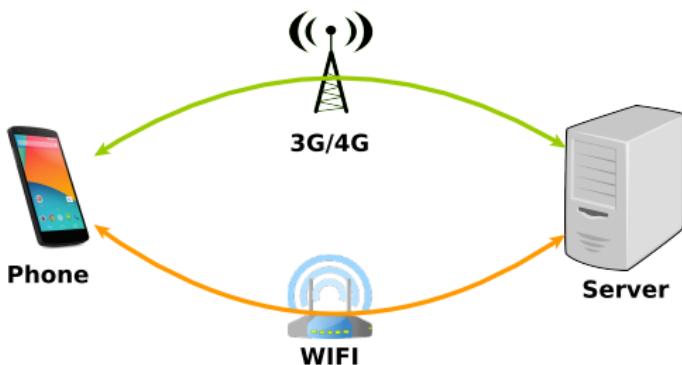
# Multipath TCP on smartphones: components



## Scheduler

Select subflow on which sending data (RTT-based)

# Multipath TCP on smartphones: components



## Reinjections

TCP has retransmissions (one path)

Multipath TCP has reinjections (multiple paths)

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Delay perceived by the smartphone applications

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# Automated Measurements

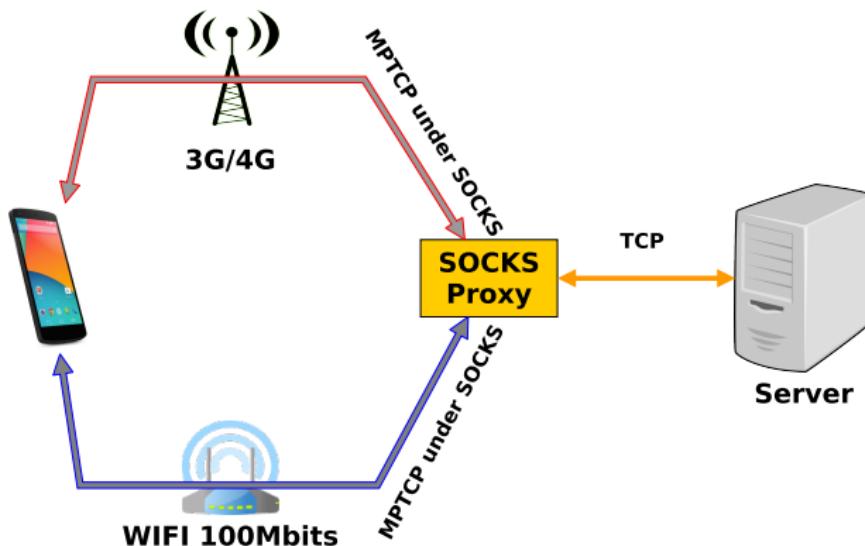
## Objective

- Understand behaviour of Multipath TCP on smartphones

## Methodology

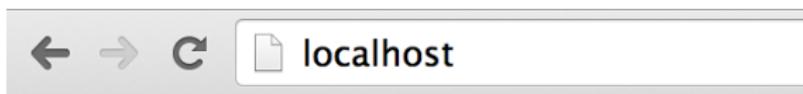
- Controlled environment
- Development of a measurement framework tool
- Scenarios developed to mimic smartphone usages
- Application to open both interfaces

# Automated Measurements



- Multipath TCP between smartphone and proxy

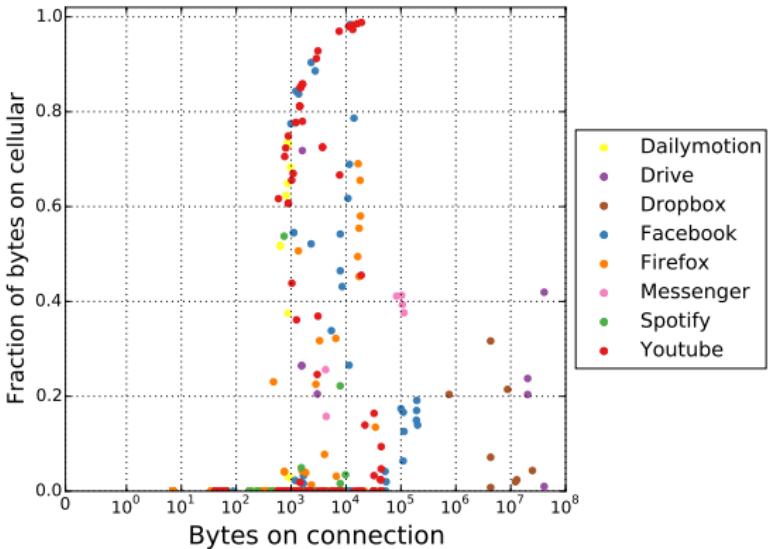
# Automated Measurements



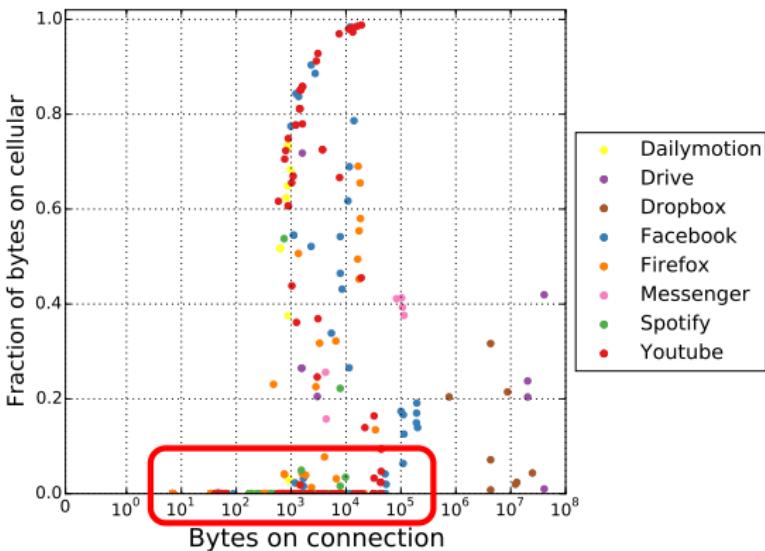
## It works!

No change is required on applications

# Balance of the traffic on both interfaces

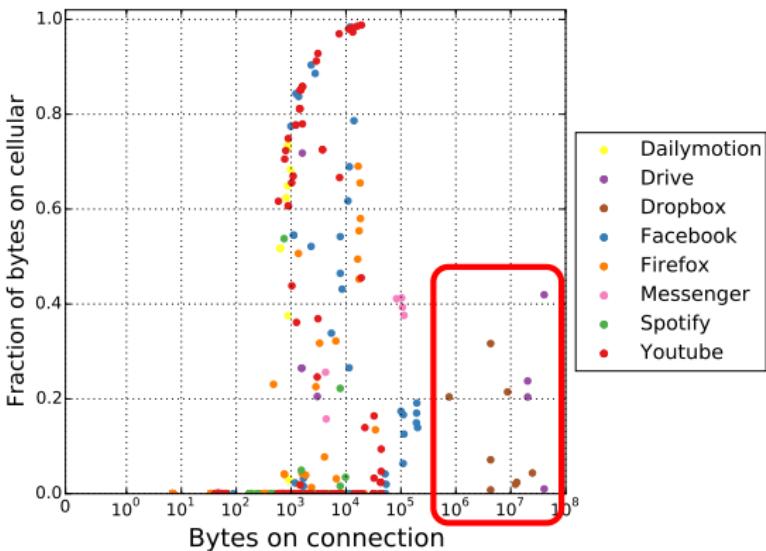


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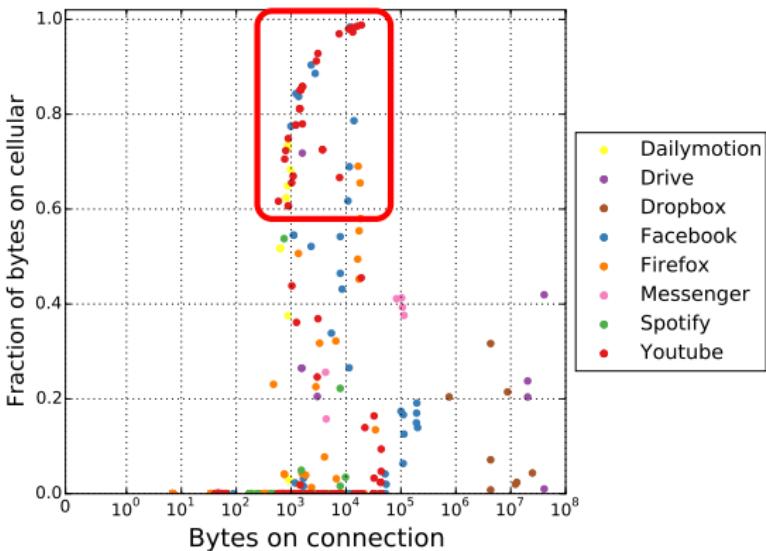
- Smartphone sends only on WiFi (default interface) on more than 90% of connections

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## Balance of the traffic on both interfaces



- Smartphone sends only on WiFi (default interface) on more than 90% of connections
- Some small connections (KBs) use a lot the 4G

# Delay perceived by the smartphone applications

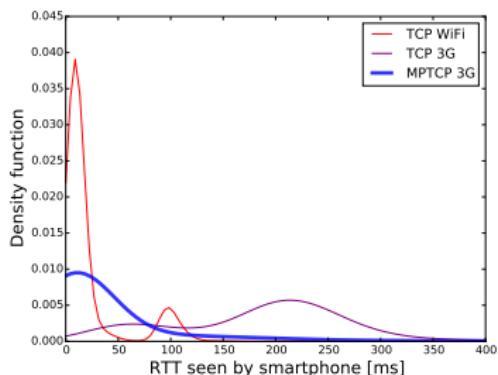


Figure: With 3G

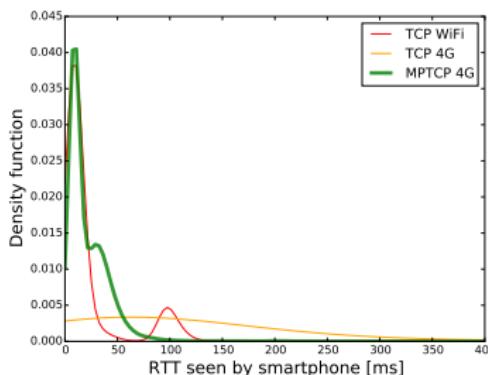


Figure: With 4G

- With upload traffic, smartphone perceives lower RTTs with Multipath TCP and both interfaces than with TCP on the worst interface

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# Real Traffic

## Objectives

- Observe Multipath TCP with real smartphone usages
- Confirm previous Multipath TCP results

## Methodology

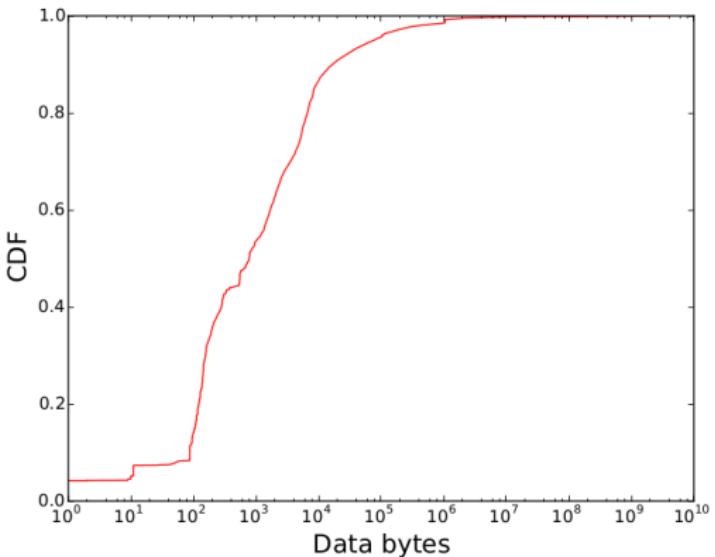
- Dozen of smartphone users
- SOCKS proxy used (as previously described)
- Proxy point of view
- Application to open both interfaces
- 7 weeks measurements, 20.3 GB

## Real Traffic

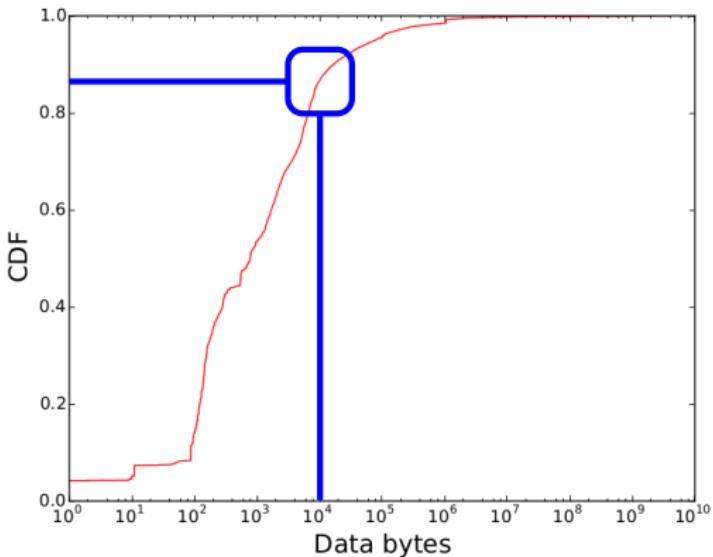


Our automated scenarios were close to the reality!

# Connections sizes



## Connections sizes



More than 85% of the connections carry less than 10 KB

## Subflow utilisation

Among all connections:

- 66% have 1 subflow
- 31% have 2 subflows
- 3% have more than 2 subflows → sign of handovers

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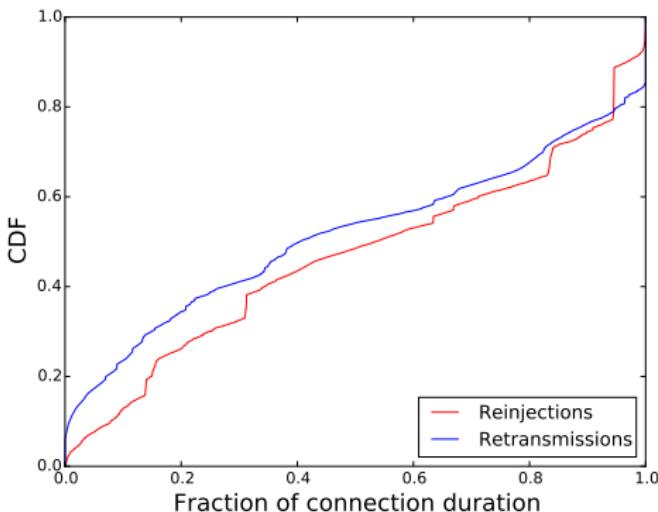
Among connections with at least 2 subflows:

- 54% are additional subflows
- 41% are unused subflows (76% of additional subflows unused)

**Overhead:** useless subflows opened, waste of resources on small connections (< 20 KB)

# Reinjections

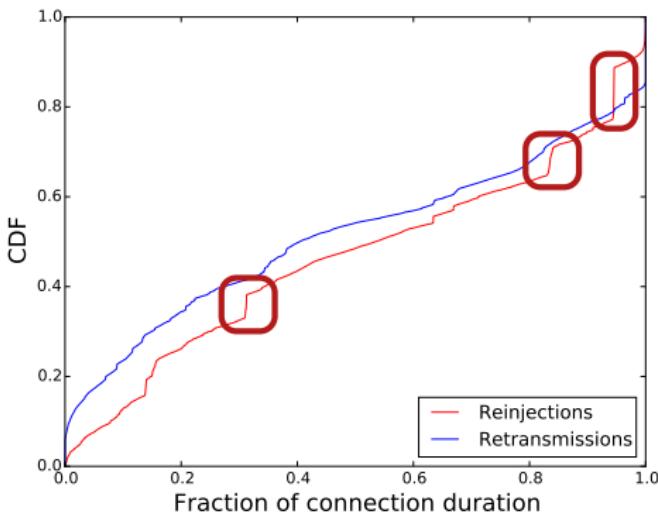
- 10.6% of multi-flows connections experience reinjections
- 63.7 MB reinjected over 19.8 GB of download traffic ( $\approx 0.3\%$ )



- Correlation between retransmissions and reinjections

# Reinjections

- 10.6% of multi-flows connections experience reinjections
- 63.7 MB reinjected over 19.8 GB of download traffic ( $\approx 0.3\%$ )



- Correlation between retransmissions and reinjections
- Vertical bars for reinjections: bursts of reinjections due to handovers

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**Streaming Applications**

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Handover at application level

Handover at Multipath TCP level

With 2G: interesting results

Multipath TCP's backup mode

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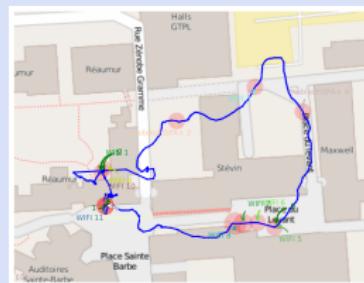
# Streaming Applications

## Objectives

- New use-case: radio streaming
- Observe handovers managed by the application and Multipath TCP
- Analyse Multipath TCP's backup mode feature

## Methodology

- Set up several controlled WiFi routers
- Walk around the building
- Two smartphones: with and without Multipath TCP
- Controlled Streaming server, no proxy



## Handover at application level

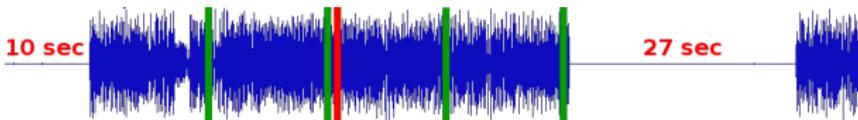


Figure: Handover: supported by Radio Streaming apps?

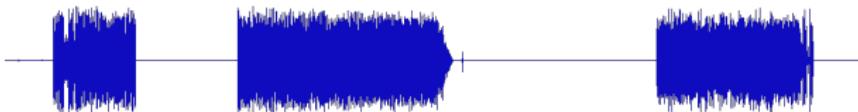


Figure: Regular TCP is used during a walk

# Handover at Multipath TCP level

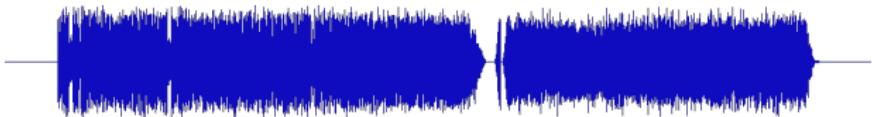
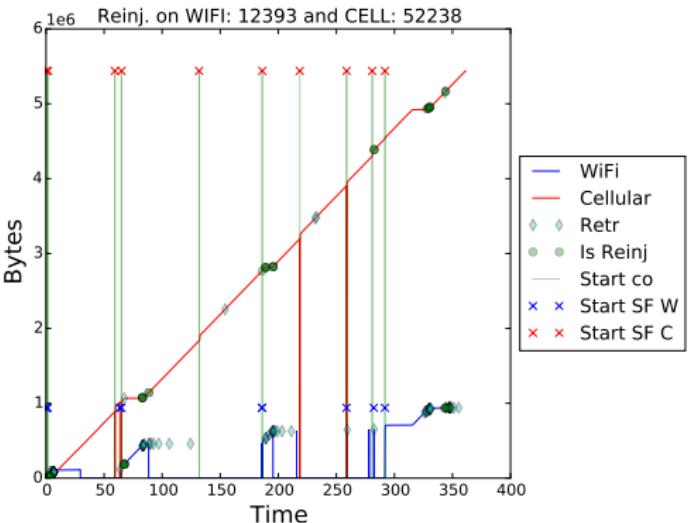


Figure: With WiFi and 3G

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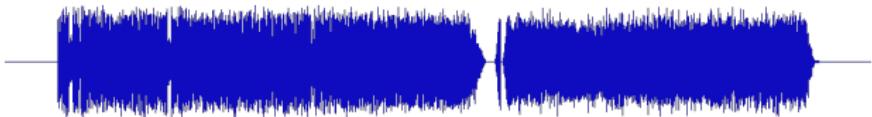
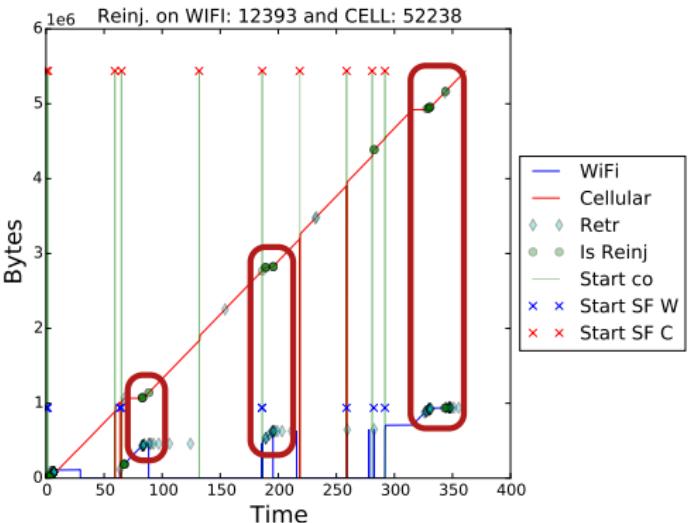


Figure: With WiFi and 3G

# Reasons: RTT, retransmissions

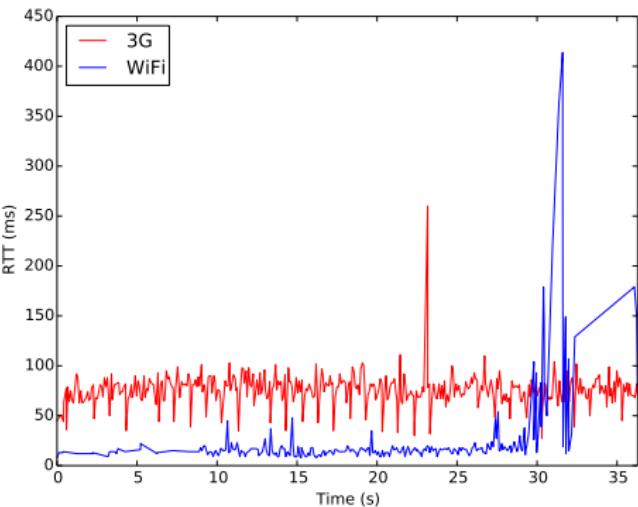


Figure: RTT when moving away from an WiFi access point

## With 2G: interesting results

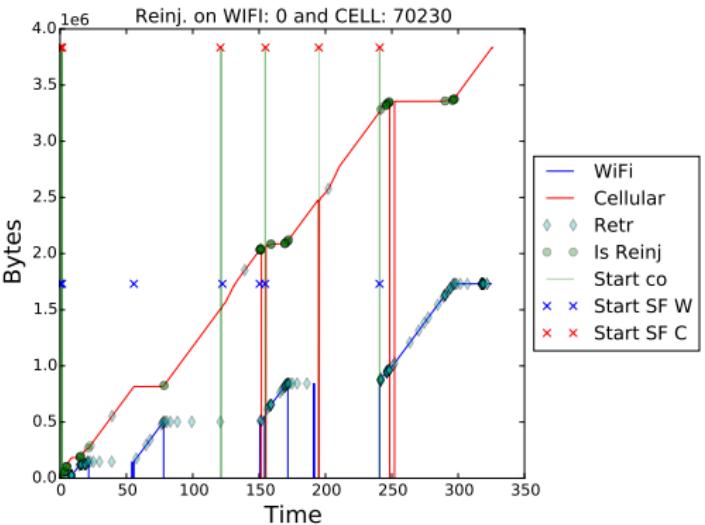


Figure: More traffic via the WiFi interface

# Multipath TCP's backup mode

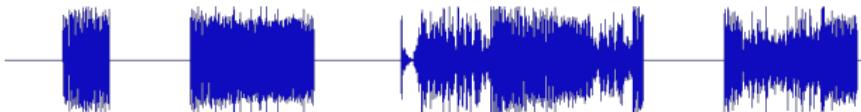
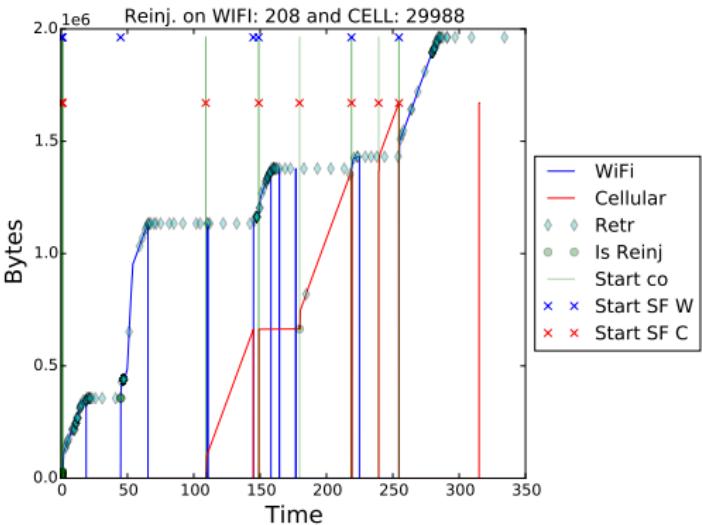


Figure: Current implementation is not what we want

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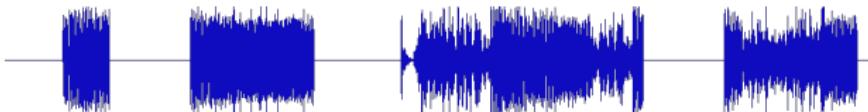
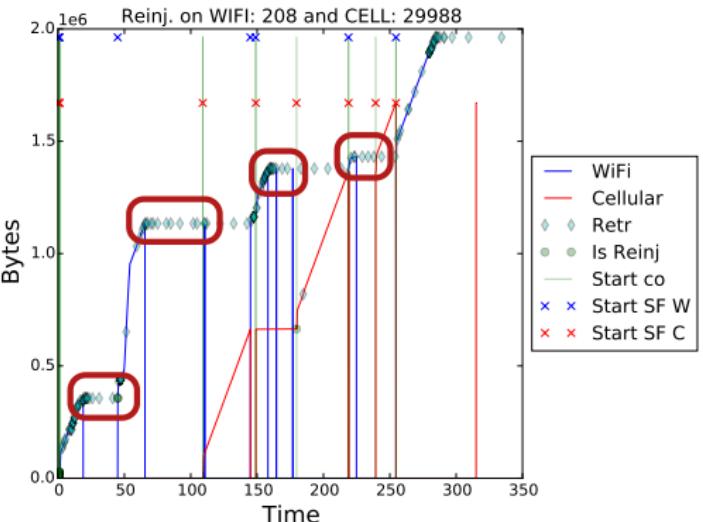


Figure: Current implementation is not what we want

# Conclusion

- Multipath TCP works well on smartphones
  - ▶ No need to change applications
  - ▶ Handover
  - ▶ Delay
  - ▶ Bandwidth
- Optimisation for the smartphone case required:
  - ▶ Backup mode adapted to the smartphone case
  - ▶ Multipath TCP not needed on short connections
  - ▶ Full integration in Android framework
  - ▶ Power consumption (not studied)

# Questions

Public                      Presenters

