MPTCP in the upstream kernel

A long road that started almost 15 years ago

5th of February 2023

Matthieu Baerts — @matttbe@fosstodon.org

tessares

Agenda

1. **MultiPath TCP**
   Introduction and use cases

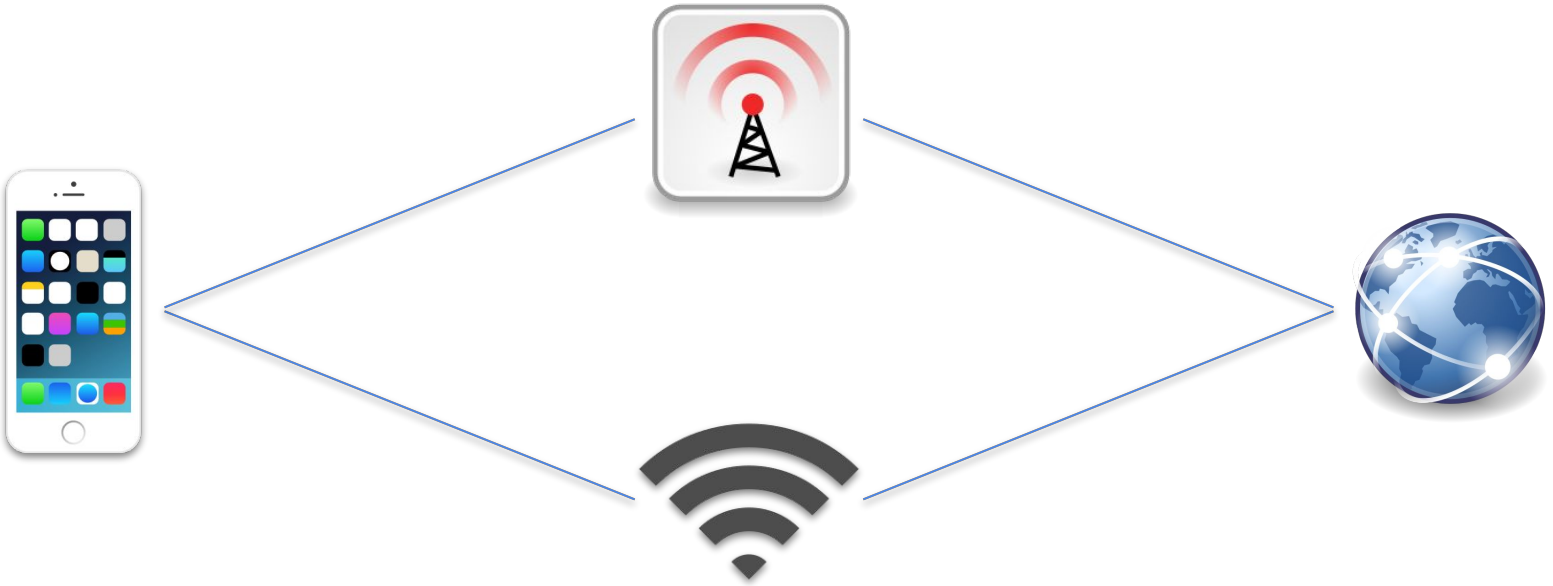
2. **What can we do today?**
   And what will we be able to do tomorrow?

3. **The long road to have MPTCP upstream**
   15 years: protocol definition, experimentations, rewriting from scratch

MultiPath TCP
What is it MPTCP?

- Extension to TCP, defined in RFC 8684
- One TCP session is no longer tight to a fixed pair of IP/ports
- Exchange data for a single connection over different paths, simultaneously

Smartphone use-case (Apple iOS - Android in South Korea)



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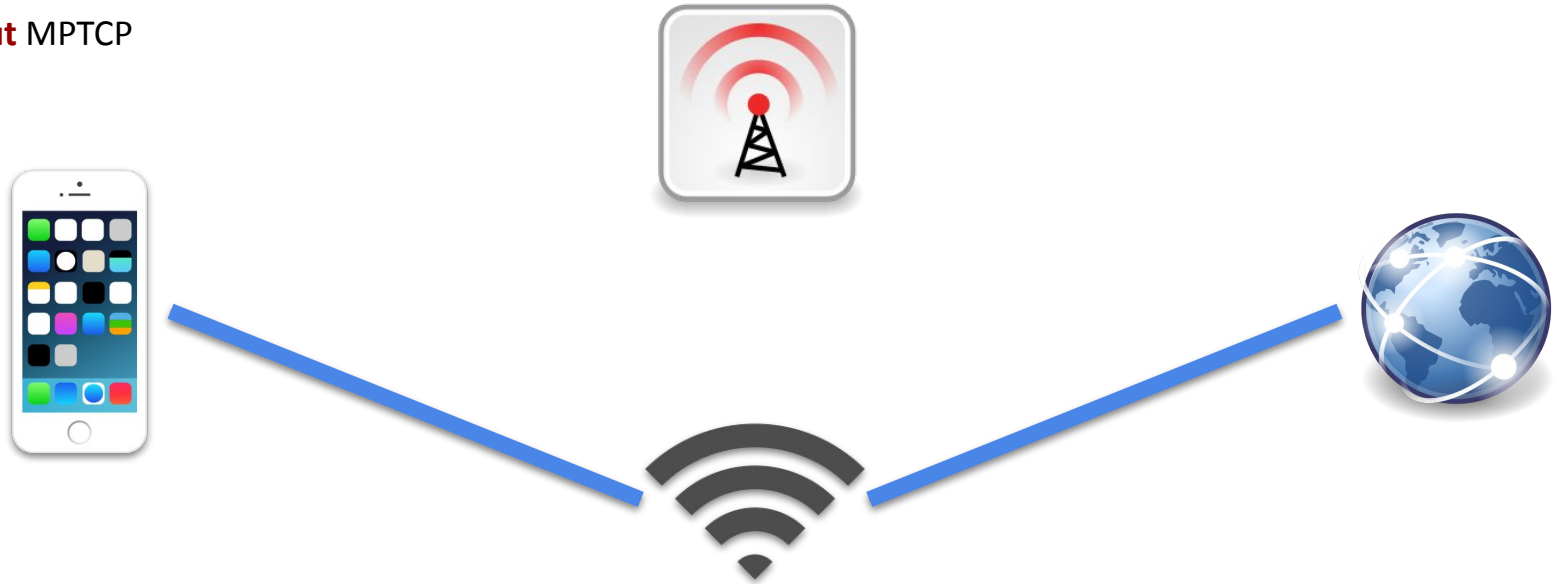
Without MPTCP



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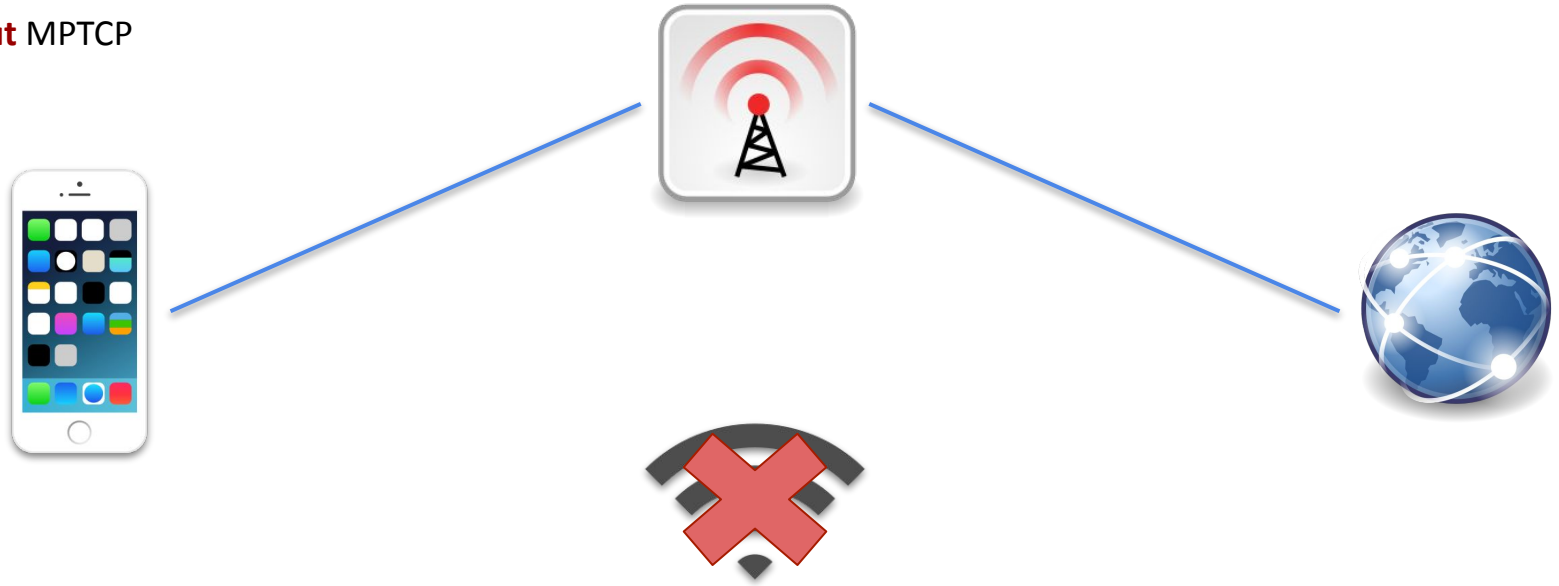

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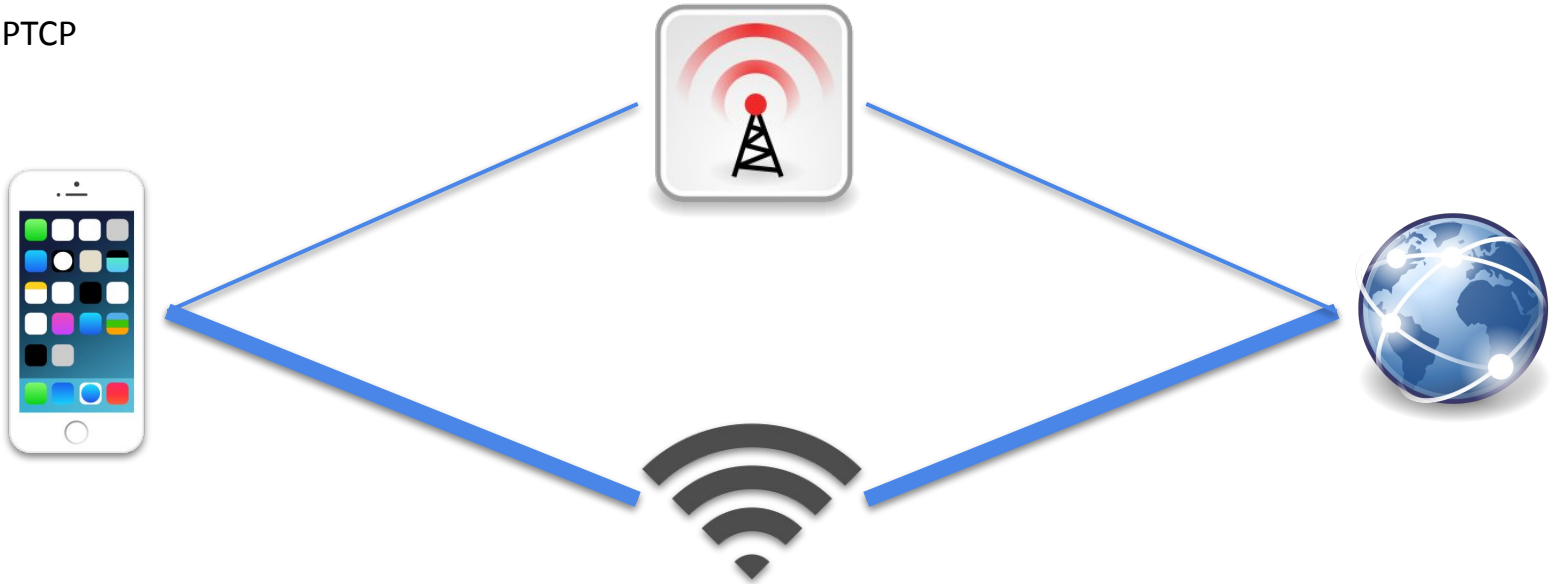

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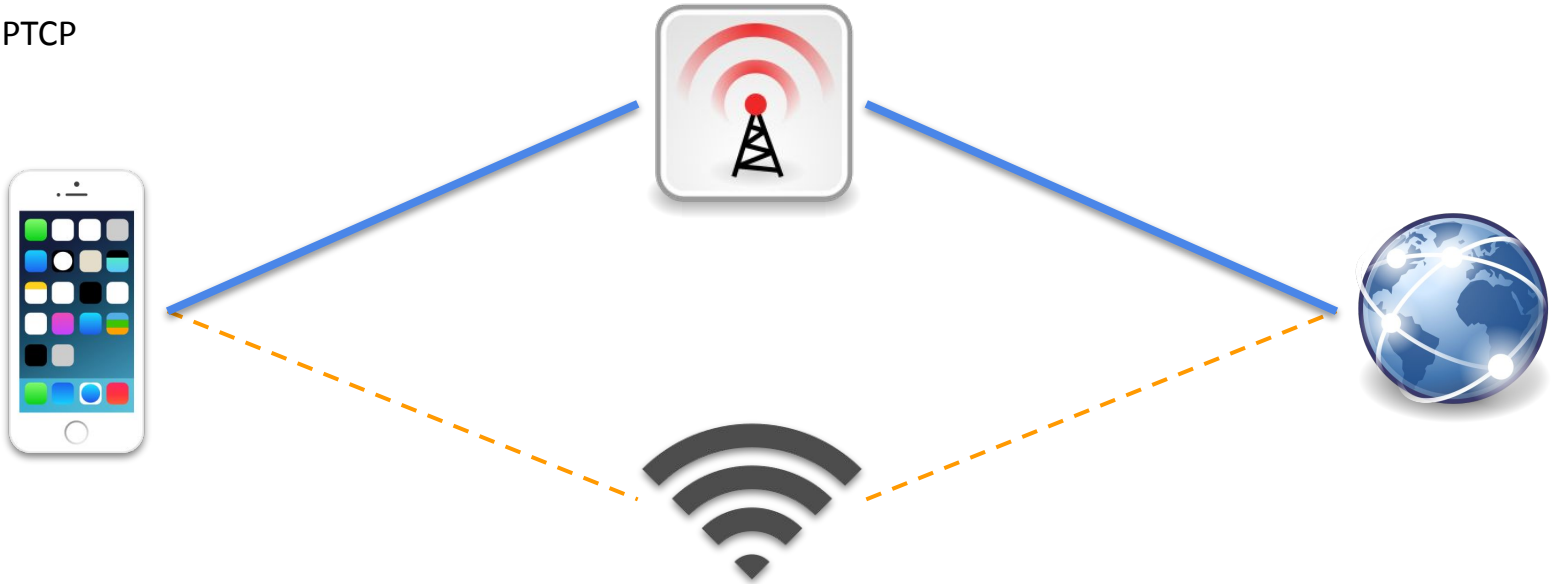

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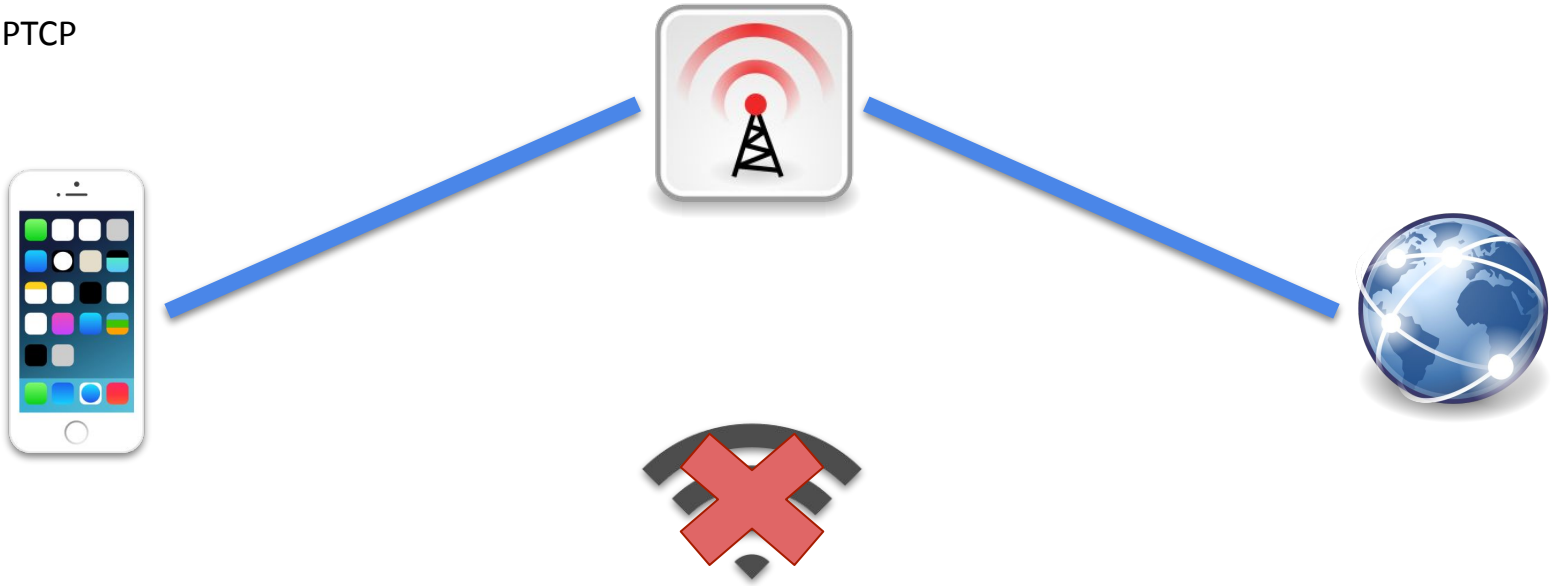

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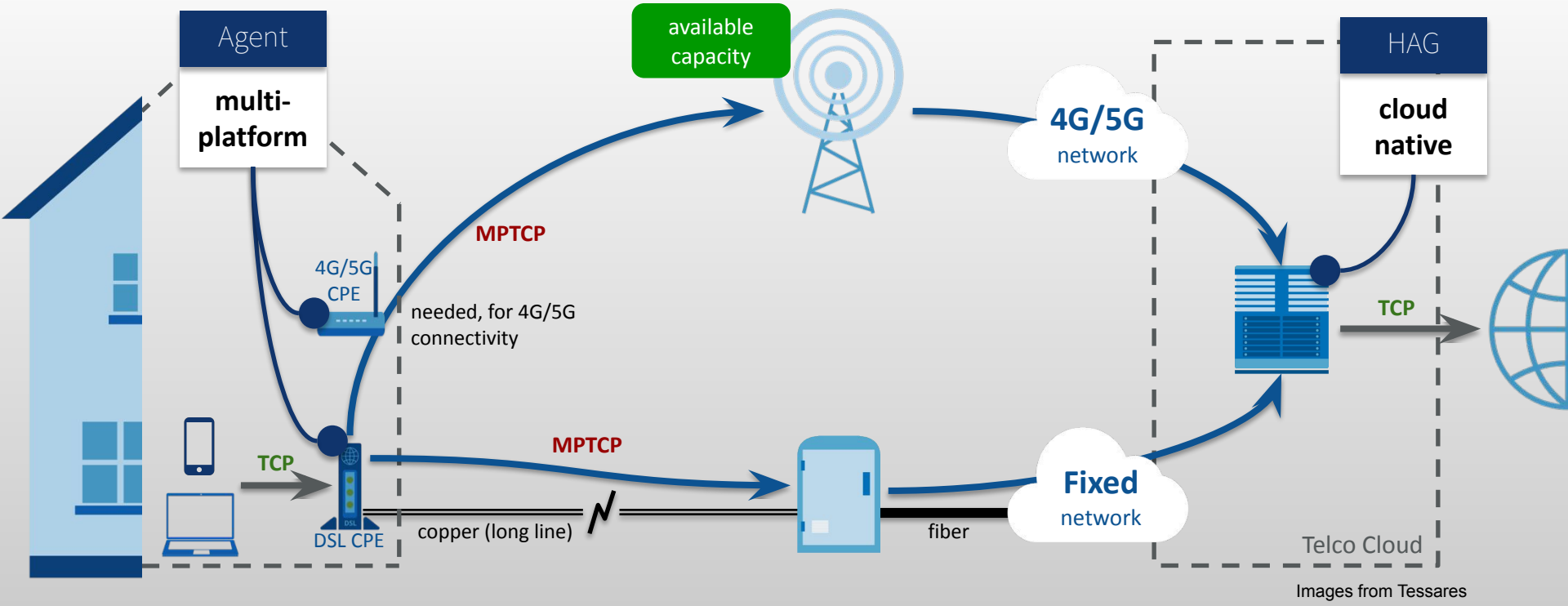
MultiPath TCP

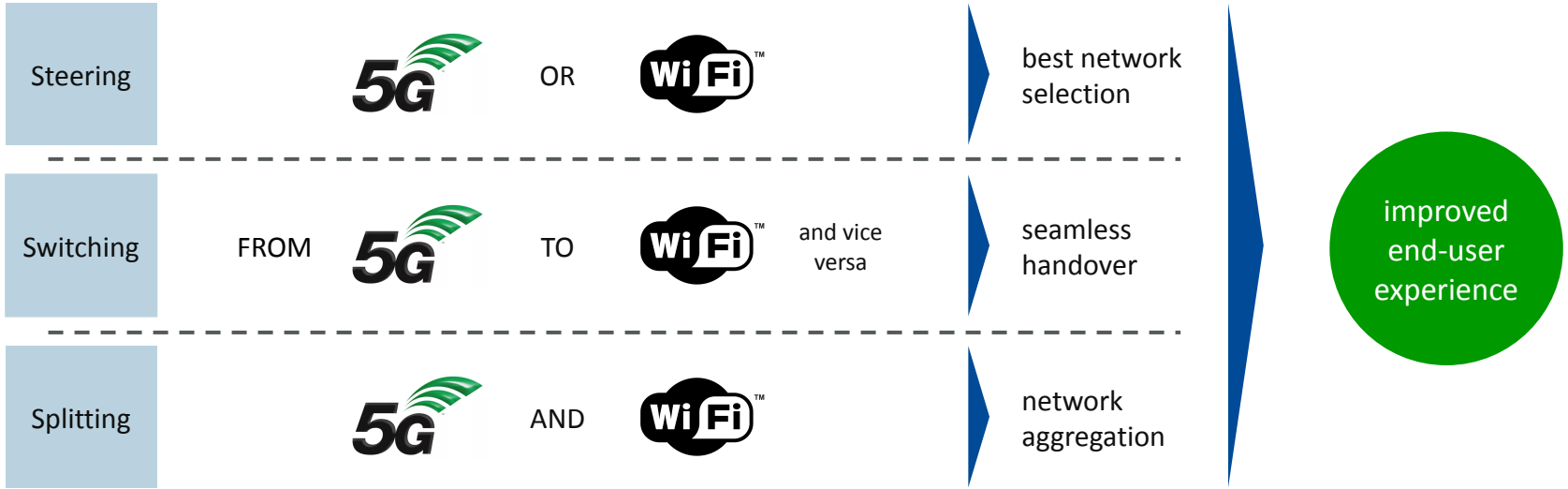
Typical use cases: Hybrid access network



Images from Tessares

MultiPath TCP

Typical use cases: 5G (ATSSS)



Defined in 3GPP Release 16, ATSSS is a core network function in 5G networks, playing a key role in managing data traffic between 3GPP (5G, 4G) networks and non-3GPP (Wi-Fi) networks

Logos from 3GPP and Wi-Fi Alliance

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How to use it?

- Get a recent enough kernel:

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socket(AF_INET(6), SOCK_STREAM, IPPROTO_MPTCP);
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  Or use **`mptcpize`**: **`LD_PRELOAD`** to force creating MPTCP socket

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- Configure the network:

  With: **`NetworkManager`** 1.40+ or **`mptcpd`** or **`ip mptcp`** + **`ip route`**

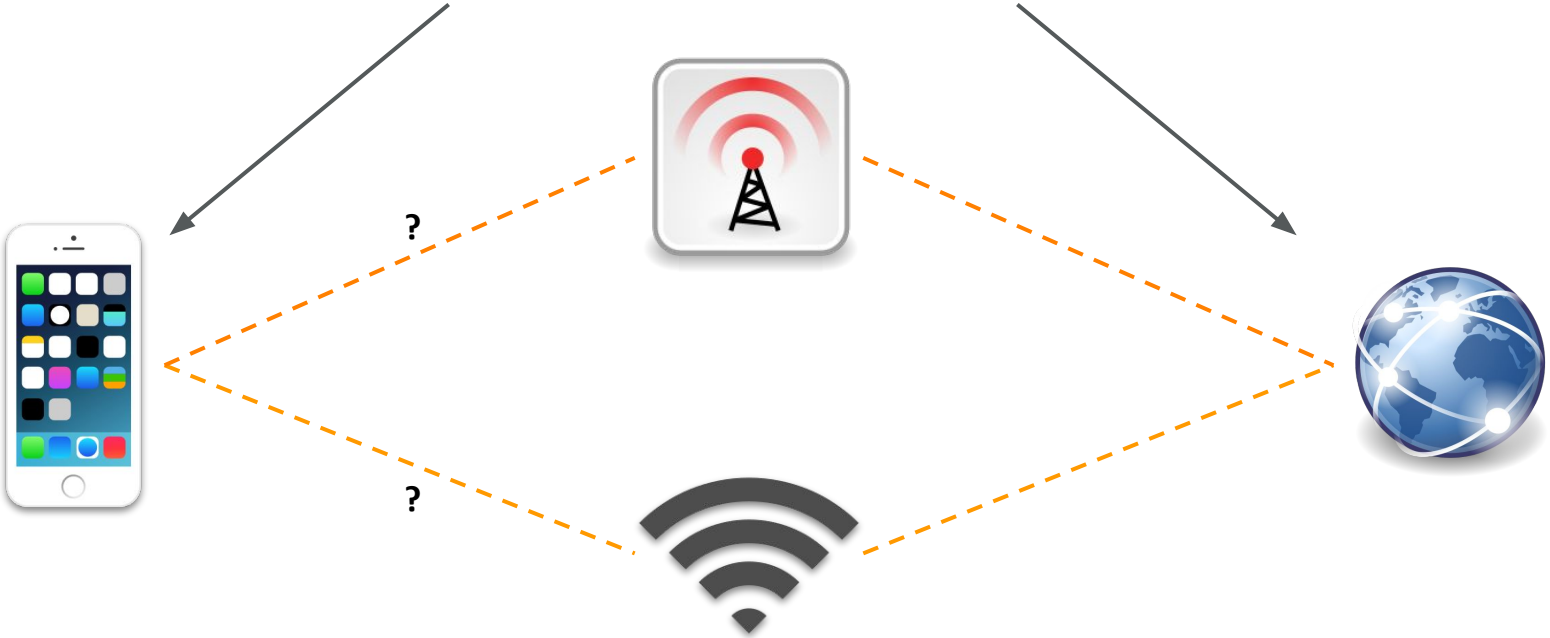
What can we do today?
How to use it? Example

- Get a recent GNU/Linux distribution
- Manual network configuration for additional IPs (or use NM)
  - `sudo ip mptcp endpoint add <IP> dev <iface>` (subflow | signal)
  - `sudo ip rule add from <IP> table 42`
  - `sudo ip route add default via <next hop> table 42`
- Run your app:
  - `mptcpize iperf3 --client|--server`

What can we do today?
Features

- Most protocol features are supported: multiple subflows, announce addresses and priority, fast close, etc.
- Many socket options are supported: **`SO`**, **`IP`**, **`TCP`**
- Info from MIB counters, **`INET_DIAG`** interface and **`MPTCP_INFO`**
- 2 Path Managers and 1 Packet scheduler

Which path to create/remove? Which address to announce?



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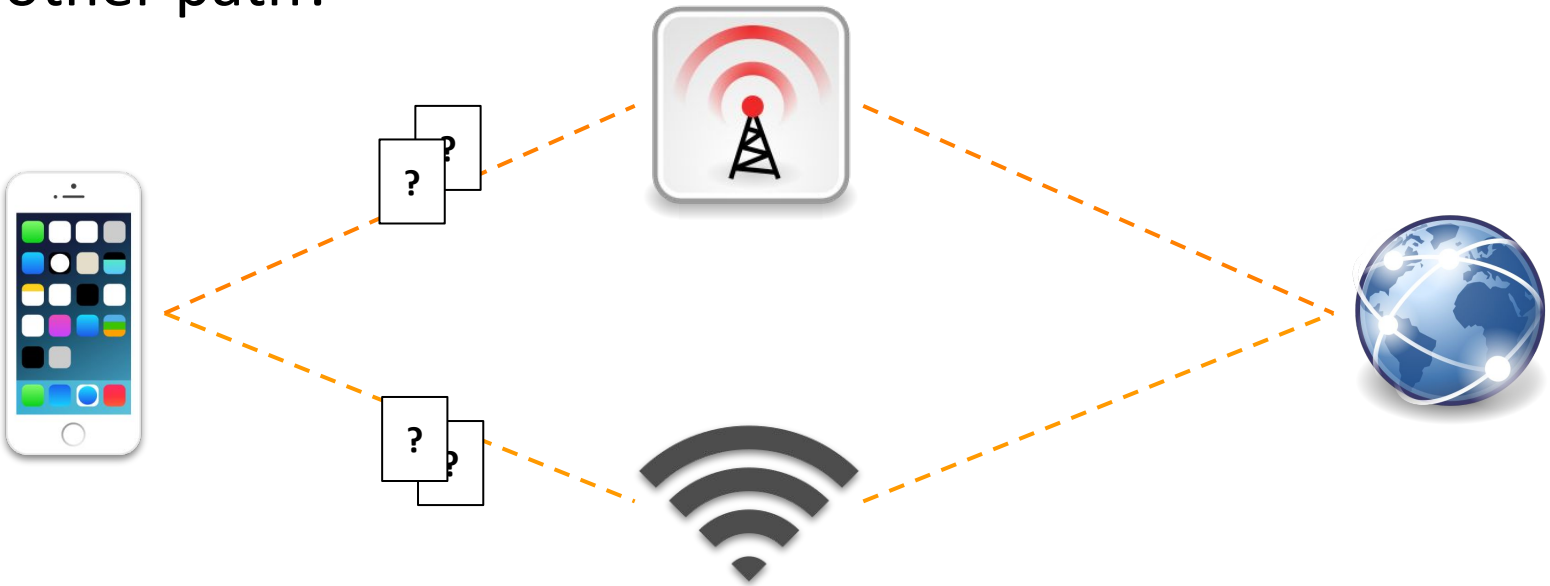
On which available path packets will be sent? Reinject packets to another path?



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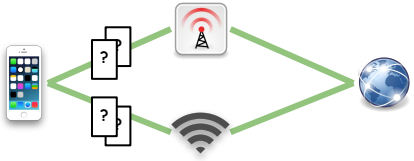
What will we have?
Extracted from the wish list

- eBPF Packet scheduler:
  - Ending up changing the scheduler and its API



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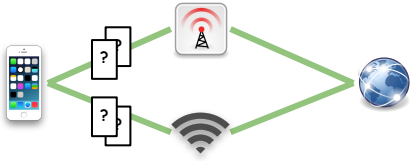

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- More socket options:
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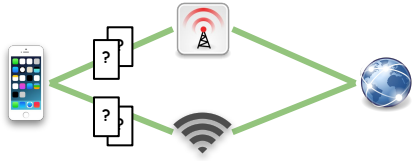
- Golang support:
  - No compatible with mptcpize (LD_PRELOAD)
  - `net` package doesn't allow selecting another protocol



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Logo by the Go Authors

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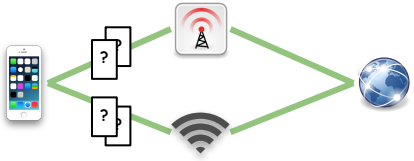

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- More socket options:
  - `[gs]etsockopt(…)`
- Golang support:
  - Eventually used MPTCP by default instead of TCP?
  - Accepted proposition 🍾: github.com/golang/go/issues/56539

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Road to have MPTCP upstream

The beginning

- Project started ~15 years ago at UCLouvain 🇧🇪 🍟 🍻

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Photo: hln.be

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The beginning

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- As fork:
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  - Initial author: Sébastien Barré
  - Moving to “production ready”: Christoph Paasch, Gregory Detal
- MPTCPv0 RFC published in January 2013
- Used in production on servers having millions of clients

Photo: hln.be

Road to have MPTCP upstream

Maintaining a fork

- It is easy to fork …

From doomworld.com

Road to have MPTCP upstream

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  - but you will pay for it!

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Screenshot by Tomer Gabel

From doomworld.com

Road to have MPTCP upstream

Maintaining a fork: different levels

- It is easy to fork …
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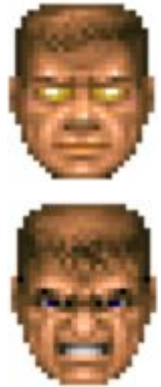
- The Linux kernel is big, complex, very active



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Road to have MPTCP upstream

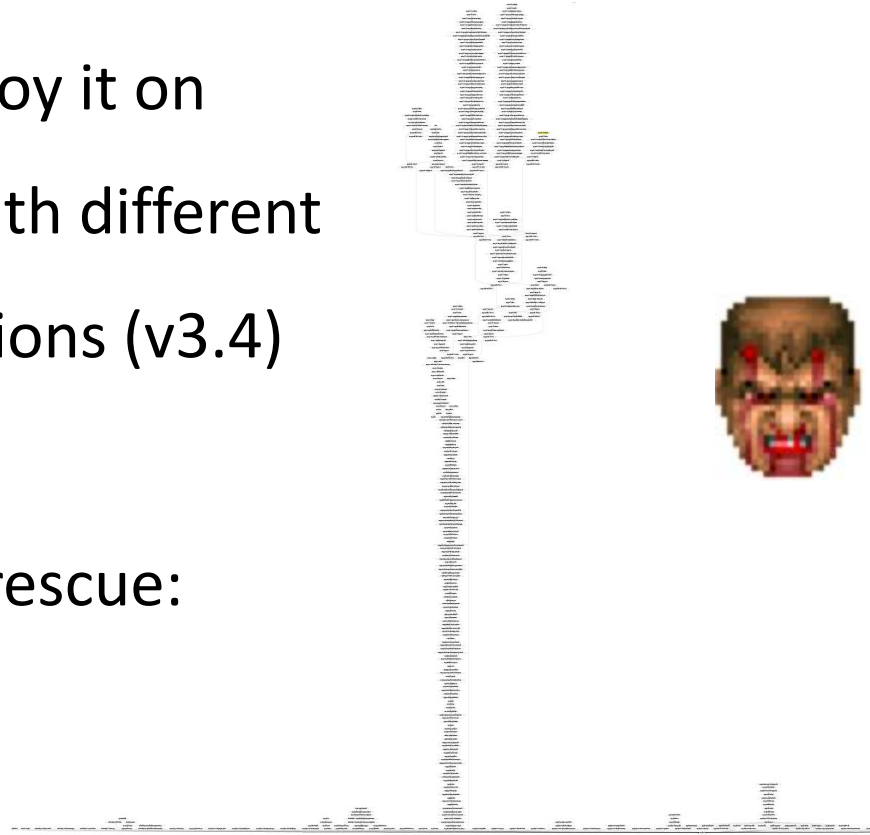
Maintaining a fork: different levels

- It is easy to fork …
  - but you will pay for it!
- The Linux kernel is big, complex, very active
- The fork is quite invasive:
  - 21k lines in total
  - 2.5k in TCP / IP / … with many “`if (mptcp)`”
  - With duplicated functions adapted for MPTCP case

Road to have MPTCP upstream

Maintaining a fork: nightmare mode

- Now imagine you have to deploy it on various embedded systems, with different LTS kernels, from very old versions (v3.4)
- Backports and conflicts 🎉
- Git's rerere and TopGit to the rescue:
  - Cherry-Pick once, propagate
  - Resolve conflicts once



Road to have MPTCP upstream

Still used today

- Most MPTCP deployments today are still using this fork:
  - Millions of devices in different types of deployments
  - New releases done 2 days ago (kernels v4.14, v4.19, **v5.4**)
  - Probably (one of) the last releases!

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  - New releases done 2 days ago (kernels v4.14, v4.19, **v5.4**)
  - Probably (one of) the last releases!
- MPTCP support in the upstream kernel started in 2020 (v5.6)
  - Why a so long delay?
  - Not a new idea: discussions and attempts in 2010 & 2015

Road to have MPTCP upstream

Upstreaming: requirements

- Linux TCP is highly optimized

Road to have MPTCP upstream

Upstreaming: requirements

- Linux TCP is highly optimized
- New implementation cannot affect existing TCP stack:
  - No performance regressions
  - Maintainable and possibility to disable it
  - Can be extended via the userspace

Road to have MPTCP upstream

Upstreaming: requirements

- Linux TCP is highly optimized
- New implementation cannot affect existing TCP stack:
  - No performance regressions
  - Maintainable and possibility to disable it
  - Can be extended via the userspace
- Cannot take the initial fork:
  - Built to support experiments and rapid changes but not generic enough
  - Special purpose implementation of MPTCP

Road to have MPTCP upstream

Upstreaming: solutions

- Rewriting (almost) from scratch
- A different concept: introduction of MPTCP socket
- Minimal differences in TCP code thanks to TCP ULP (+ SKB ext)
- Carefully review and detail modifications in TCP stack
- APIs to extend the path-manager and the scheduler
- And …

- A lot of work!
  - Special thanks to Mat Martineau and other fellows at **Intel** (Peter, Ossama, Kishen, Todd)
  - **RedHat** (Paolo, Florian, Davide, etc.), **SUSE** (Geliang), **Apple** (Christoph), **Tessares** (Benjamin, myself), and more (Dmytro, Menglong, Poorva, Yonglong, Nicolas, Netdev maintainers, etc.)

Conclusion

A long road… and it is not over!

Questions? Discussions?

Mailist list is open!

One public conf call per week!

mptcp.dev

tessares.net

@matttbe@fosstodon.org

@mptcp@social.kernel.org

matthieu.baerts@tessares.net

Backup slides

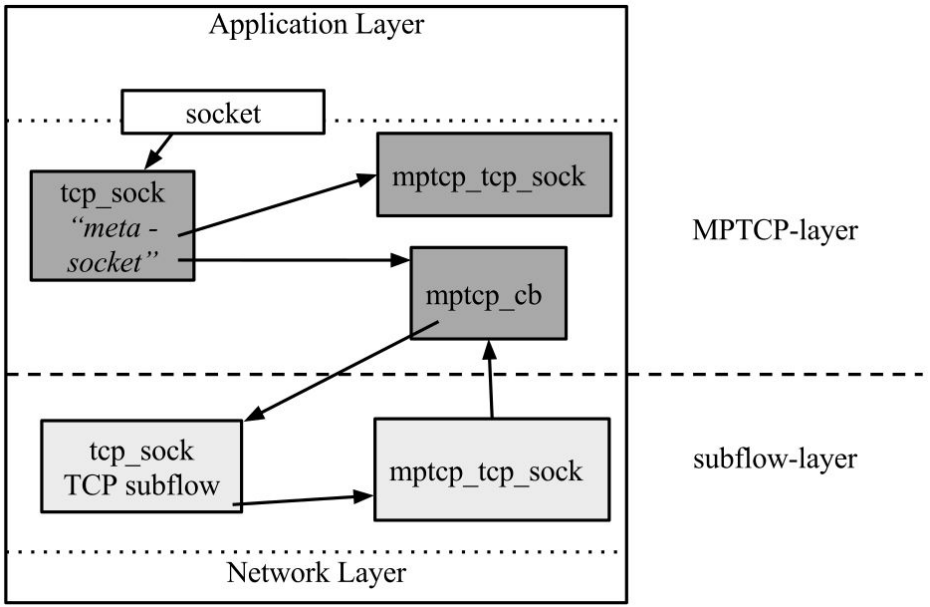
Road to have MPTCP upstream

Development: contributors are welcome

- Virtme is great to start working in the kernel
- Build, run, test with a one-line command:

```
cd <kernel source code>
docker run -v "${PWD}:${PWD}:rw" -w "${PWD}" --privileged --rm -it \
       --pull always mptcp/mptcp-upstream-virtme-docker:latest \
       <entrypoint options>
```

A special TCP socket (meta) is used to interact with the apps and the subflows



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