Telefónica

Insights from Operating an IP Exchange Provider

RIPE 83

Virtual | 22 - 26 Nov 2021

Telefónica

Telefónica Research

Andra Lutu

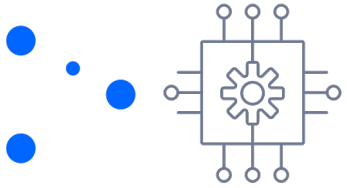
Diego Perino

University Carlos III of Madrid

Marcelo Bagnulo

Northwestern University

Fabián Bustamante



What is mobile roaming and why is it important?

Roaming allows cellular devices to connect everywhere in the world, using only one single (mobile) connectivity subscription (from the home mobile network).

This enables the global movement of devices and users.

IoT Global Connectivity

Cellular IoT is the fastest growing mobile device category

M2M connections will be half of the global connected devices and connections by 2023

Connected cars represent the fastest growing application type

Global SIM is now a product that IoT companies demand, and it is powered by **international cellular roaming**

Today

01
What makes Roaming Possible?

The IPX Ecosystem

View from an IPX Provider

02
Signaling Traffic Patterns

SS7 (2G/3G) and Diameter (4G/LTE) Signaling

03
Patterns and Performance of Data Tunnels

GTP-C Signaling

04
Data Roaming Traffic

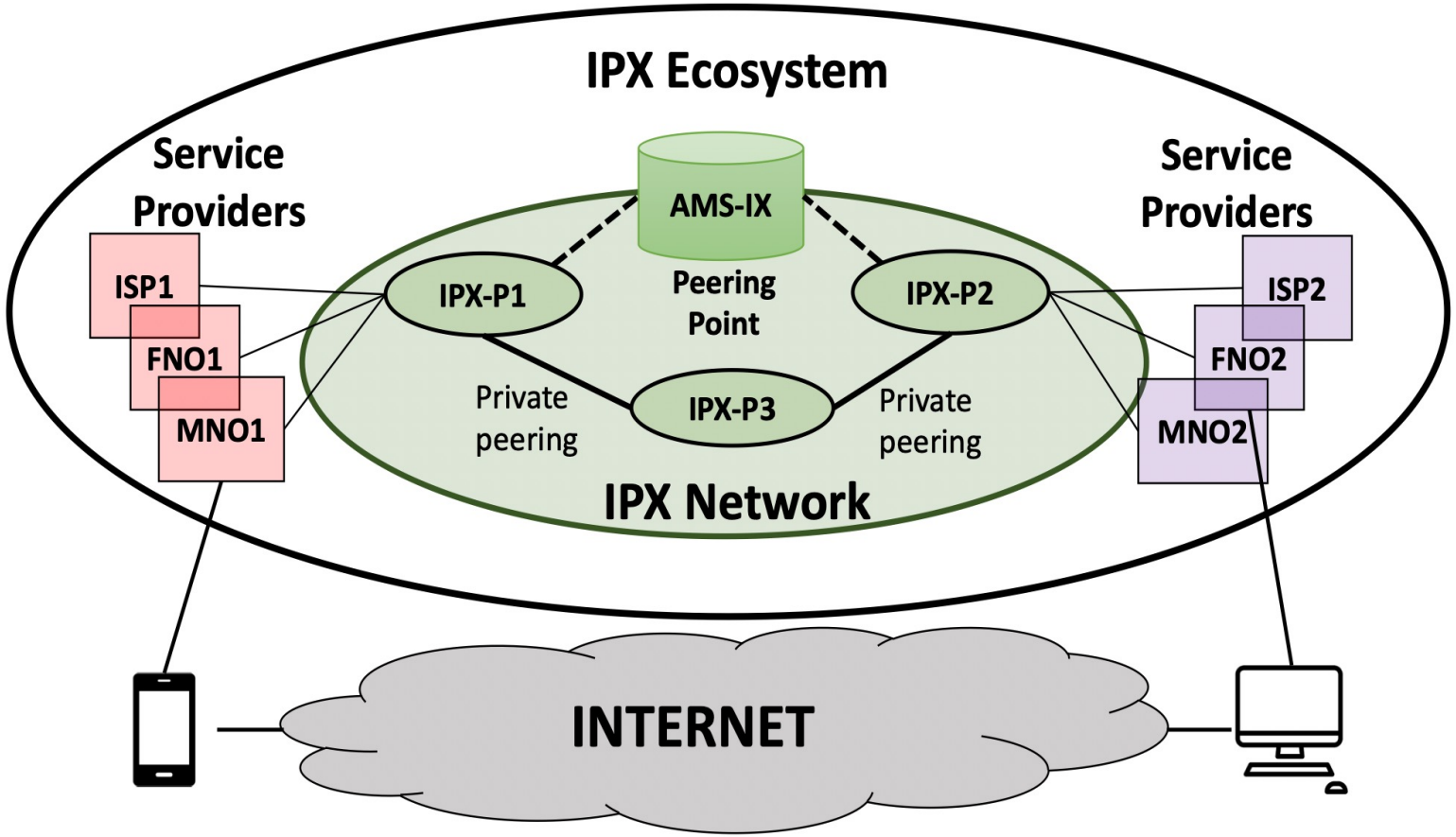
Roaming Performance

The first detailed analysis of operations in a large IPX Provider

An IP eXchange is a private platform that carriers (or IPX Providers) operate in order to enable their customers devices to operate world-wide

IPX Providers peer with each-other to form the IPX Network, today composed of 29 active IPX-Ps peering using three major peering exchange points, and interconnecting about 800 MNOs worldwide

This is an isolated network that bypasses the public Internet, ensuring global, secure, SLA-compliant services



Today

01

What makes Roaming Possible?

The IPX Ecosystem

> View from an IPX Provider

02

Signaling Traffic Patterns

SS7 (2G/3G) and Diameter (4G/LTE) Signaling

03

Patterns and Performance of Data Tunnels

GTP-C Signaling

04

Data Roaming Traffic

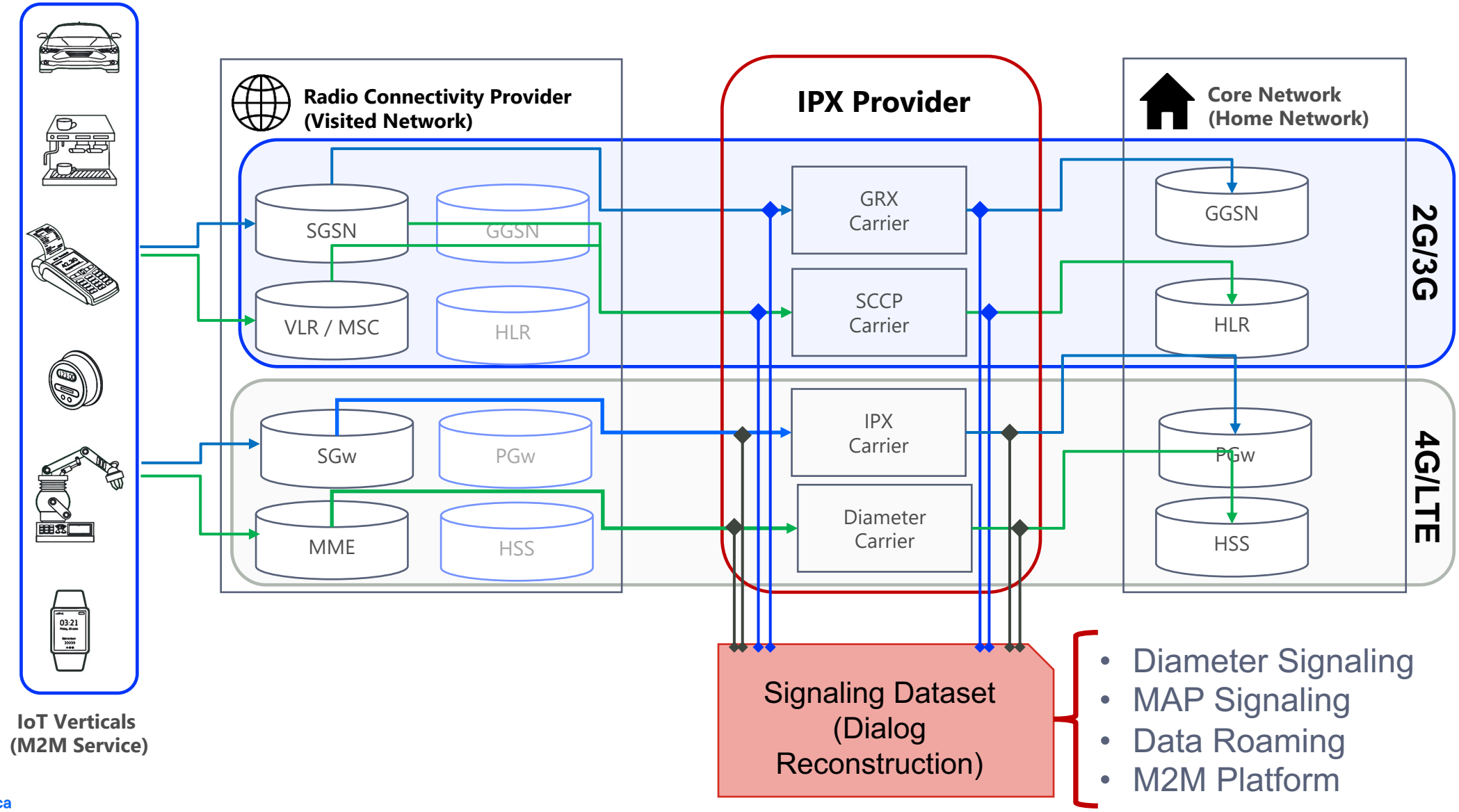
Roaming Performance

Telco Provider with a Global Footprint

87,000 km network of high-capacity submarine fibre optic cables and a Tier-1 IP network

World-wide MPLS network supports the IP eXchange platform and its services

Dataset to capture the operations of the IPX Provider



Today

01

What makes Roaming Possible?

The IPX Ecosystem

View from an IPX Provider

02

Signaling Traffic Patterns

> SS7 (2G/3G) and Diameter (4G/LTE) Signaling

03

Patterns and Performance of Data Tunnels

GTP-C Signaling

04

Data Roaming Traffic

Roaming Performance

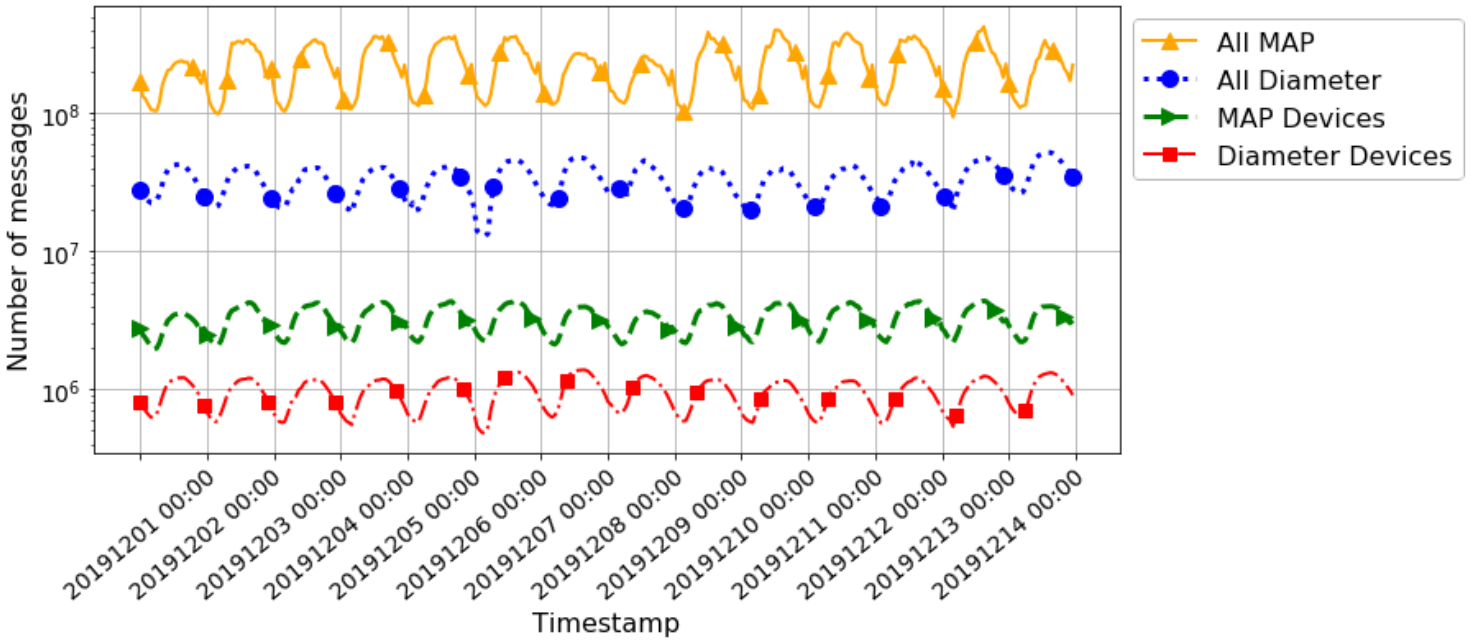
IPX Signaling Traffic Patterns

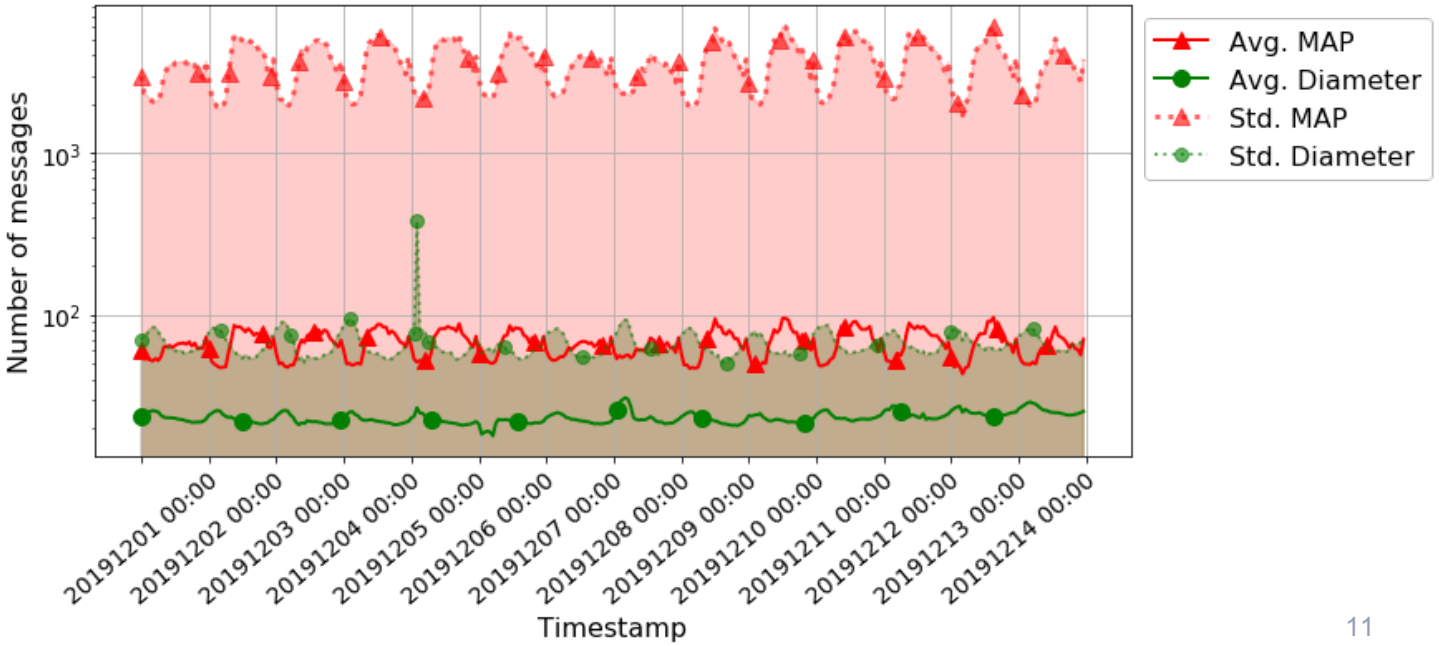
Two types of samples:

- SCCP Signaling (2G/3G)
- Diameter Signaling (4G)

We see that more devices depend on legacy radio technologies

Legacy 2G/3G devices generate one order of magnitude higher volume of signaling traffic than 4G devices



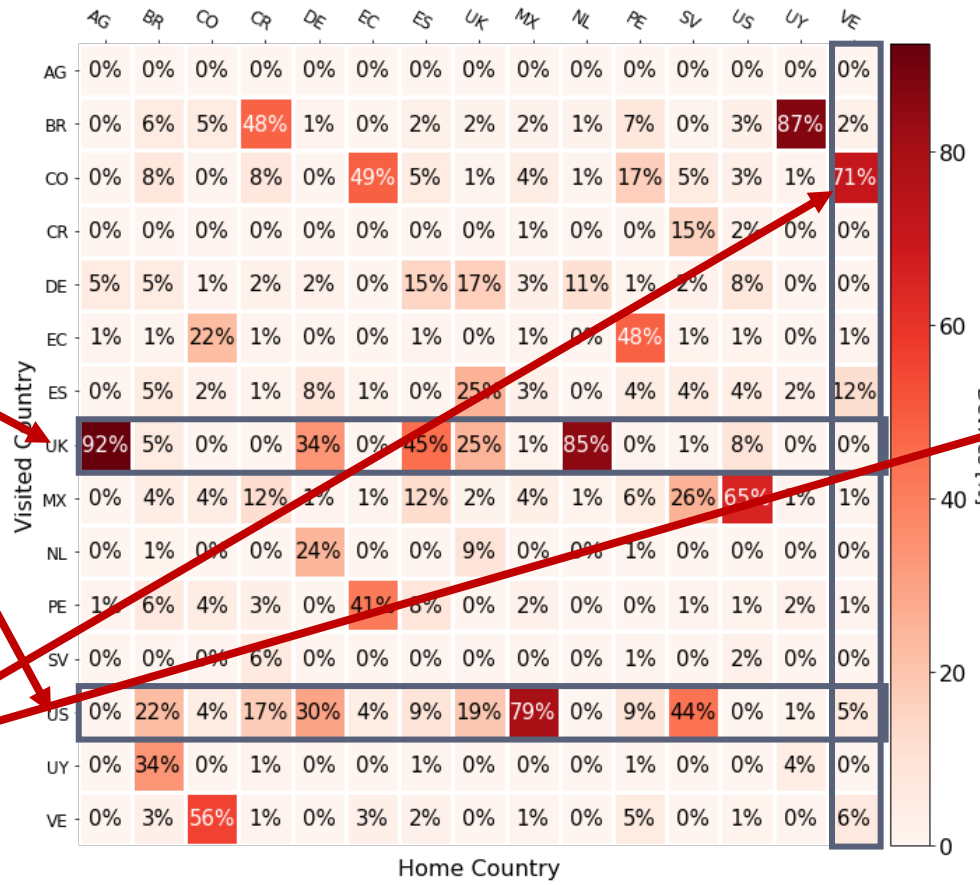


International Mobility Patterns

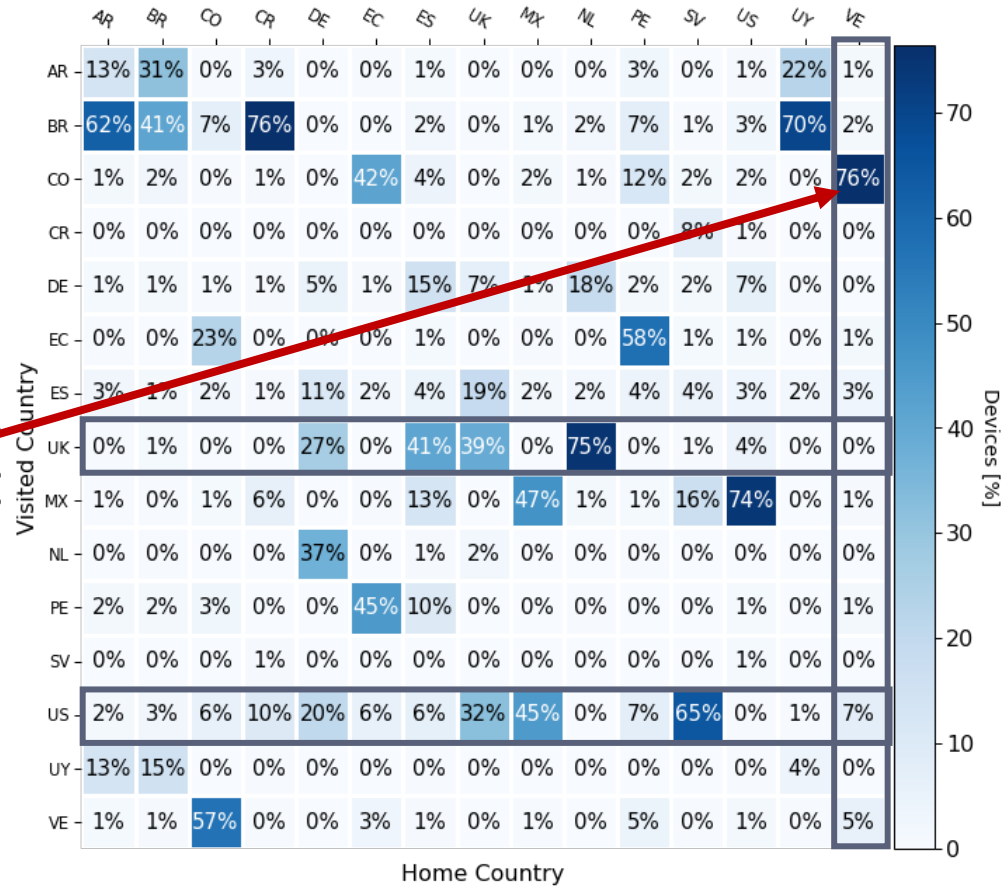
We can observe <u>where</u> devices travel from their home countries

Two major visited hubs: UK and US

Capture socio-economic patterns in international mobility (Venezuela – Colombia migration crisis)



December 2019



July 2020

Today

01

What makes Roaming Possible?

The IPX Ecosystem

View from an IPX Provider

02

Signaling Traffic Patterns

SS7 (2G/3G) and Diameter (4G/LTE) Signaling

03

Patterns and Performance of Data Tunnels

> GTP-C Signaling

04

Data Roaming Traffic

Roaming Performance

Data Roaming Activity for IoT Devices

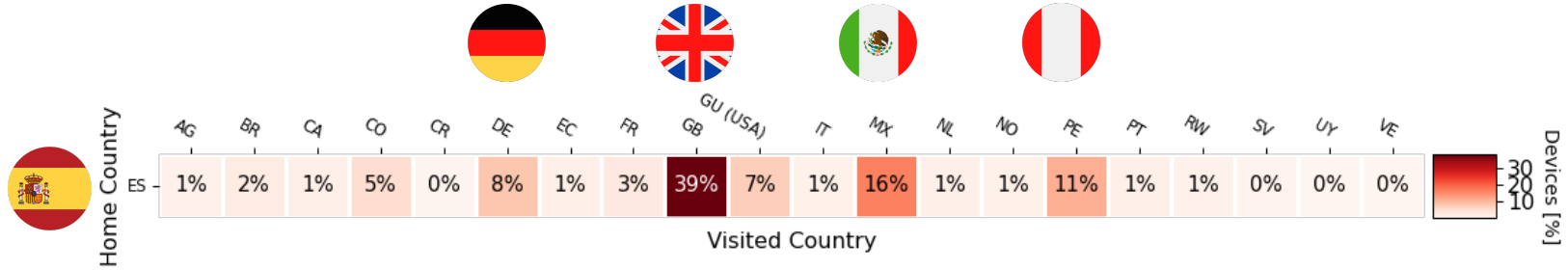
Analyze GTP Signaling (only control plane) to capture from where in the world devices trigger data communications

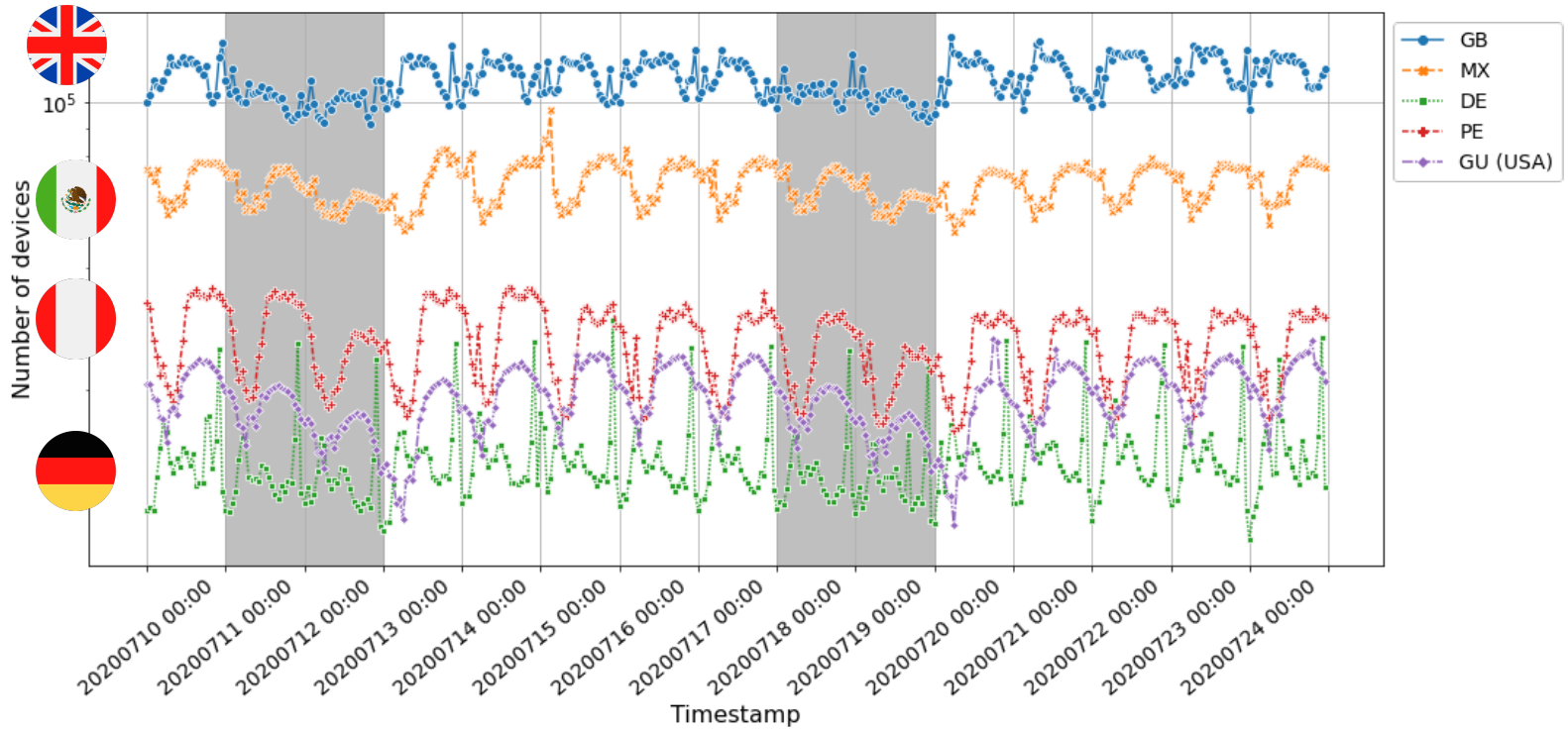
Focus on the countries where there is significant number of devices

- GB, MX, PE, DE, USA → top 5 countries

Clear week-end pattern

- Grey area corresponds to weekends
- Number of active devices per hour per visited country
- Devices in DE don't follow a clear pattern here (higher mobility)





Today

01

What makes Roaming Possible?

The IPX Ecosystem

View from an IPX Provider

02

Signaling Traffic Patterns

SS7 (2G/3G) and Diameter (4G/LTE) Signaling

03

Patterns and Performance of Data Tunnels

GTP-C Signaling

04

Data Roaming Traffic

> Roaming Performance

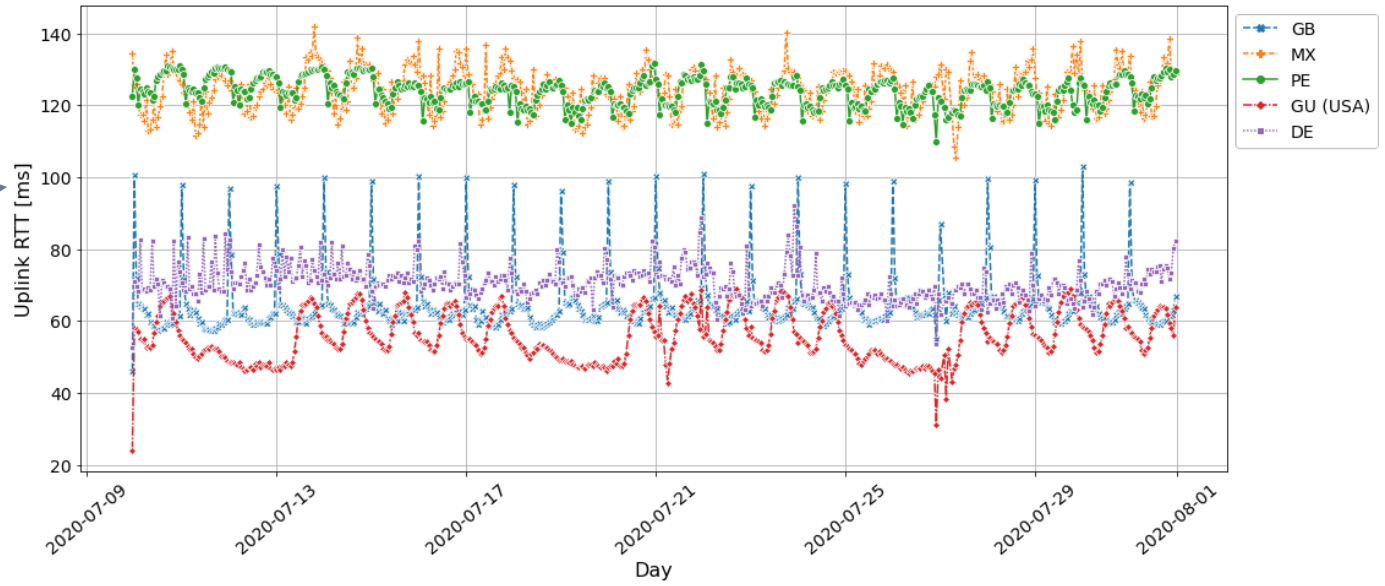
GTP User Plane: RTT Uplink and RTT Downlink

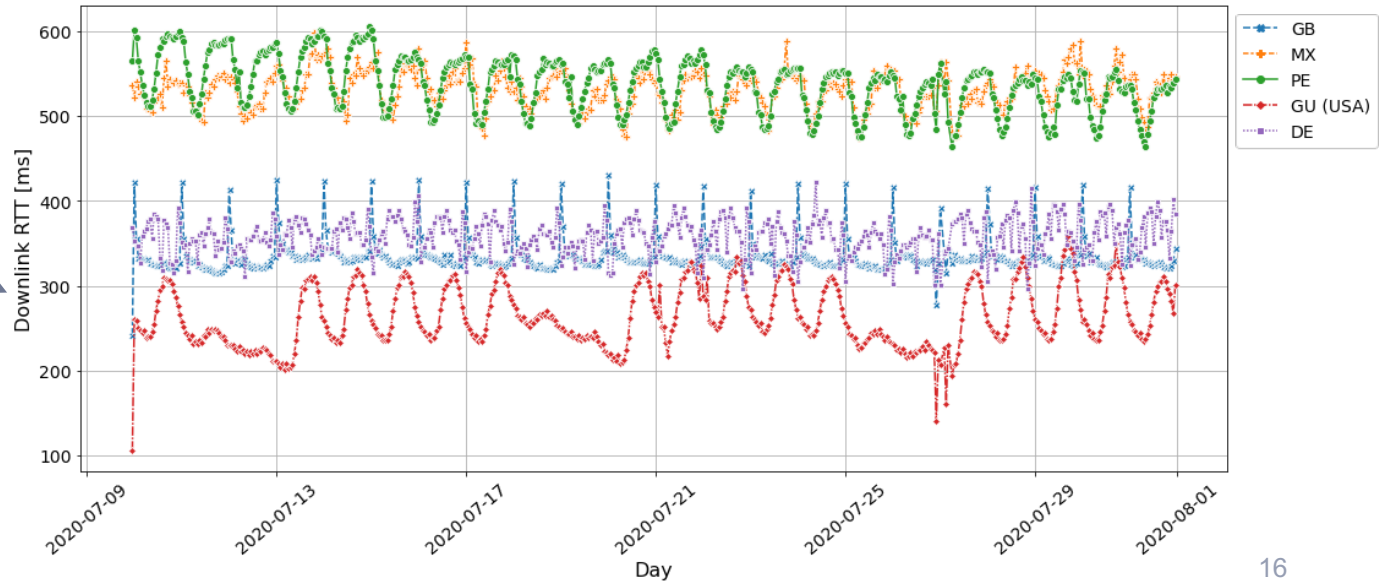
Uplink RTT: impact of the PGw (or the GGSN) and the latency over the Internet path towards the application server

Downlink RTT: impact of the visited network (including the radio access network) and the SGw (or the SGSN)

All devices show daily patterns in the RTT (uplink and downlink)

Devices in the UK have synchronized behaviour that we conjecture explains the periodic peaks in RTT





Today

01

What makes Roaming Possible?

The IPX Ecosystem

View from an IPX Provider

02

Signaling Traffic Patterns

SS7 (2G/3G) and Diameter (4G/LTE) Signaling

03

Patterns and Performance of Data Tunnels

GTP-C Signaling

04

Data Roaming Traffic

Roaming Performance

References

Insights from Operating an IP eXchage Provider

Andra Lutu, Diego Perino, Marcelo Bagnulo, Fabián E. Bustamante (**2021**). Insights from Operating an IP eXchage Provider. In *Proceedings of the 2021 ACM SIGCOMM 2021 Conference* (*SIGCOMM '21*). Association for Computing Machinery, New York, NY, USA, 718–730. DOI: https://doi.org/10.1145/3452296.3472930

Where Things Roam: Uncovering Cellular IoT/M2M Connectivity

Andra Lutu, Byungjin Jun, Alessandro Finamore, Fabián E. Bustamante, and Diego Perino. 2020. Where Things Roam: Uncovering Cellular IoT/M2M Connectivity. In *Proceedings of the ACM Internet Measurement Conference* (*IMC '20*). Association for Computing Machinery, New York, NY, USA, 147–161. DOI: https://doi.org/10.1145/3419394.3423661

https://arxiv.org/abs/2007.13708

A first look at the IP eXchange Ecosystem

Andra Lutu, Byungjin Jun, Fabián E. Bustamante, Diego Perino, Marcelo Bagnulo, and Carlos Gamboa Bontje. 2020. A first look at the IP eXchange ecosystem. *SIGCOMM Comput. Commun. Rev.* 50, 4 (October 2020), 25–34. DOI: https://doi.org/10.1145/3431832.3431836

https://arxiv.org/abs/2007.13809

Telefónica

Open Questions

- Bringing the Peering Fabric of the Internet to the cellular ecosystem
- Roaming for the Next Generation Networks (5G and beyond)
- Ensuring security and privacy in the IPX Ecosystem
- Anomaly detection (IoT as critical infrastructure)