Where Things Roam:
Uncovering Cellular IoT/M2M Connectivity

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Why do "things" need to "roam"?

- **<u>Any device that is not a smartphone</u>** people use day-to-day
- **Cellular IoT** devices rely on mobile operators for seamless connectivity
- Even if they don't move, they connect over mobile networks ☺
- ..and **<u>sometimes they roam!</u>**
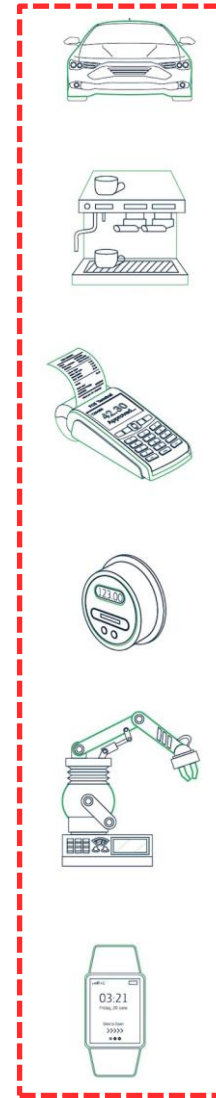
IoT Verticals

- *Connected cars*
- *Connected coffee vending machines*
- *Connected point of sale (PoS)*
- *Smart meters (e.g., energy, gas)*
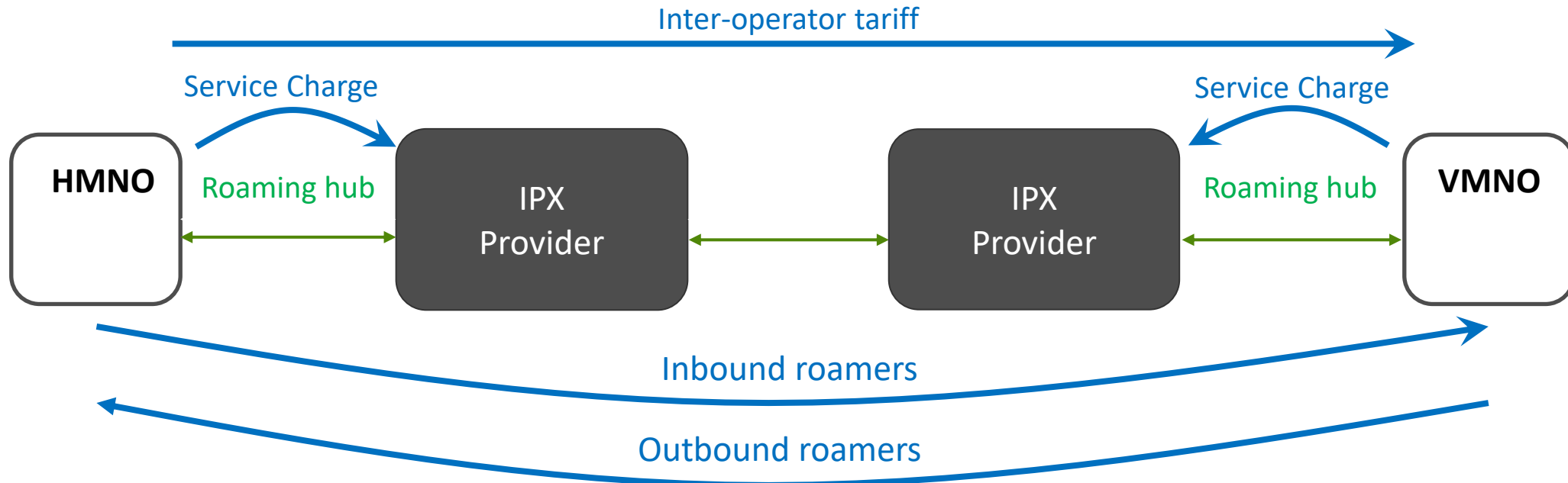- *Wearables (e.g., smart watches, e-readers)*

More mobile users, more roaming

- Cellular networks support user mobility across operators with national or international roaming

- Growth on international roaming driven by
  - New regulation (e.g., *Roam like at Home* in the EU)
  - Increased mobility of users and new technologies (e.g., VoLTE)
  - Other industry trends (e.g., Internet of Things)

Goodbye **#roaming** fees in the EU
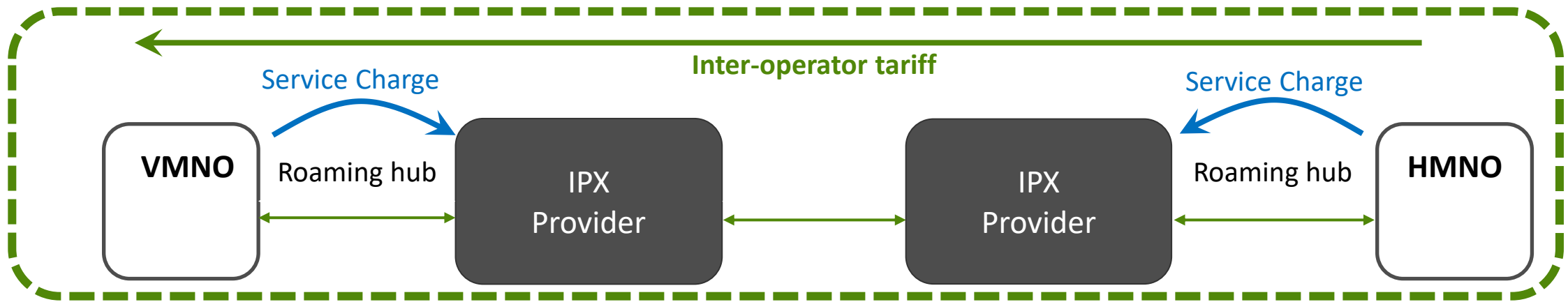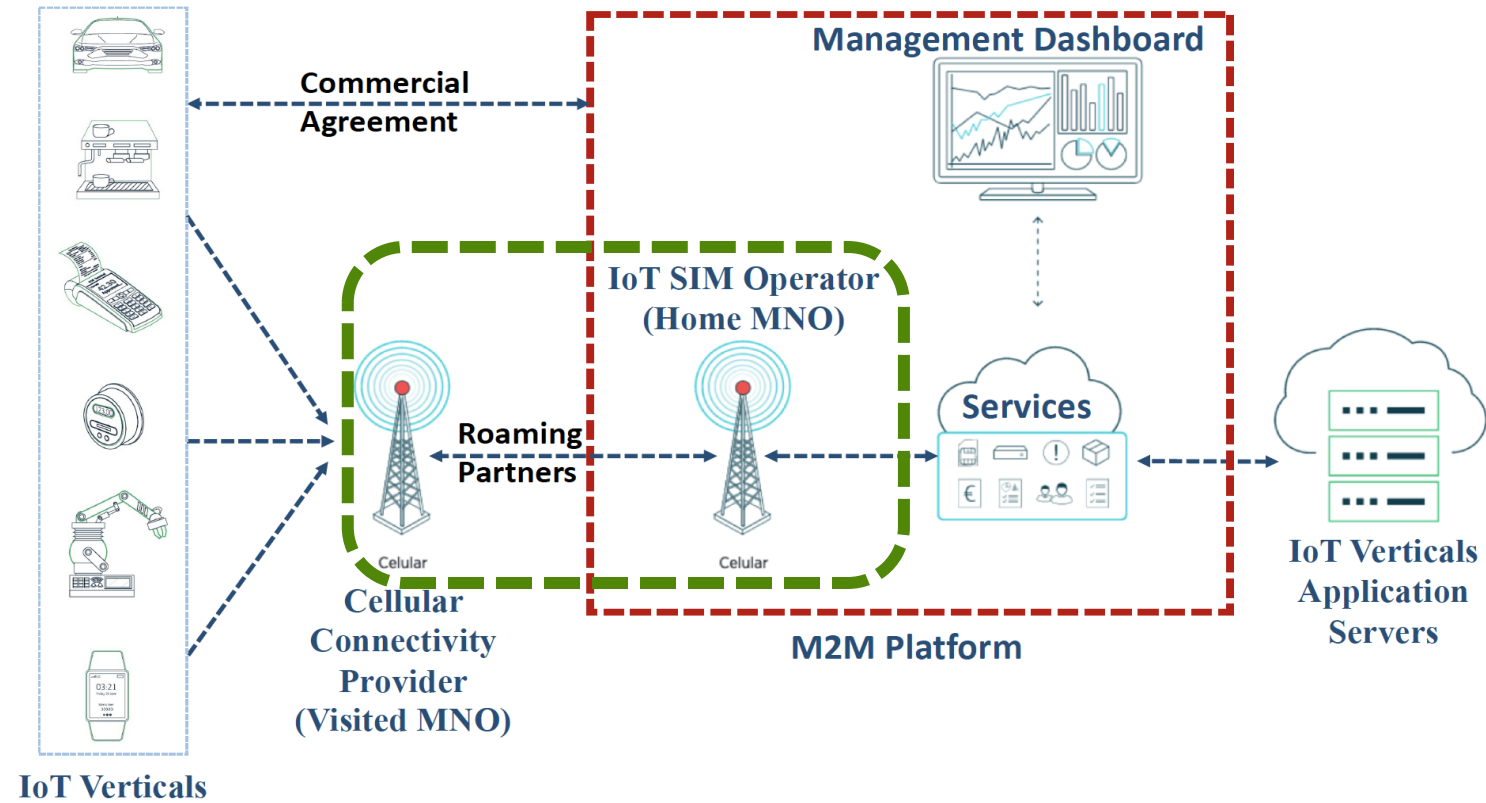as of 15 June 2017

International Roaming

- Operators contract with IPX providers
  - IPX provider provides the roaming hub function
- Operators/roaming partners don't need bilateral contracts
  - Instead pay a service charge to the roaming hub
- Inter-operator tariff (IOT) between the Home MNO(HMNO) and Visited MNO (VMNO)

Inter-operator tariff

Service Charge

Service Charge

HMNO

Roaming hub

IPX Provider

IPX Provider

Roaming hub

VMNO

Inbound roamers

Outbound roamers

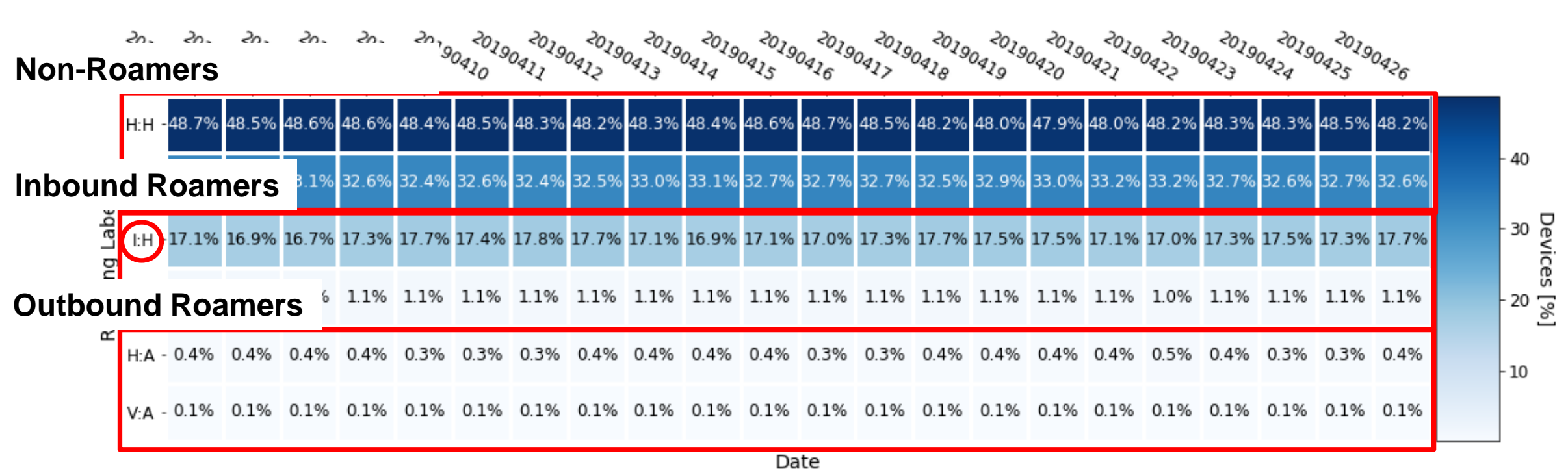# Things Roaming using an M2M platform

Our dataset

- An operational **M2M platform**
  - 100K 4G-enabled IoT devices
  - 11 days in November 2018
- **Visited MNO**: Operational network in UK
  - ~30M devices (Smartphones, feature phones, and IoT devices)
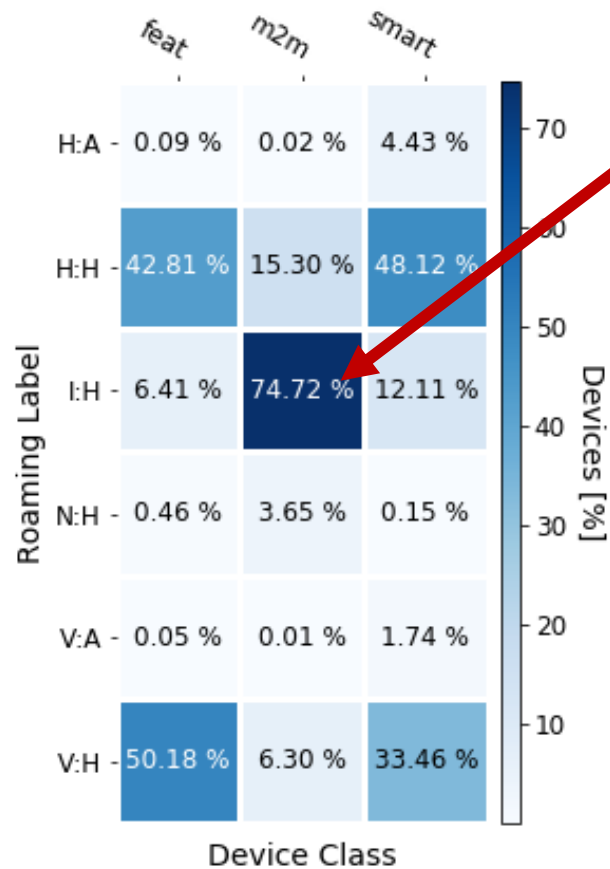 - 22 days in April 2019
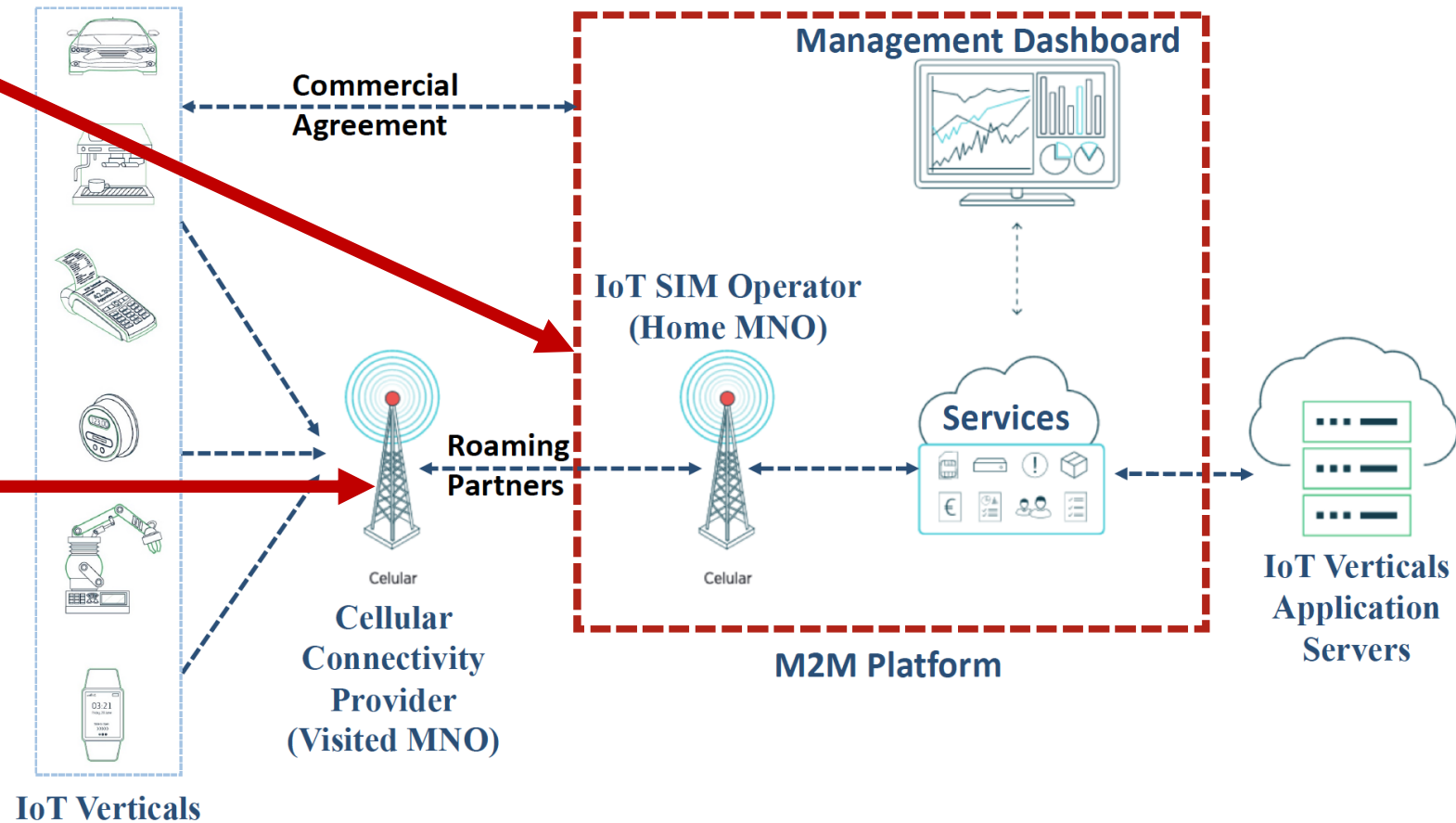
View from an Operational Mobile Network Operator
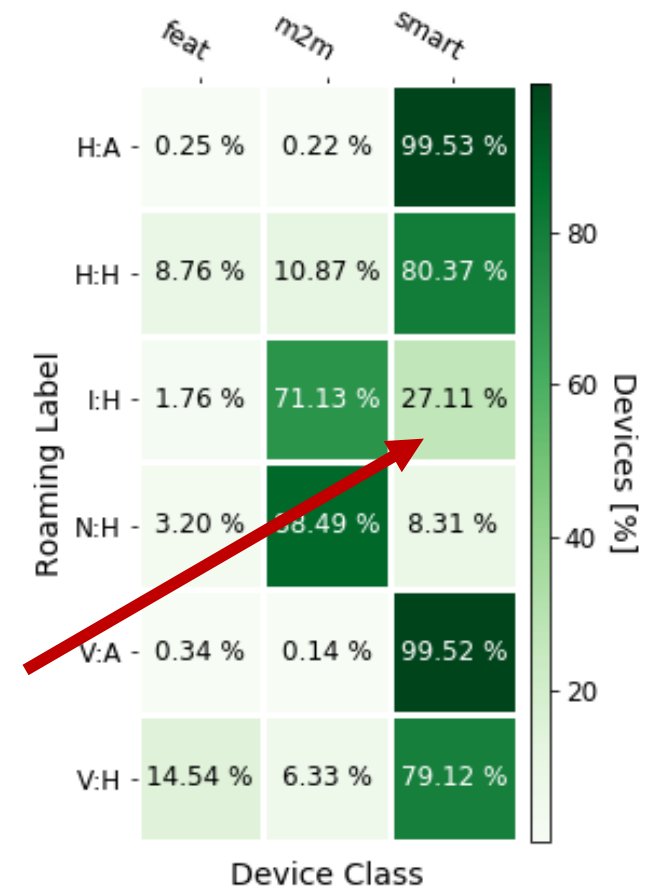
- How many are roaming?

Inbound Roamers: *Things* or *People*?

- Device type is classified with the GSMA TAC database and the APN
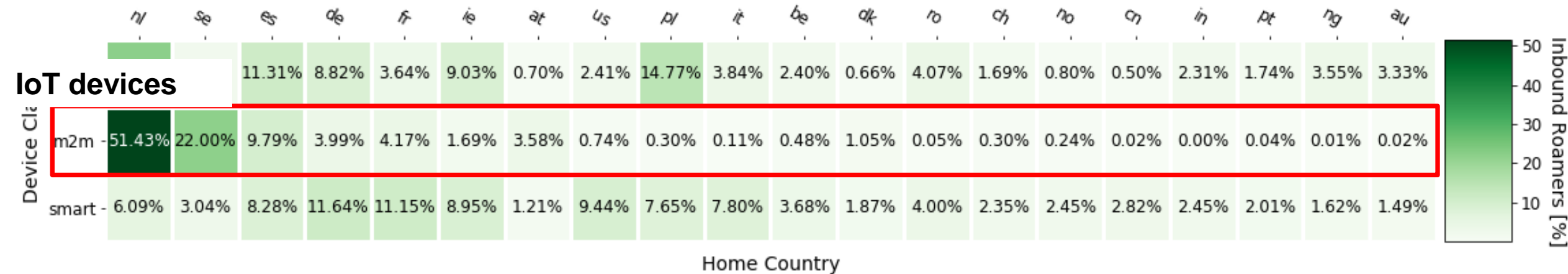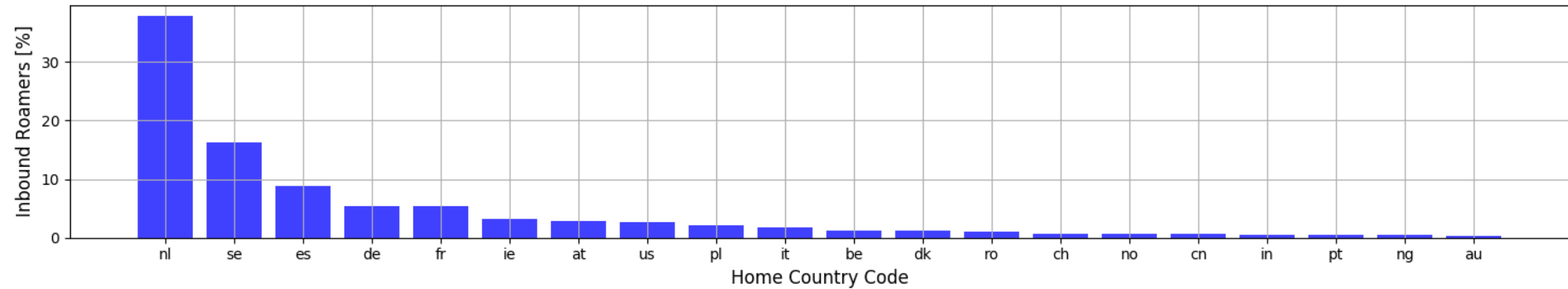 - GSMA DB: device manufacturer and operating systems

Majority of IoT devices are inbound roamers!

Out of all inbound roamers, only 27% are people!

Where are devices roaming from in a MNO?
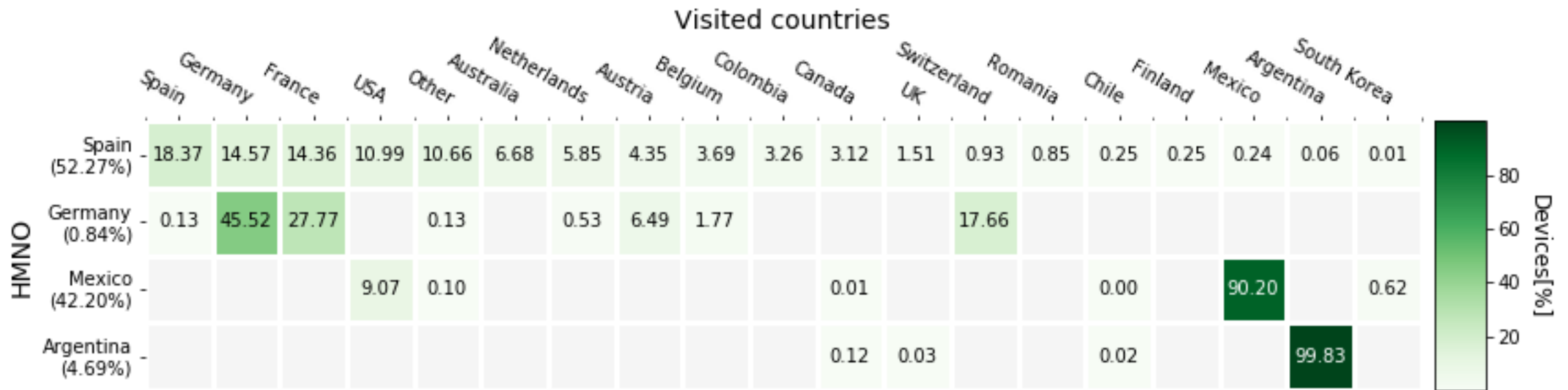

IoT devices
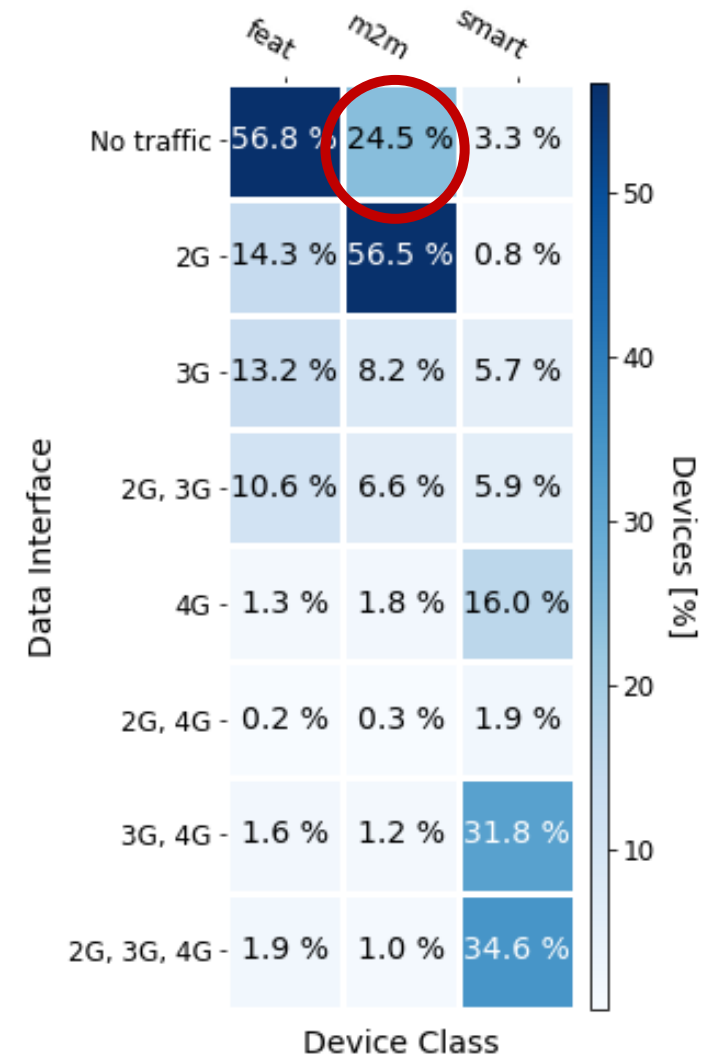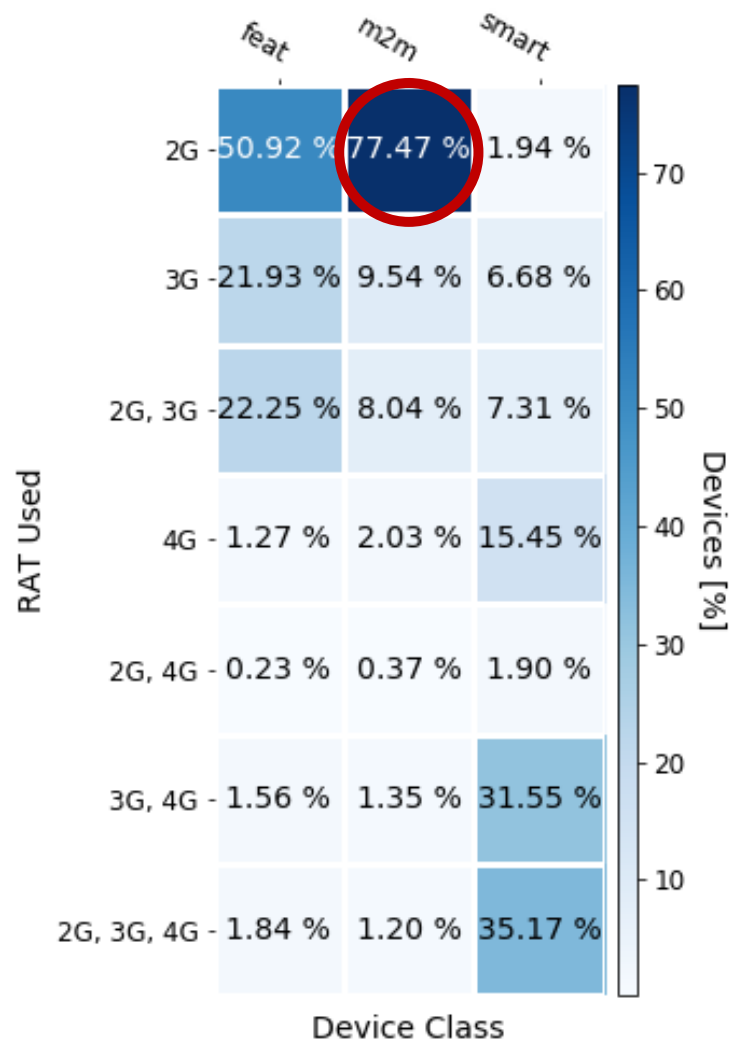
Many THINGS are roaming

- Why they roam?
  - IoT services need a global connectivity

- International Carriers leverage their extensive infrastructure and deploy M2M platforms to support IoT verticals
  - Carriers: Telefónica, Orange, Syniverse, Tata Communications …
  - IoT verticals: smart meters, connected cars, health …

Breadth of an M2M platform

- A view from one of the largest M2M platforms in the world enabling 4G/LTE devices world-wide
 - 77 countries and 127 VMNOs

Visited countries / HMNO heatmap of Devices[%]

HMNO	Spain	Germany	France	USA	Other	Australia	Netherlands	Austria	Belgium	Colombia	Canada	UK	Switzerland	Romania	Chile	Finland	Mexico	Argentina	South Korea
Spain (52.27%)	18.37	14.57	14.36	10.99	10.66	6.68	5.85	4.35	3.69	3.26	3.12	1.51	0.93	0.85	0.25	0.25	0.24	0.06	0.01
Germany (0.84%)	0.13	45.52	27.77		0.13		0.53	6.49	1.77				17.66						
Mexico (42.20%)				9.07	0.10						0.01				0.00		90.20		0.62
Argentina (4.69%)										0.12	0.03				0.02			99.83	

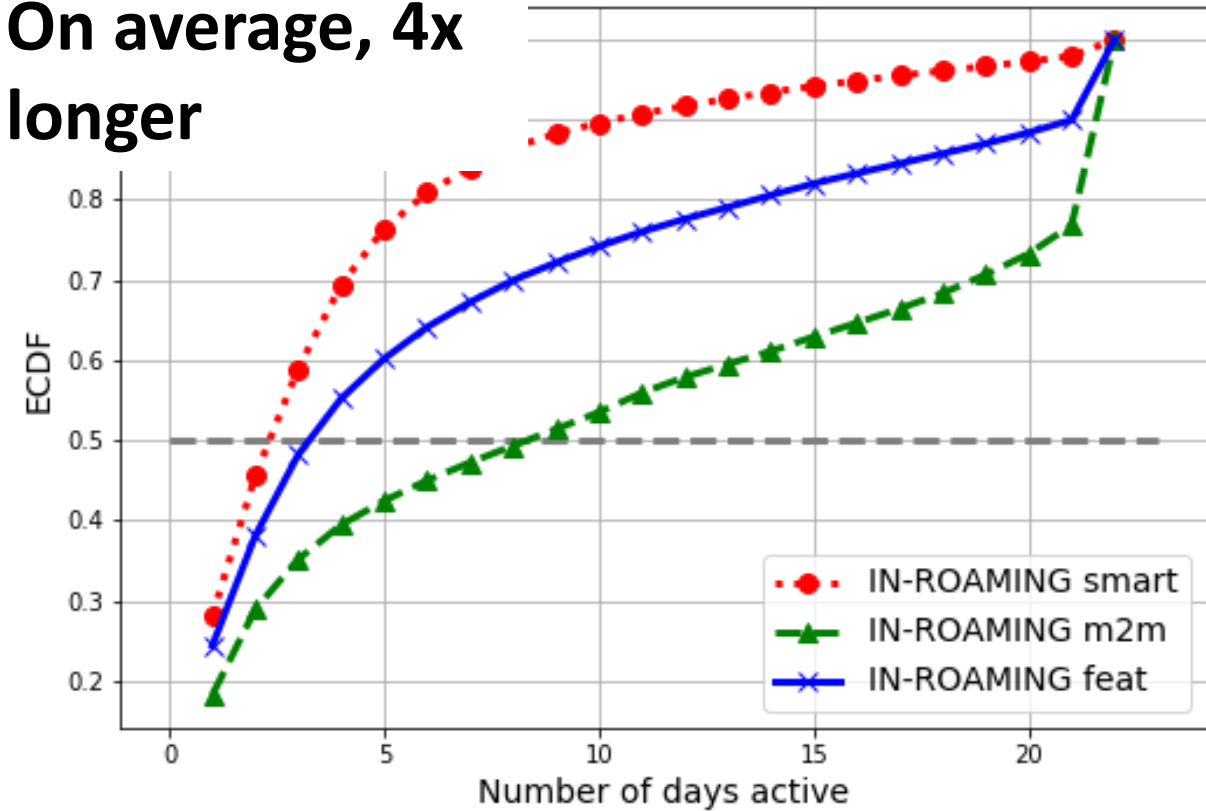# IoT devices – depend mostly on 2G connectivity

IoT devices – Less active but longer lived
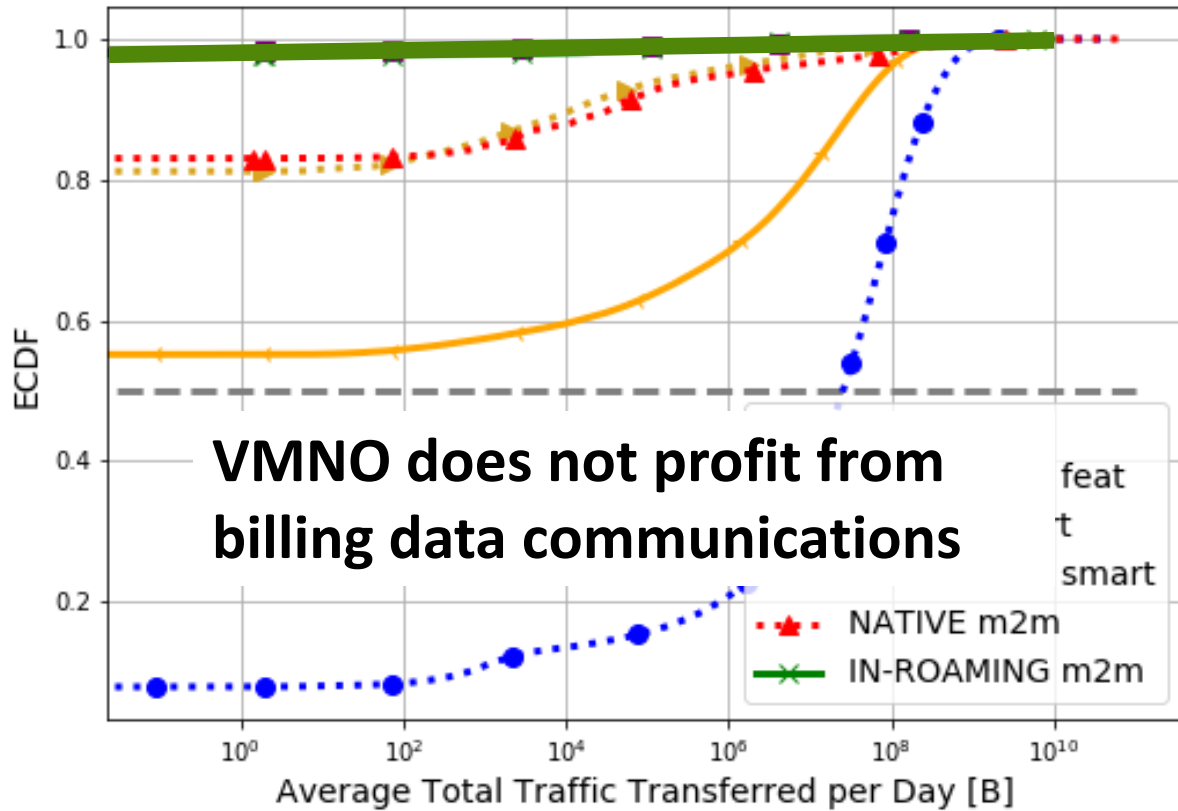
Not moving as much
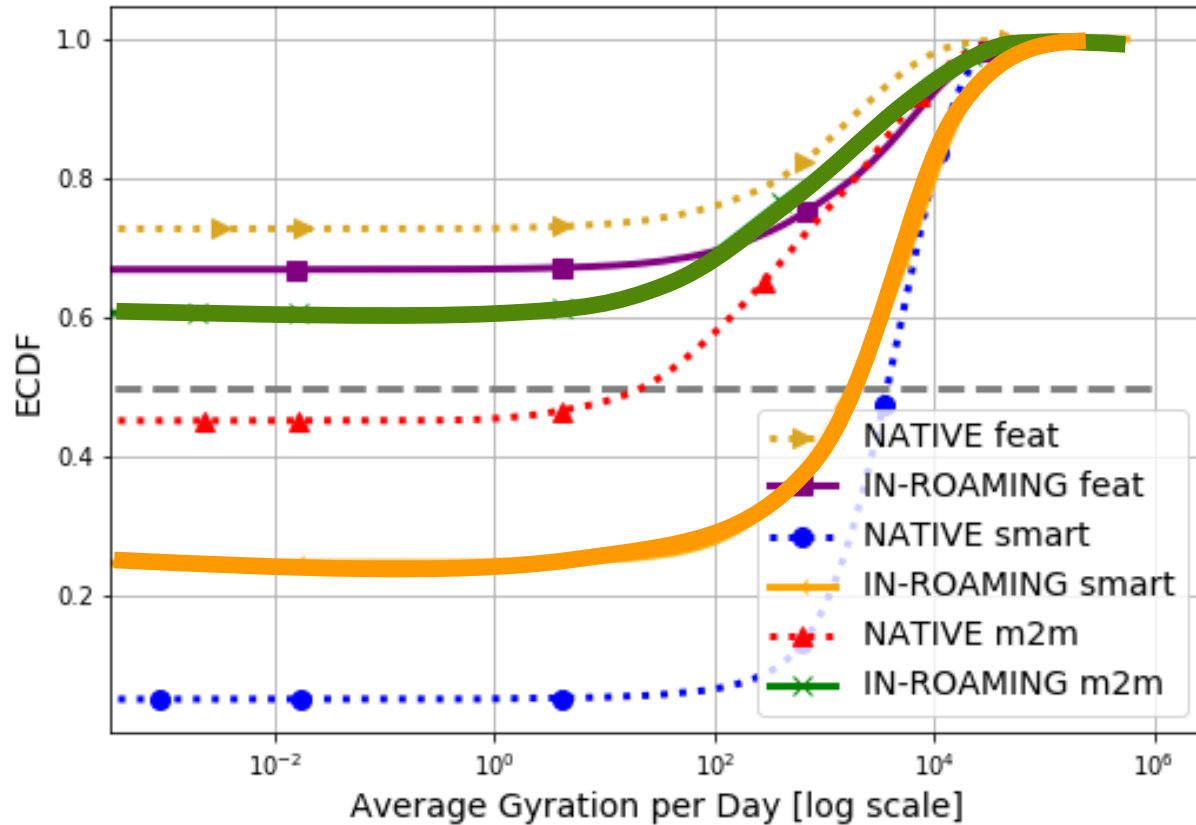
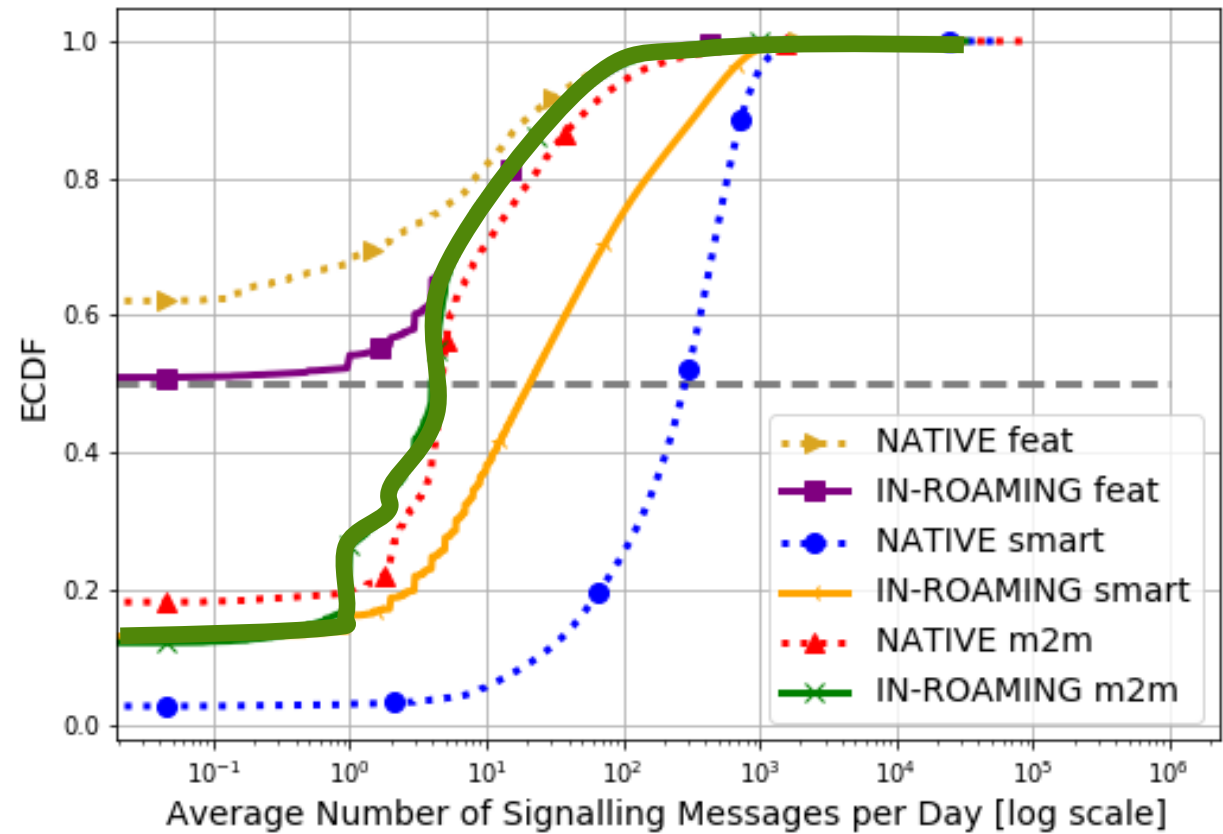## But active for longer times

On average, 4x longer

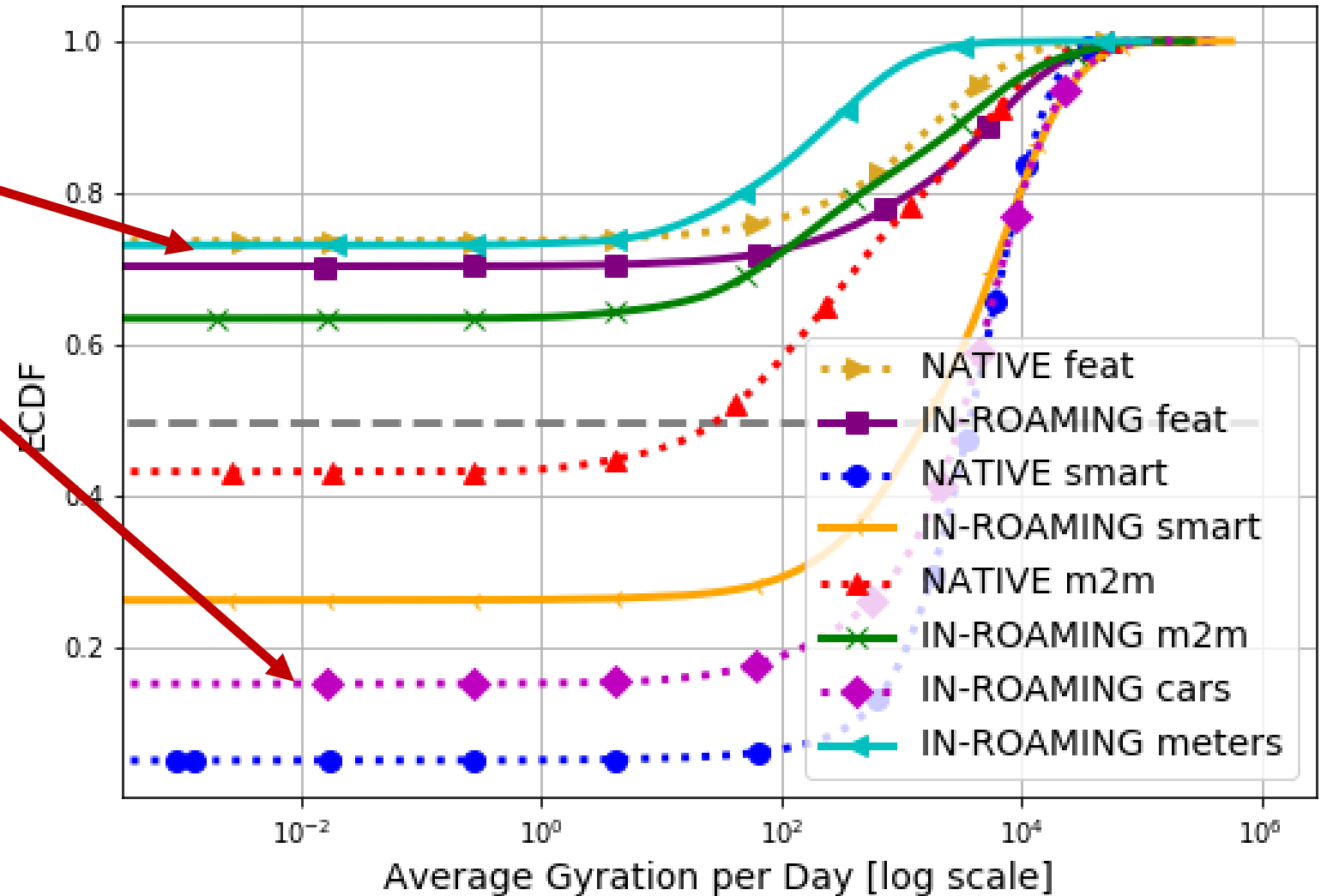# IoT devices – Less traffic but much more signaling

IoT consumes little data

But a lot of signaling

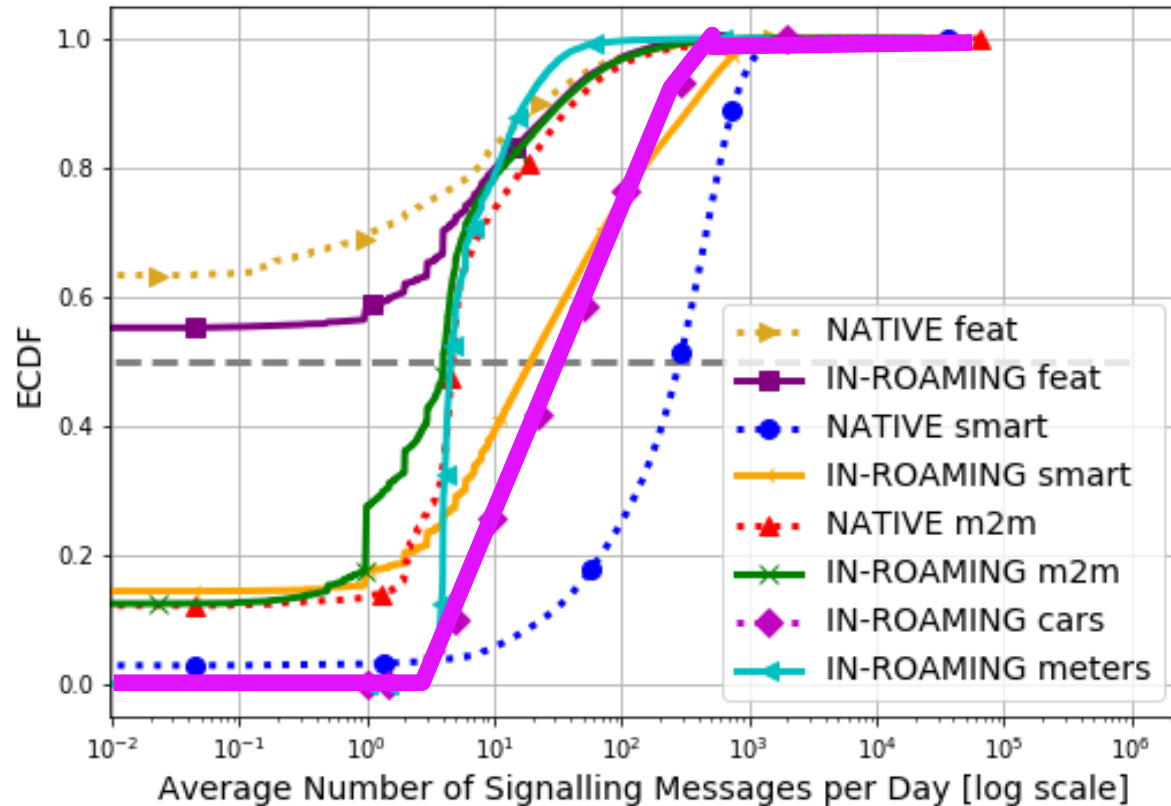**VMNO does not profit from billing data communications**

Moving cars and stay-at-home smart meters

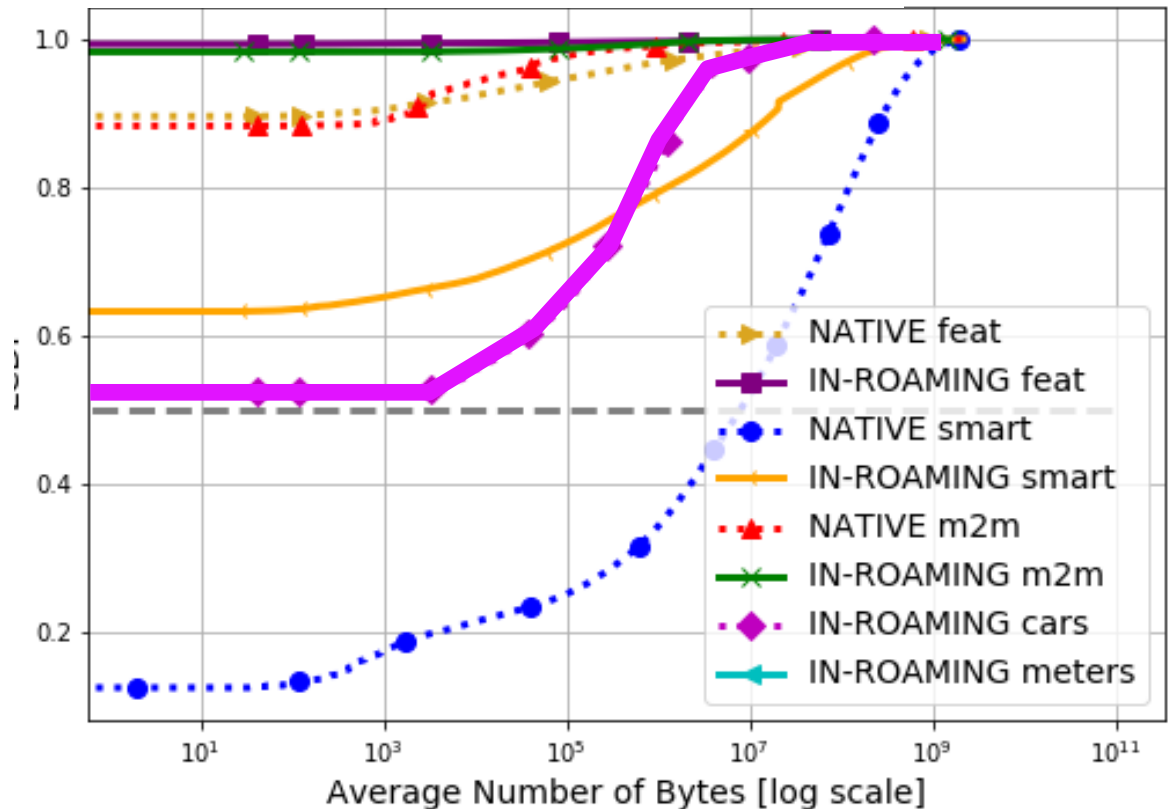Smart meters and connected cars

Moving cars – similar to smartphones

Connected cars are similar to roaming smartphones
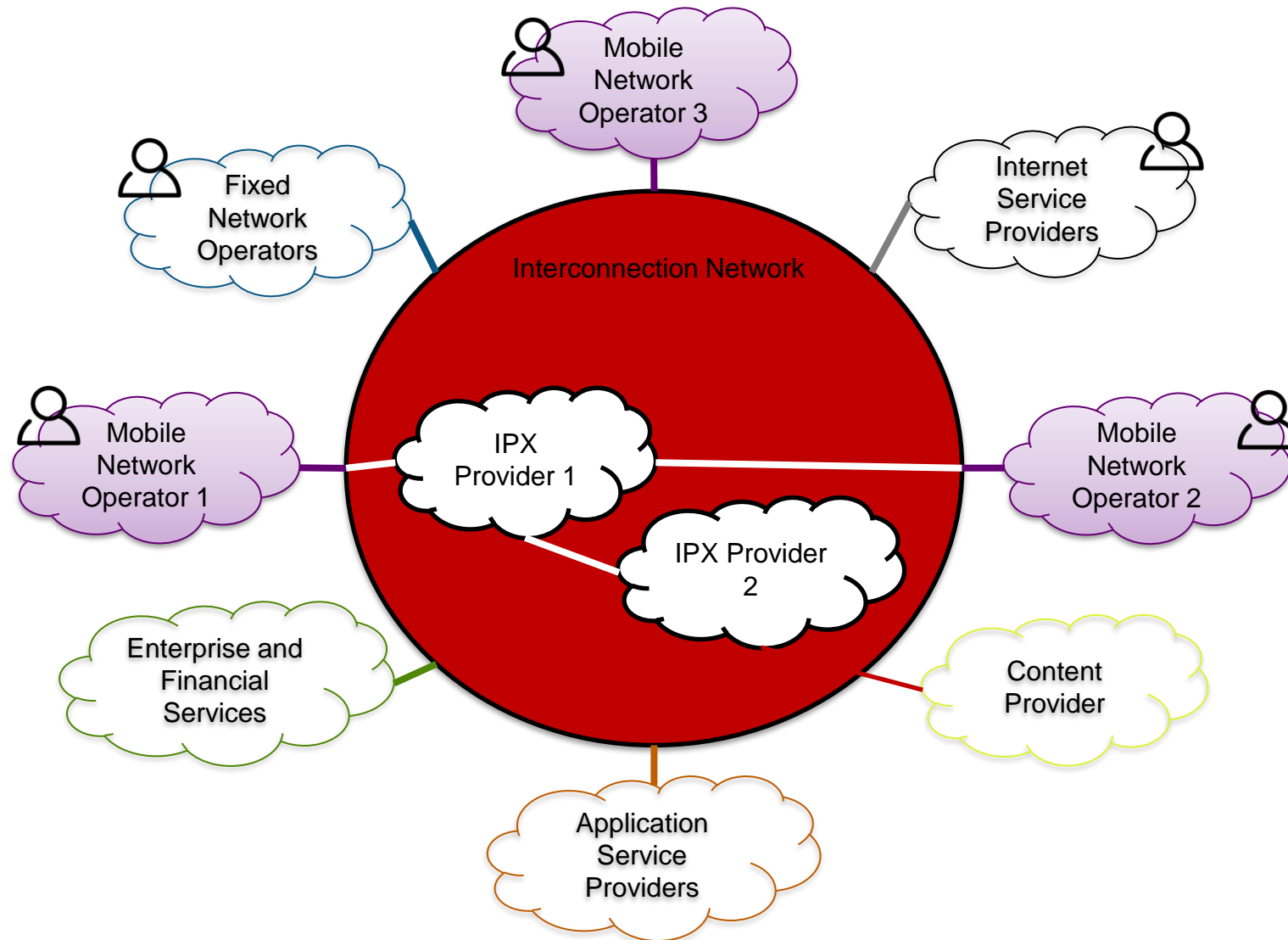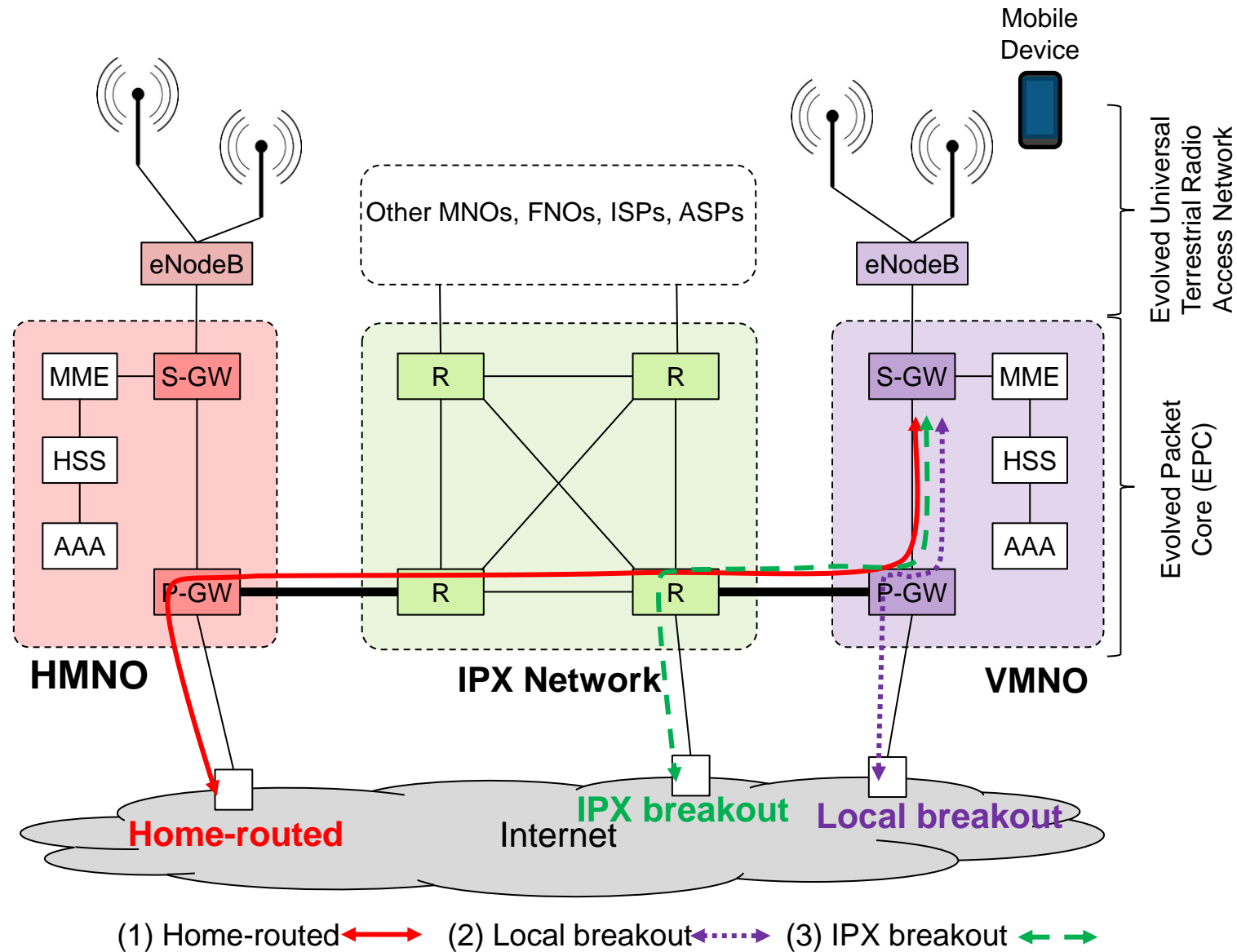
And transfer large amounts of data

Conclusion

- First characterization of roaming support for M2M communication
  - IoT traffic patterns greatly differ from those of smartphones

- IoT devices increase stresses on a visited MNO's infrastructure
  - Occupy radio resources
  - Do NOT generate traffic that translates into revenue

- Identifying IoT devices help manage the network
  - We propose an approach for classifying devices into M2M, smartphones and feature phones
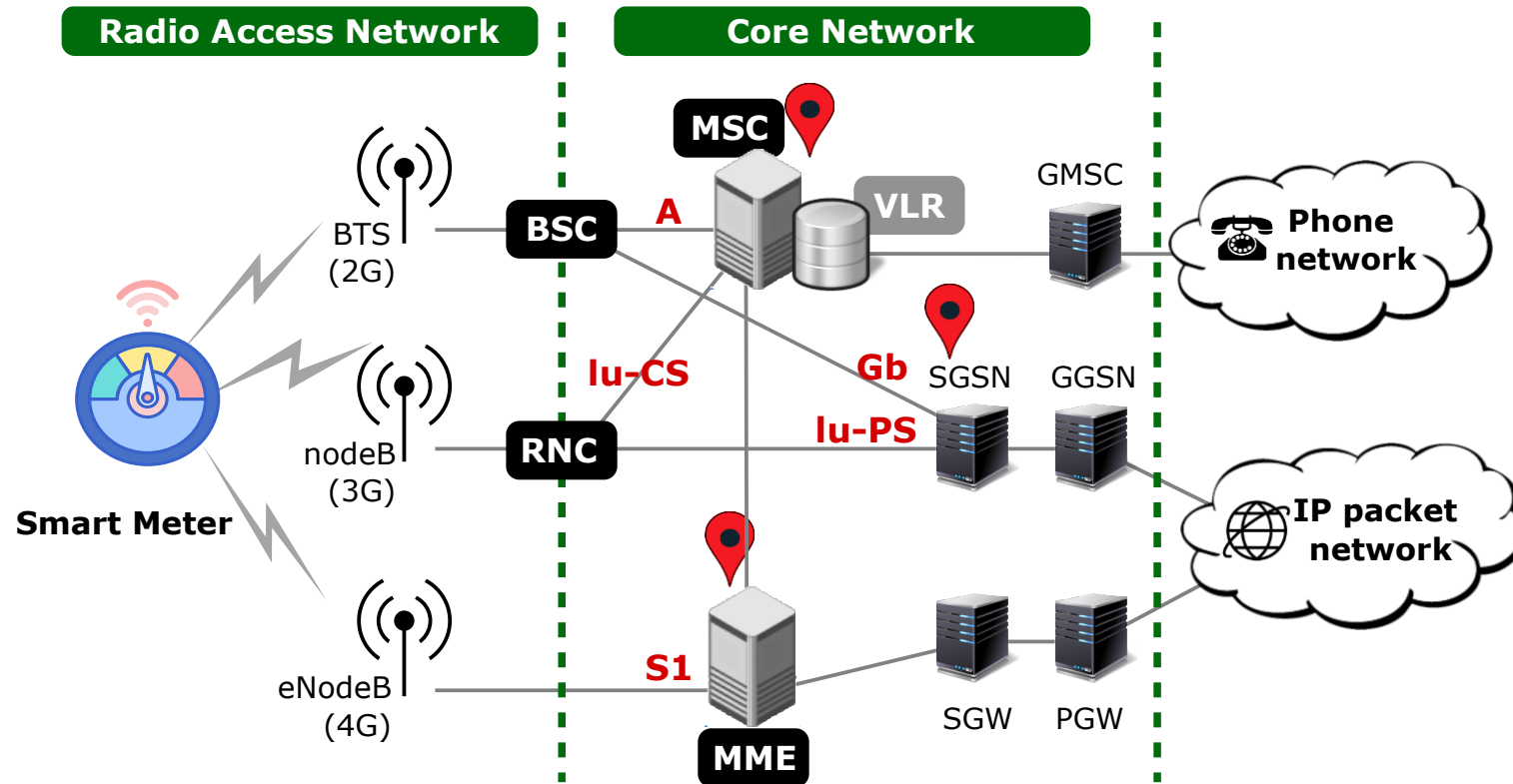
Backup slides

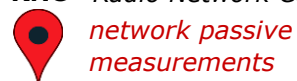# The Roaming interconnection ecosystem

Configurations for Roaming

High level MNO architecture

Radio Access Network

Core Network

Smart Meter

BTS (2G)

nodeB (3G)

eNodeB (4G)

BSC

RNC

A

Iu-CS

Gb

Iu-PS

S1

MSC

VLR

GMSC

SGSN

GGSN

MME

SGW

PGW

Phone network

IP packet network

BTS - *Base Transceiver Station*
BSC - *Base Station Controller*
RNC - *Radio Network Controller*

network passive measurements

MSC - *Mobile Switching Center*
VLR - *Visitor Location Register*
MME - *Mobility Management Entity*

GMSC - *Gateway Mobile Switching Center*
SGSN - *Serving GPRS Support Node*
GGSN - *Gateway GPRS Support Node*
SGW - *Serving Gateway*
PGW - *Packet Data Network Gateway*

Roaming between operators

- Operators contract with IPX providers
  - IPX provider provides the roaming hub function
- Operators/roaming partners don't need bilateral contracts
  - Instead pay a service charge to the roaming hub
- Inter-operator tariff (IOT) between the Home MNO(HMNO) and Visited MNO (VMNO)