# Experience: Implications of Roaming in Europe

Anna Maria Mandalari (University Carlos III of Madrid)
Andra Lutu (Telefonica Research, Simula Research Laboratory)
Ana Custura (University of Aberdeen)
Ali Safari (Politecnico di Torino)
Ozgu Alay (Simula Research Laboratory)
Marcelo Bagnulo (University Carlos III of Madrid)
Vaibhav Bajpai (Technische Universität München)
Anna Brunstrom (Karlstad Universitet)
Joerg Ott (Technische Universität München)
Marco Mellia (Politecnico di Torino)
Gorry Fairhurst (University of Aberdeen)

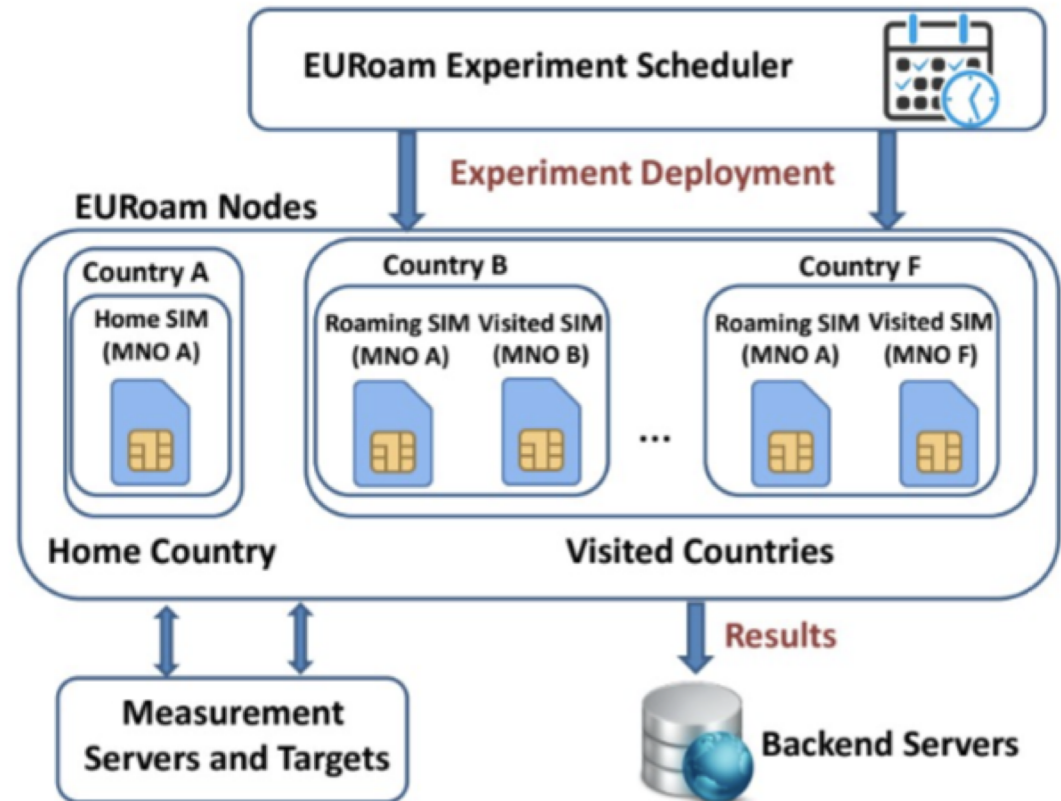Goodbye **#roaming** fees in the EU
as of 15 June 2017

Experimental Setup
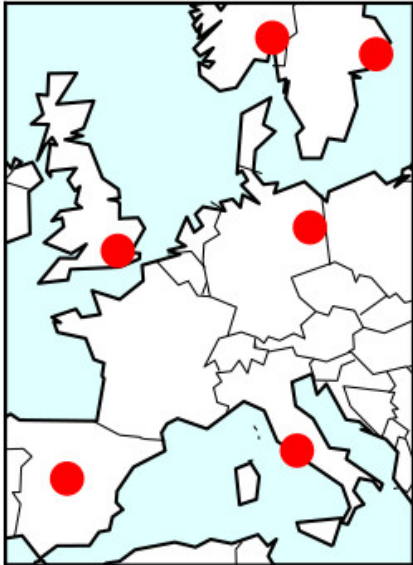
Mobile Network Operators (MNOs)			
NO	Telia NO	Telenor NO	
SE	Telia SE	Telenor SE	Tre
UK	Vodafone UK	EE	
DE	Vodafone DE	T-Mobile DE	O2 DE
ES	Vodafone ES	Movistar	Orange
IT	Vodafone IT	TIM 3	3 IT

Horizon 2020
European Union Funding
for Research & Innovation

European Commission

- traceroute
- dig
- curl
- traffic differentiation
- ooniprobe

EURoam Experiment Scheduler

Experiment Deployment

EURoam Nodes

Country A
Home SIM (MNO A)

Country B
Roaming SIM (MNO A) Visited SIM (MNO B)

Country F
Roaming SIM (MNO A) Visited SIM (MNO F)

...

Home Country **Visited Countries**

Measurement Servers and Targets

Results

Backend Servers

- Accepted at MobiCom:The Annual International Conference on Mobile Computing and Networking

MEASURING MOBILE BROADBAND NETWORKS IN EUROPE

Results: Roaming configuration

- HR used by all operators tested, based on:
  - MNO that allocates the public IP address
  - First public IP address on the path
- Stability in selection of visited network
- The number of hops to traceroute targets is the same (visited SGW→home PGW tunnel)
- MNOs - different infrastructure deployments
  - O2 DE have 20 first IPs (20 PGWs?)
  - Vodafone UK have 1 first IP (1 PGW?)
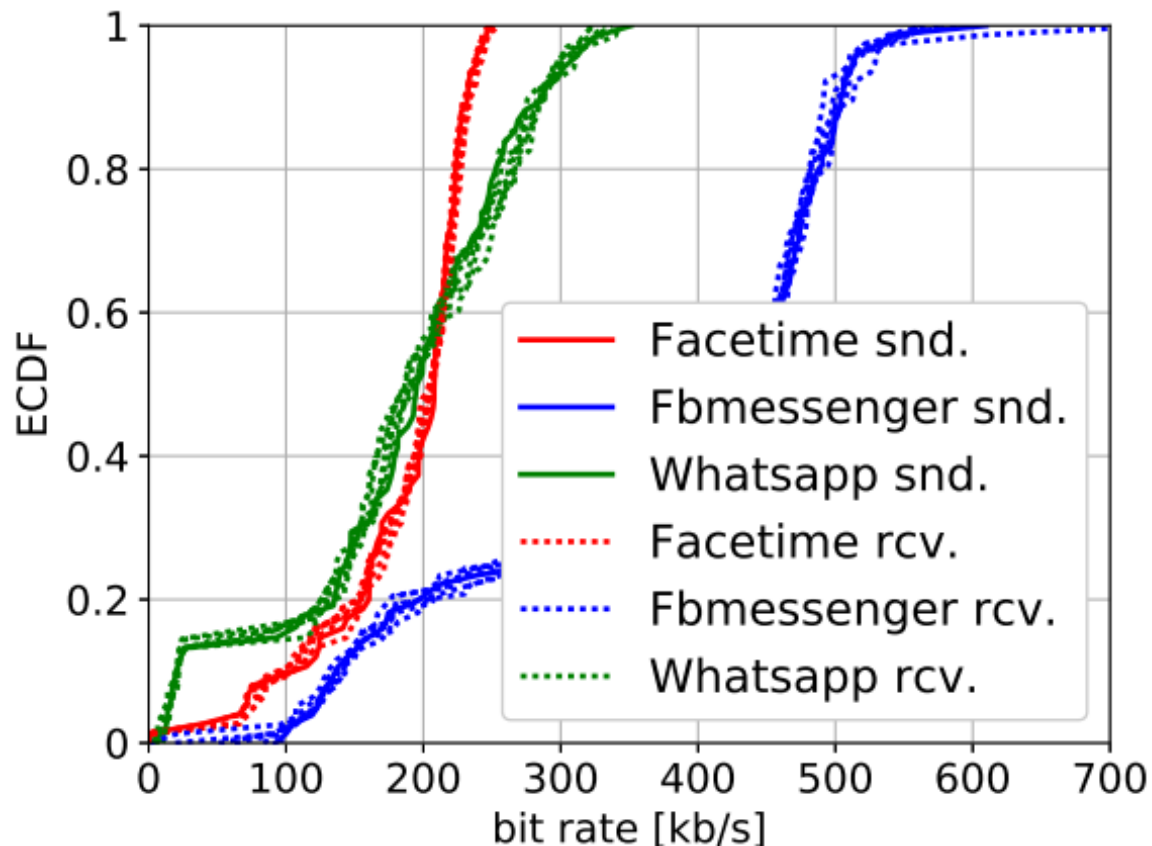
Results: HR penalty delay
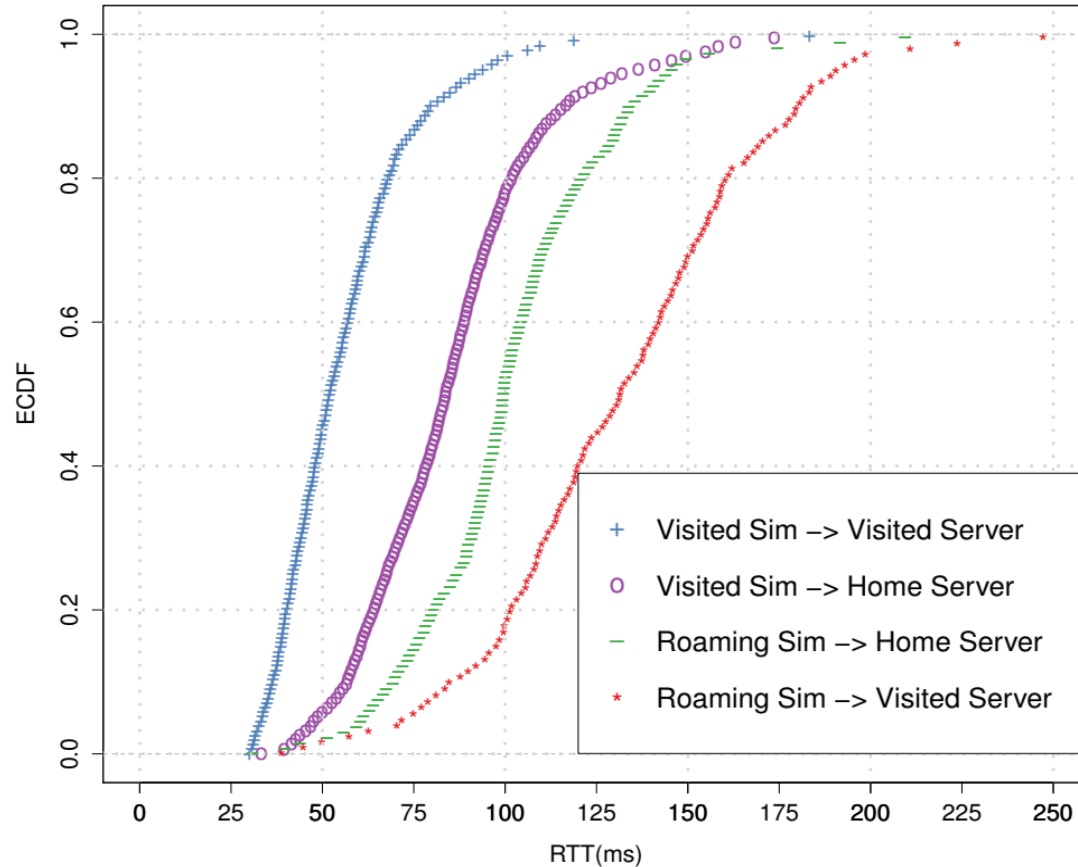
- **TCP Handshake time delay penalty of approximately 60ms for roaming users**

Results: HR penalty delay
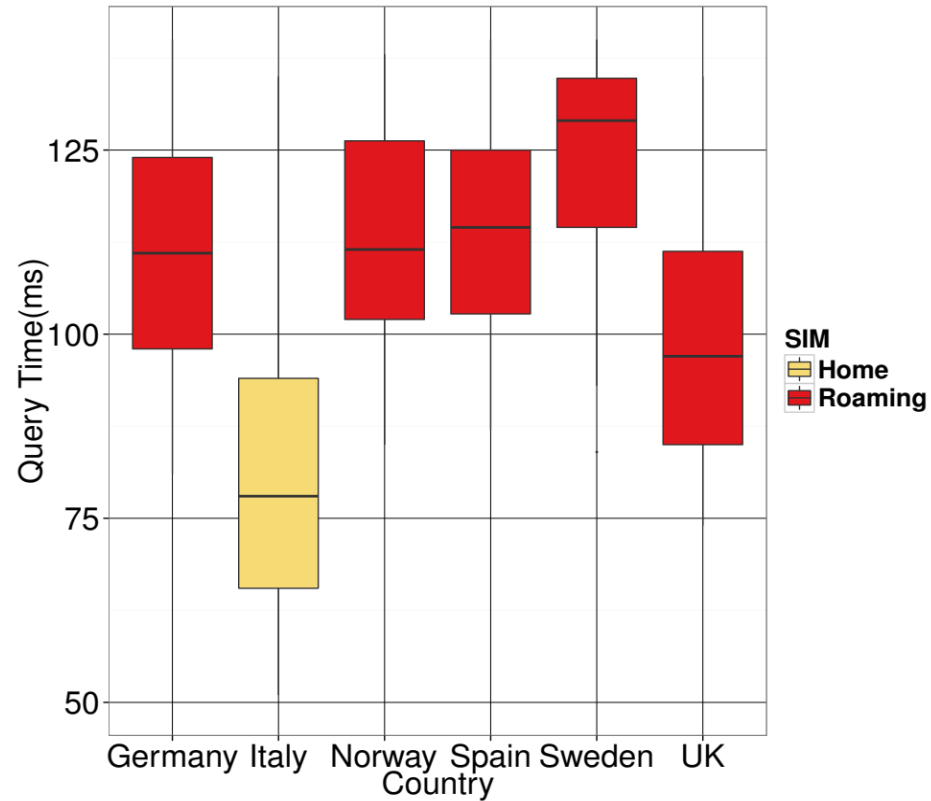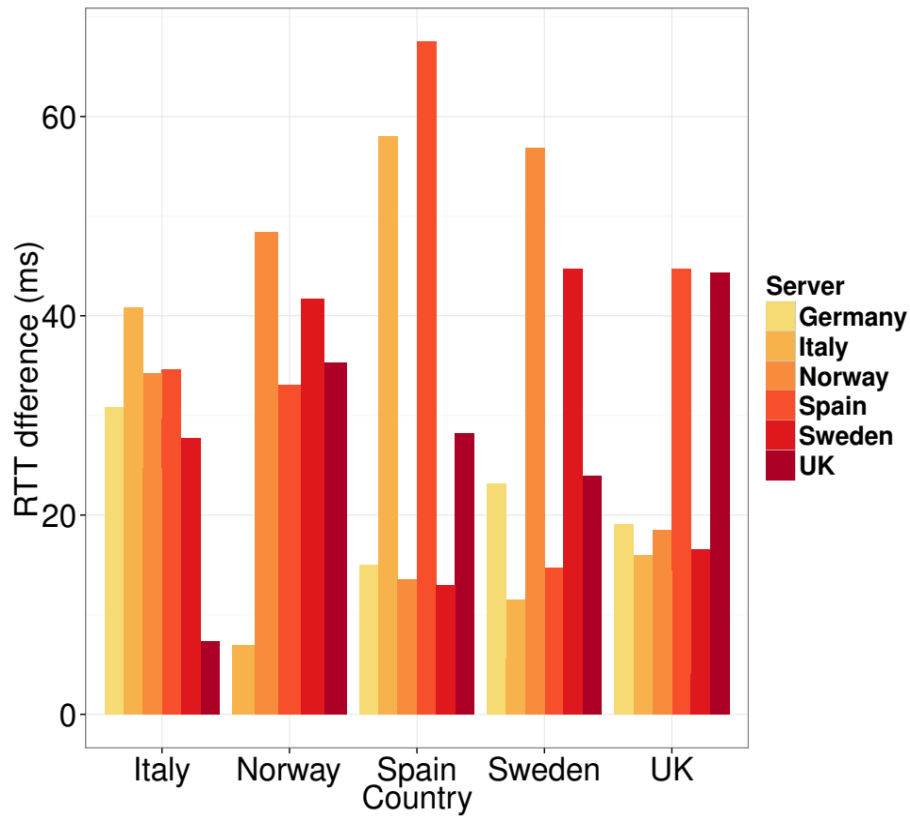
Results: VoIP call

- **Applications behave in the same way regardless of country SIM is roaming in**

Results- ooniprobe

Table 2: Interference profile match Home vs. Roaming

	UK	NO	SE	DE	IT	ES
Vodafone UK	100%	98%	99%	98%	99%	86%
Telenor NO	99%	100%	98%	98%	98%	97%
Telia SE	99%	97%	100%	99%	99%	99%
Vodafone DE	98%	97%	99%	100%	98%	97%
TIM IT	98%	98%	98%	97%	100%	97%
Orange ES	99%	98%	98%	N/A	97%	100%

Next steps

- Finish addressing the reviews

- Web QoE measurements
- Measure more MNOs
- Journal publication