WiFi tracking

— *Research Internship* —

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iCIS | Digital Security
Radboud University

Think of ways how you can use a mobile device to protect your privacy.

Context

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  - MAC addresses
  - Personal data?
  - Broadcast of MAC addresses by a smartphone

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- Potential address space: $2^{48} \approx 281 \cdot 10^{12}$ (trillion) addresses
- Currently, 25k OUIs registered[6]
  - $25000 \cdot 2^{24} \approx 419 \cdot 10^{9}$ (billion) addresses
  - *about* 0.15% of the original address space

[1] Spoofing through software is possible.

MAC addresses — personal data?

General Data Protection Regulation (EU Regulation 2016/679)

> *"(1) 'personal data' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name,* ***an identification number****, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person;"*
>
> — *Article 4[10], emphasis added*

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- "[a] smart mobile device is very intimately linked to a specific individual"[2]
- Smartphones emit their MAC address regularly when WiFi/Bluetooth is activated

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- *Additional* information that can lead to identification of a natural person

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[3] *Autoriteit Persoonsgegevens*

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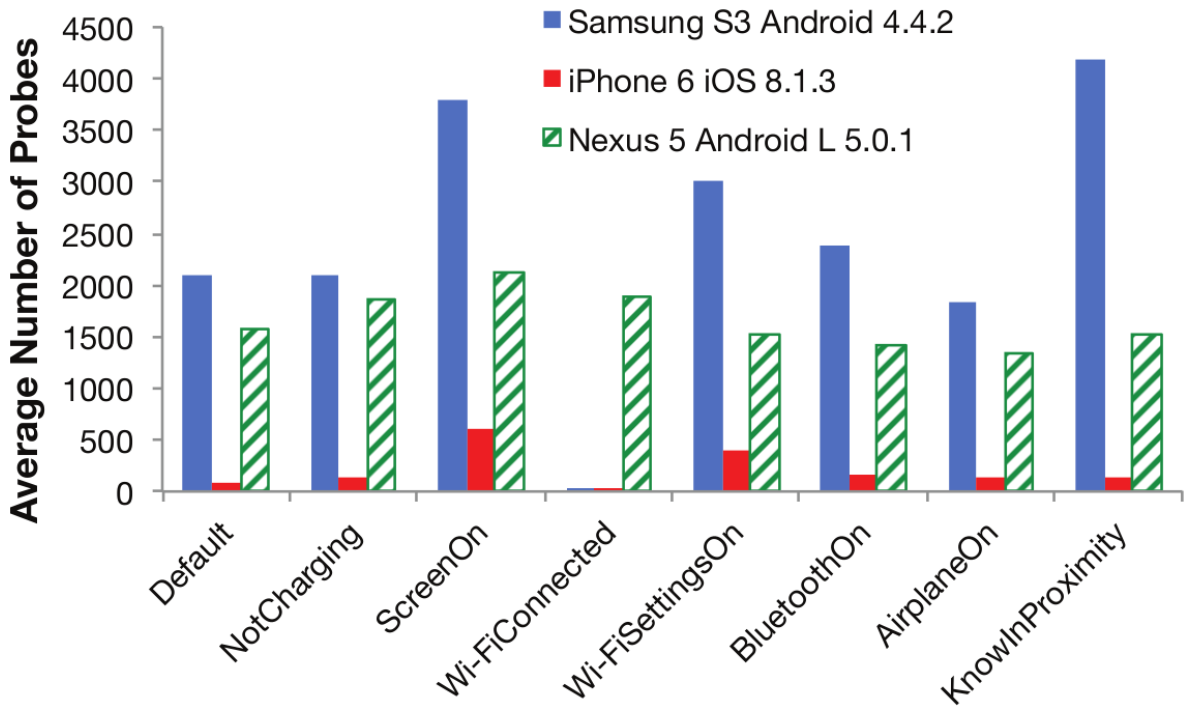
- MAC addresses should be considered personal data!
- Confirmed by the Dutch data protection authority[3]:
  - WiFi tracking for following people only allowed under strict conditions[11] (Nov 2018)
  - Simply hashing MAC addresses without extra data is a reversible process[5]

[3] *Autoriteit Persoonsgegevens*

Smartphone fingerprinting

- Number of probes emitted in various device states (ScreenOn, WiFiConnected, . . .)[13]



"Effect of device configuration on average number of probes[..]"[13, Figure 6]

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331	2.923264000	2a:21:fd:74:38:aa	Broadcast	Probe Request, SN=1035	SSID=Broadcast
338	2.995396000	2a:21:fd:74:38:aa	Broadcast	Probe Request, SN=1039	SSID=Broadcast
538	4.896581000	Apple_74:16:d4	Broadcast	Probe Request, SN=1040	SSID=Broadcast
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- Circumvention of MAC address randomization
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- *Information Elements* (network name, supported rates, country, supported channels)

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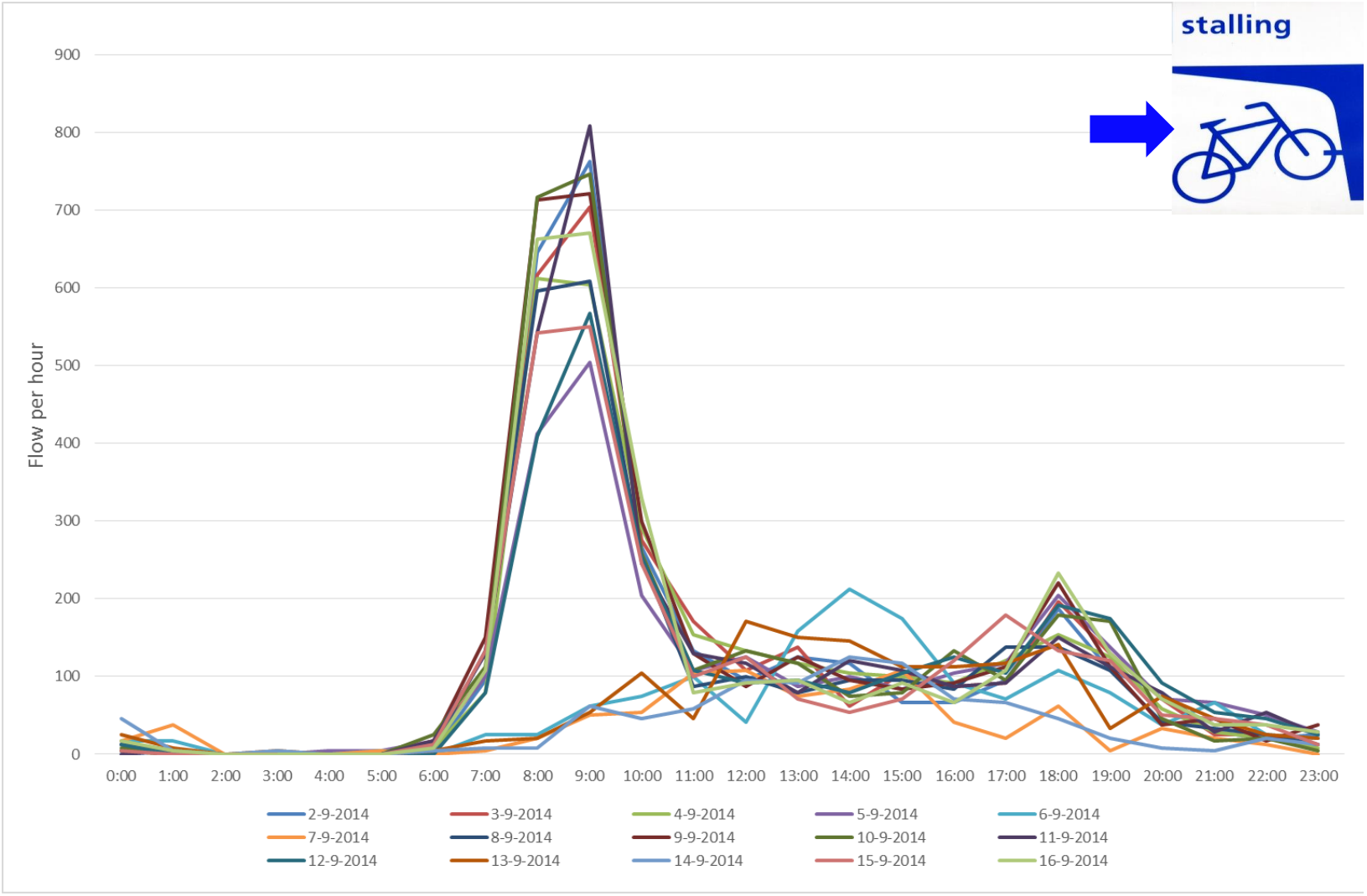
WiFi trackers

- Smartphones use *probes* to actively find known WiFi networks
- WiFi trackers collect *MAC addresses* from probes[4]
- Useful for *flow analysis* of people (e.g. on train stations)

(next slides taken from "Advances in measuring pedestrians at Dutch train stations using Bluetooth, WiFi and Infrared technology."[1])

[4] and store timestamp + signal strength + ...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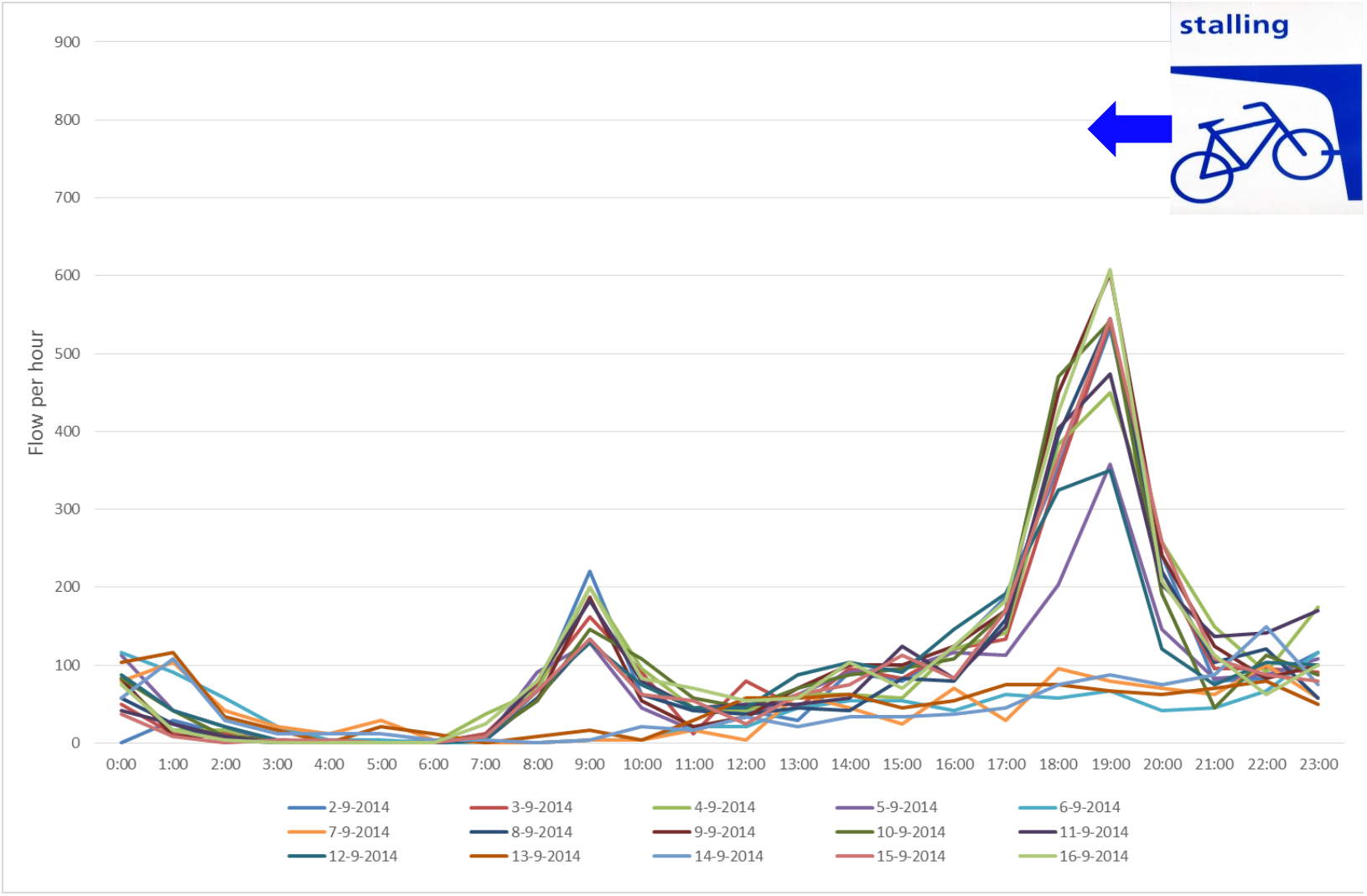
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WiFi trackers — Bluetrace

- Offered *WiFi tracking in retail*

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> *"Visitors are counted and tracked individually by following the Wi-Fi signal of their mobile phone. The visitor remains anonymous because only the phone's MAC address is recognized. So it's nothing personal. Just an amazing opportunity to maximize efficiency, security, service and revenue. By dealing flexibly and smart with the available data about location, product, personnel and people. Gathering data for predictive analysis of costumer and crowd behavior: now available for the offline world."*
> — *retrieved from the Internet Archive[2] (2014)*

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- Hashing algorithm not sufficient for anonymization
- Conclusion: Bluetrace processed personal data

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Detecting trackers

- *Remember the graphs?*

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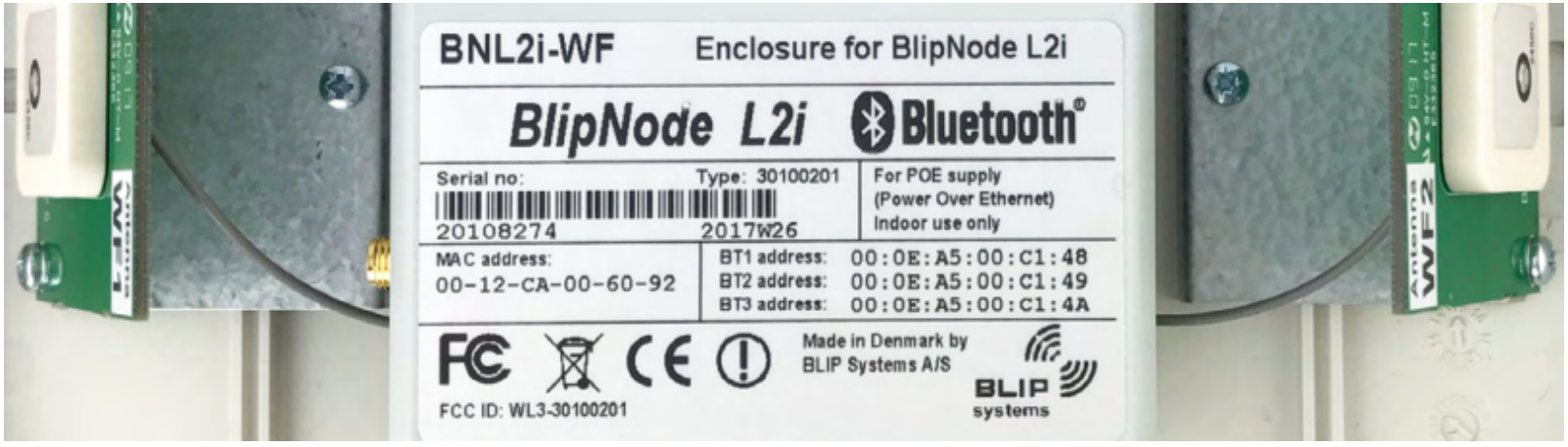

MAC addresses in a Bluetooth tracker[4, p. 6]

Detecting trackers

BlipTrack™

BlipNodes Status

Zone	Name	Address	Status
Blip	5102	00:0E:A5:00:8F:B8	Online
Blip	5102	00:0E:A5:00:8F:B9	Online
Blip	5102	00:0E:A5:00:8F:BA	Online
Blip_1	WiFi_1	17:0B:47:00:8F:B8	Online
Blip_2	WiFi_2	17:0B:48:00:8F:B8	Online

Status web page[3, p. 6]

Detecting trackers

- Wired network interface `00:12:CA`, *Mechatronic Brick Aps* (System-on-Chip)

- Bluetooth sensors `00:0E:A5`, *BLIP Systems*
- WiFi sensors `17:0B:47` *and* `17:0B:48`, not registered

Detecting trackers

- Wired network interface `00:12:CA`, *Mechatronic Brick Aps* (System-on-Chip)
  - Besides, their website[7] contains firmware images
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Future work

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Future work

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- "Urban WiFi characterization via mobile crowdsensing"[12] used smartphones to collect WiFi coverage information in Edinburgh
  - If WiFi sensors announce their presence, can we use smartphones to collect WiFi trackers coverage information?

Wrapping up

- Smartphones actively announce their presence when WiFi is activated
- WiFi trackers (ab)use this feature
- MAC addresses are considered *personal data*
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- Beware of "disabled WiFi but still enabled for location services" features

Thanks for your attention!

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