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## Privacy-preserving Wi-Fi tracking systems

Célestin Matte, Marine Minier, Mathieu Cunche, Franck Rousseau

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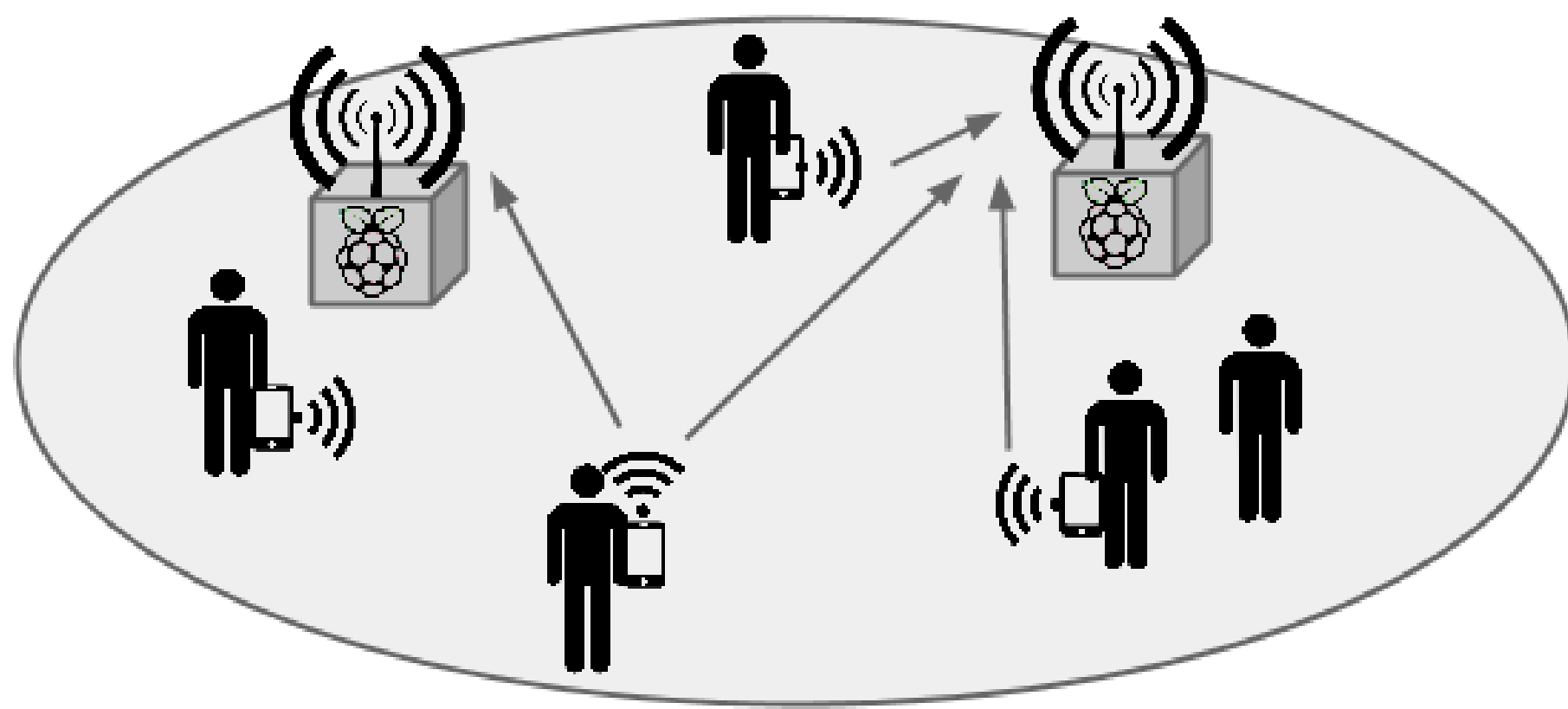
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## WI-FI TRACKING SYSTEMS

- Wi-Fi-enabled smartphones frequently emit frames because they scan for access points
- Each frame contains a unique identifier of the device: the **MAC address**
- Wi-Fi tracking systems monitor and store these frames in order to make statistics:
  - number of visitors
  - frequency of visits
  - travel paths
  - etc.



## PRIVACY ISSUES

- Lot of private information stored - much more than needed to make basic statistics
- Anyone with access - legitimate or not - to that data can get a lot of information about passers-by
- In France, made illegal by the "Informatique et Liberté" law (LIL). The CNIL made precise recommendations for this case of information collecting so that one knows if they respect the law [1]:
  - Data must be deleted when the person exits the place
  - Used algorithm must ensure a strong collision rate, i.e. an identifier must correspond to several people
  - People must give their explicit consent if one wants to store data for a longer period (opt-in system).
- We can work on storing only information valuable for statistics
- There is no miracle solution
- We aim to propose a privacy/utility tradeoff

## OBJECTIVES

- Short term:
  - First, comparing the different methods
  - Finding a good privacy metric
- Long term:
  - Having a ready-to-use system with the same functionalities than existing Wi-Fi tracking systems, augmented with privacy-by-design

## DATA COLLECTION

- We need datasets to perform all our tests, containing logs of raw MAC addresses seen at a certain time at a certain place.
- Legislation forbids the collection of such datasets, as they contain personal identifiers
- Need consent of all concerned people
  - difficult to set up
- Possible solutions:
  - getting the consent of concerned people (one try at ACM Middleware, small dataset obtained)
  - generate synthetic datasets from models

## PRIVACY METRICS

- We need metrics to quantify "privacy", in order to evaluate our methods
- Possible metrics are (non-exhaustive list):
  - K-anonymity
  - Collision rate: how many devices may be identified by the same identifier?
  - entropy?
- Other considerations:
  - Is the collision rate evenly distributed?
  - What happens on extreme values? (e.g. very few number of passers-by)
- We have to determine which one (among these ones or other ones) best fits our needs

## HASHING

- Principle:** Using a simple cryptographic hash function, such as MD5 or functions of the SHA family, with no salt
- Problems:**
  - Easy to reverse in the case of MAC addresses [2]
  - Almost no collision
  - Almost useless

aa:bb:cc:dd:ee:ff  $\xrightarrow{\text{sha1sum()}}$  fc06e09ced76b0f3510cd617c36929aae08023be

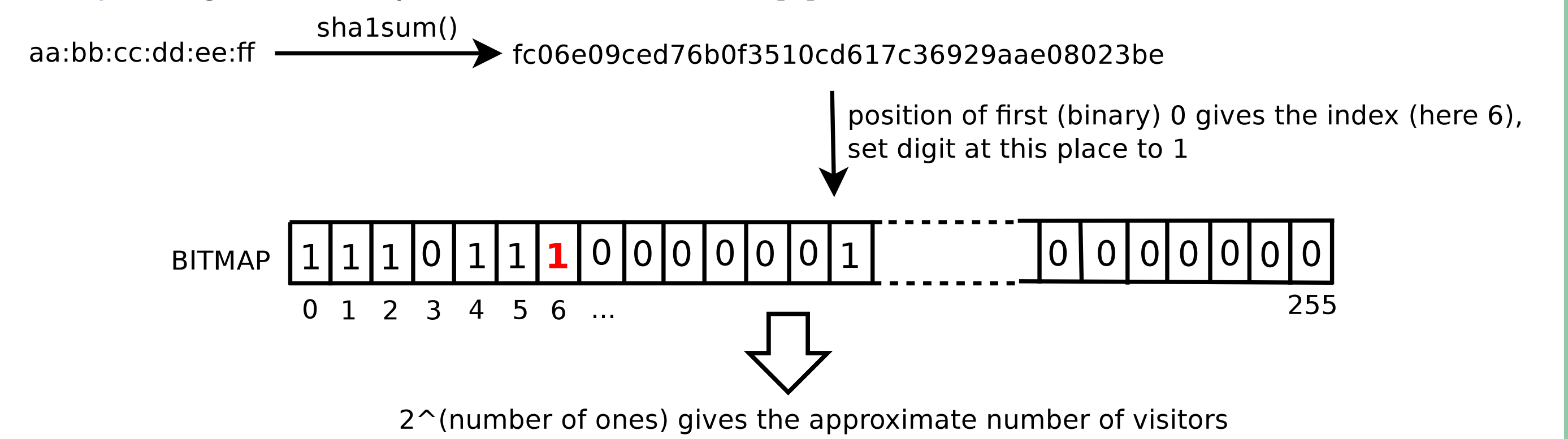
## HASHING AND TRONCATION

- Principle:** Same as hashing, but only keep a small part of the result
- the less you keep, the more collisions you'll get
- Also possible to truncate before hashing, in order to manually increase collision rate (first 3 bytes of the MAC address are the constructor identifier)
- Problem:** Still easy to reverse?

aa:bb:cc:dd:ee:ff  $\xrightarrow{\text{sha1sum()}}$  fc06e09ced76b0f3510cd617c36929aae08023be  $\xrightarrow{\text{truncate()}}$  fc06e09

## BITMAPS

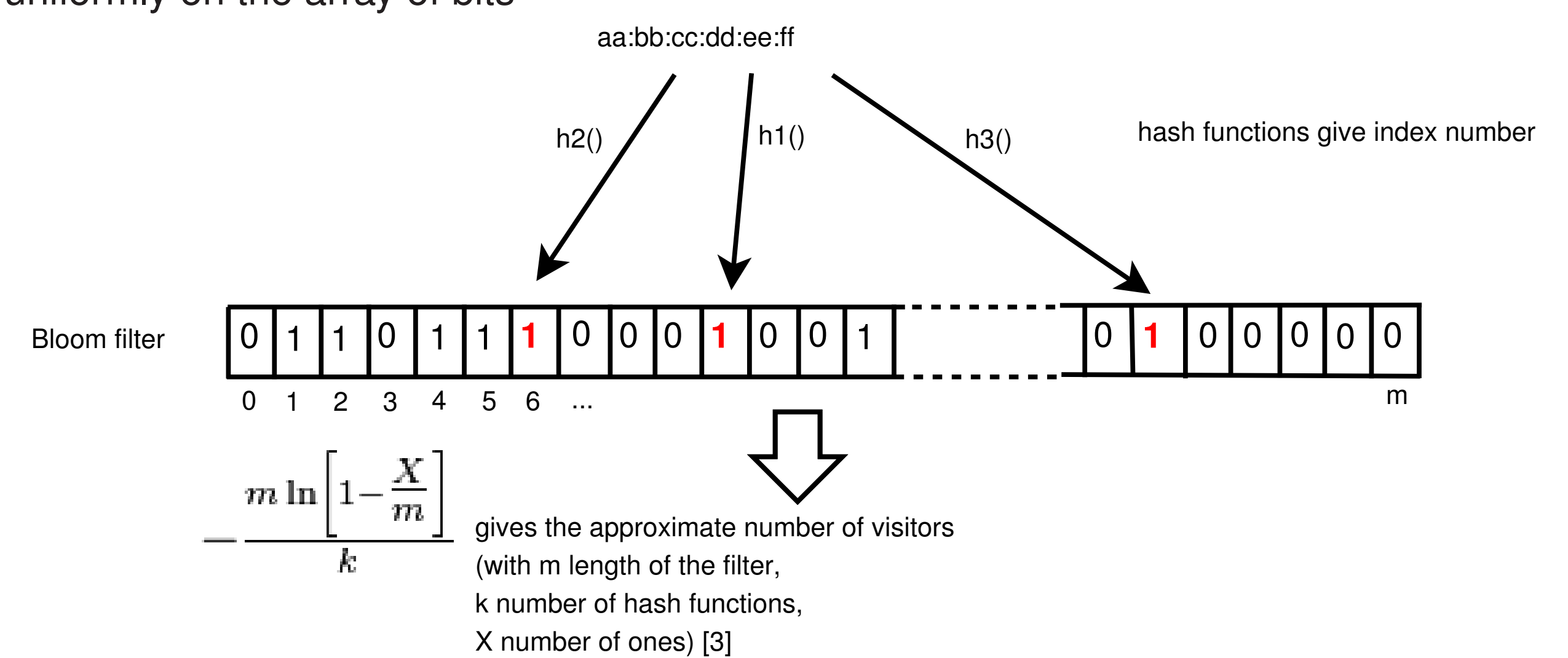
- Principle:** logarithmic repartition of the hashes [4]



- Problems:**
  - Unequal collision probability (half MAC addresses will set first bit or one while only one will set the last bit to one)
  - Very approximate for low numbers of MAC addresses (which is our case most of the time)

## BLOOM FILTERS

- Data structure useful for many applications
- Insertion and search in  $O(1)$
- ...but false positives
- ...which we use for privacy purpose
- We aim to be able to say that a person *may* have been here, but never be sure about it
- Principle:** about the same as bitmaps, but use several hashing functions spreading bits uniformly on the array of bits



- Problems:**
  - It may be possible to know for sure that some MAC addresses were seen
  - May still give bad results for low numbers of MAC addresses (tests ongoing)

## OTHER POSSIBILITIES

- Using other phone characteristics instead of MAC addresses (plenty of fingerprinting techniques exist) [5]
- Hashing with salts (keys), and destroying keys after a predefined period of time. Key destruction is not a trivial problem.

## DEPLOYMENT

- Simple tools: raspberry pis with Wi-Fi dongles



- Partnership with UrbaLyon
- Searching for partners with an infrastructure to share (electricity + network access)

## FUNDING

- Project funded by Academic Research Community (ARC), Rhône-Alpes region (ARC 7).



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