

Location Privacy in Mobile Systems: A Personalized Anonymization Model

by

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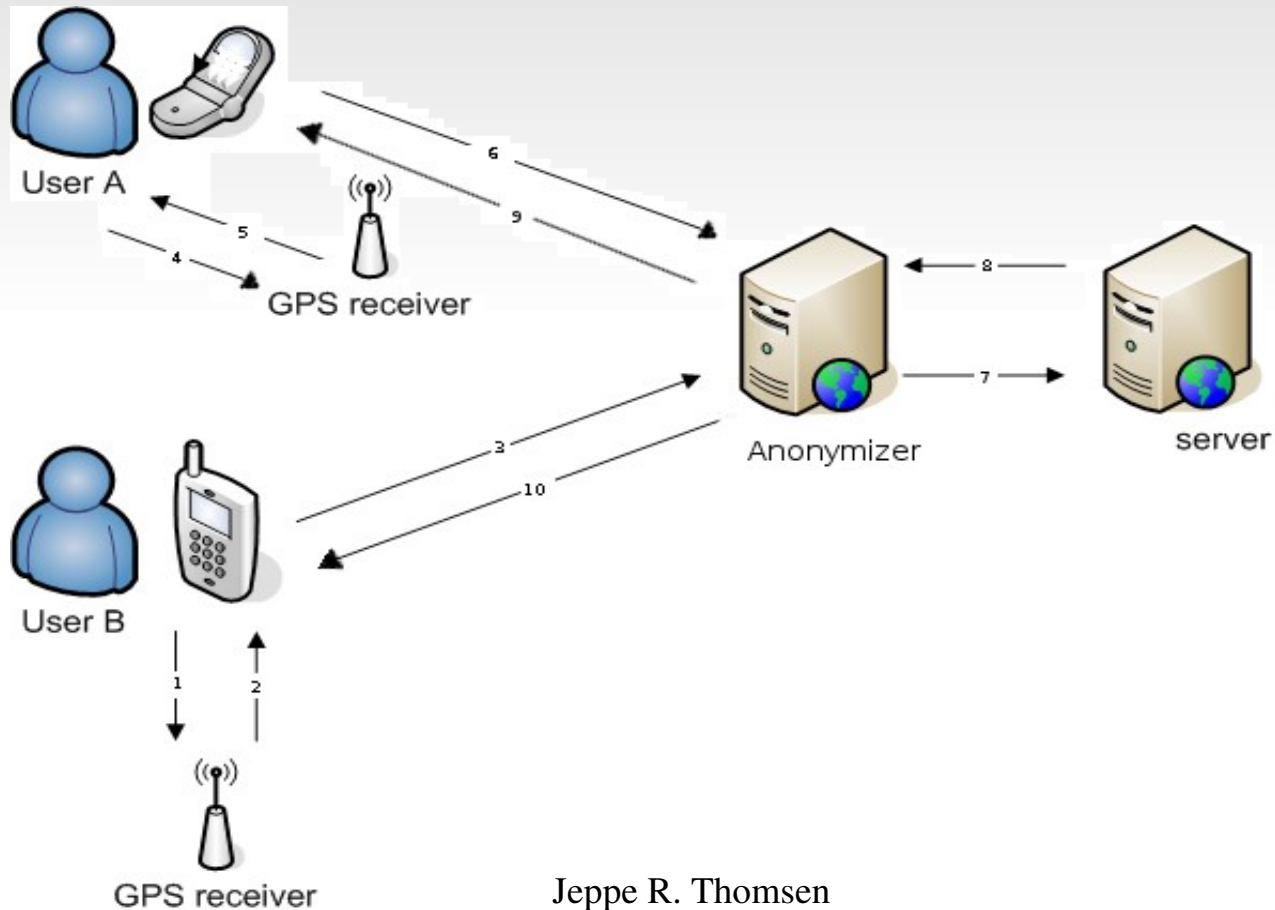
**Presented by
Jeppe R. Thomsen**

Overview

- Architecture and idea
- Algorithm
- Results
- Related work
- Evaluation

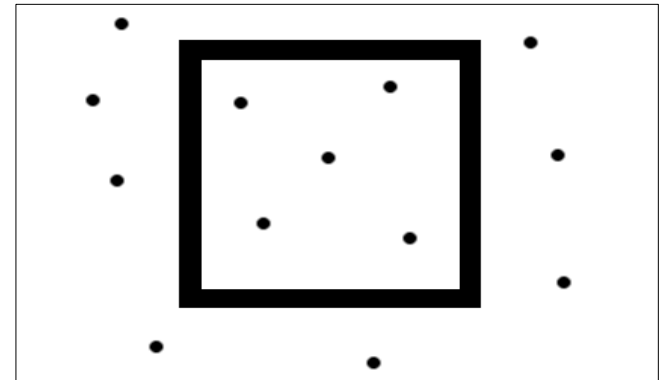
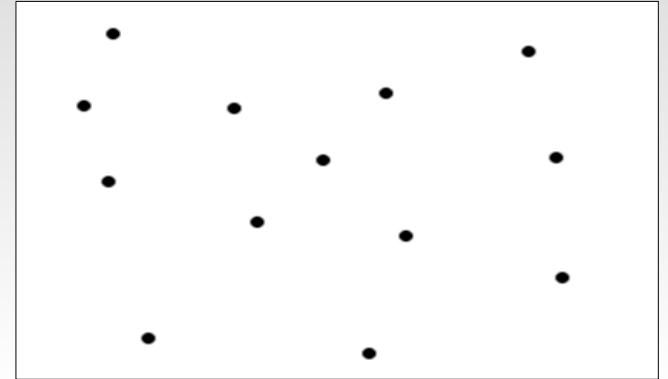
Architecture

- Client – Server with anonymizer



User Privacy

- K-anonymity
- User specified
 - Minimum anonymity level
 - Maximum temporal resolution
 - Maximum spatial resolution



Anonymizer

- Message anonymisation
 - $R(m_s)$, one to one mapping from M to T

- M: the set of messages

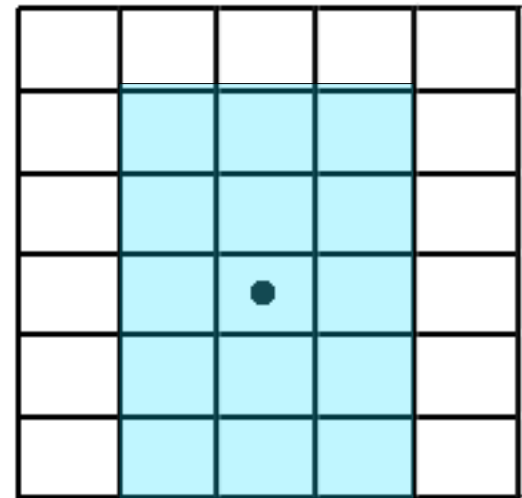
$$m_s = \langle u_{id}, r_{no}, \{t, x, y\}, k, \{d_t, d_x, d_y\}, C \rangle$$

- T: the set of anonymized messages

$$m_t = \langle u_{id}, r_{no}, \{X:[x_s, x_e], Y:[y_s, y_e], I:[t_s, t_e]\}, C \rangle$$

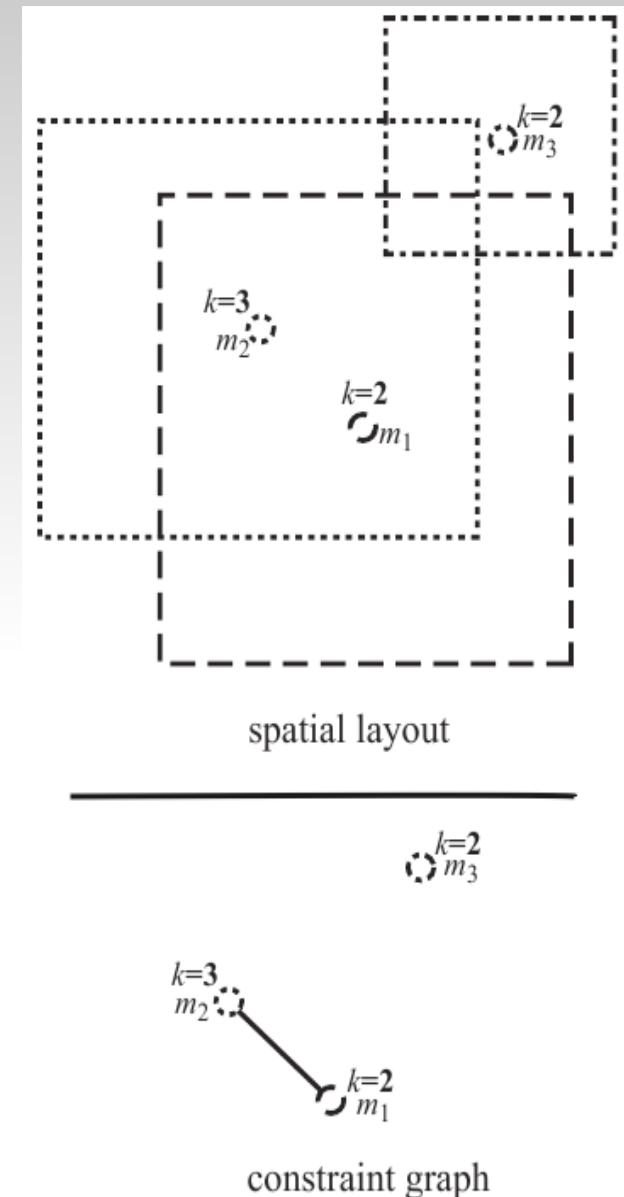
- E.g. $\langle u_{id}, r_{no}, (4,3,3), k, (1,1,2), C \rangle \rightarrow$

$$\langle u_{id}, r_{no}, [2,4], [1,5], [3,5], C \rangle$$



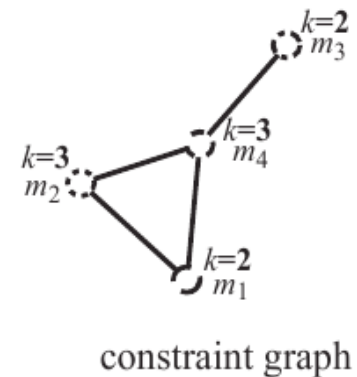
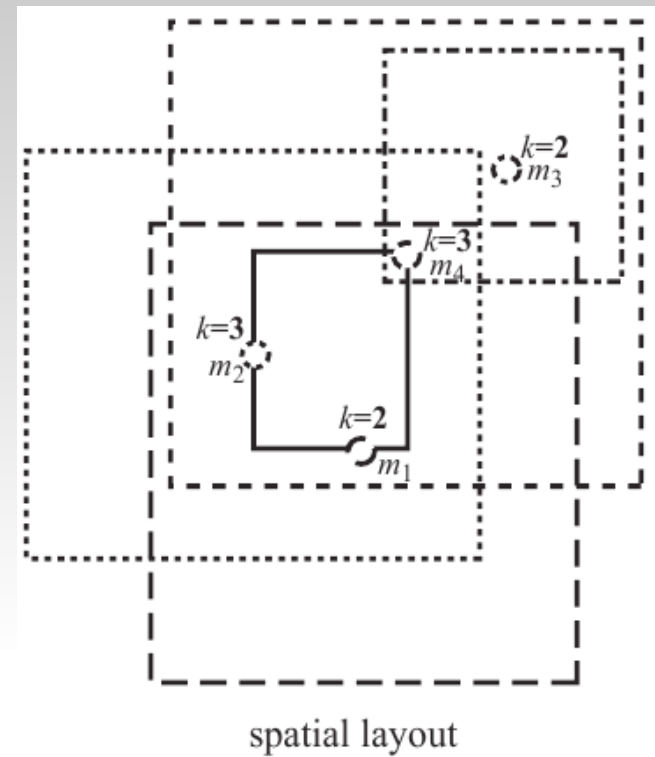
Anonymizer

- (1) Find a set of messages which can be anonymized together.
- (2) Find a MBR which contains all spatio-temporal points of M , called "minimum spatio-temporal cloaking box".



Anonymizer

- (1) Find a set of messages which can be anonymized together.
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Algorithm -step 1

- Zoom-in
 - Message Queue, Q_m : FIFO
 - Multi-dimensional Index, I_m
 - Expiration Heap, H_m : sorted, key: $m_s.t + m_s.d_t$
 - Construct Constraint Graph, G_m with new node m_s

Algorithm – step 2

- Detection
 - Find all neighbors of m_s
 - Discard any neighbor which has $k > m_s.k$
 - Discard any neighbor which does not have $m_s.k-2$ neighbors
 - Check if a clique containing m_s exist in the remaining set

Algorithm – step 3

- Perturbation (assignment of cloaking box)
 - For each member m_s of a clique found in previous step, output a message: $\langle h(u_{id} \parallel r_{no}), X, Y, I, C \rangle$ to LBS
 - Delete m_s from:
 - Multi-dimensional Index
 - Expiration Heap
 - Constraint Graph.

Algorithm – step 4

- Expiration
 - For any message where $\text{timestamp} + \text{time constraint} < \text{current time}$
 - Delete m_s from:
 - Multi-dimensional Index
 - Expiration Heap
 - Construct Constraint Graph.

2 Variants - 1/2

- Deferred CliqueCloak (Nbr-k)
 - Advantages
 - Include m_s with small values of k into cliques with larger k , could give extra spatial privacy.
 - Deferre detection(step 2) to increase chance of success finding clique.
 - Disadvantages
 - User may percieve a degradation in service, due to the posponening of the detection step.

2 Variants - 2/2

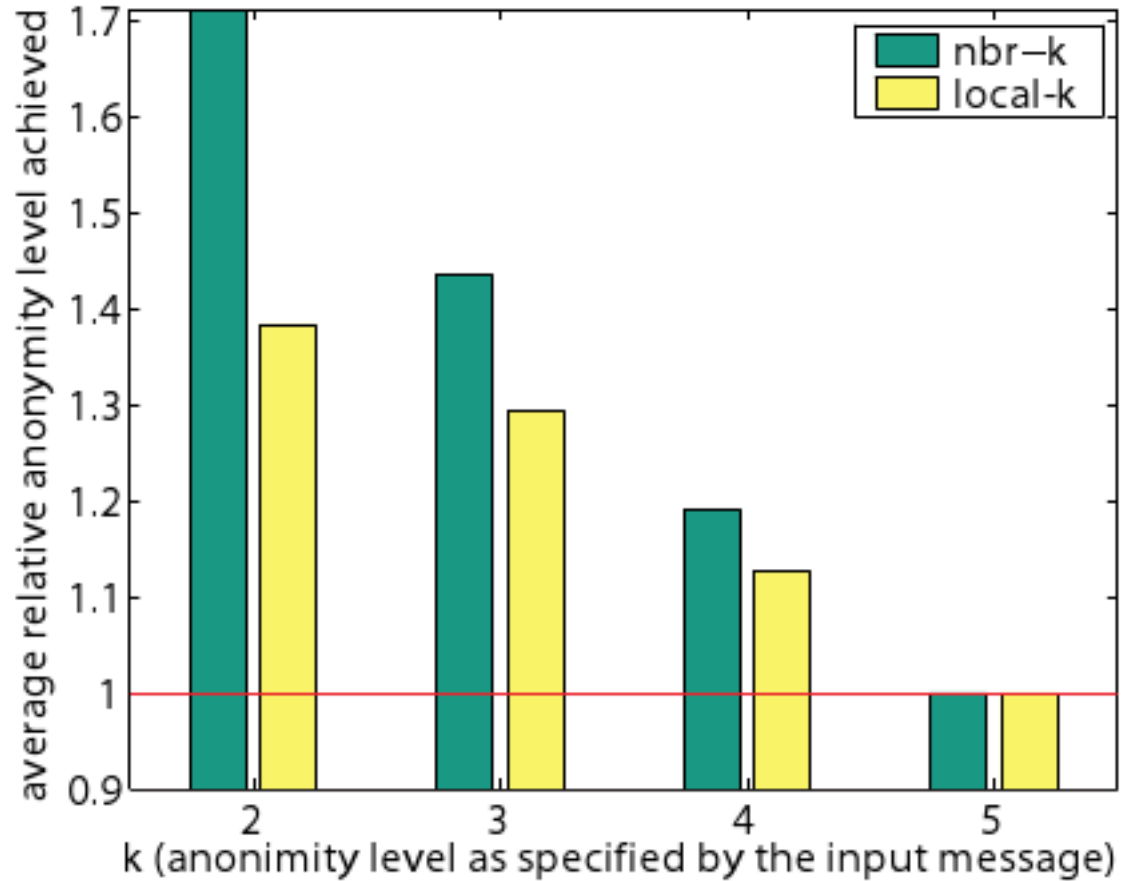
- Immediate CliqueCloak (local-k)
 - Advantages
 - User may get a quicker response, all m_s are tried with local-k to find clique as fast as possible
 - Disadvantages
 - Lower success rate than nbr-k

Evaluation metrics

- Relative anonymity level (QoS)
 - Normalized by min level of anonymity accepted
- Relative spatial resolution
 - Normalized by min acceptable spatial resolution
- Relative temporal resolution
- Message processing time (Performance)
 - CPU time to process 10^3 messages

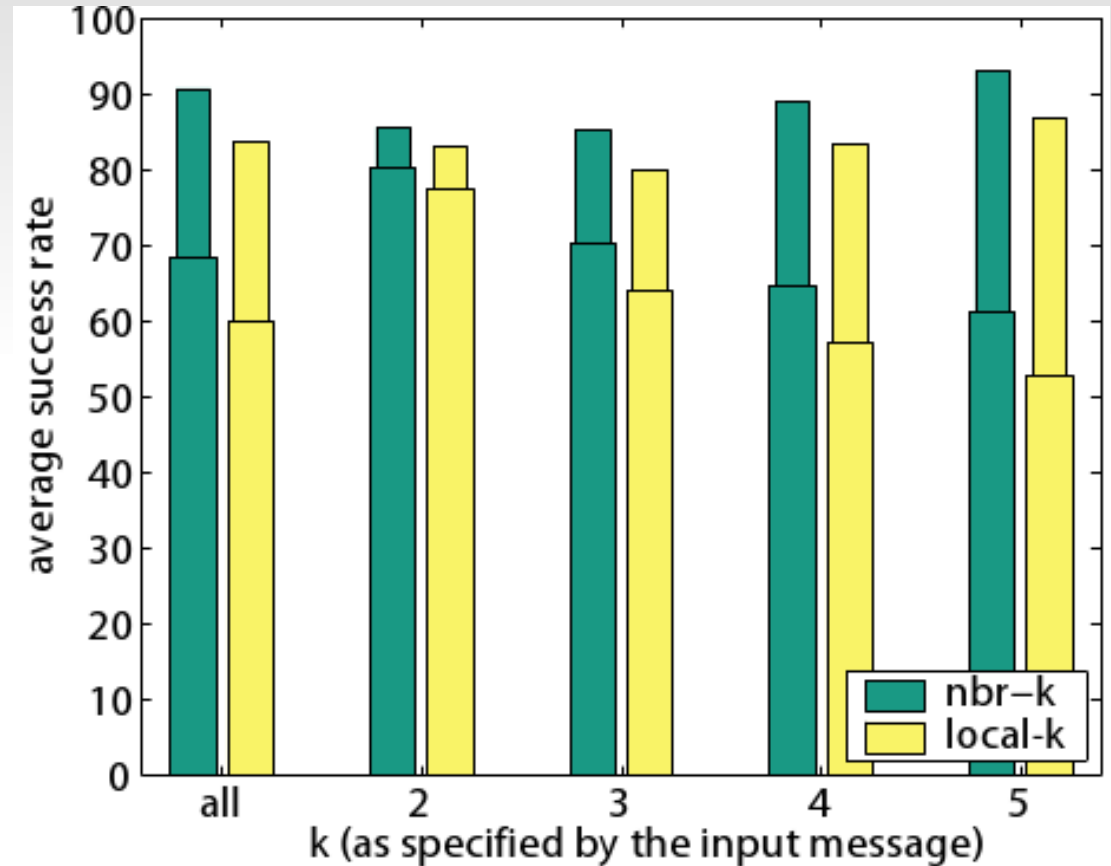
Results

Relative anonymity levels
for different k values



Results

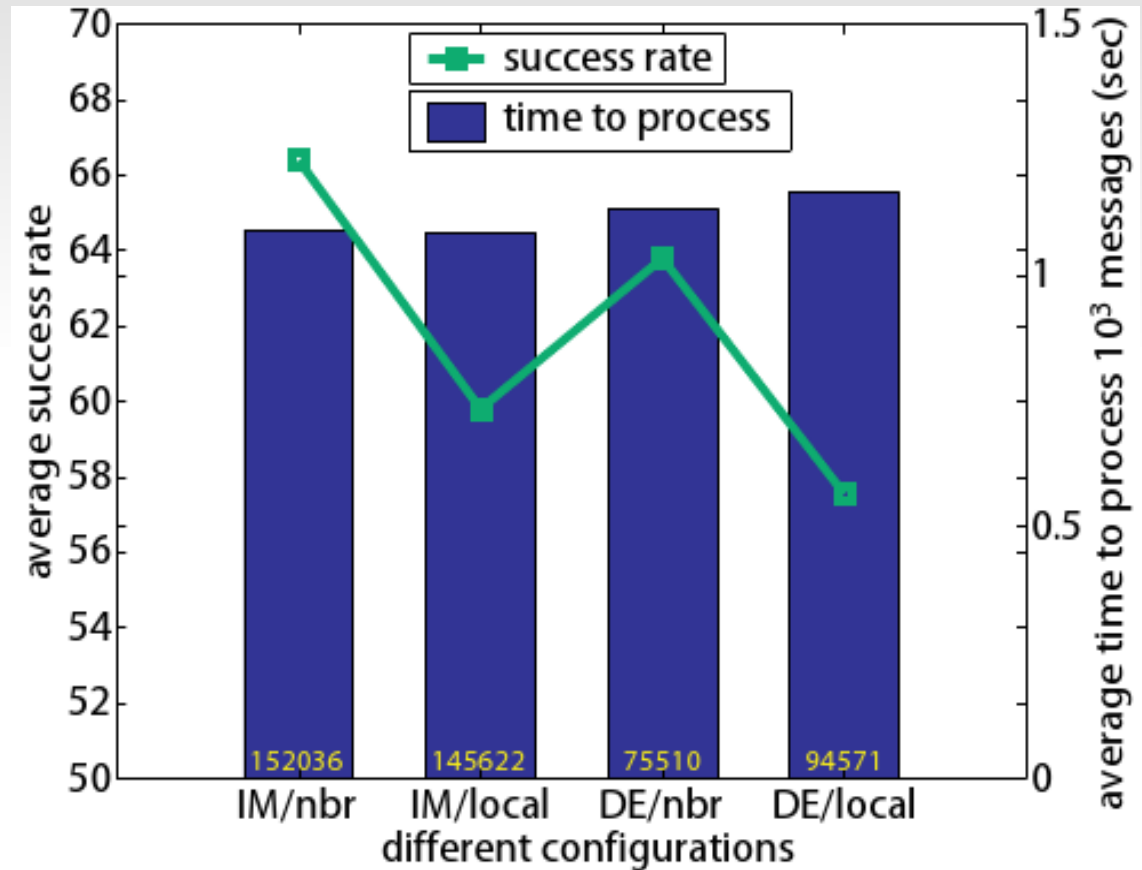
Success rates for
different values of k



Results

Message processing time and success rate of different approaches.

DE reduce clique search by 50%



Related Work

- Contributions
 - Individual user anonymity specification with anonymizer
 - Minimum anonymity level
 - Maximum temporal resolution
 - Maximum spatial resolution
 - Provide quality of service in respect to size of cloaking box produced by anonymizer

Evaluation

- Okay paper
- Contributes CliqueCloak algorithm.
- Nice results