



Trustworthy and Secure
Future Internet



Privacy-Preserving Mobility-Casting in Opportunistic Networks

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Overview

- ▶ Opportunist Networks
- ▶ Mobility-Casting
 - Motivation
 - Experiments and Results
 - Privacy issue
 - MobileFairplay and Mobility-Casting
- ▶ Conclusions and Future Work

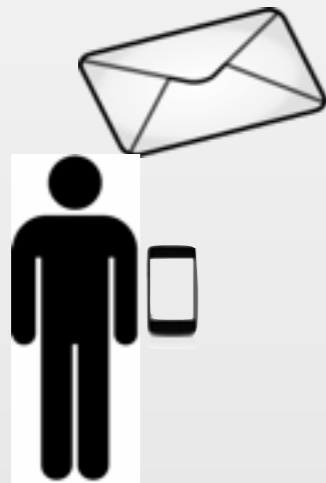


Network Context

- **Opportunist networks** are characterised by the presence of mobile devices, like:
 - ▶ *SmartPhones;*
 - ▶ *Tablets;*
- Messages are spread using the **Store, Carry** and **Forward** technique;

Opportunistic Networks .2

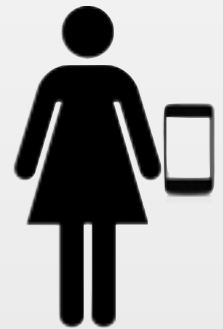
Forward



Bob



Alice



Carol

Mobility-Casting

- It is an information dissemination mechanism;
- People who have similar mobility patten may be interested in sharing similar information;
- Forwarding mechanism:
 - ▶ Delivering a message M generated by a User (U) to users who display a similar mobility pattern;

Mobility Casting

Motivation

- “About 30% of new social interactions arise between **Place-Friends**”;
 - S. Scellato, A. Noulas, C. Mascolo, “Exploiting Place Features in Link Prediction on Location-Based Social Networks”, *Proc. ACM KDD*, 2011.
- “Individuals with **similar mobility patterns** are likely to be close in the social network graph”;
 - D. Wang, D. Pedreschi, C. Song, F. Giannotti, A.L. Barabasi, “Human Mobility, Social Ties, and Link Prediction”, *Proc. ACM KDD*, 2011.
- “It is possible **to infer social ties** from colleagues working in same places, people attending same fitness class”;
 - D.J. Crandall, L. Backstrom, D. Cosley, S. Suri, D. Huttenlocher, J. Kleinberg, “Inferring Social Ties from Geographic Coincidences”, *Proc. National Academy of Science (PNAS)*, 2010.

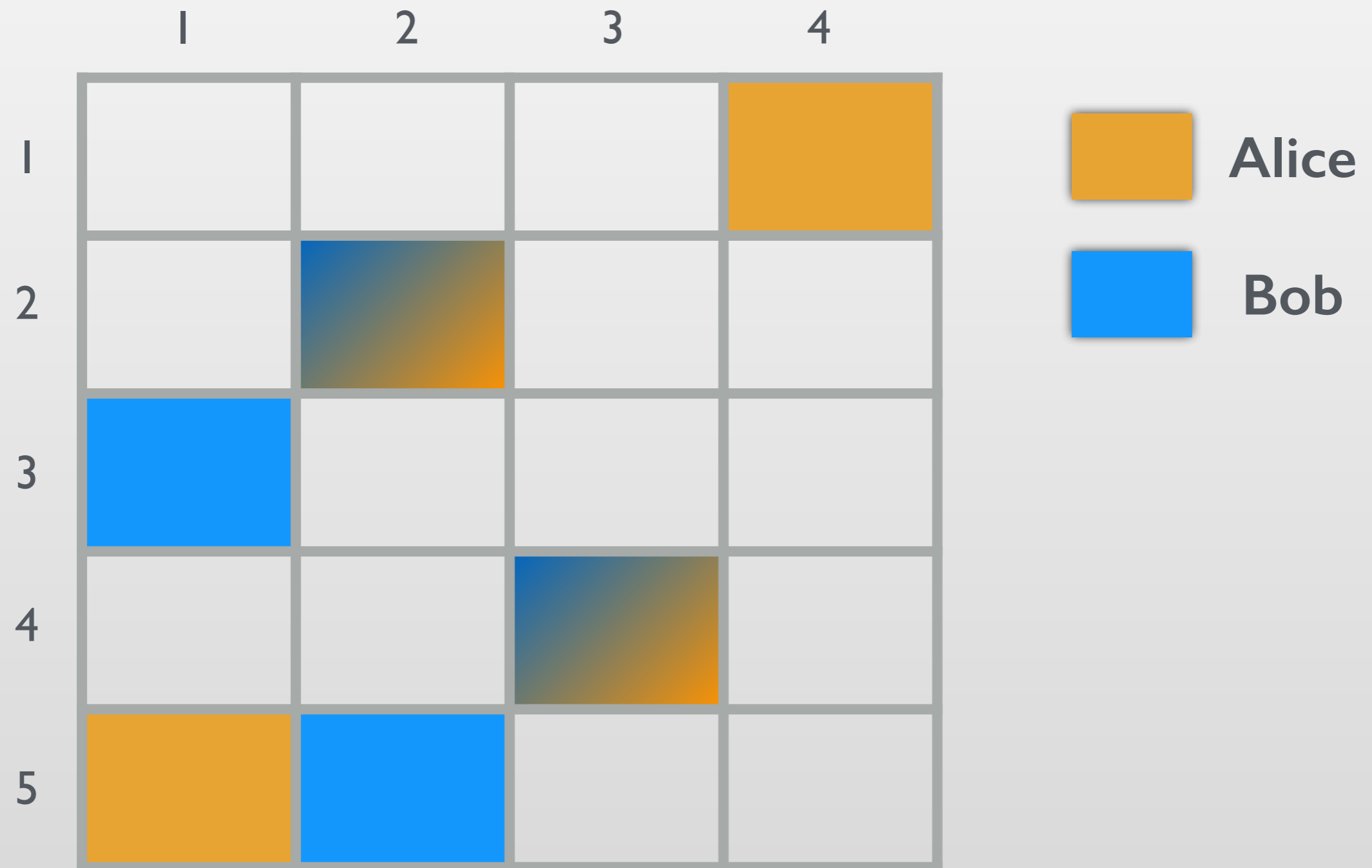
Mobility Casting Metric

- We use similarity metric based on comparing the k -cells most frequently visited;
- **Two users:**
 - Alice most visited cells: $F_A = \{i_1, \dots, i_k\}$
 - Bob most visited cells: $F_B = \{j_1, \dots, j_k\}$
- **Place-Friend:** $|F_A \cap F_B| \geq \lambda$

where λ represents minimum number of
common cells

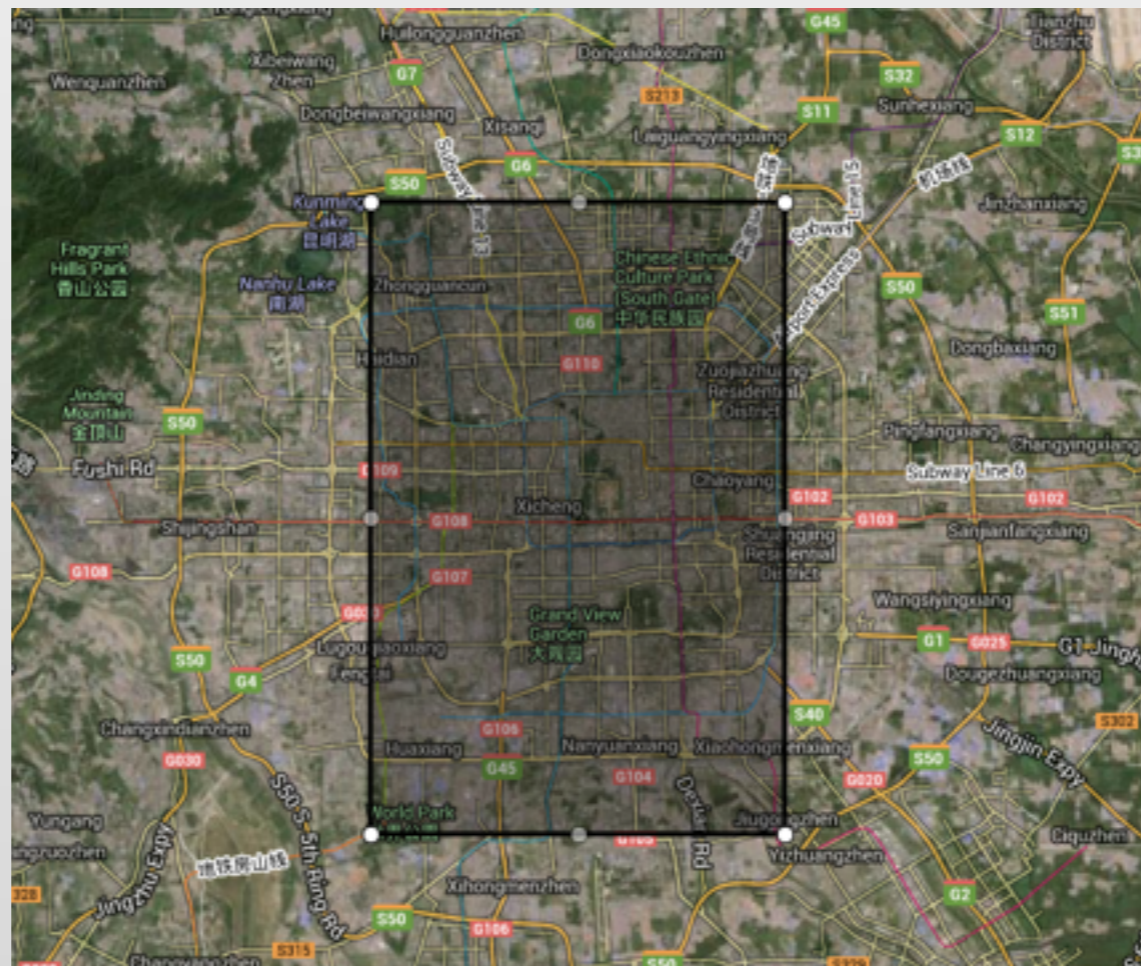
Mobility Casting

Place-Friend



Mobility Casting Experiments

- Microsoft Research **GeoLife GPS trajectories**;
- **77 Users** recorded in 2008, Beijing City;
- Each point of latitude, longitude stored every 1s to 5s;



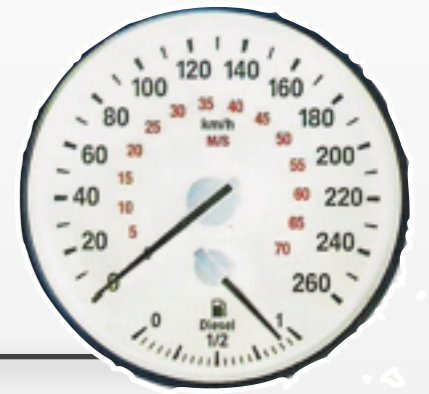
Mobility Casting

Experiments

We estimate the performance of our Mobility-Casting comparing four forwarding protocols:

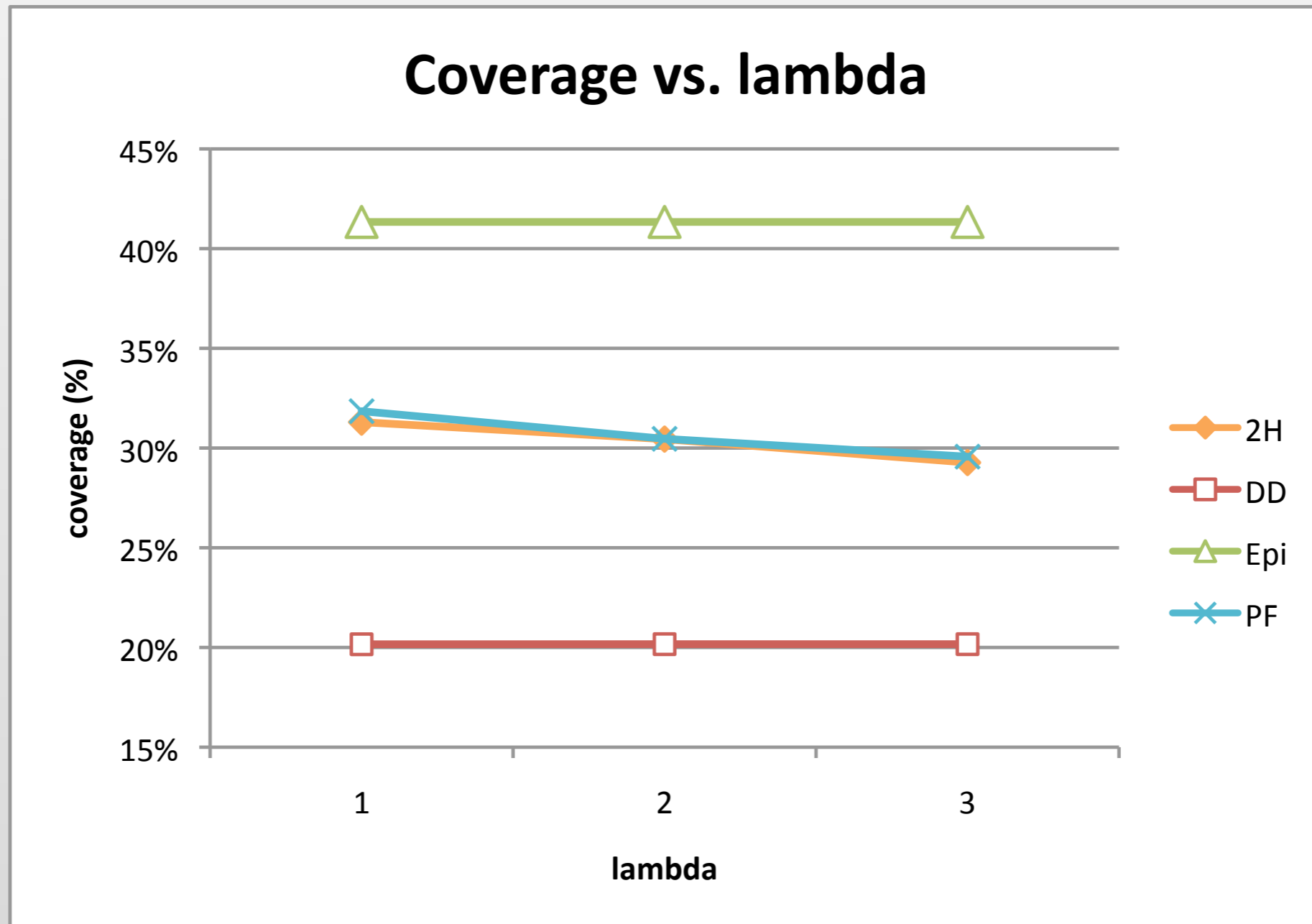
- **2H or Mobility-Casting**: a message is propagated only up to the second hop if users are places-friends.
- **DD (Direct Delivery)**: a message is propagated only to the met person if users are places-friends.
- **EP (Epidemic Protocol)**: a message is always propagated to the met person.
- **PF (Probabilistic Forwarding)**: it is similar to 2H but a message is probabilistically forwarded.

Mobility Casting Experiments



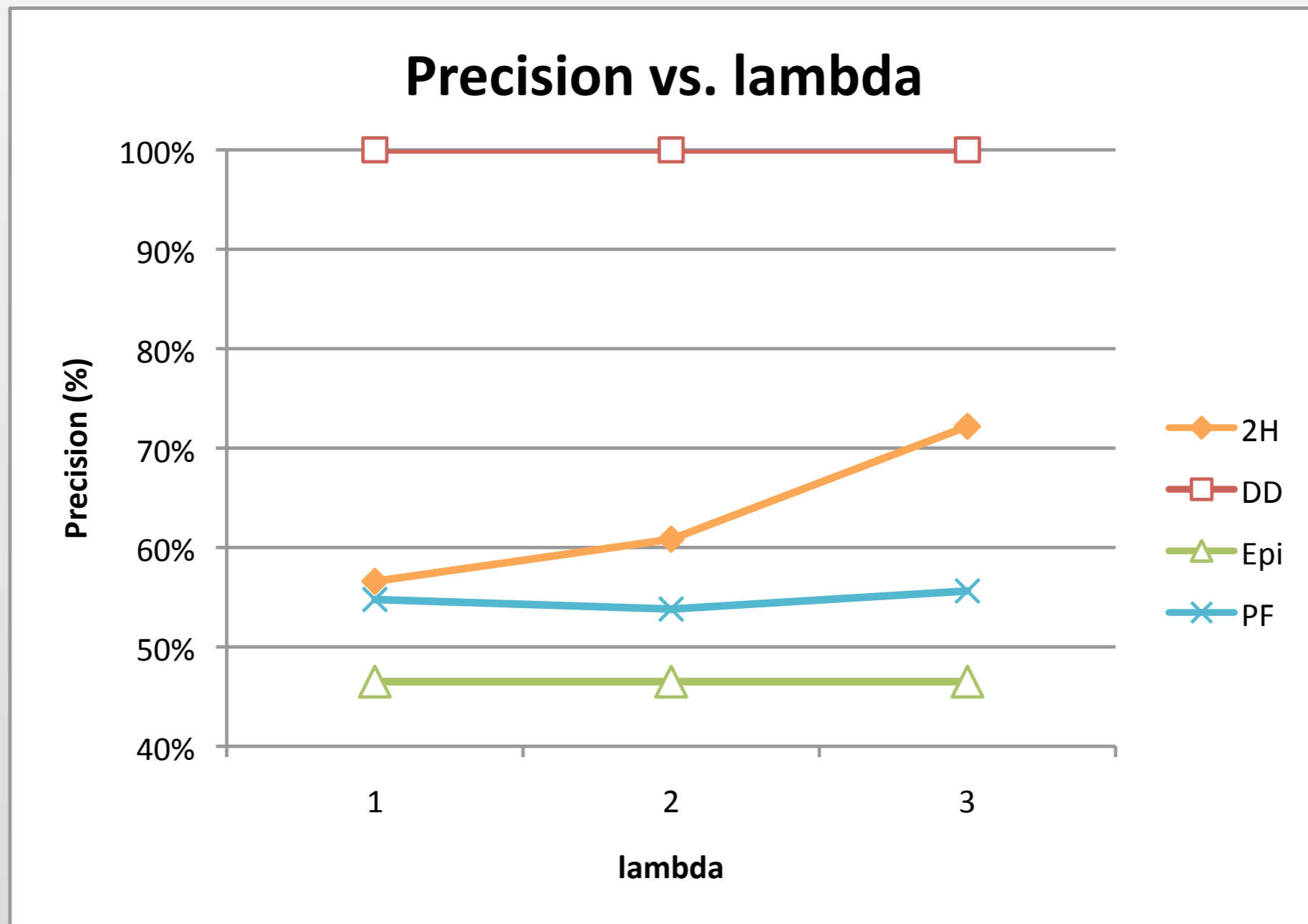
- We evaluated our Mobility-Casting with four metrics:
 - **Coverage:** is the ratio between the number of agents who visit locations similar the source and those who have received the message, and the total number of agents who visit the locations similar to the source. *It expresses the delivery rate;*
 - **Precision:** is the ratio between the number of agents who visit locations similar the source and those who have received the message, and the number of agents who have received the message. *It measures the accuracy;*
 - **Cost:** it is the total number of copies of M circulating in the network at the end of the protocol execution. *It measures the overhead;*
 - **Delay:** it is the average time interval elapsing since a place-friend receives a message. *It expresses the dissemination power*

Mobility Casting Coverage



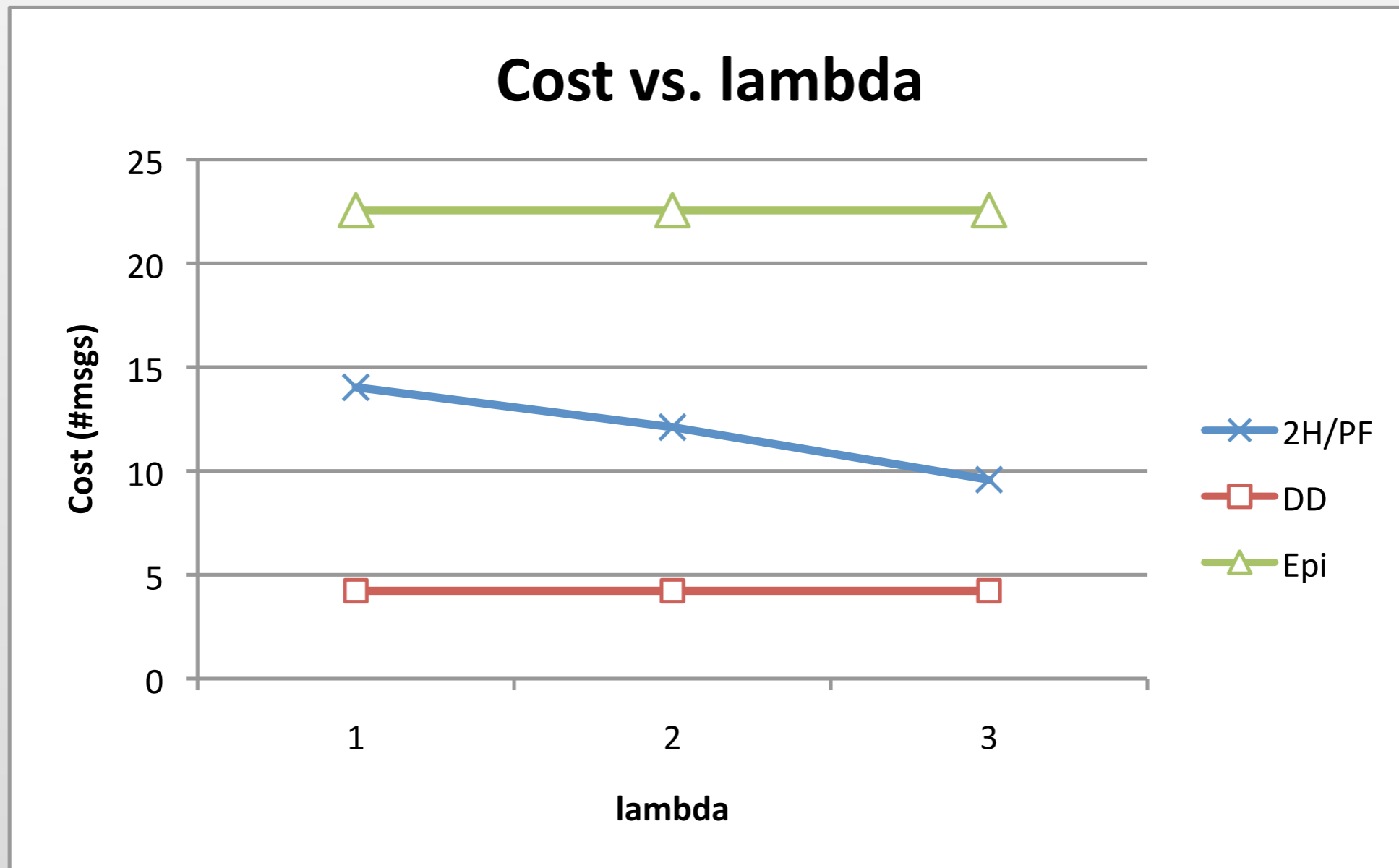
Mobility Casting

Precision



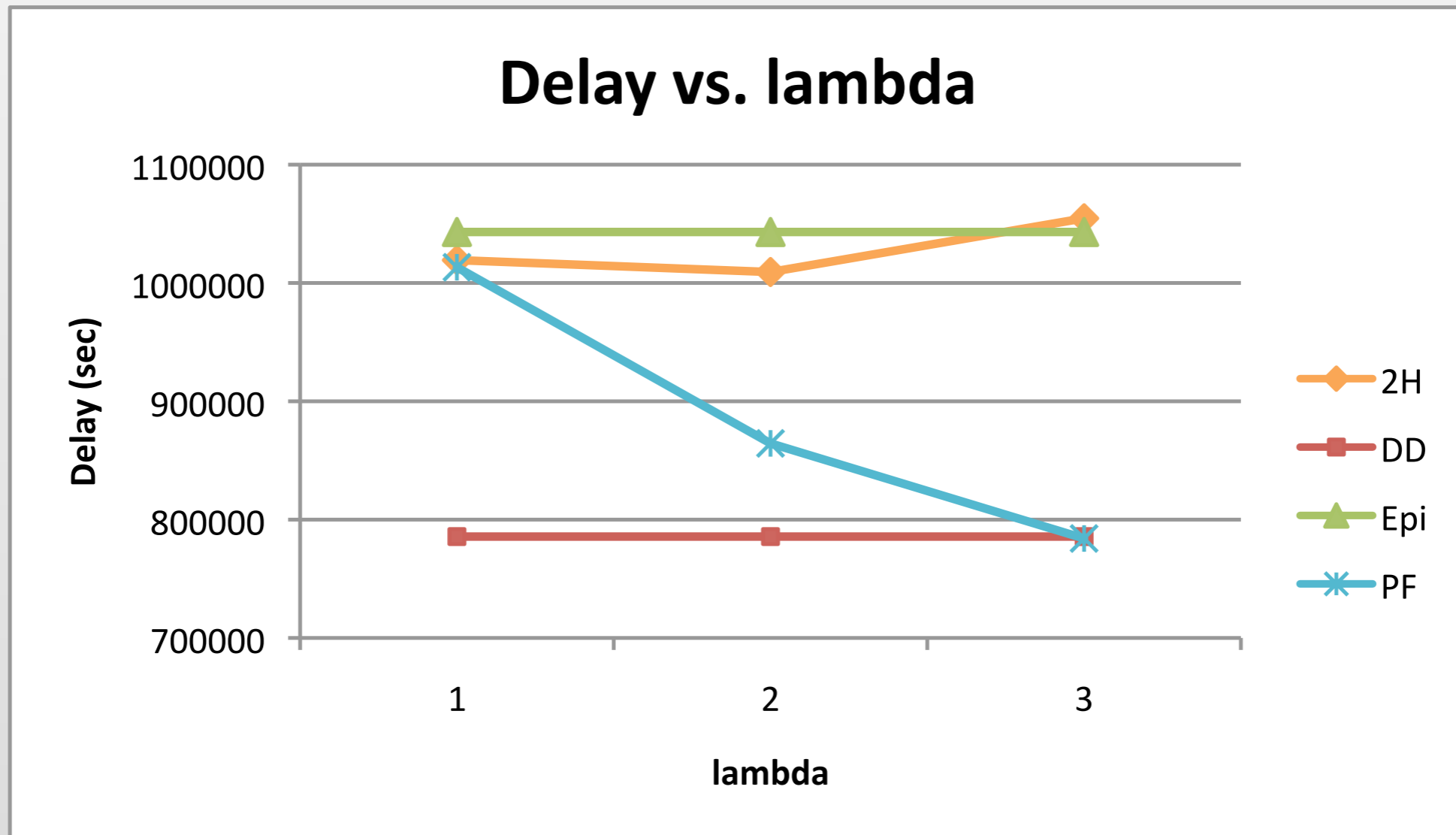
Mobility Casting

Cost



Mobility Casting

Delay



Mobility Casting

Privacy Issue

- Values of most visited cells are disclosed to find common cells;
- Alice may discover the habits of Bob and vice-versa:
 - In Opportunistic Network Alice and Bob **usually are not friend.**
- The smaller is the cell-area, the higher is the accuracy of the discoverable mobility patten;

Secure Two-party-Computation

- **Secure two-party** computation allows users **to run secure function**;
- Alice and Bob run:

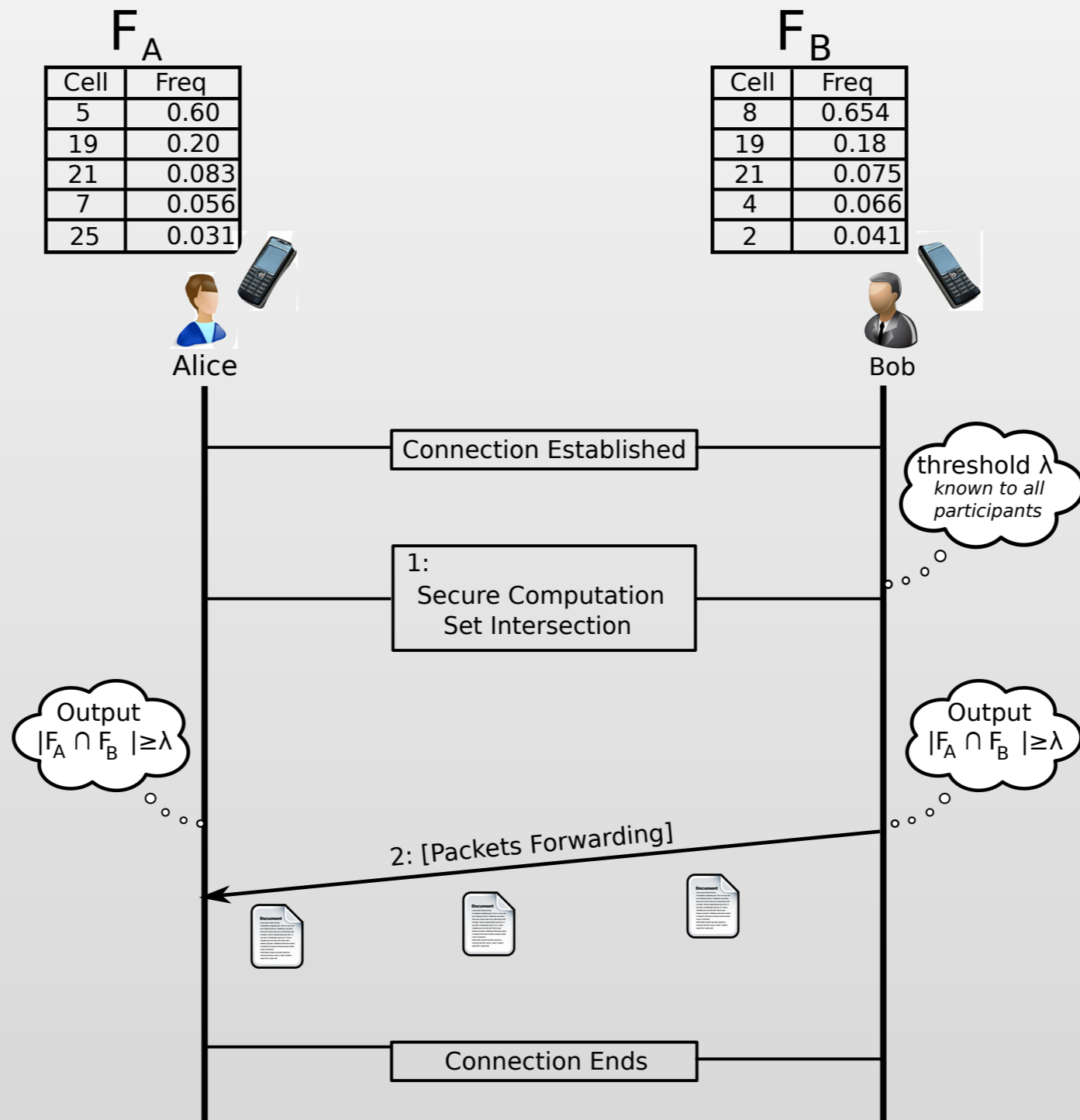
$$f(x,y)$$

- Alice and Bob will know the result of the function **without disclosing out** their input.
- No Trusted Third Party (TTP) is needed.

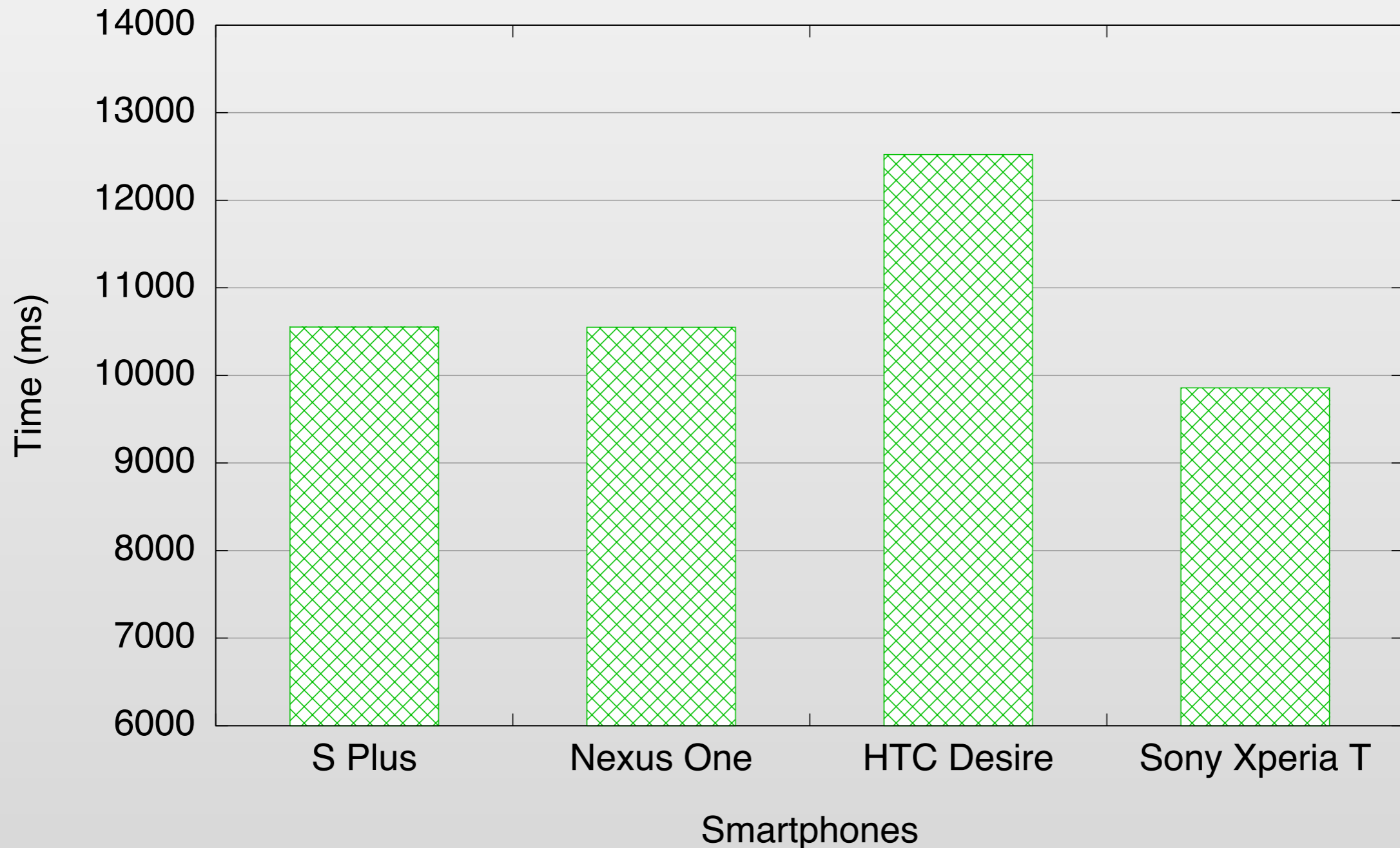
Secure Two-party-Computation

- We use **MobileFairplay**, which is our porting of FairPlay to Android Smartphone;
- The Mobility-Casting protocol is written using the high-level language (*SFDL*), then compiled to boolean circuits;
- Alice and Bob exchange their garbled circuits;
- At the end of all interactions, they know if they are **place-friends**.

Secure Two-party-Computation Protocol-Flow



Secure Two-party-Computation Prototype



Conclusion

- We have introduced a new forwarding primitive based on similar mobility pattern.
 - ▶ Avoiding to disclose out sensible information;
- Users' privacy is preserved using Secure Two-party Computation
 - ▶ Running time should be improved;
- Future work:
 - ▶ Running other simulations using synthetic traces;
 - ▶ Investigating new up-to-date STC framework.

