ScuDo
Scuola di Dottorato ~ Doctoral School
WHAT YOU ARE, TAKES YOU FAR
XXXIV Cycle

Hacking a complex world
unraveling the mechanisms underlying complex social and technological phenomena
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Research context and motivation

- Network theory is a powerful modeling paradigm for real-world applications: epidemics, social networks, economics, robotics.
- Temporal networks encapsulate the inherent variability of human contacts. However, their rigorous characterization is still challenging.
- Activity Driven Networks are temporal networks that conjugate rigorous modeling ability with analytical treatment.
- We aim at developing optimization and control strategies with main focus on diffusion processes (epidemics, economics, innovations) over temporal networks.
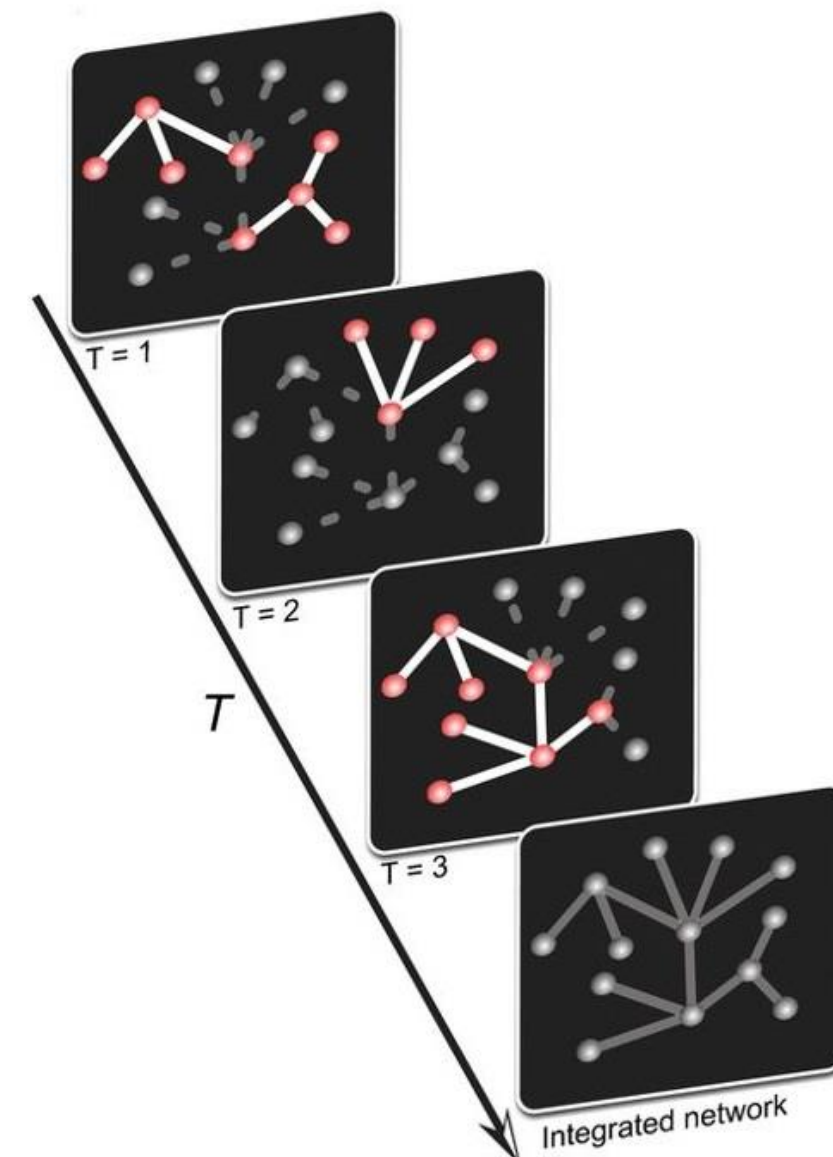
Schematic modeling of Activity Driven Networks
Perra et al. "Activity driven modeling of time varying networks." Scientific reports

Novel contributions

- We developed an Android Application that, using Bluetooth technology, is capable of inferring the relative distance among the devices on which it is installed.
- The Application can be downloaded from Google Play Store, from the portal of "Politecnico di Torino", and is named "HumanToHuman" - http://bit.ly/HumanToHuman
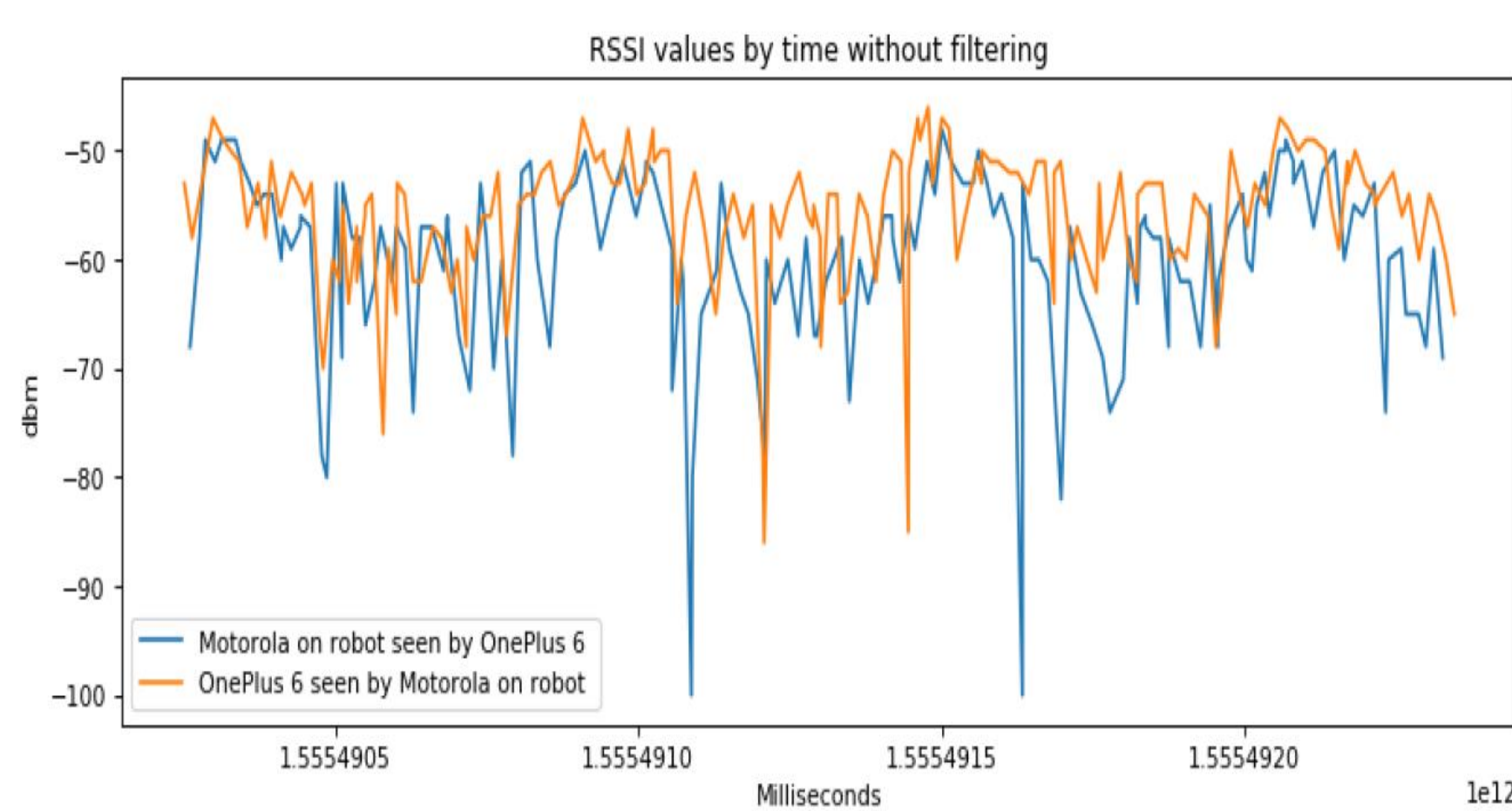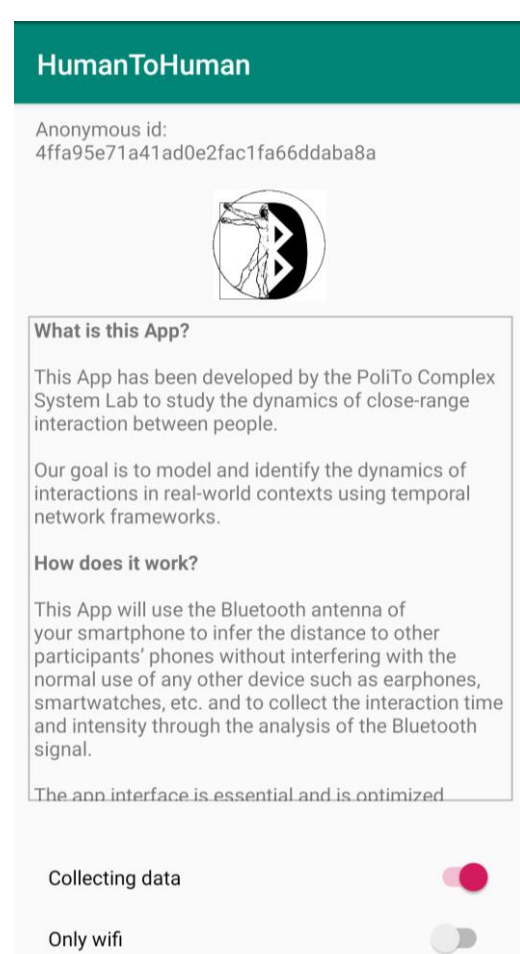
Layout of the Android Application (left) – Example of data gathered (right)

- From the observation of the individuals' state changes in an epidemic model on a temporal network, we develop a probabilistic framework that allows us to detect the backbone links

$$\lim_{T \to \infty} \mathcal{P}_{j \to i} \geq \frac{\mu \lambda \gamma \left[\left(1 - \lambda \frac{a_i}{d_i}\right) \left(1 - \lambda \frac{a_M}{d_m}\right) \right]^{d_i - 1}}{\lambda(a_i + (1 - \gamma(1 - \frac{d_i}{d_m}))a_M) + \mu} \times \frac{1}{e^{\lambda(1-\gamma)(a_i + a_M)}} \left(\frac{a_i}{d_i} + \frac{a_j}{d_j} - \gamma \lambda \frac{a_i a_j}{d_i d_j} \right) > 0$$

Time-series of mutual infection (up) – Equation for probability of changing state (down)

Future work

- Designing data collection campaigns for sufficiently large populations
- Performing backbone reconstruction in realistic scenarios, even in presence of hidden nodes
- Developing control strategies based on the backbone inference
- Part of the future work will be developed at the Dynamical Systems Laboratory of the New York University Tandon School of Engineering

Submitted and published works

- Francesco Vincenzo Surano, Christian Bongiorno, Lorenzo Zino, Maurizio Porfiri and Alessandro Rizzo, "*Backbone reconstruction in temporal networks from epidemic data*", Physical Review E (Submitted 2019/07, 2nd review ongoing)

Addressed research questions/problems

- How do humans create a temporal social network by contacting their peers? Modeling such a dynamics will shed light on the formation of social networks and will provide benchmarks to test control strategies. We address this question by developing a mobile app to record temporal interactions.

- Can we model a social network through a sparse representation? ? Starting from the full set of temporal interactions, can we isolate the system backbone? We address this question through a statistically-principled filtering technique that detects real dyadic relationships.
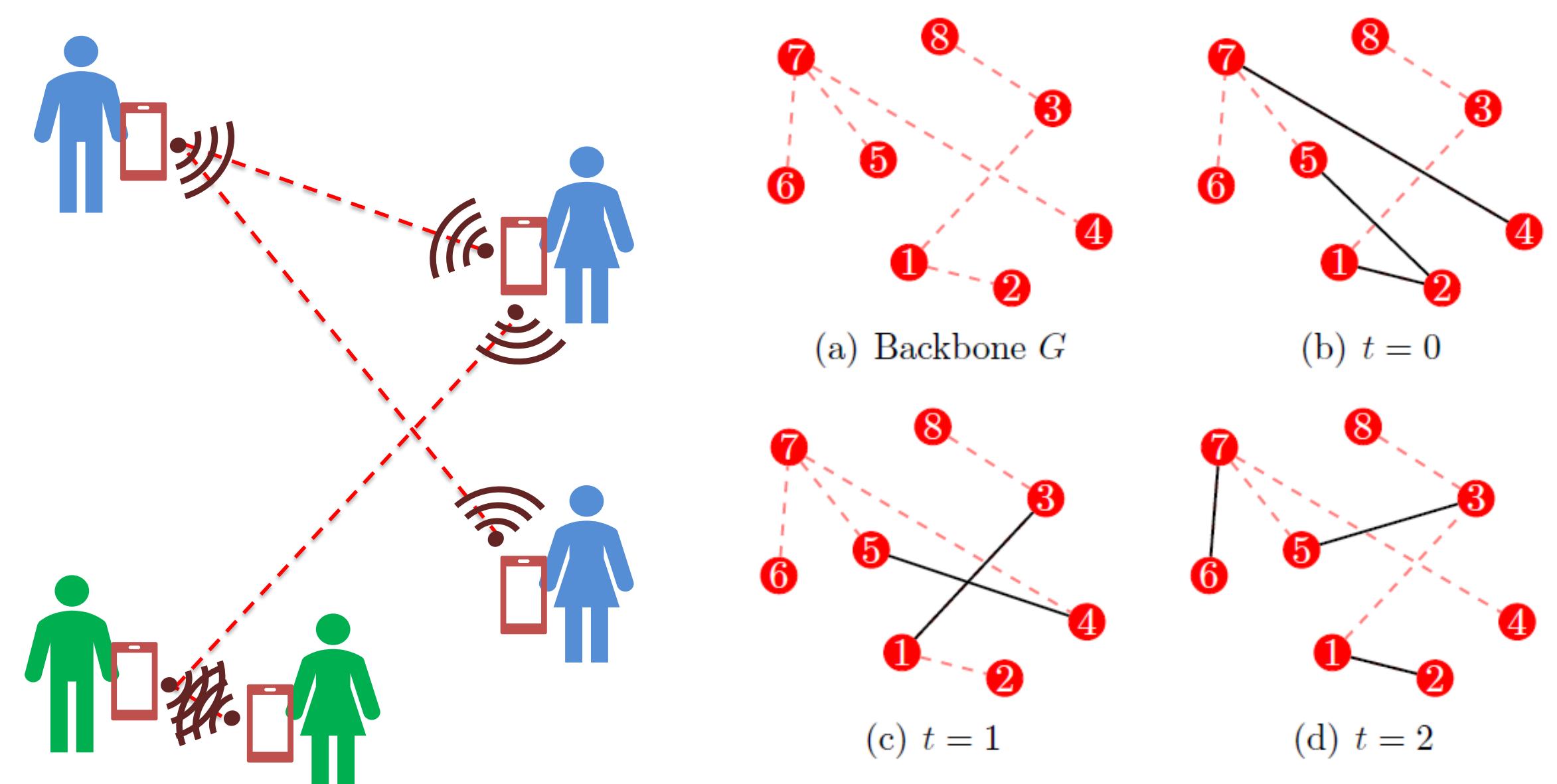
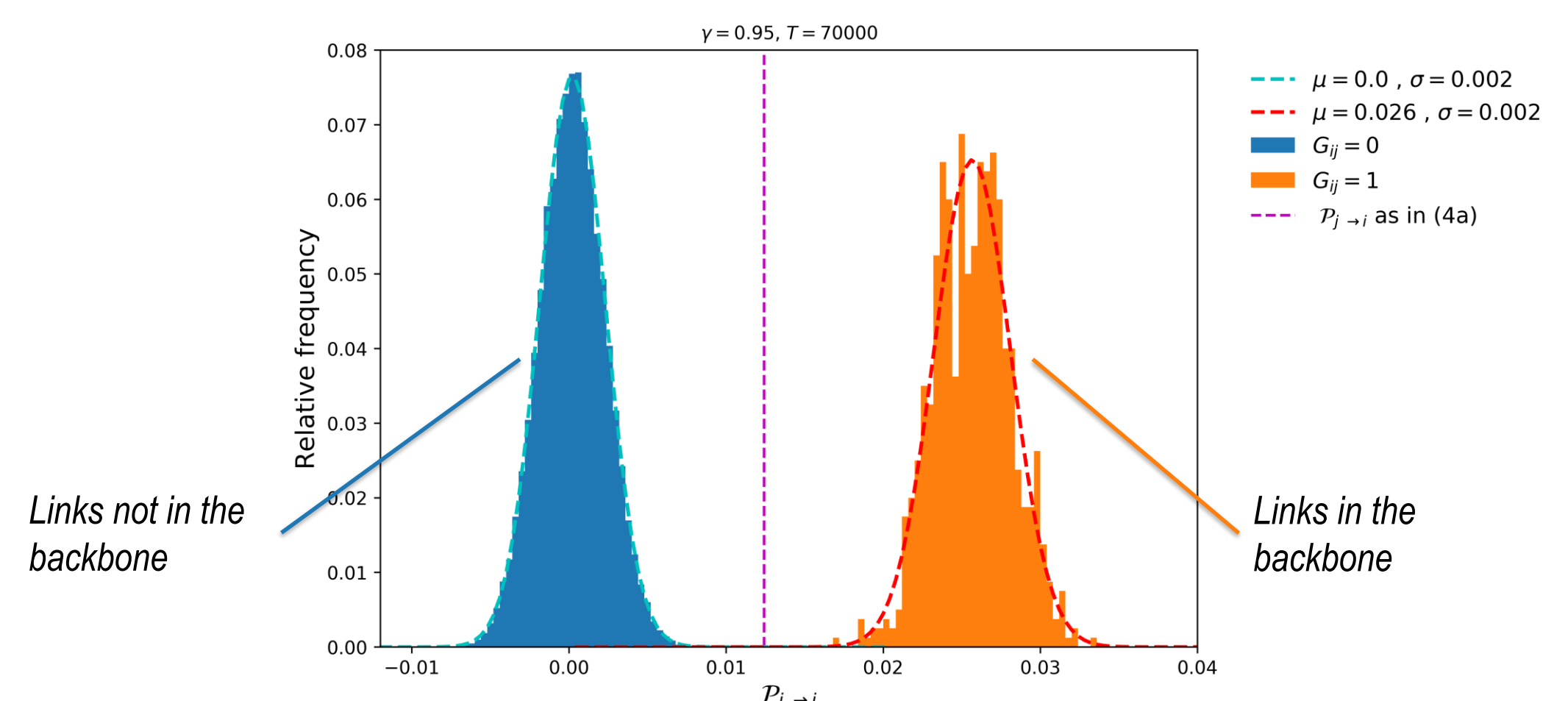*Inferring human interaction using smartphones (left) – Modeling of network backbone (right)*

Adopted methodologies

- Temporal interactions are identified by inferring the distance between smartphones using the signal strength RSSI measured by one device with respect to another.

$$d = 10^{\frac{RSSI - \alpha}{10\beta}}$$
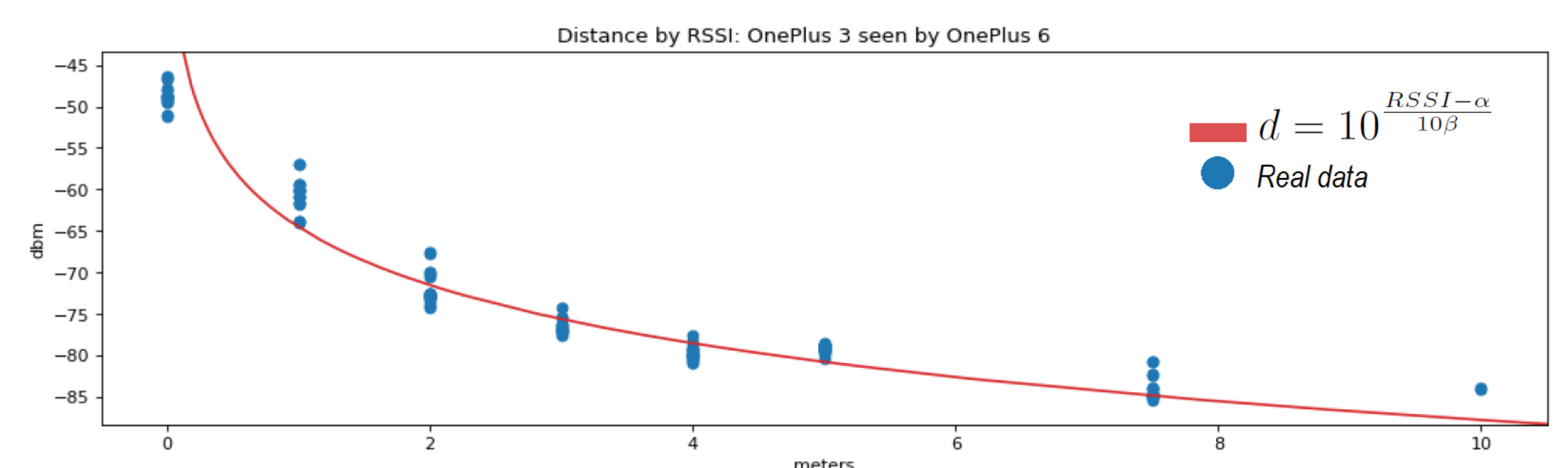
Modelling the distance from the Bluetooth signal strength

- The statistical filter is based on the null hypothesis that the probability for a node to change state is not influenced by the state of another, unless they share a strong tie.

Conditional probability of changing state, for all couples of nodes

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PhD program in
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