Inferring Occupant Ties in Dynamic Office Environments

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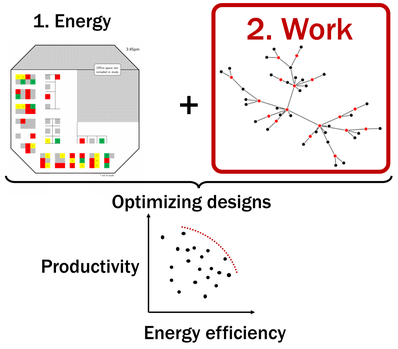
Problem: We want to design energy-efficient and productive workplaces

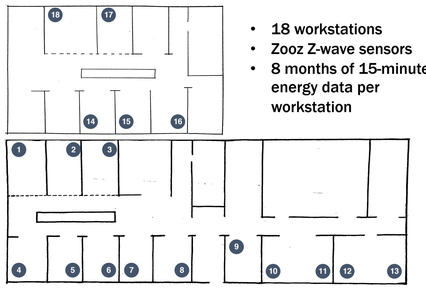


Question:
How can we understand key relationships within organizational structure?

Insight:
Utilize distributed IoT sensors that produce time-series data tied to occupant activities and patterns.

Case Study: Berkeley office

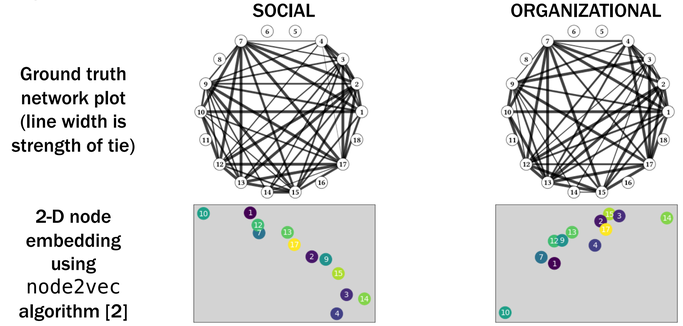
We outfitted a real office building in Berkeley, CA with smart plug sensors from August 2018 to May 2019. The office has two floors and each occupant has his or her own individual workstation.



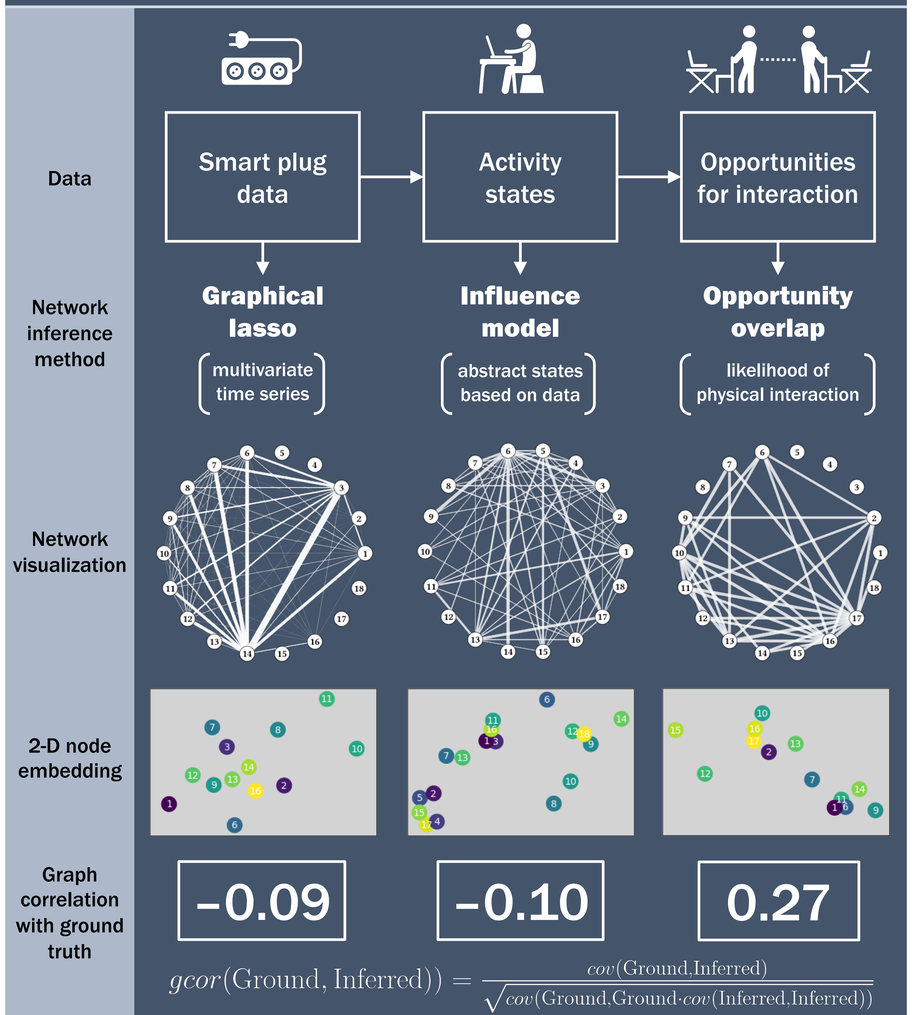
- 18 workstations
- Zooz Z-wave sensors
- 8 months of 15-minute energy data per workstation

Ground Truth: Survey questions from social science

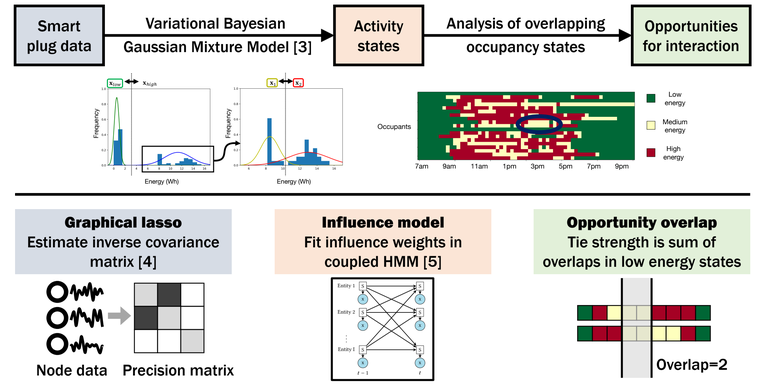
To validate and benchmark the goal—the inferred network—against the actual structure of the organization, we conducted a survey asking occupants about both **social** and **organizational** ties [1].
Response rate = 72%



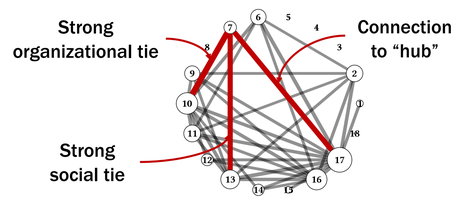
Learning the socio-organizational occupant network from time-series sensor data:



Methodology Details: Combining data and knowledge



Results: Unpacking the ties (opportunity overlap)



The networks obtained through surveys enable us to check the inferred ties against the ground truth. Here, we show that for occupant 7, each of the three inferred ties matches with a reported tie.

Conclusions:

- Common network inference algorithms from the literature—the graphical lasso and the influence model—are unable to capture socio-organizational structure
- Leveraging domain knowledge about the meaning of **occupant activity states** enables us to better uncover the opportunity for social interaction in a building—and therefore, socio-organizational structure
- Knowing this structure will enable the preservation of key relationships when designing new layouts that optimize for both energy efficiency and organizational objectives (e.g., productivity, collaboration)

References:

[1] Gächter S, Starmer C, Tufano F. Measuring the Closeness of Relationships: A Comprehensive Evaluation of the “Inclusion of the Other in the Self” Scale. PLoS One 2015;10:e0129478
[2] Grover A, Leskovec J. node2vec. Proc. 22nd ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. - KDD ’16, New York, New York, USA: ACM Press; 2016, p. 855–64.
[3] Sonta AJ, Simmons PE, Jain RK. Understanding building occupant activities at scale: An integrated knowledge-based and data-driven approach. Adv Eng Informatics 2018;37:1–13.
[4] Friedman J, Hastie T, Tibshirani R. Sparse inverse covariance estimation with the graphical lasso. Biostatistics 2008;9:432–41.
[5] Pan W, Dong W, Cebrian M, Kim T, Fowler JH, Pentland AS (Sandy). Modeling Dynamical Influence in Human Interaction: Using data to make better inferences about influence within social systems. IEEE Signal Process Mag 2012;29:77–86.

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