



WiFiMod: Transformer-based Indoor Human Mobility Modeling using Passive Sensing

AMEE TRIVEDI, University of Massachusetts, Amherst

KATE SILVERSTEIN, Oracle Labs

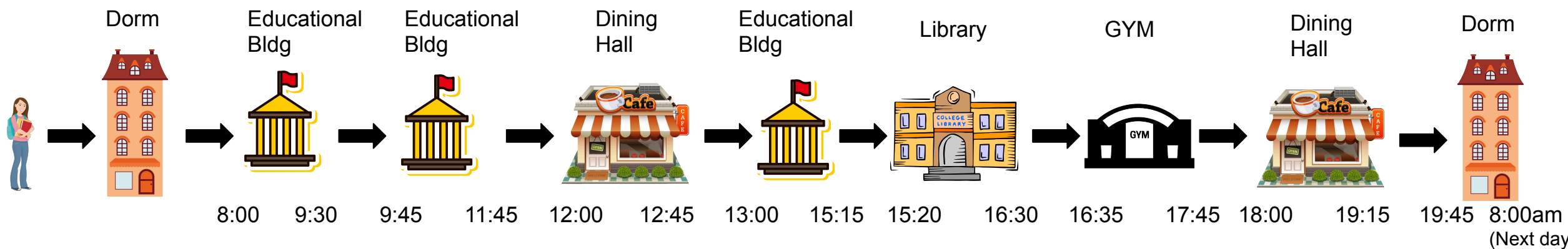
EMMA STRUBELL, Carnegie Mellon University

MOHIT IYYER, University of Massachusetts, Amherst

PRASHANT SHENOY, University of Massachusetts, Amherst

Human Mobility Nature

- Human Mobility Nomadic in nature



Importance of Human Mobility

Understanding and Modeling mobility is a fundamental problem with wide applications:

- Urban Planning
- Smart Cities : Urban Transportation
- Location Based Services
- Personalized Systems
- Smart Buildings
- Systems modeling and design

Motivation

- Indoor Outdoor Mobility
 - Users spend 80% of their lives indoors.
 - Indoor and outdoor mobility are different.
 - Prior Indoor mobility work focus from network perspective.
- Problems modeling indoor mobility
 - the absence of easily acquirable, reliable, low-cost indoor mobility datasets
 - high prediction space in modeling the frequent indoor mobility
 - multi-scalar periodicity and correlations in mobility.

Problem Statement

- We focus on the problem of **modeling indoor mobility trajectories** of users over the timescale of several hours to a day using easily acquirable, reliable, and low-cost data source.

Data Source for indoor mobility

- Mobile Phones are ubiquitous
 - Smartphone mobility is a proxy for user mobility
- WiFi logs collected for network performance analysis and network attack analysis.

Outline of the Talk

- ~~Indoor Mobility Modeling Motivation~~
- Indoor Mobility Dataset
- Hierarchical View of Mobility
- WiFiMod Architecture
- Evaluation Results
- CaseStudy
- Summary

Syslog to Trajectories



Syslog to Trajectories



Syslog to Trajectories



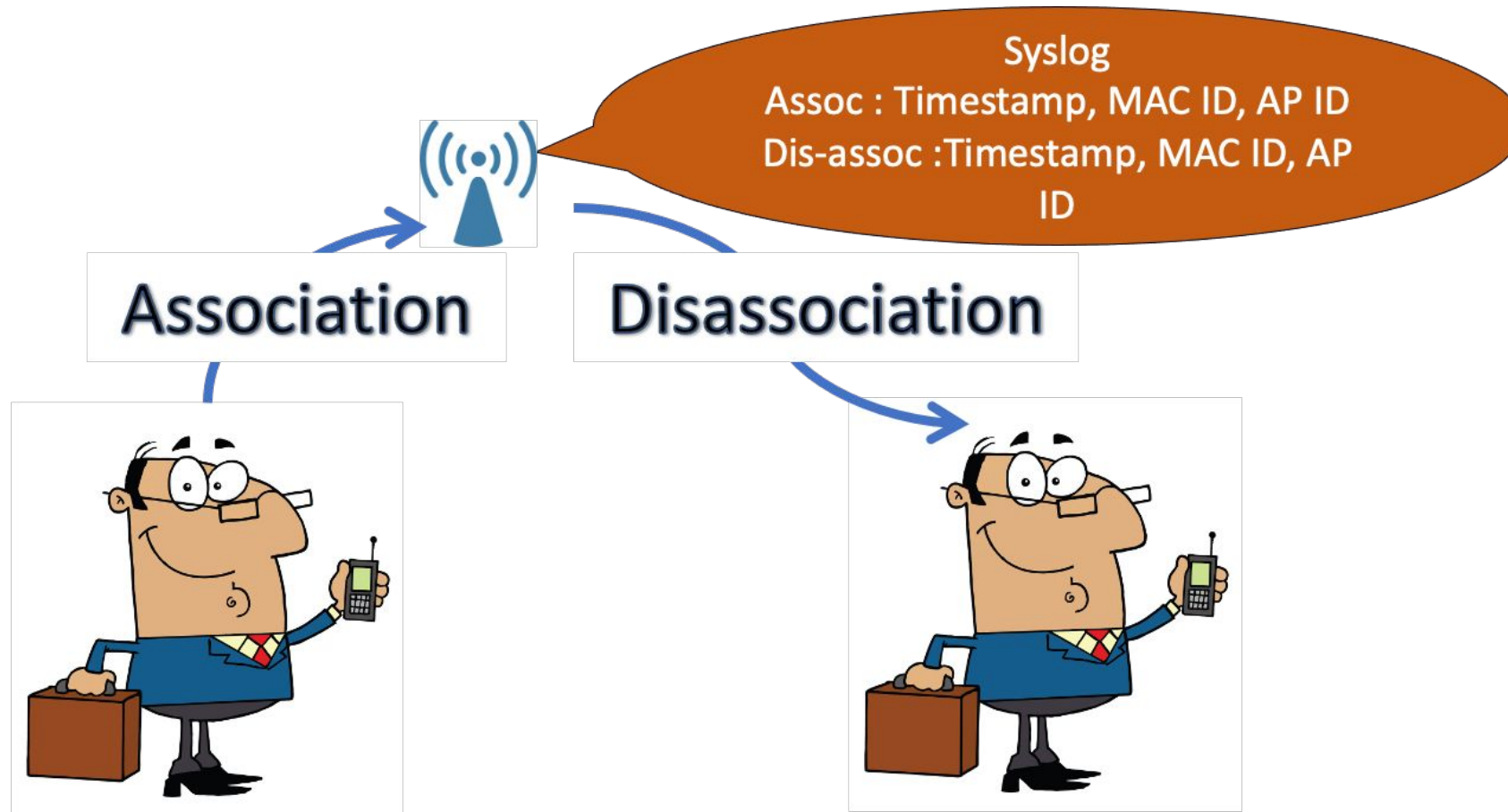
Syslog to Trajectories



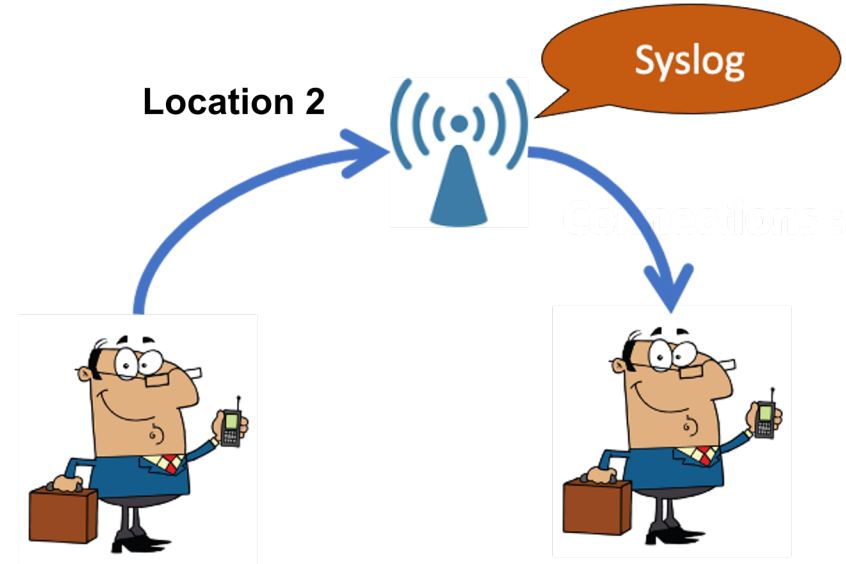
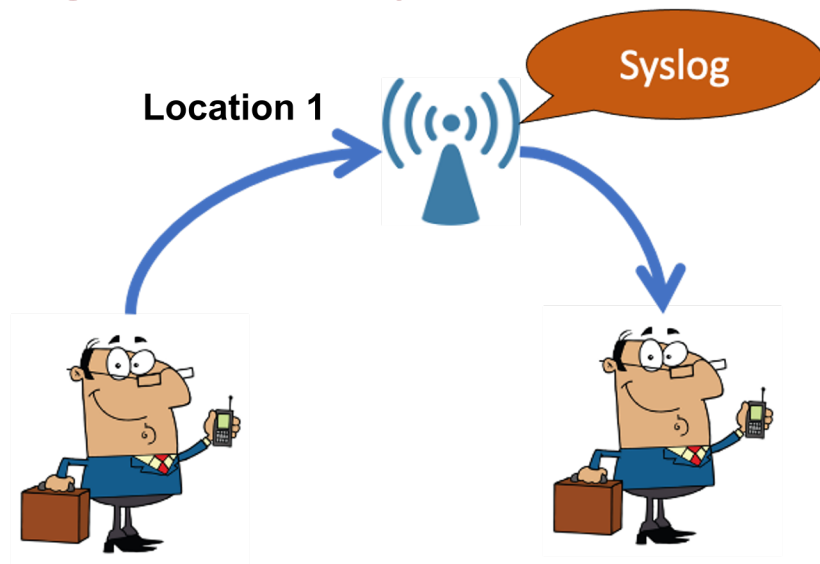
Disassociation



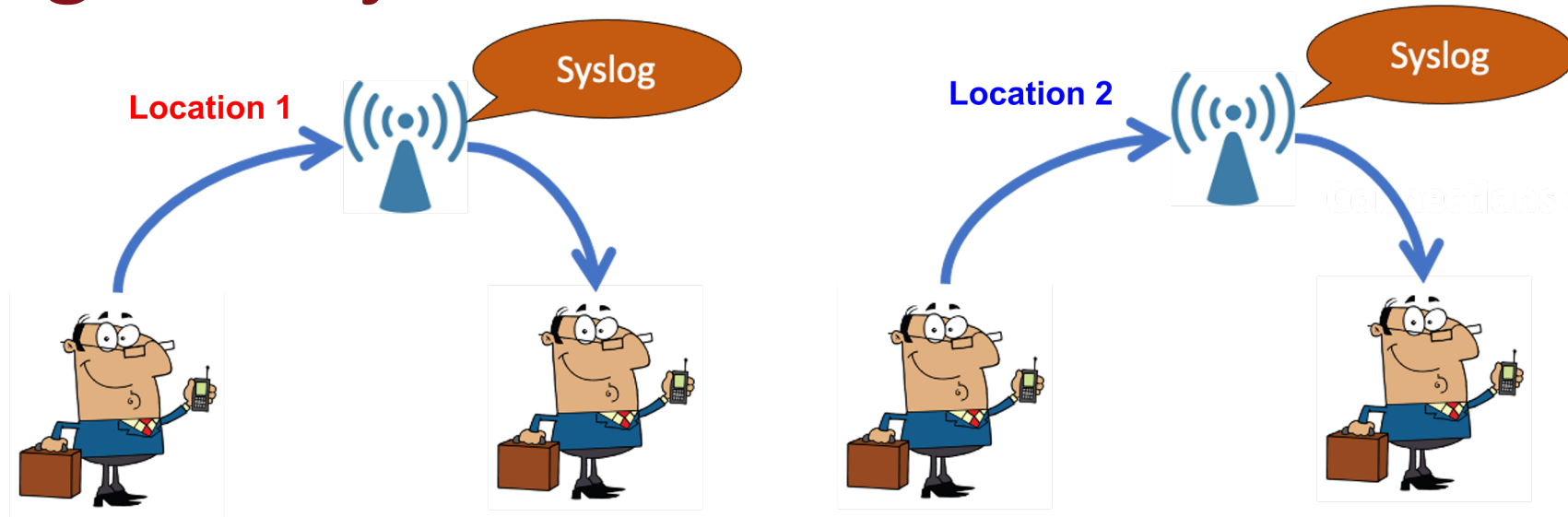
Syslog to Trajectories



Syslog to Trajectories



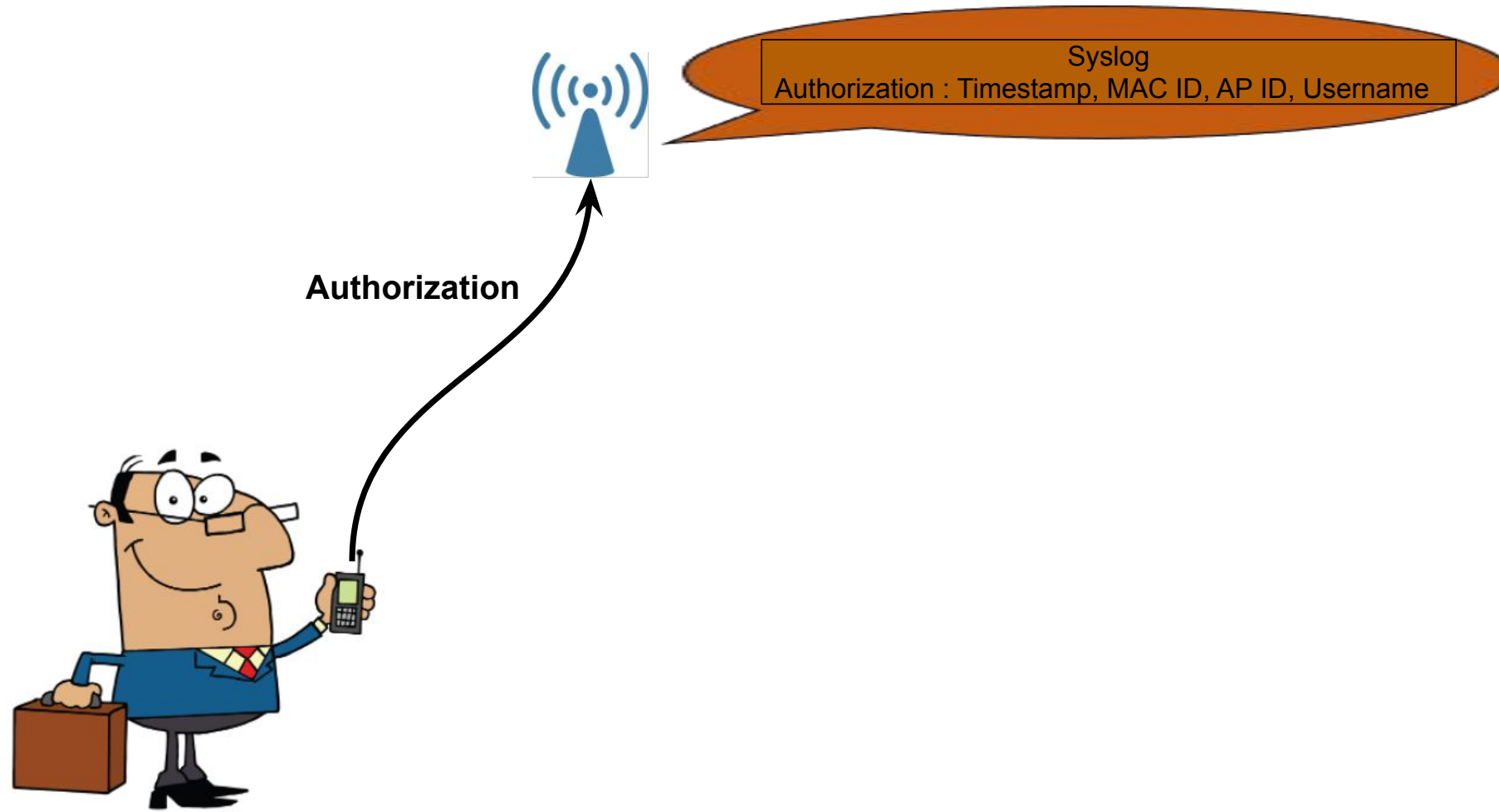
Syslog to Trajectories



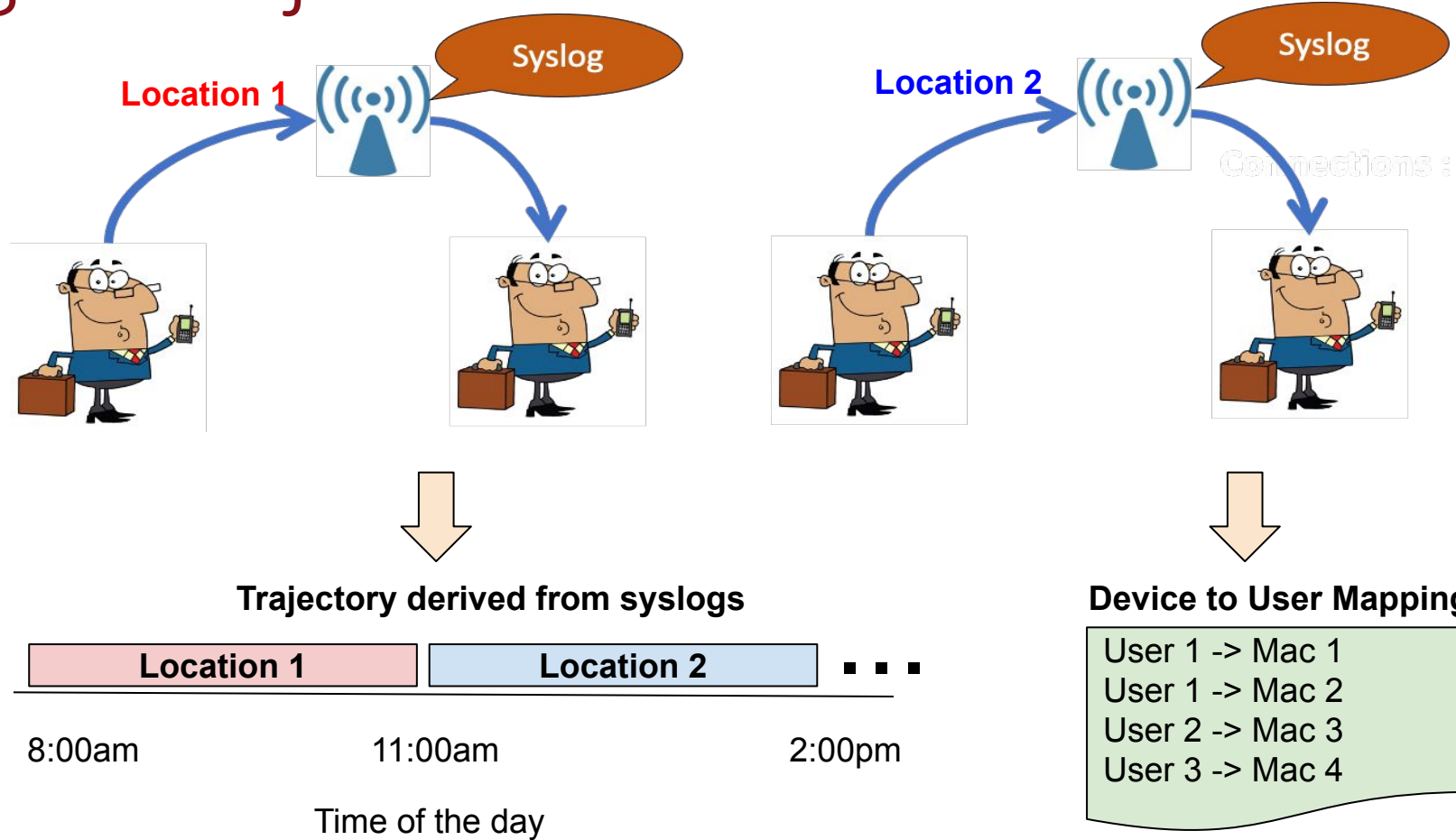
Trajectory derived from syslogs



Syslog to Trajectories



Syslog to Trajectories



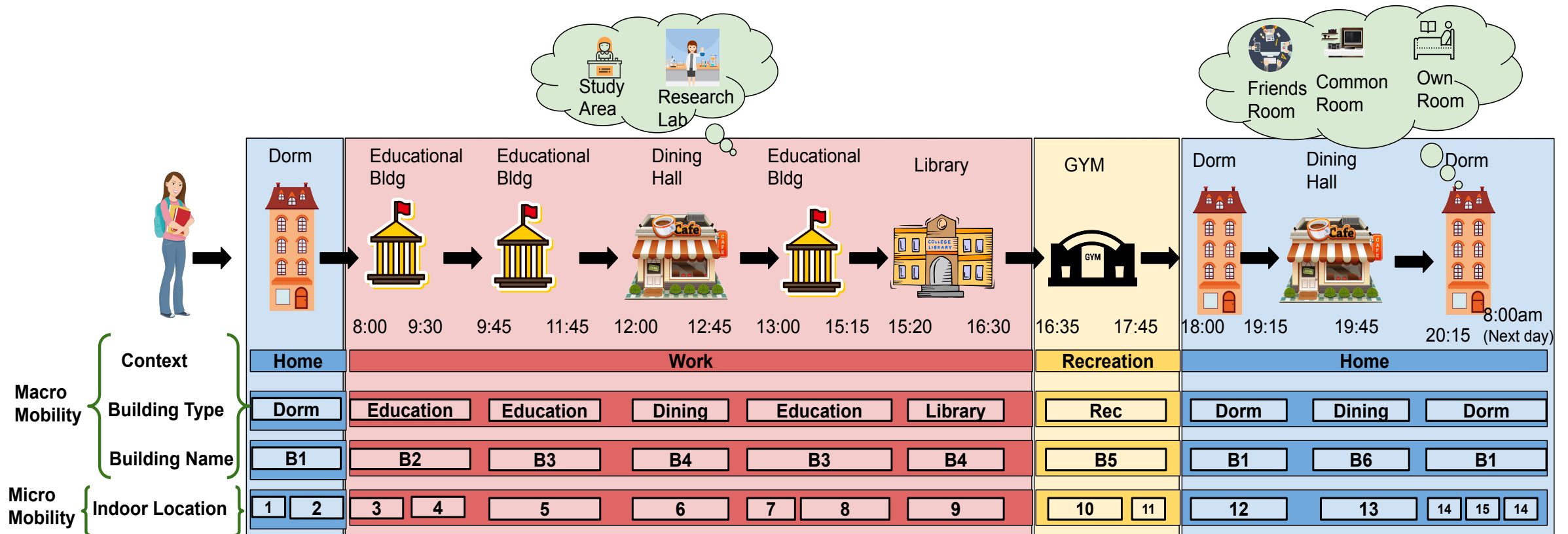
Privacy and Security

1. Data (MAC ID, Username) is anonymized
2. Approved IRB and Signed DUA

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Human Mobility – Hierarchical View

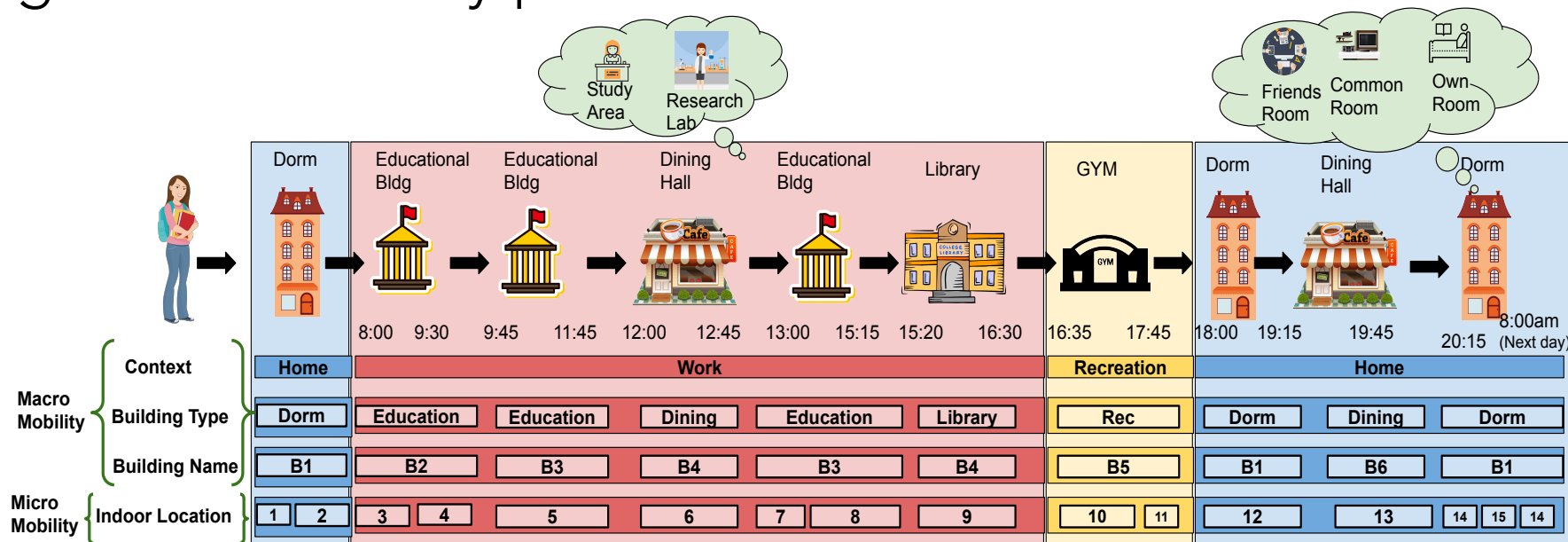


Multi-scalar periodicity and correlations in mobility.

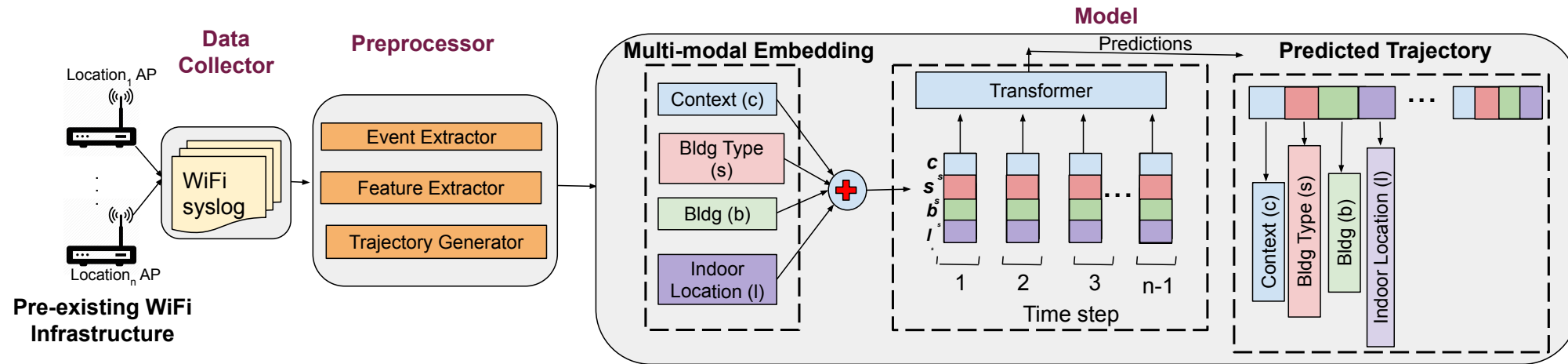
Human Mobility – Hierarchical View

Features impacting indoor mobility prediction:

- Spatial Scale
- Building Type
- User Type
- Past Behavior



WiFiMod : Architecture

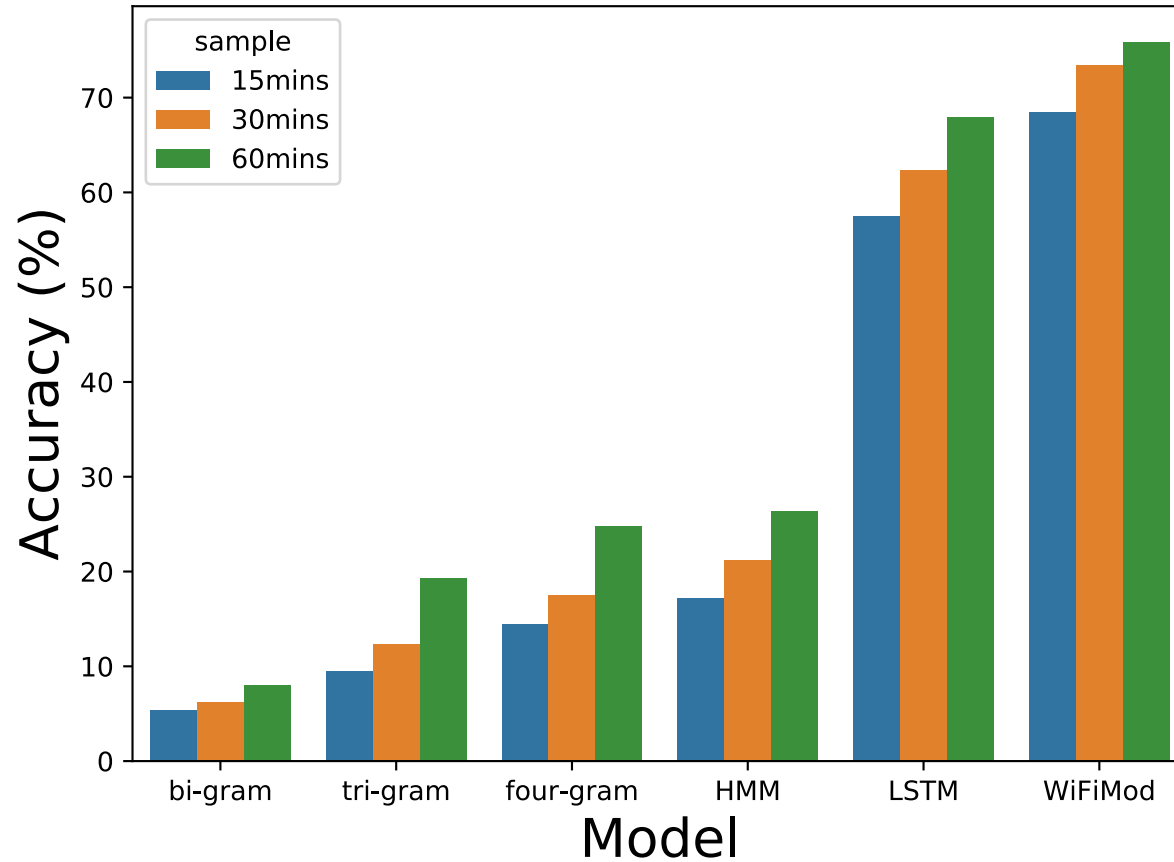


Input to the Transformer(off-the-shelf GPT, trained from scratch) is a multi-scale sampled trajectory of users.

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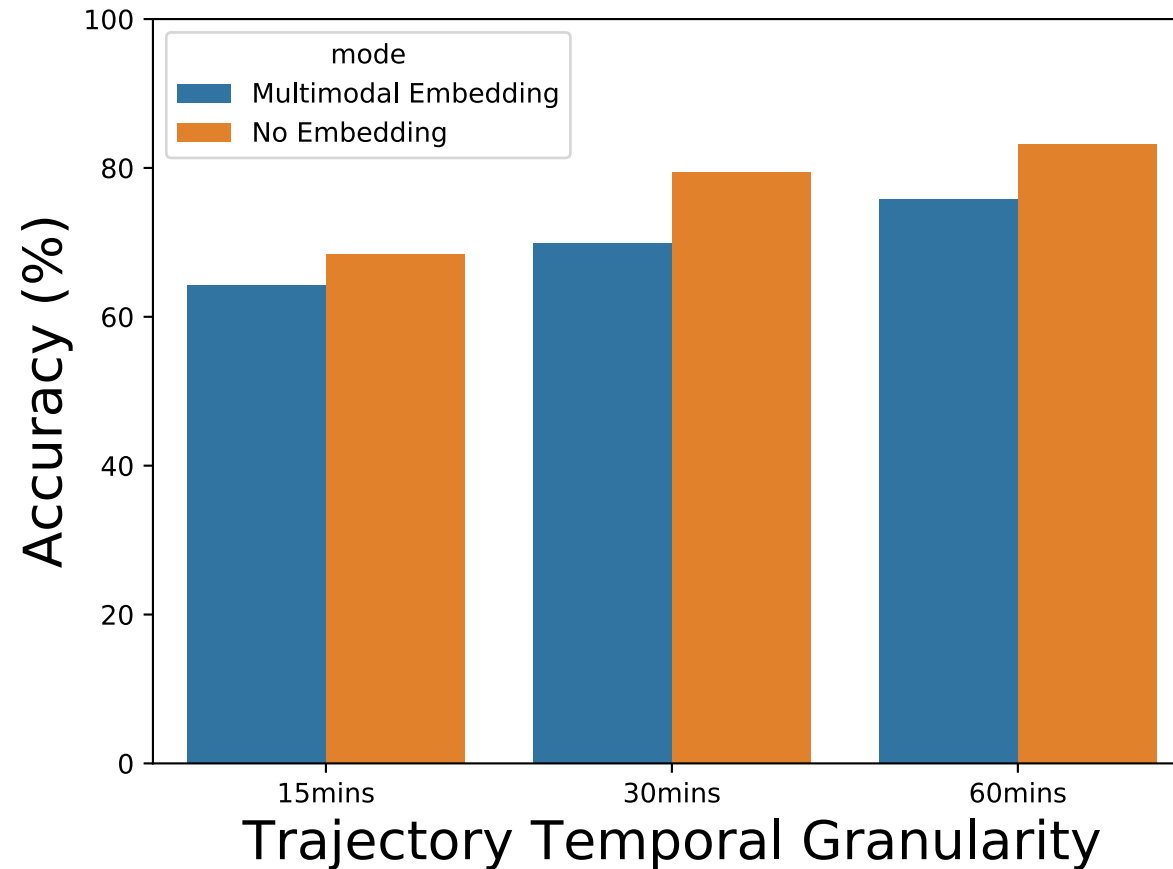
WiFiMod : Baseline Evaluations



Takeaways:

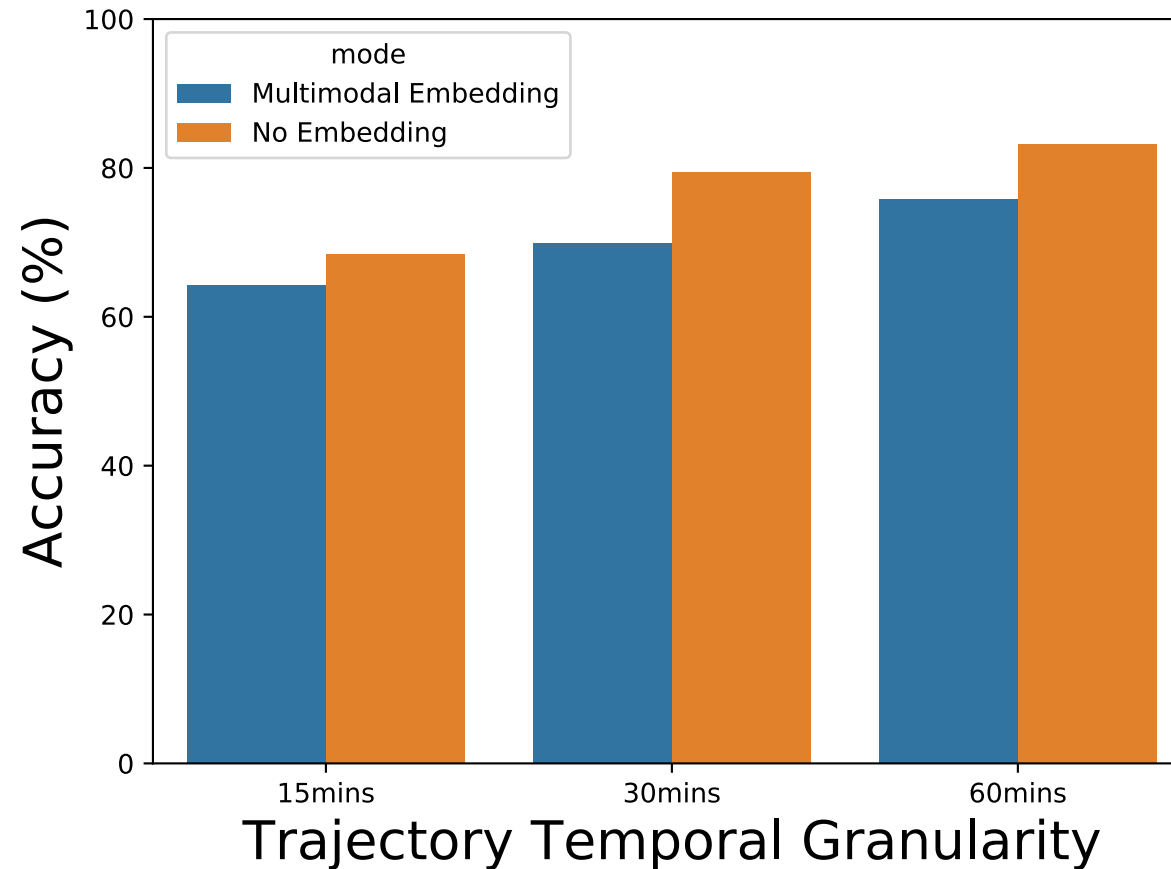
- DNN show superior performance in capturing long term performance.
- Impact of Temporal Granularity: As the model temporal granularity becomes coarser, the indoor mobility accuracy increases.
- Non-regular visits are hard to predict, predictions for some spaces such as dining halls have large variations and high error.

Evaluations: Multimodal Embedding



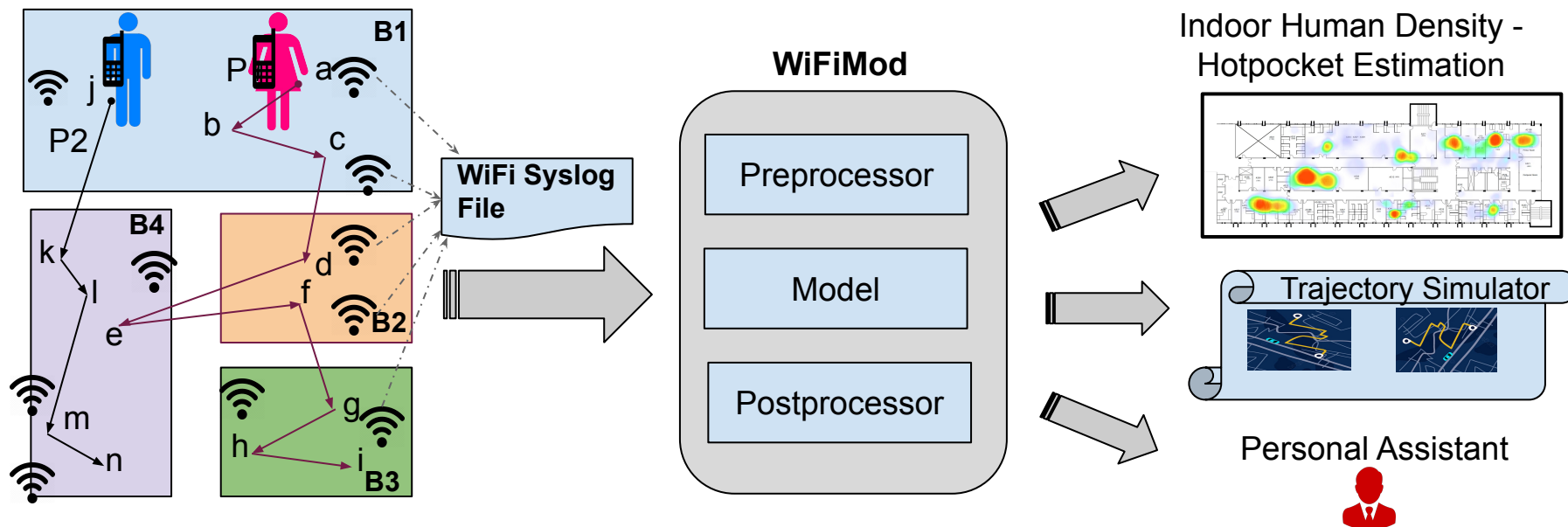
Multimodal embedding effectiveness : Comparison of indoor location prediction of a transformer for multimodal and non-multimodal embedding input

Evaluations: Spatial Granularity



Multimodal embedding effectiveness : Comparison of indoor location prediction of a transformer for multimodal and non-multimodal embedding input

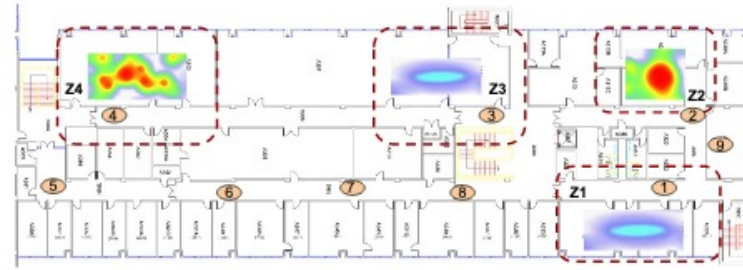
WiFiMod System



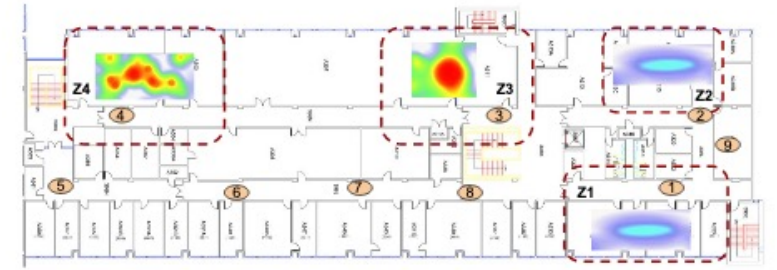
WiFiMod: CaseStudy



(a) 8:30am



(b) 12:00pm(Noon)



(c) 3:30pm

Heatmap of predicted indoor occupancy of educational building with classrooms, research labs, faculty office, kitchenette

Summary

- Presented WiFiMod, a Transformer-based, data-driven approach that models indoor human mobility at multiple spatial scales using WiFi system log.
- Mobility is inherently hierarchical in nature.
- Practical real-life usecases of WiFiMod.

Questions?