***Modellet*: Experiencing and Handling the Diversity in Data Density and Environmental Locality in an Indoor Positioning Service**

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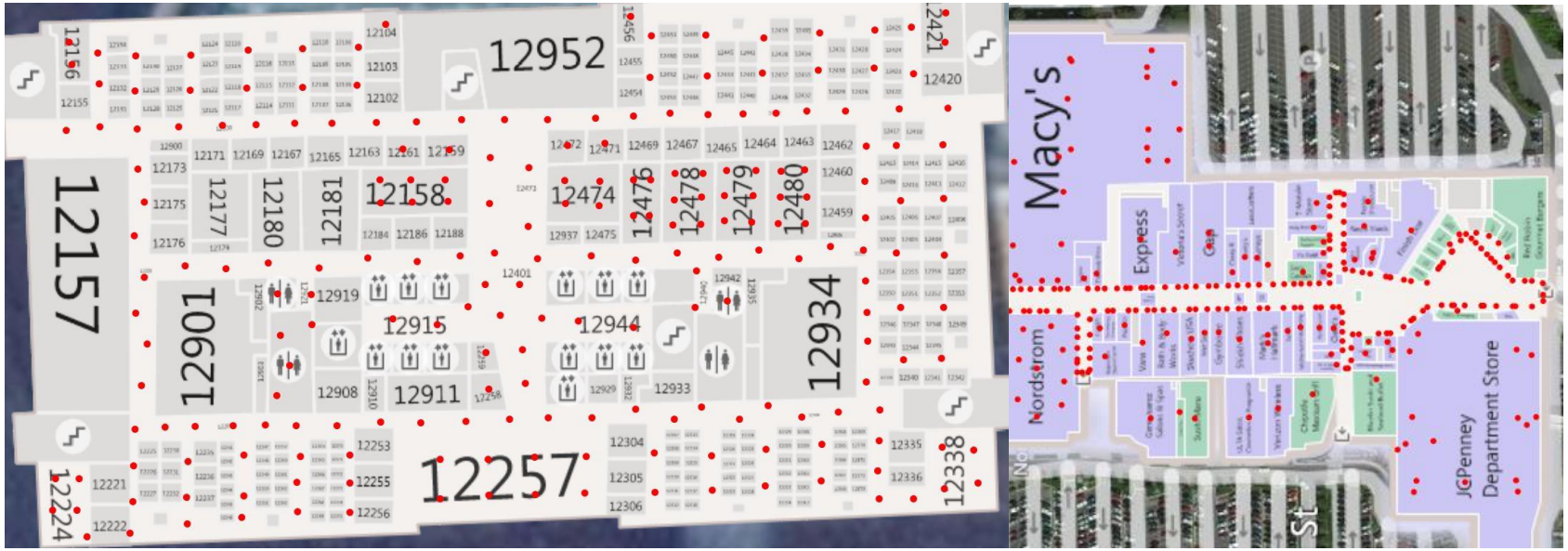
The Real Situation…



Given a WiFi location database, which approach should we apply to achieve the best accuracy?

A Microbenchmark Study

A $75 \times 45\ m^2$ Microbenchmark with 329 fingerprints

RADAR [1] (fingerprint-based)

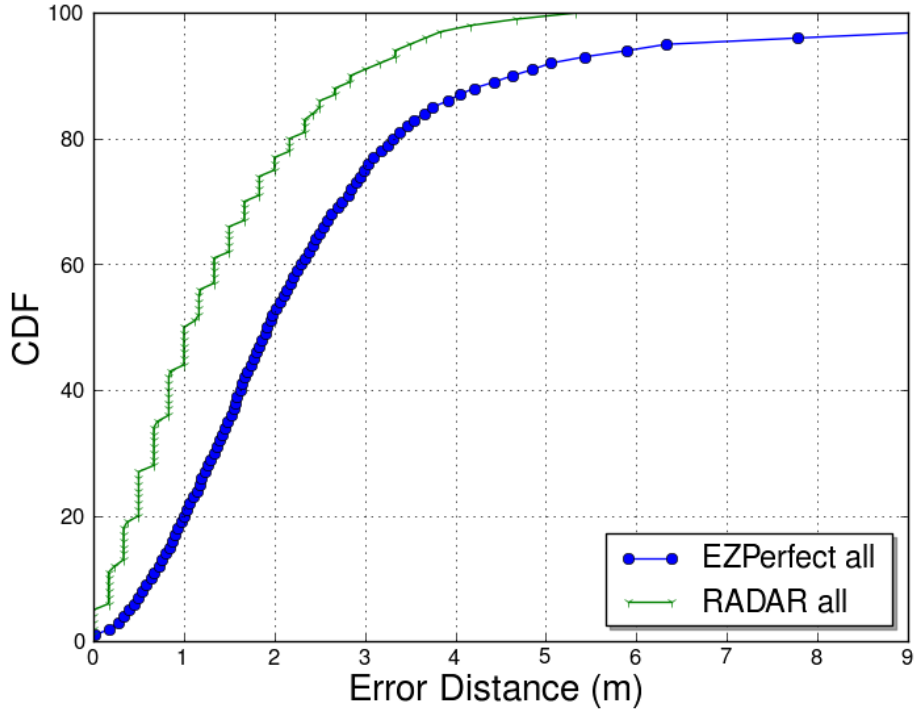
- **Offline:** fingerprinting various locations
- **Online:** mapping a query fingerprint using KNN

EZPerfect [2] (model-based)

- **Offline:** training Log-distance path loss (LDPL) models $RSS_{x,y} = P_0 - 10\gamma \log d_{x,y}$
- **Online:** applying triangulation to find the location

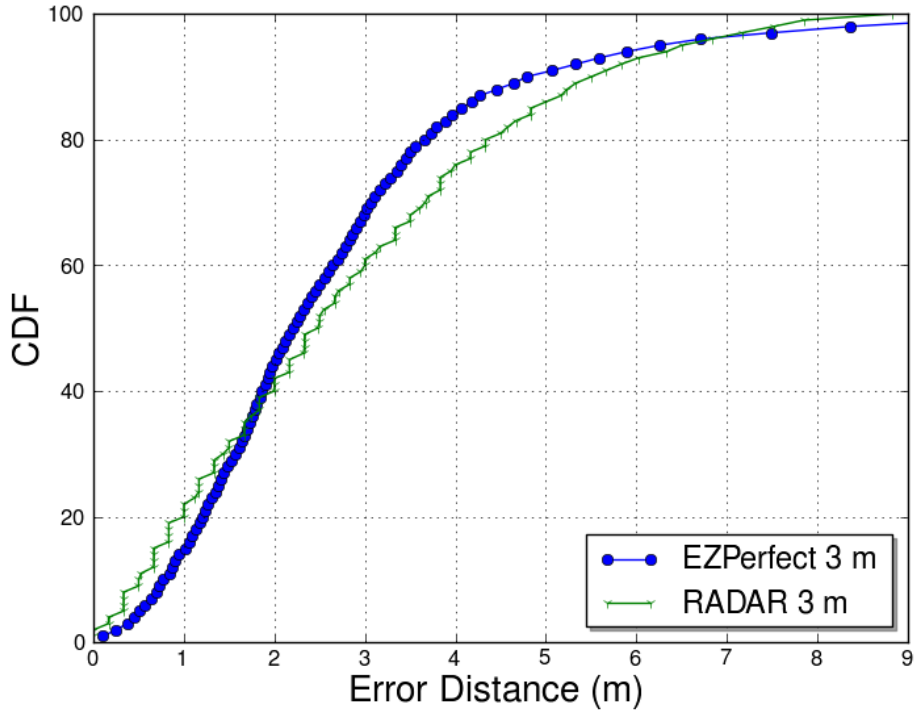
[1] P. Bahl and V. N. Padmanabhan. *RADAR: An in-building RF-based user location and tracking system*. In INFOCOM, 2000.
[2] R. Nandakumar, K. K. Chintalapudi, and V. N. Padmanabhan. *Centaur : Locating Devices in an Office Environment*. In Mobicom, 2012

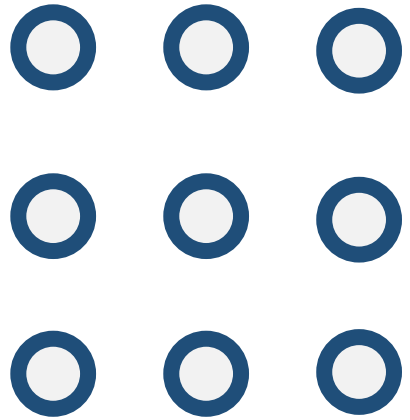
Data Density Matters



Dense

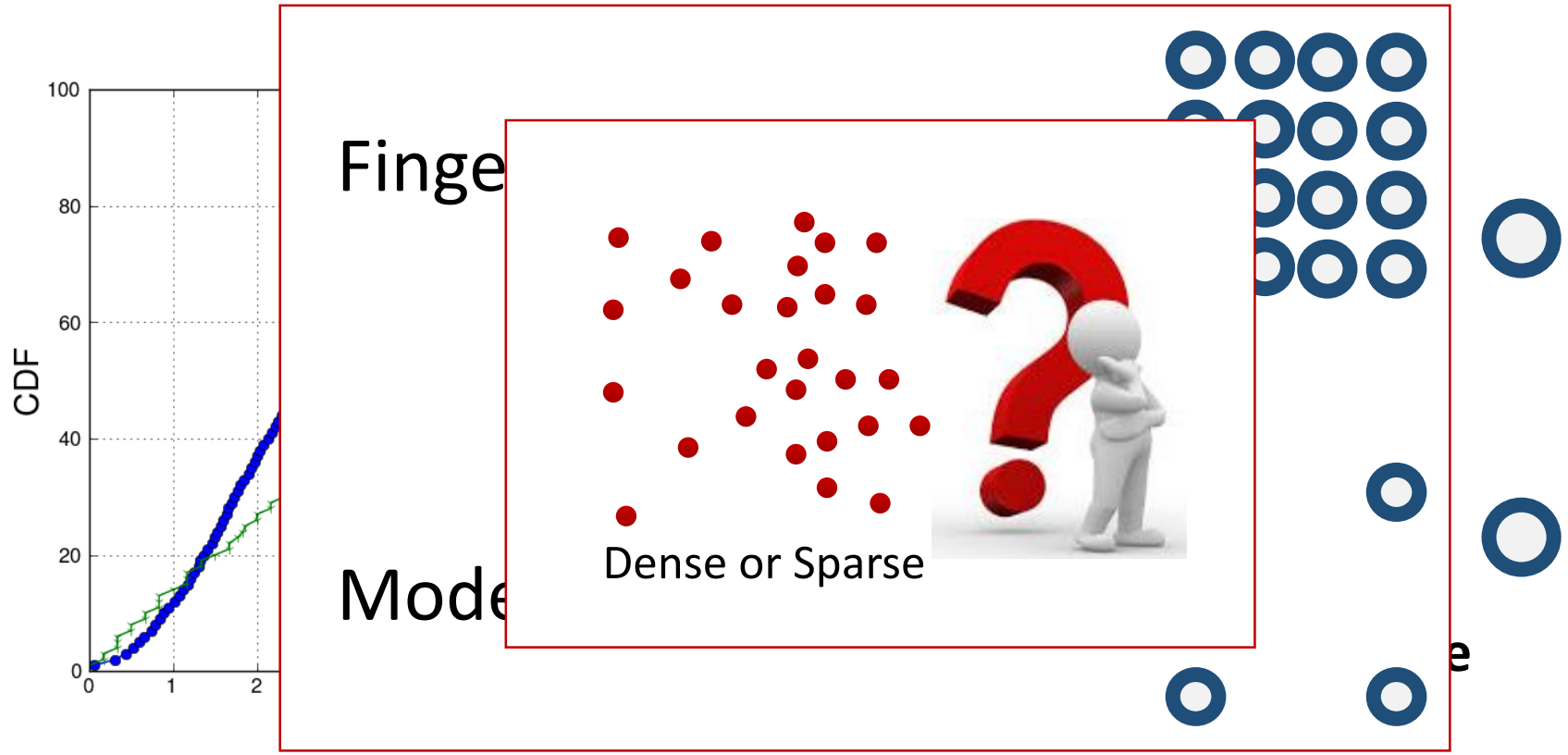
Data Density Matters





Median

Data Density Matters



Observation 1: fingerprint- and model-based approaches are more suitable for different densities

Diverse Environment Conditions

Model fitness error = measured RSS – model-calculated RSS

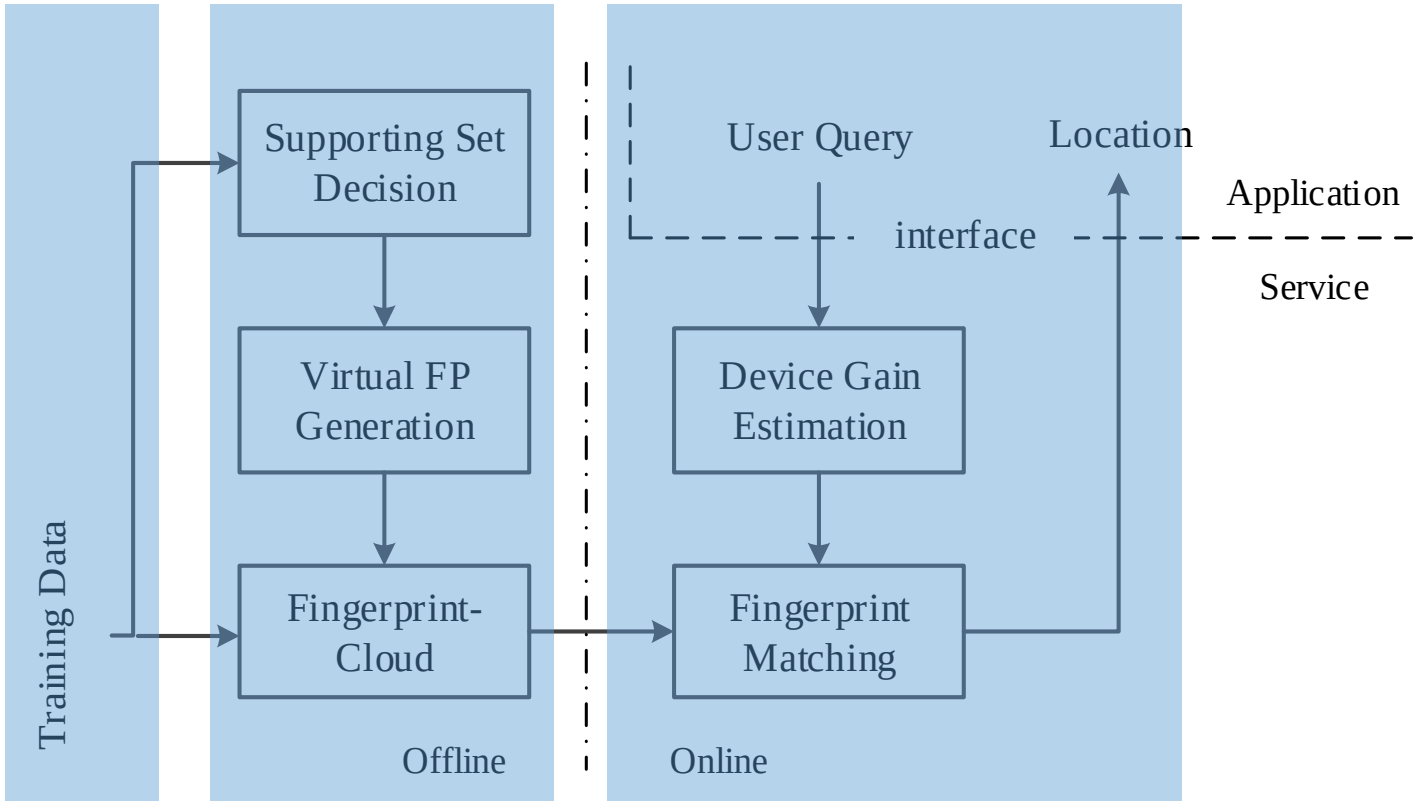
Observation 2: Local area exhibits similar fitness errors for environmental locality

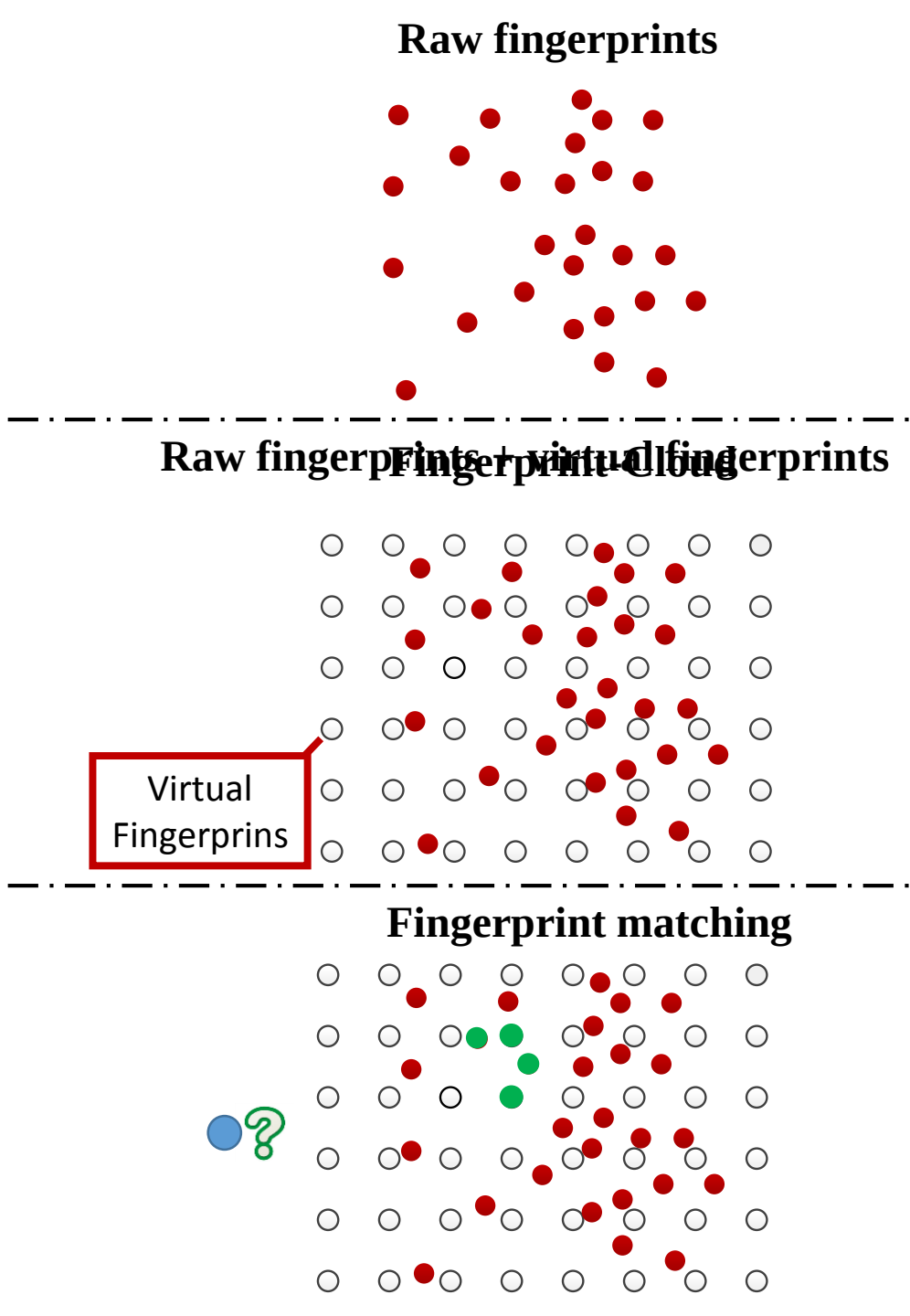
The Localization System Should

- Automatically adapt to training data density, which may even be altered over time

- Automatically explore the environmental locality, without the assumption of any priori knowledge of actual layout

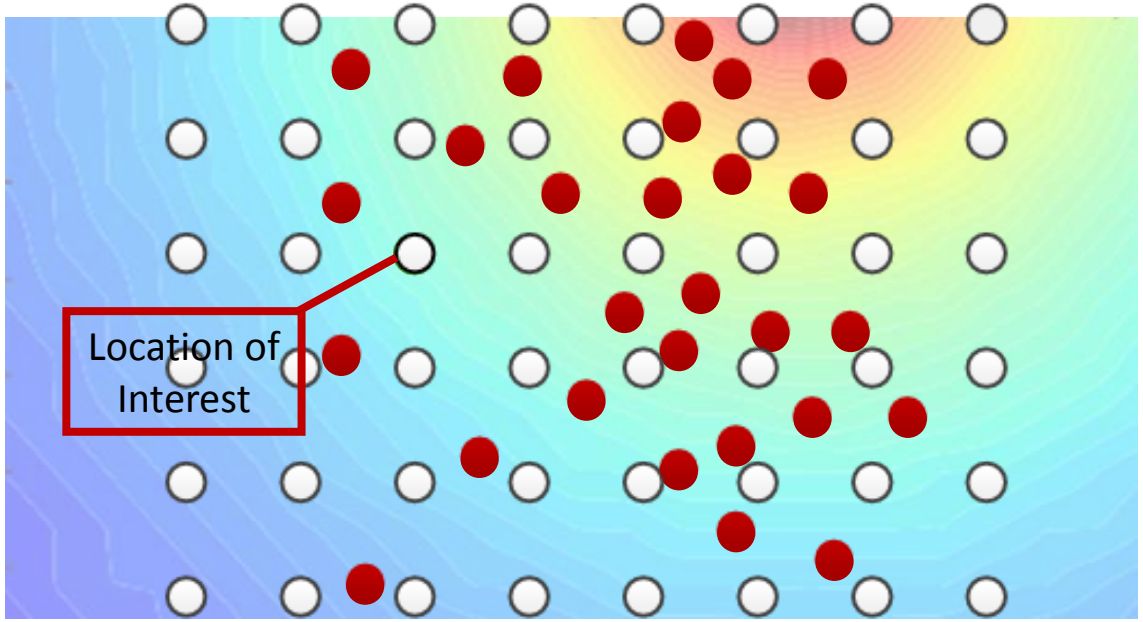
Modellet Overview





Fingerprint Cloud

- **Location of interest**: the location where we insert a virtual fingerprint

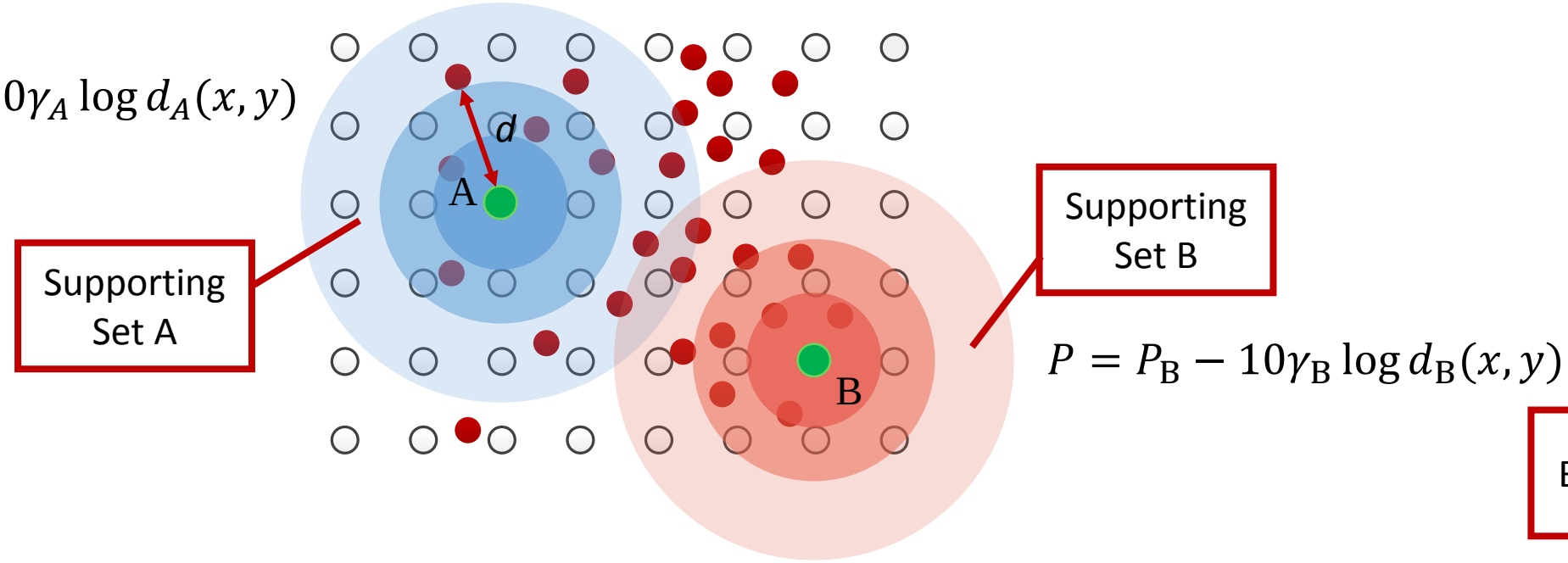


Integrate information from both sides: measurement + signal propagation model

Explore Environment Locality with Supporting Set

- **Supporting set**: the set of data used to train local models

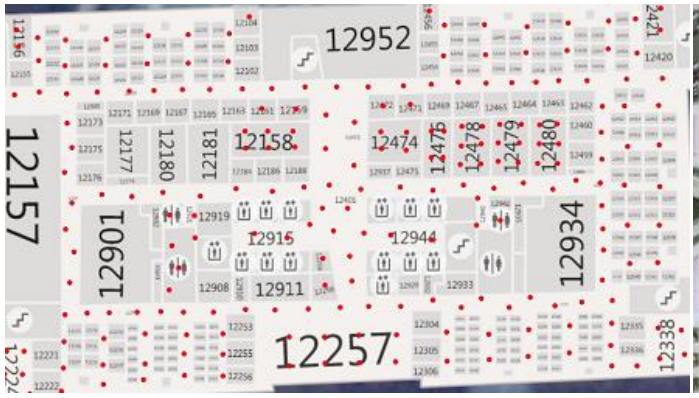
$P = P_A - 10\gamma_A \log d_A(x, y)$

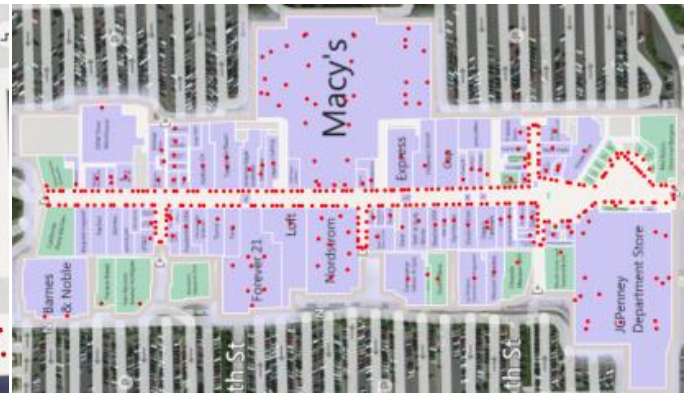


Assign more weight to training data in proximity with $K(d) = e^{(d_{min}-d)/k}$

Evaluations

- A small office area
  - 221 samples in $75 \times 45\ m^2$
- 13 large shopping malls and airports
  - Hallway: 3 ~ 5 m
  - Less in inner shop areas



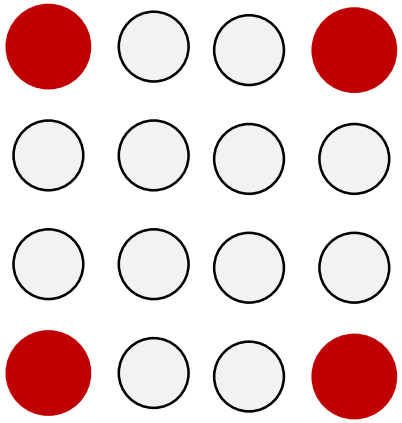


AP deployment is less regular

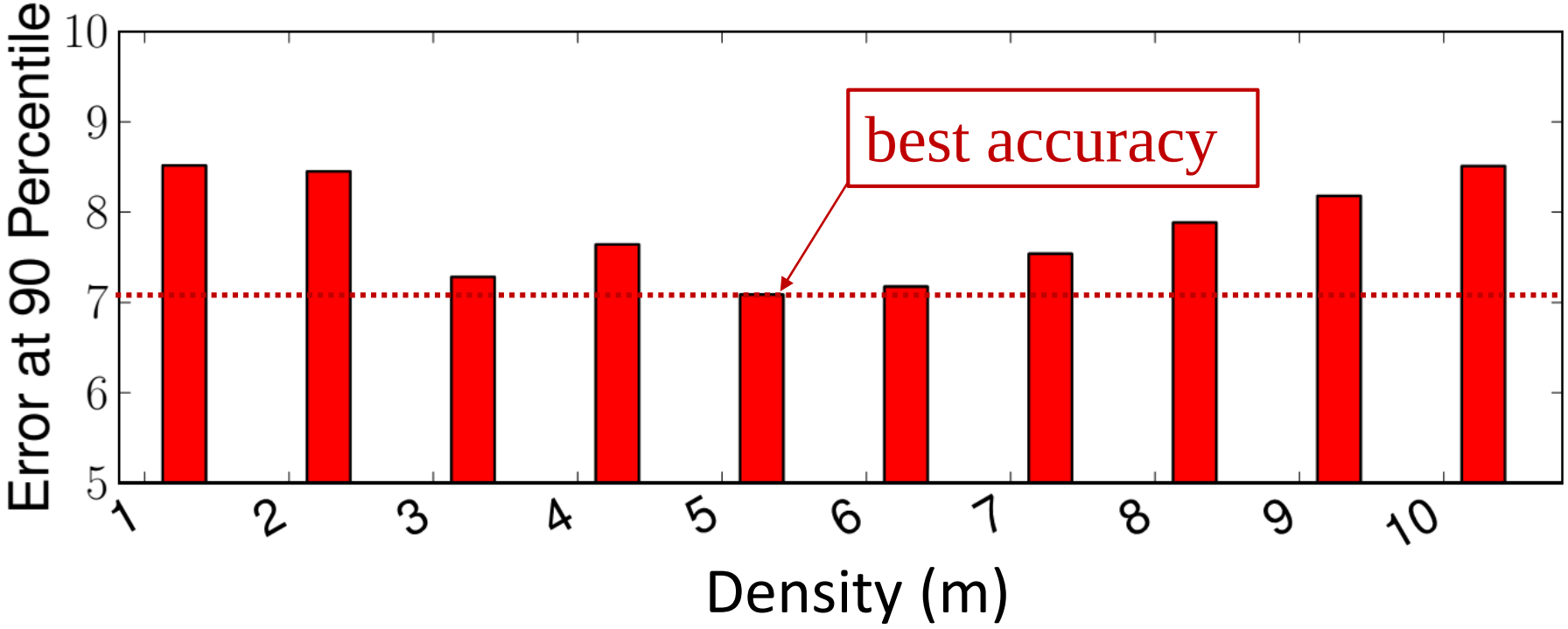
List of large venues

Venue Name	Area (m^2)	Bssids	FPs
Bellevue Square Mall	89216	1349	453
Redmond Town Center	29812	232	171
The Bravern	24244	675	148
Alexa Shopping Mall	35472	260	262
Commons At Federal Way	102172	398	329
Crossroads	129449	227	256
Los Angeles Intl Airport	127893	743	287
Marketplace at Factoria	135596	376	292
Northgate Mall	94810	749	403
Pacific Place	8619	258	97
South Hill Mall	237028	506	202
Supermall-Great Northwest	231188	440	632
Tacoma Mall	157491	749	455

Virtual Fingerprint Density

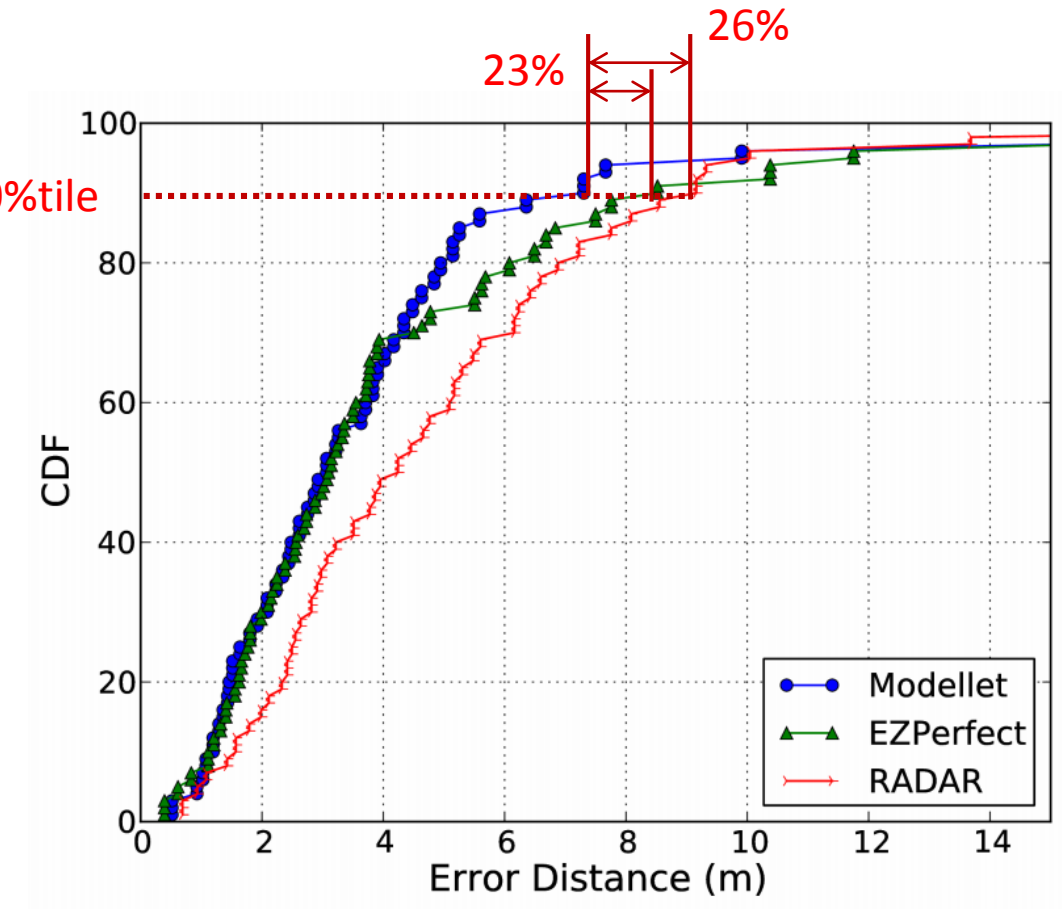


KNN



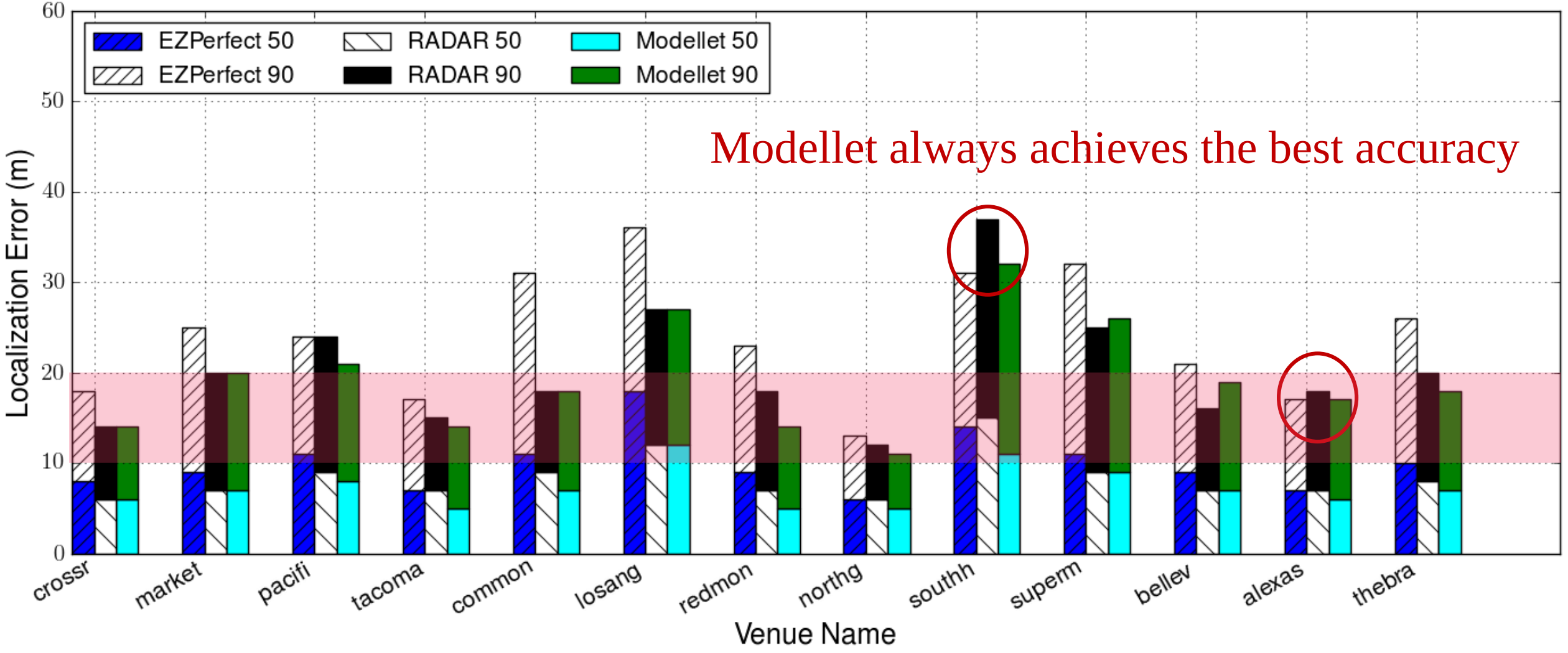
Dense virtual fingerprints eliminate the robustness of fingerprint matching

Localization Accuracy



Modellet outperforms both RADAR and EZPerfect in an office area

Evaluations on 13 Large Venues



Conclusions

- Data density and environment conditions matter
- Fingerprint cloud takes advantage from both sides
- Supporting set explores the environment locality
- Localization for large venues remains unsolved

Thanks

Q/A