WiFi Based Indoor Positioning System

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Global Positioning System (GPS)

- Prominent contributor in location tracking
- Works efficiently in open areas
- Used by many location tracking apps

  Eg: Google Maps
  Apple Maps
  OpenStreetMap

Indoor Positioning

- GPS needs an unobstructed line-of-sight to 4 or more satellites.
- Fails inside enclosed spaces
- Increasing need for Indoor Positioning inside Malls, Airports etc
- No common existing system for Indoor Positioning
  - Google's experimental Indoor Map

How can it be done ?

- Radio Frequency Identification (RFID)
- Bluetooth
- WiFi
- Motion Sensors & Position Sensors

Why choose WiFi ?

- Commonly available inside buildings
- All smart phones come with inbuilt WiFi adapters
- WiFi signal strength varies with distance
- Can be used as a distance indicator for positioning

Design Overview

- Works in two phases.
  - Calibration phase
  - Positioning phase
- Calibration phase
  - Location Fingerprinting
- Positioning phase
  - Weighted K Nearest Neighbours Algorithm (WKNN)

Location Fingerprinting

- Received Signal Strength (RSS) values from multiple routers act as a fingerprint for a location
- Different locations are most likely to have unique fingerprints
- Fingerprint of i^{th} location is denoted by r_i

$r_i = \{r_{i1}, r_{i2}, r_{i3}, \ldots\ldots, r_{im}\}$

r_{ij} = RSS value of j^{th} router from i^{th} location

Location Fingerprinting

- Several locations are chosen and RSS values from them are recorded and form a radio map.
- The recording at the i^{th} location is of the form

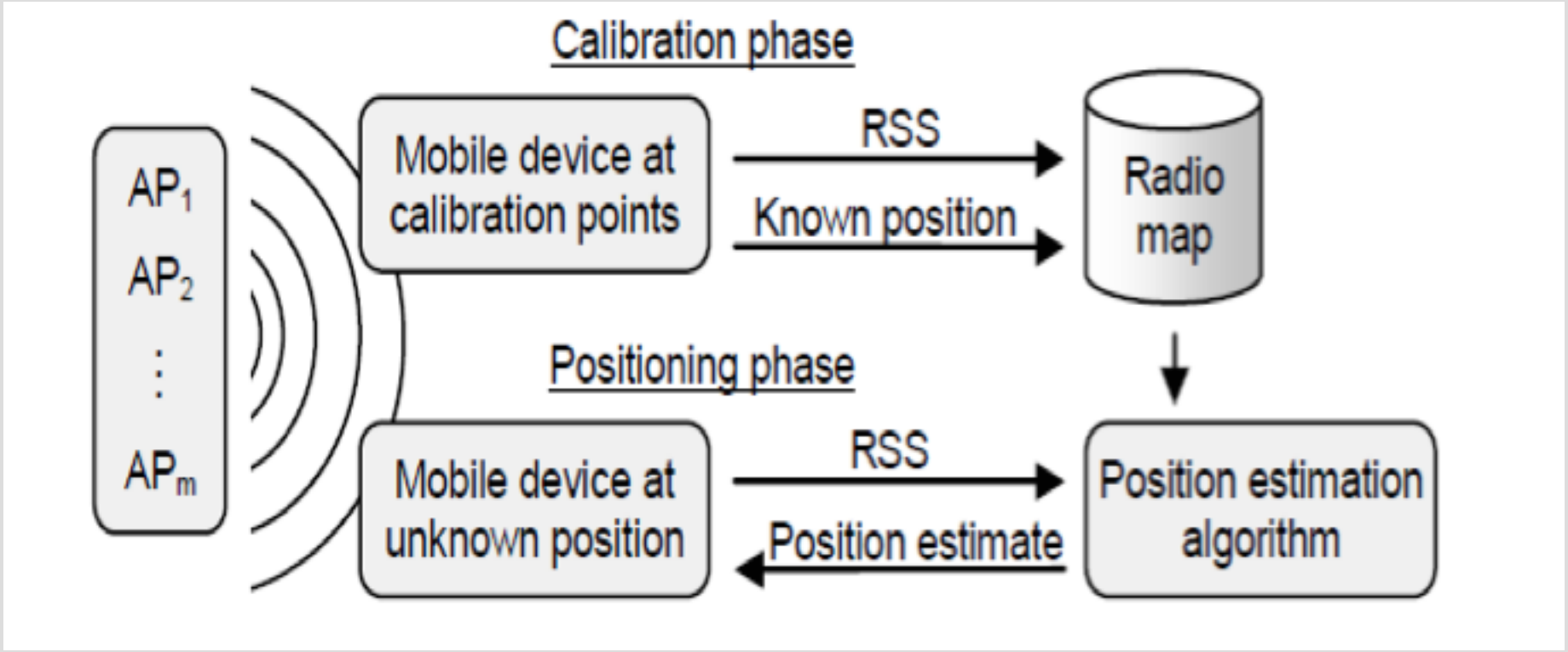
  (q_i, r_i)

  q_i - the geometric coordinates (x_i, y_i)

  r_i - the location fingerprint

Location Fingerprinting

- A position estimator algorithm is used to find the coordinates of unknown location



Weighted k Nearest Neighbour

- The position estimator algorithm used is the Weighted k Nearest Neighbour (WkNN)
- Finds the k nearest chosen locations from unknown location based on Euclidean distance
- Calculates coordinates of unknown location as the weighted average of the nearest k points

Weighted k Nearest Neighbour

- Weight is the inverse of the Euclidean distance
- k can be considered as a tuning parameter in the algorithm
- When k=1, algorithm acts as a simple look up table

How the algorithm works

Suppose there are 4 routers in the floor

How the algorithm works

The signals emanating from routers leave a unique fingerprint at each location

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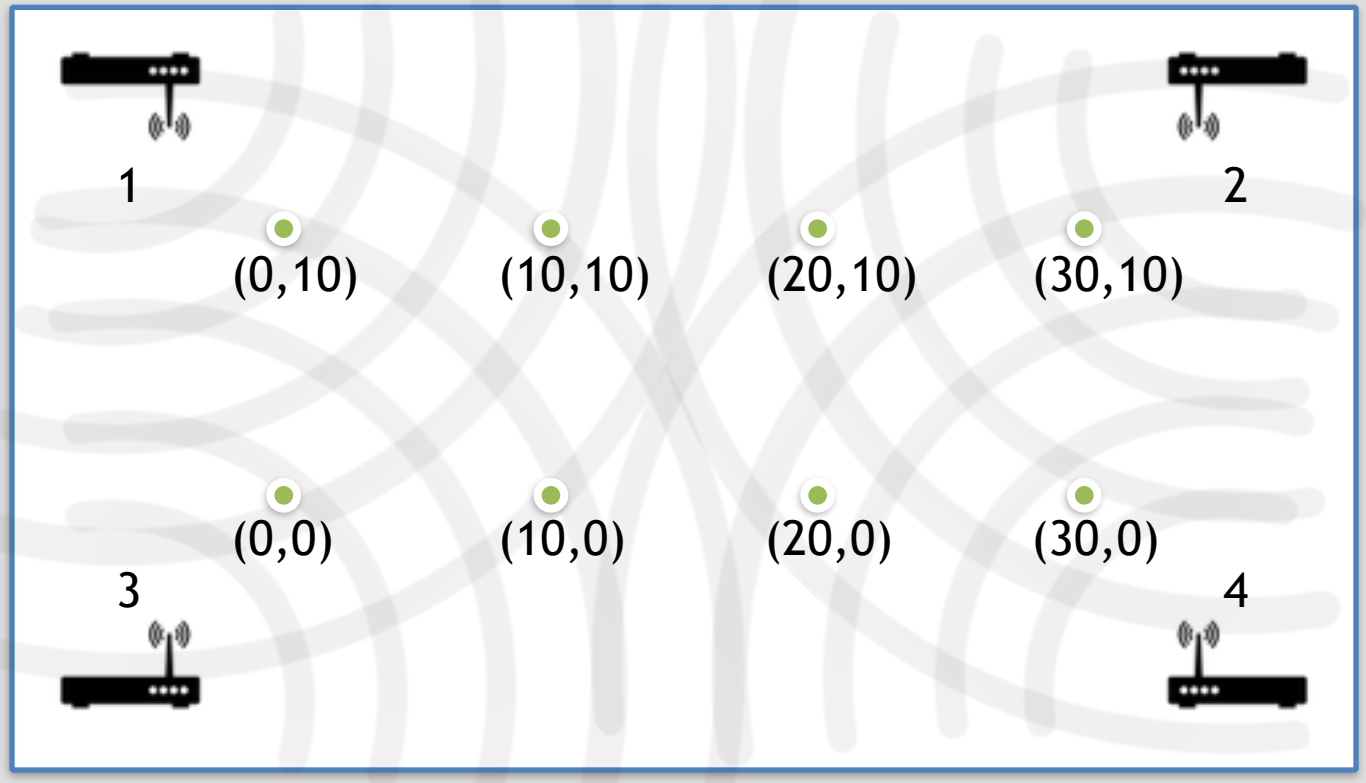
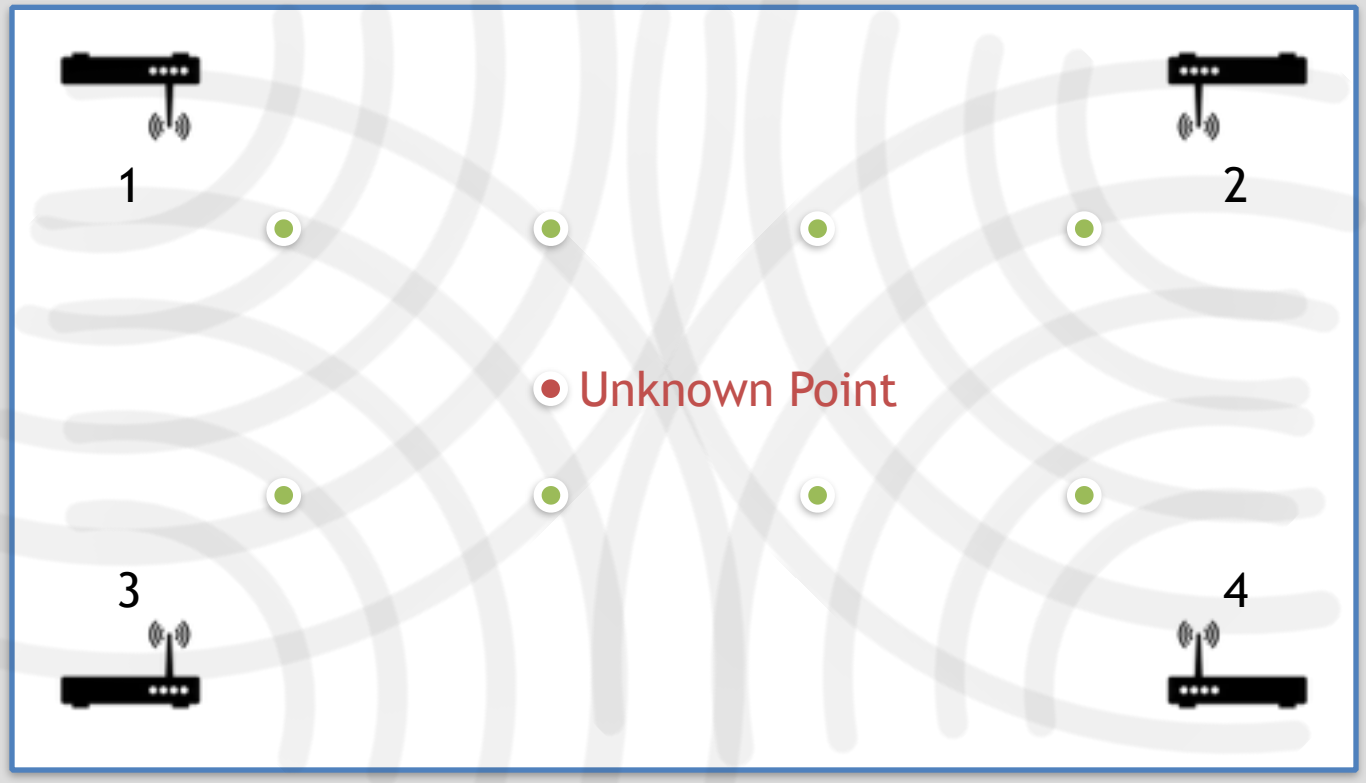


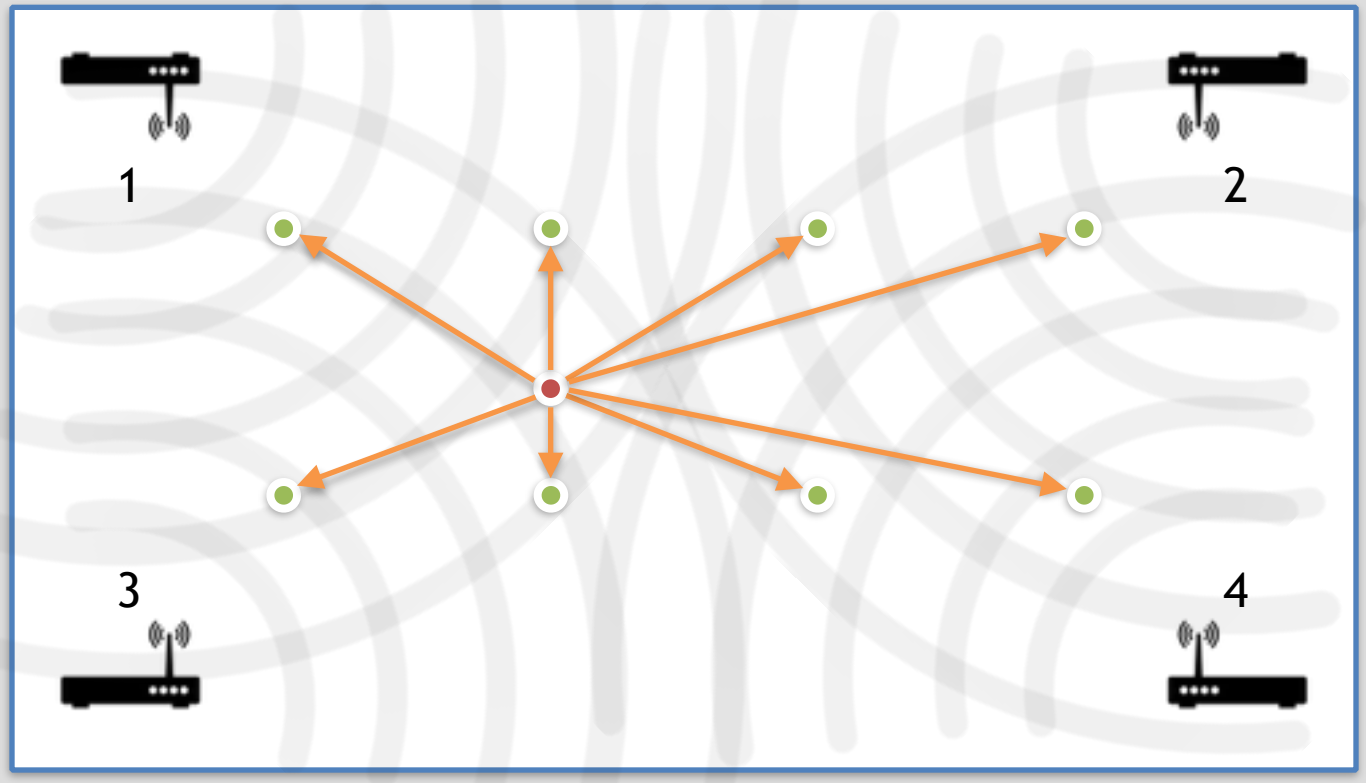
Choose 8 points on the floor and calibrate readings

How the algorithm works



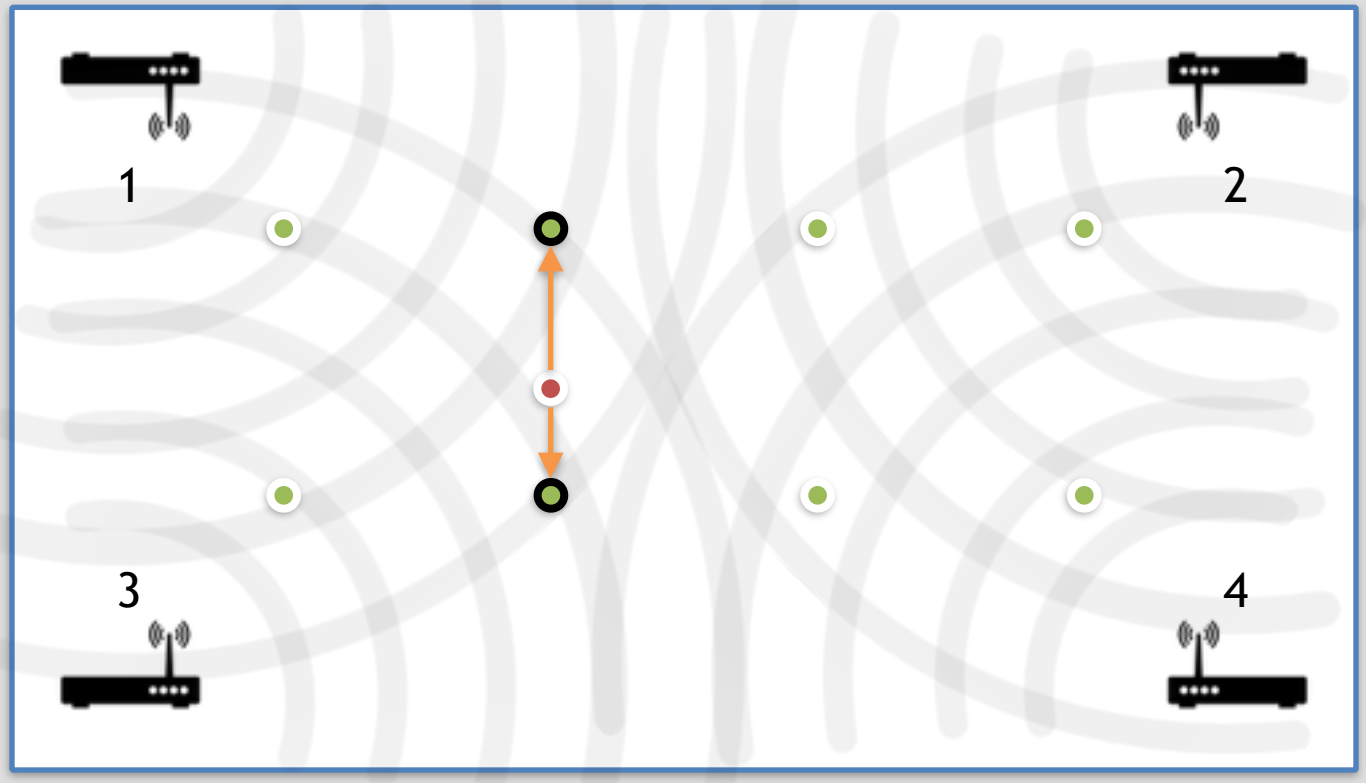
Calculate Euclidean distance from unknown point to all chosen points

How the algorithm works



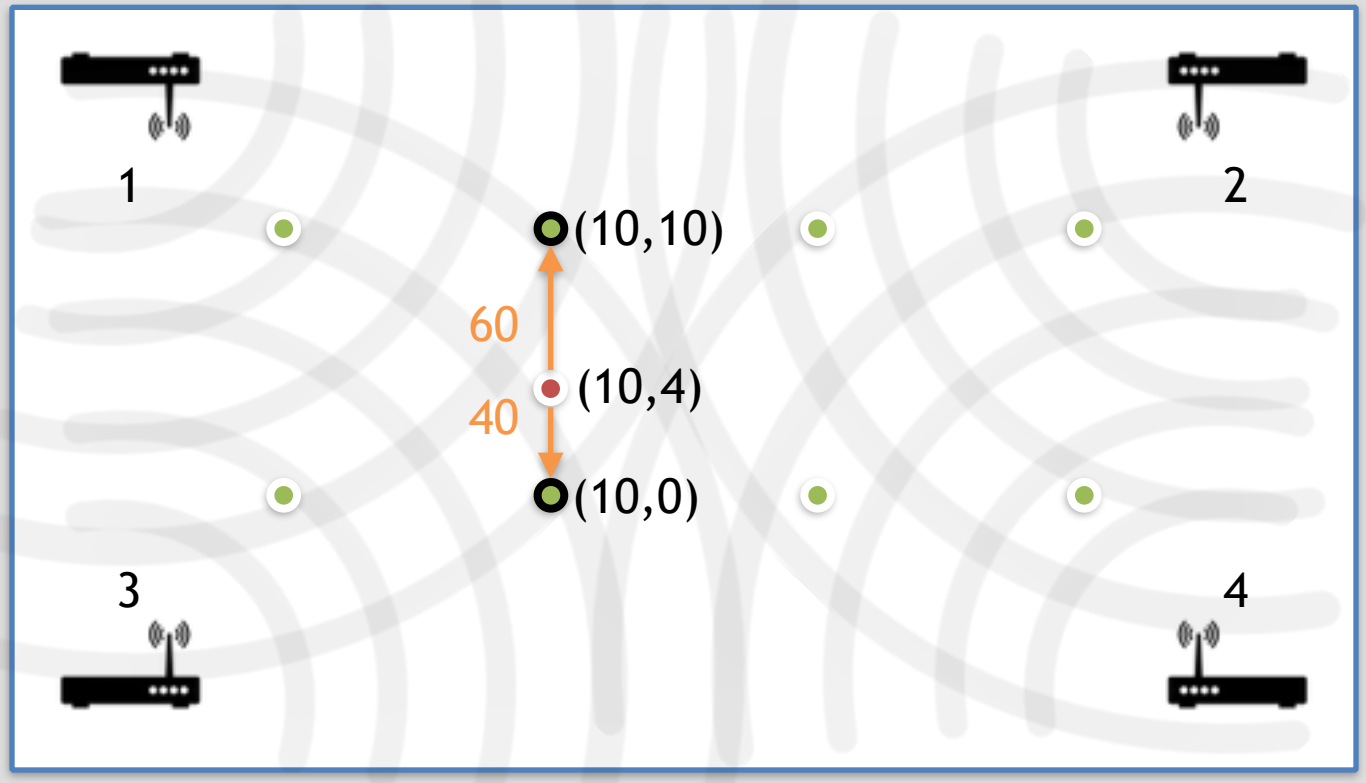
Euclidean distance between points x and y is calculated by $\text{sqrt}((r_{x1}-r_{y1})^2+(r_{x2}-r_{y2})^2+(r_{x3}-r_{y3})^2+(r_{x4}-r_{y4})^2)$

How the algorithm works



Nearest k points are chosen. Here k = 2.

How the algorithm works

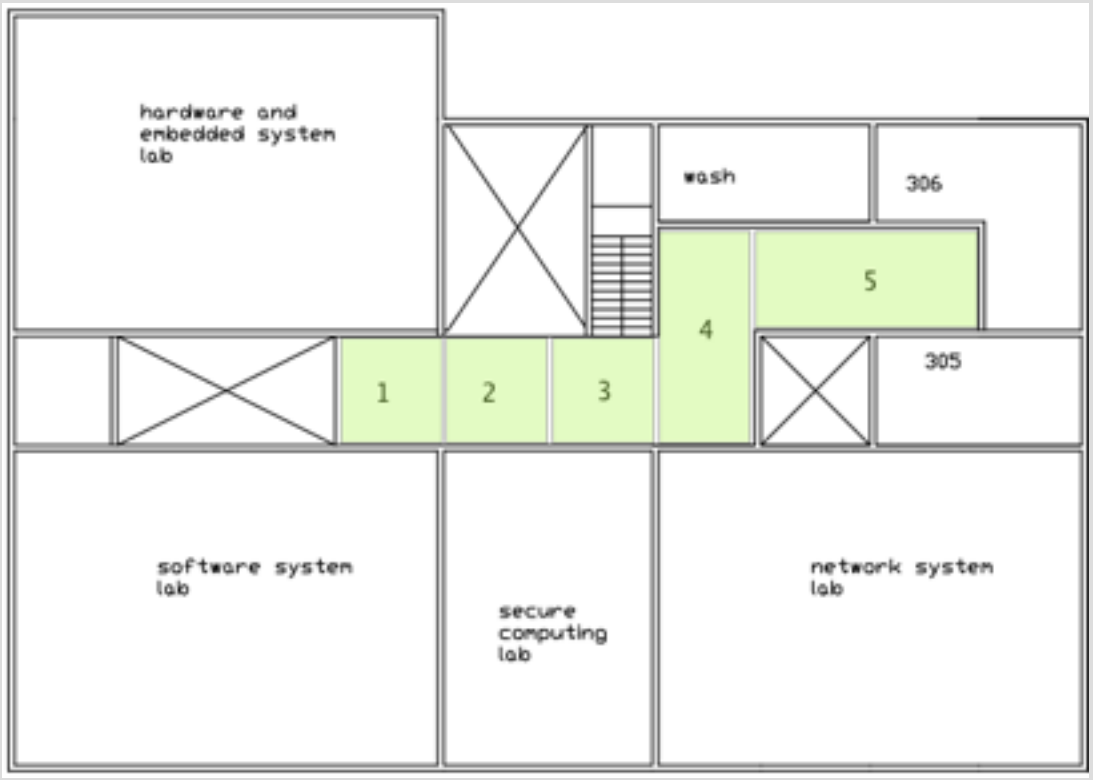


Coordinate of unknown location is the weighted average of the 2 nearest points

Work Done

- Prototype Android App created
  - Performs calibration and positioning
- Mapping done inside CSED Lab building
- WkNN algorithm with k=1 used
- Device position logs could be tracked from website

Work Done



- Application could distinguish the grids shown in the figure

DEMO

www.ajnas.in/wifips

Practical Difficulties

- Fluctuating signal readings

  Considered the average of 30 readings
- Readings might contain temporary APs

  Prepared a list of trusted APs to be used
- User orientation can affect the readings

  Orientation specific readings should be recorded

  (to be done)
- Proper positioning of APs can reduce error

Work Remaining

- WkNN should be modified to k>1 to increase accuracy
- Ideal value of k needs to be figured
- Readings taken should be normalised so as to work for all devices
- Calibrated readings should be made available for all devices

Questions?

Thank You