Differential Wi-Fi –
A Novel Approach for
Wi-Fi Positioning Using Lateration

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Positioning Methods

Cell-based positioning – Cell-of Origin CoO

Simplest and most straightforward technique
Mobile positioning technique for finding the basic geographical coverage unit

Angulation
Angle of Arrival AoA measurements

Lateration
Time of Arrival ToA measurements
RSS-based techniques employ path loss models for range conversion

Location Fingerprinting
Training and positioning phase
Lateration

Intersection of at least 3 spherical surfaces given the centres and radii of those spheres

In RSS-based techniques, it is based on the nature of the RSS which varies with the changes of distance between transmitters and receivers

RSS decreases with the transmitted energy propagating into space
RSS Path Loss Patterns in Different Environments

Log-distance pattern outdoors

Linear pattern in a corridor indoors
Long-term RSS Observations
Differential Approaches

Reference stations at known locations

Corrections for the user regarding:
- Signal propagation
- Spatial and temporal variations

2 approaches and positioning methods
Differential Wi-Fi (1st Approach)
Differential Wi-Fi (2nd Approach)
DWi-Fi Lateration Methods

1. DGPS principle
RSS corrections

\[ RSS_{corr} = RSS_{calc} - RSS_{obs} \]

2. VLBI principle
RSS differences

\[ \Delta RSS = RSS_{User} - RSS_{RS} \]
\[ d_{U,AP_i} = d_{RS,AP_i} - \Delta d_{AP_i} \]
System Components

**Wi-Fi Access Points:** distinguished by their MAC addresses

**Reference Stations:** Raspberry Pi’s
Low-cost credit-card sized computer

- **USB Wi-Fi adapter**
- **Python Script**
- **App user interface**

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Relationship Distance - RSS for SM 1

\[ RSS = a \times \log(\text{distance}) + b \]

\[ a = -8.03755 \text{ dBm} \]
\[ b = -48.79595 \text{ dBm} \]
Relationship Distance - RSS for SM 2

\[ RSS = a \times \log(distance) + b \]

- \( a = -8.17212 \text{ dBm} \)
- \( b = -42.58458 \text{ dBm} \)
Deviations from log-FCN for SM 1

mean deviations [dBm]

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<th>direction 2</th>
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<td>270°</td>
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Deviations from log-FCN for SM 2

mean deviations [dBm]

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Field Tests

9 Access Points APs
3 Reference stations RPs
10 Test points MPs
Deviations from True Position (1)

Without differential corrections using reference station measurements
Deviations from True Position (2)

With differential corrections using reference station measurements.

Robust adjustment Least Median Square
Deviations from True Position (3)

With differential corrections using reference station measurements and consideration of user orientation

Robust adjustment
Least Median Square
Areal Deviations from True Position (1)

one-slope model  multi-wall model  diff. model 1  diff. model 2
Areal Deviations from True Position (2)

Best results are achieved in area with computers

Multi-wall shows slight improvement

Differential model 1 achieves good results in central area of test site but lower accuracies in margin areas
Cooperative Positioning Solution
Summary and Outlook

Spatial and temporal variations are considered

2 new differential DWi-Fi approaches are developed

Improvement can be achieved in the network of reference stations

Shorter distance to reference stations yields better results

Application of dynamical radio maps is investigated

Additional use of personal hotspot functionality

Fusion with inertial sensors