

# Indoor Localization Framework with WiFi Fingerprinting

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# Outline

1. Introduction
2. Implementation
3. Results & Analysis
4. Conclusions

# Applications of Indoor Localization

Navigation

Emergency Tracking

Meetups

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# Objective

*“To improve WiFi based indoor localization accuracy with an in-house data acquisition system.”*

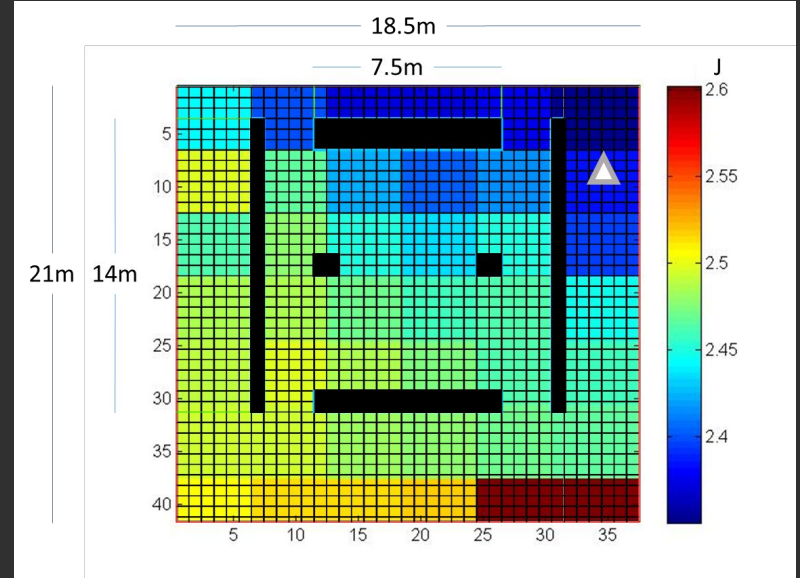
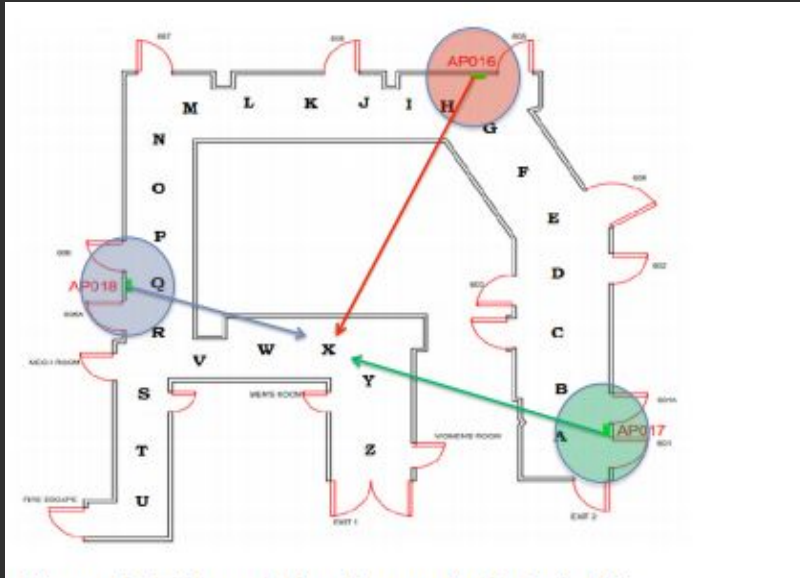
# Previous Research

2013 - WiFi Triangulation on One Floor

2015 - Energy Cost of Ping vs. Distance to Router

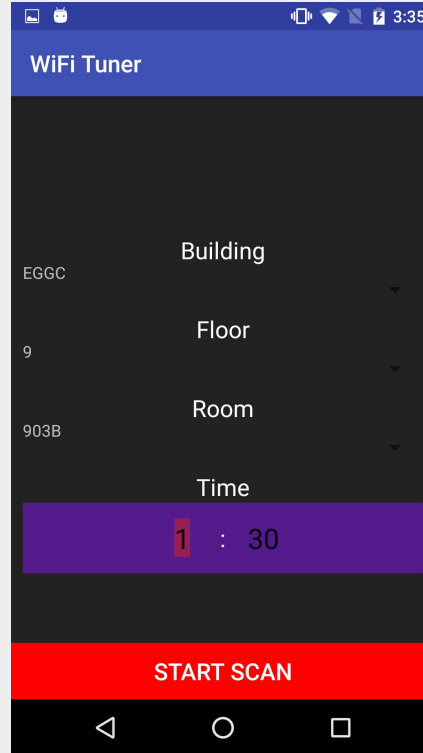
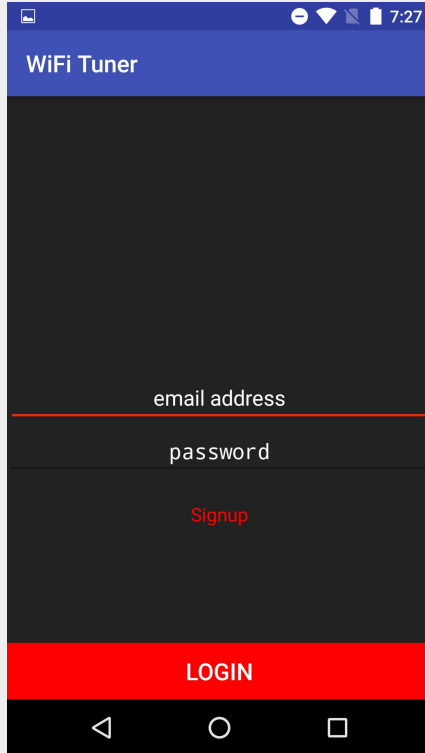
2016 - Multi Floor Indoor Localization

# Previous Research (cont)



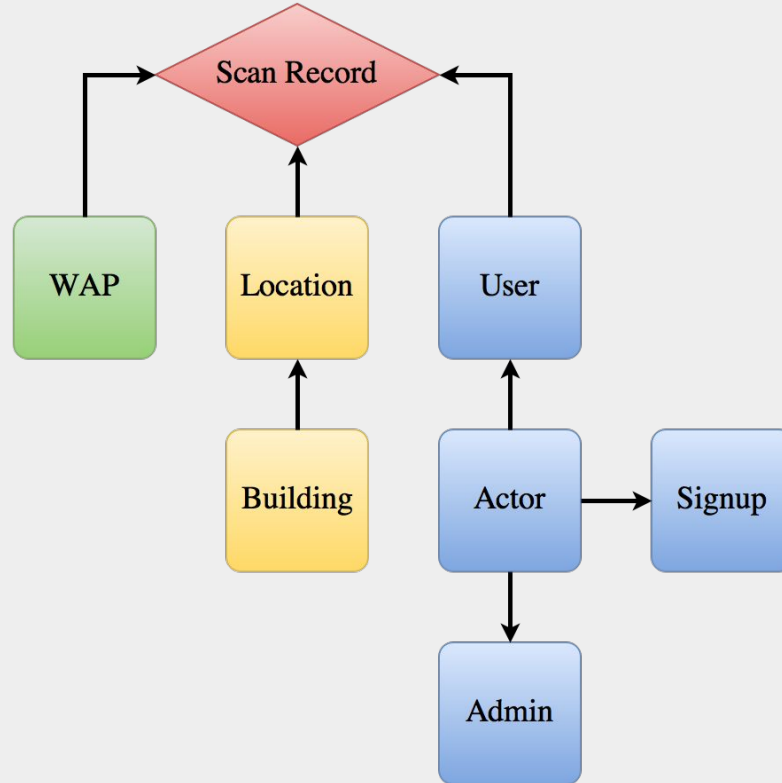
# Implementation

# Data Acquisition





# Simplified Entity Relation Diagram



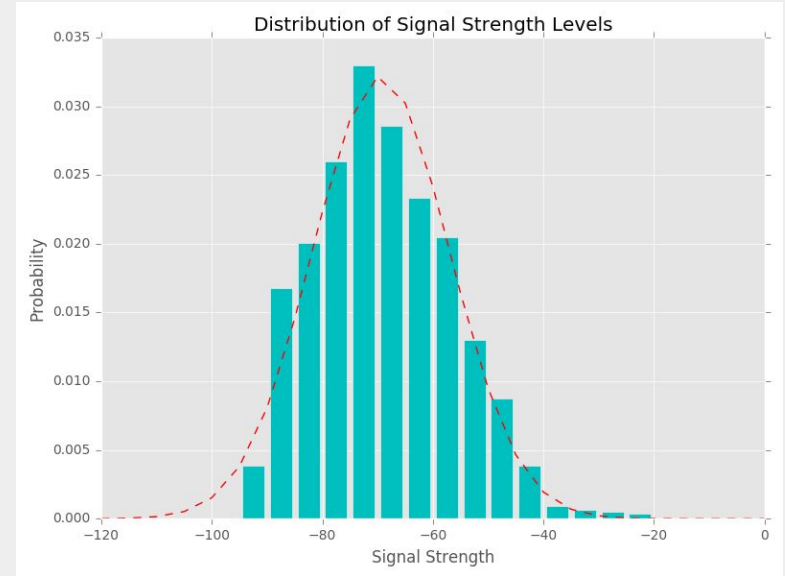
# Terminology

Symbol	Meaning
W	Wifi Access Point
L	Location
T	Hour
DoW	Day of Week
UXT	Unix Time
TT	DoW, Hour, $\frac{1}{4}$ Hour
LT	L, DoW, Hour

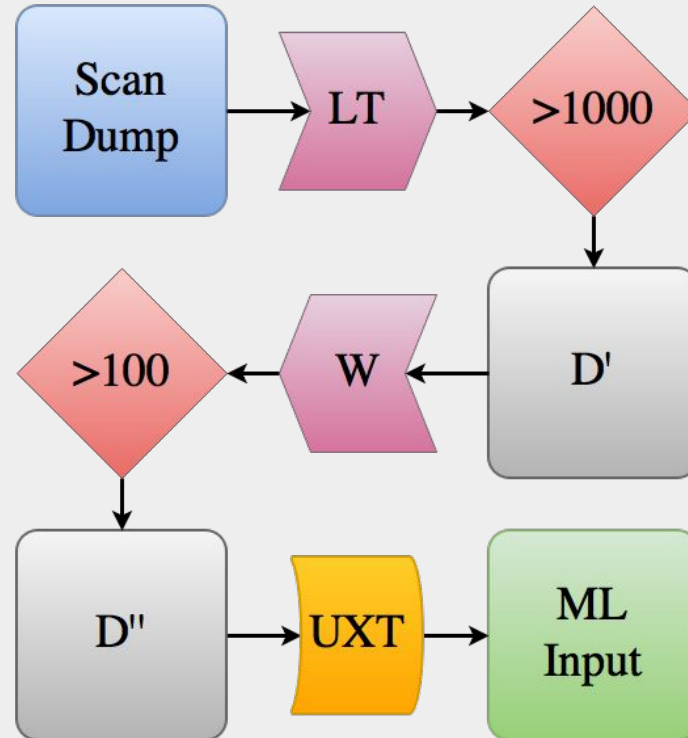
Record	Scan
1 BSSID, 1 Level	List of Records

# Data Preprocessing – Input

UXT	BSSID	Signal Strength	Location
T1	W1	W	L1
T1	W2	X	L1
T2	W2	Y	L2
T2	W3	Z	L2



# Preprocessing



# Data Preprocessing – Output

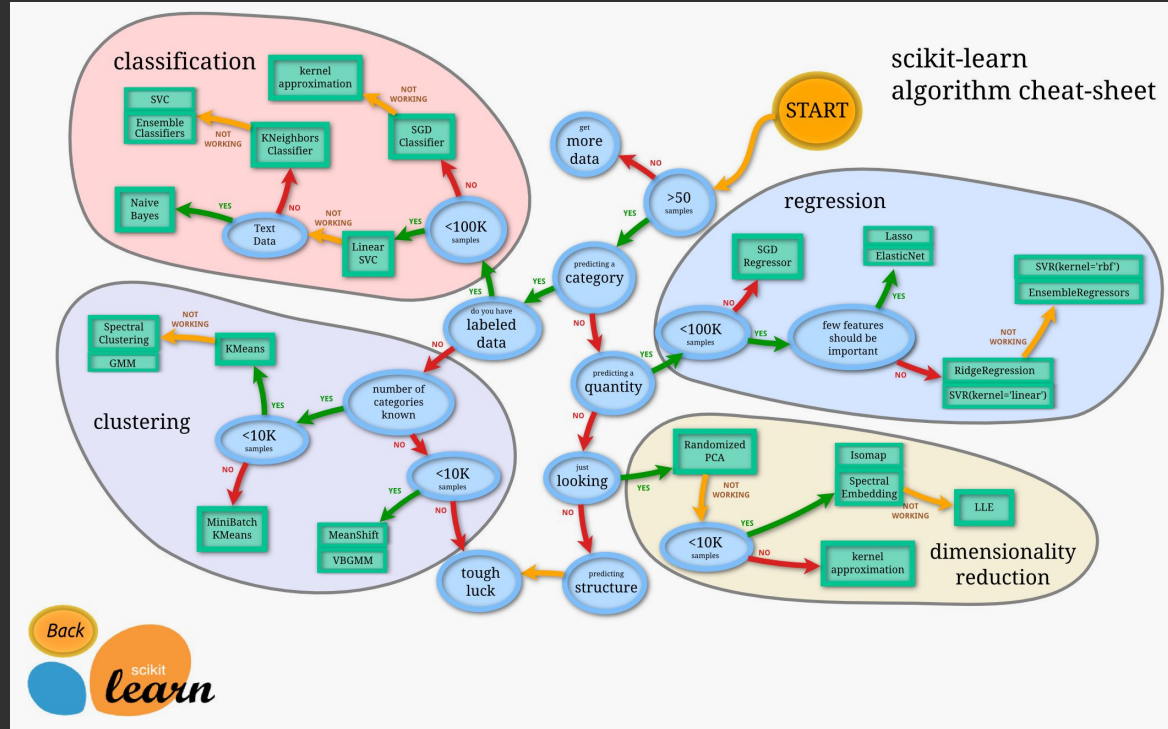
<b>DoW</b>	<b>Hour</b>	<b>W1</b>	<b>W2</b>	<b>W3</b>	<b>Location</b>
dow(T1)	hour(T1)	W	X	–	L1
dow(T2)	hour(T2)	–	Y	Z	L2

# Machine Learning

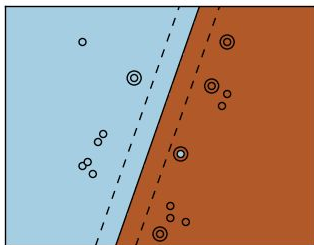


machine learning in Python

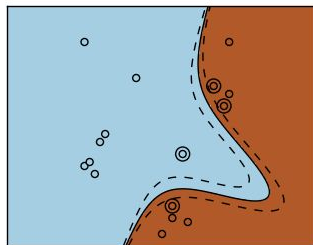
# Choosing the Algorithm



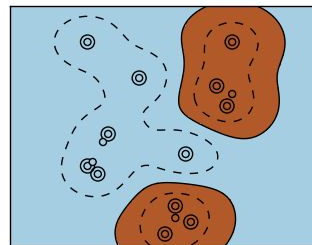
# Support Vector Machines



*Linear*



*Polynomial*



*Radial Base*



# Machine Learning Metrics

Prediction Accuracy: Correct Predictions / Total Predictions

Precision:  $TP / (TP + FP)$  *Positive Predictive Value*

Recall:  $TP / (TP + FN)$  *True Positive Rate*

F1 Score:  $2 (PPV \times TPR) / (PPV + TPR)$

# Results & Analysis

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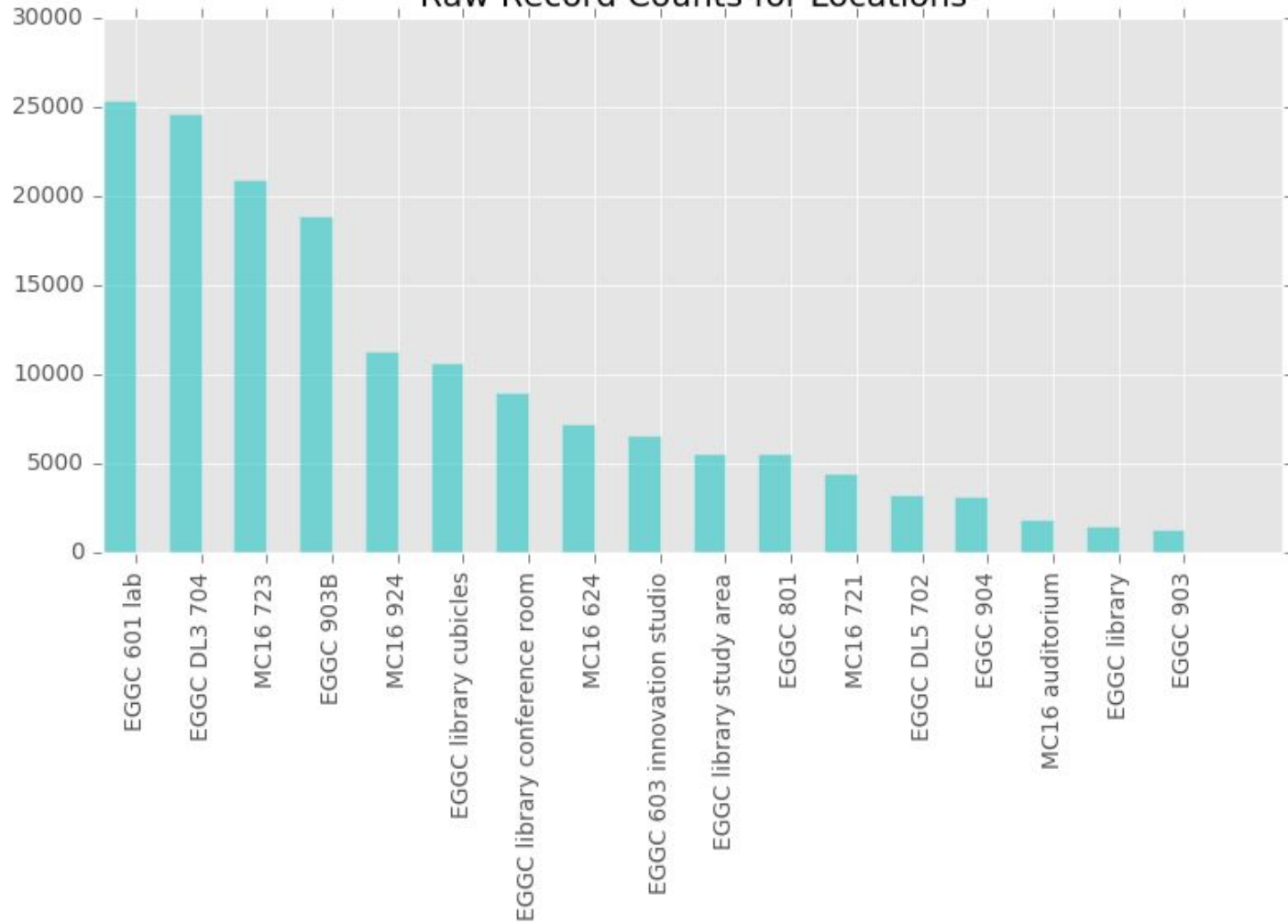
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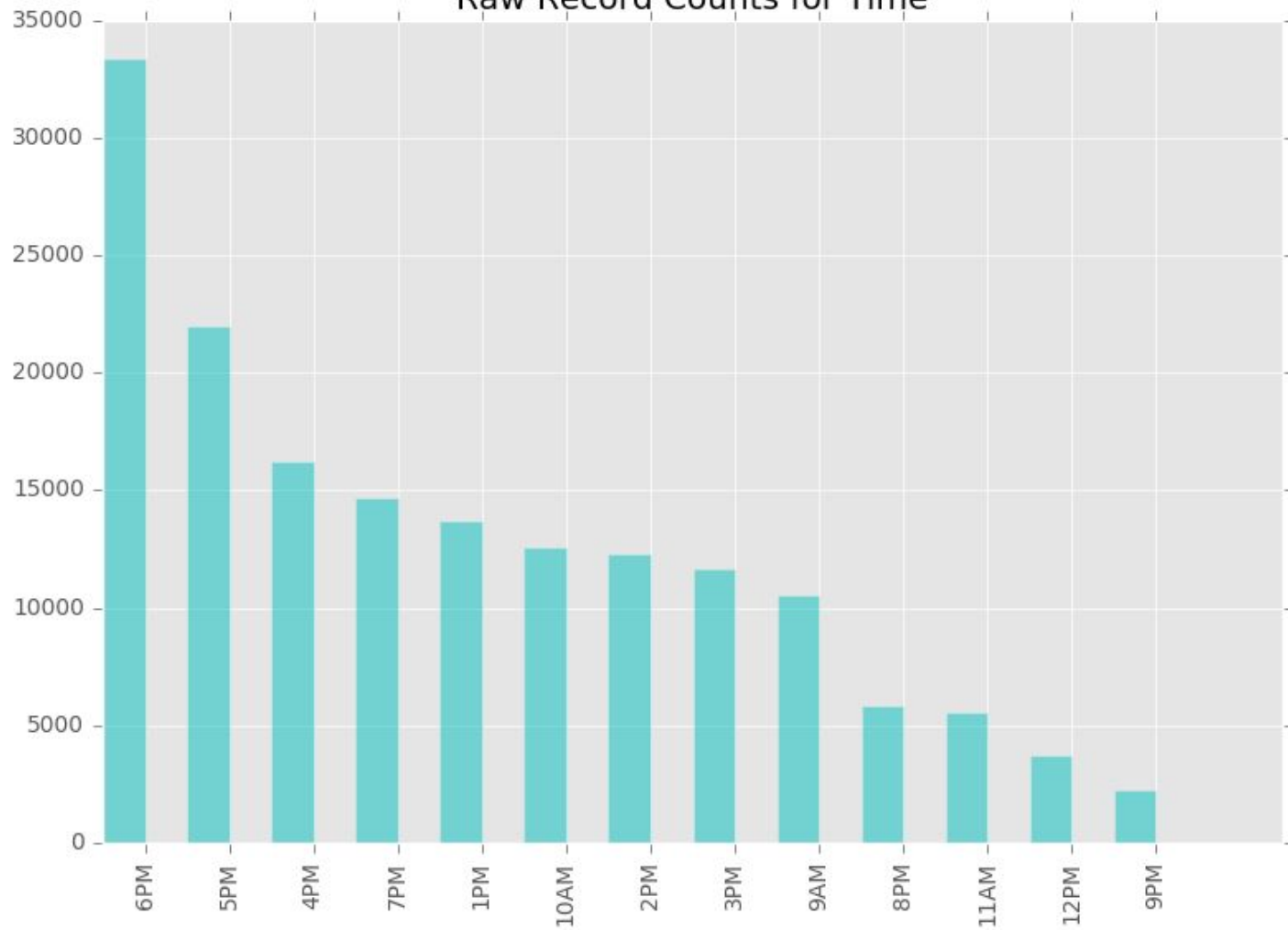
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Raw Record Counts for Locations



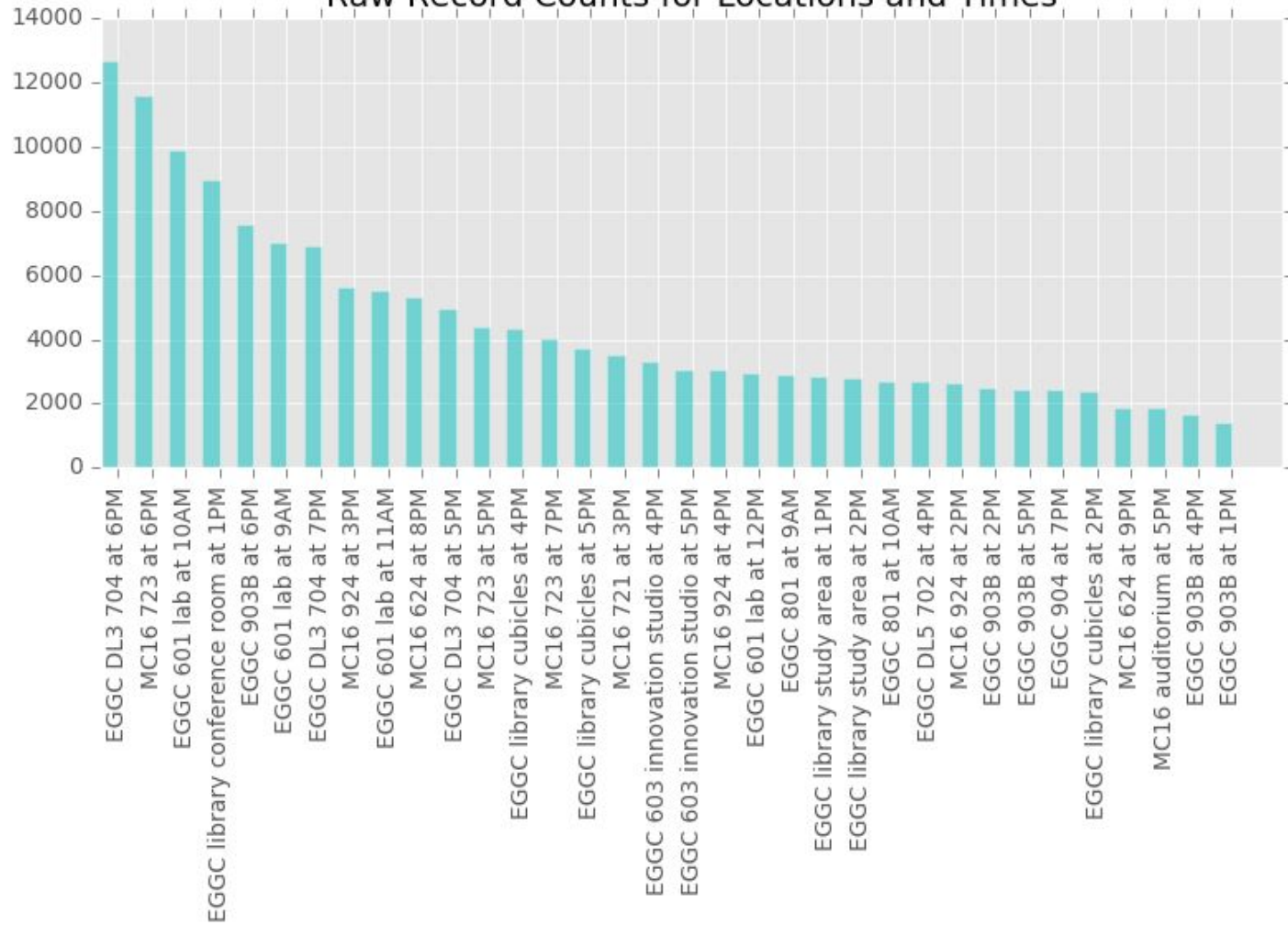
Raw Record Counts for Time

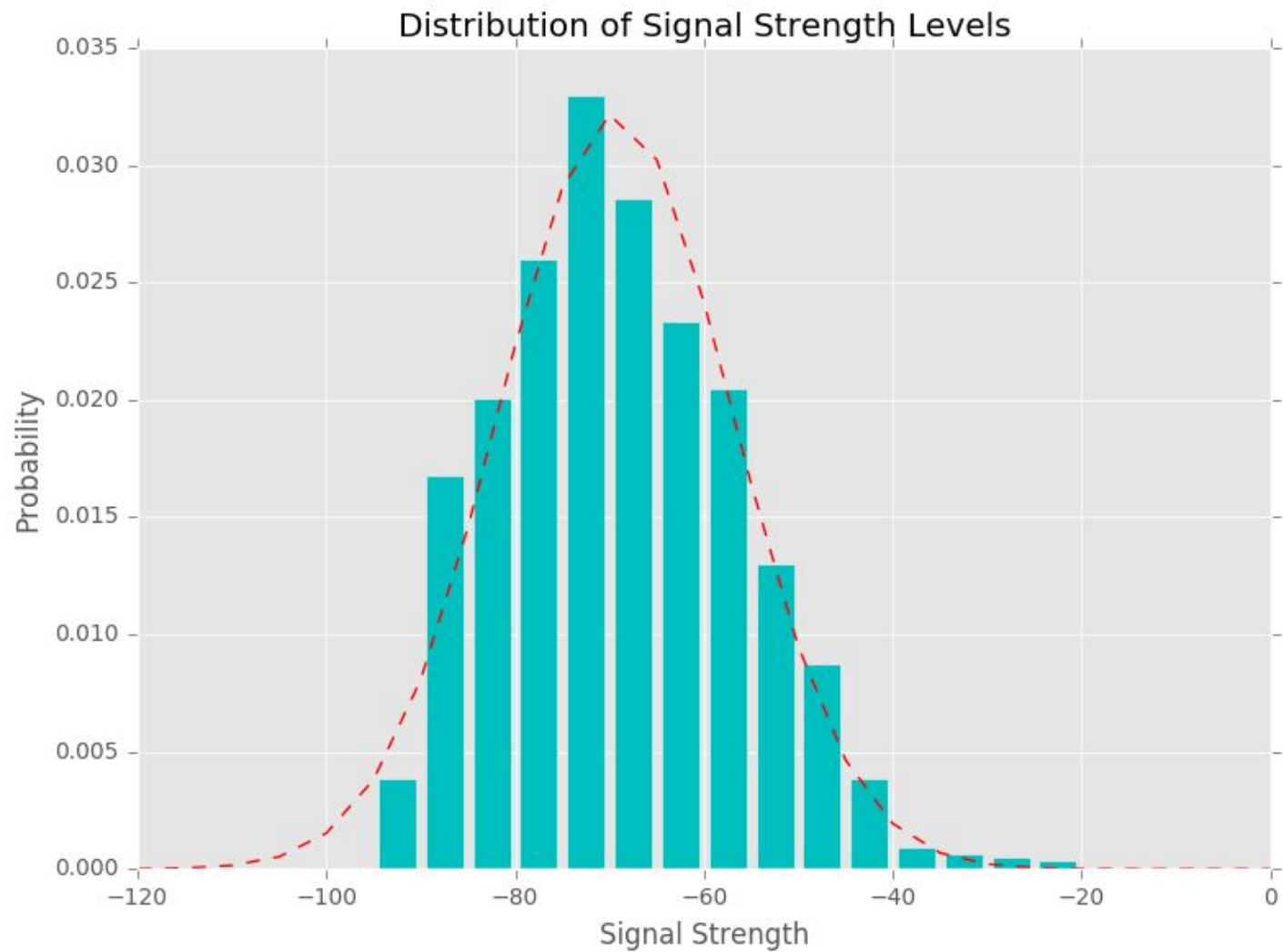


Raw Record Counts for WiFi Access Points

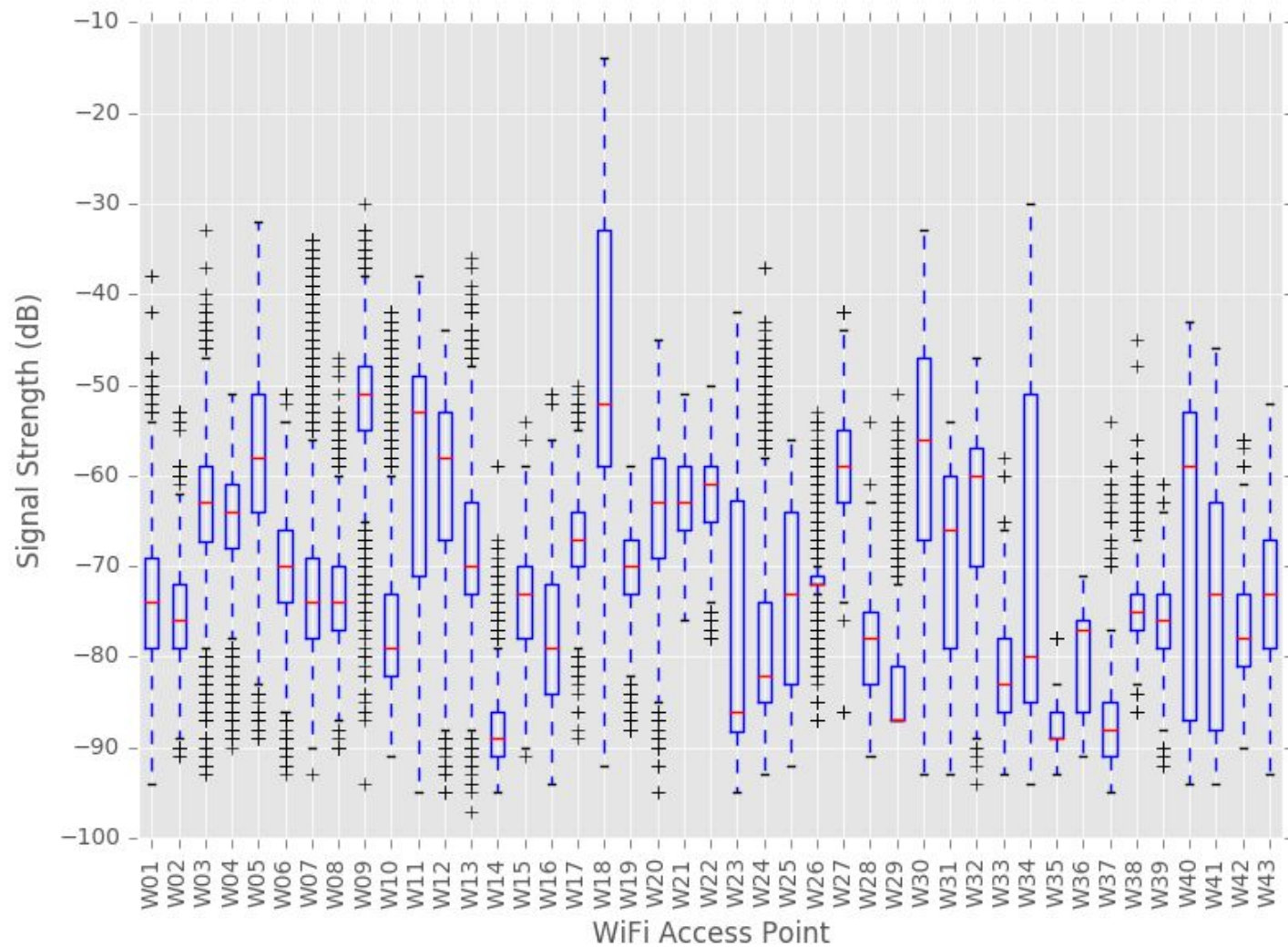


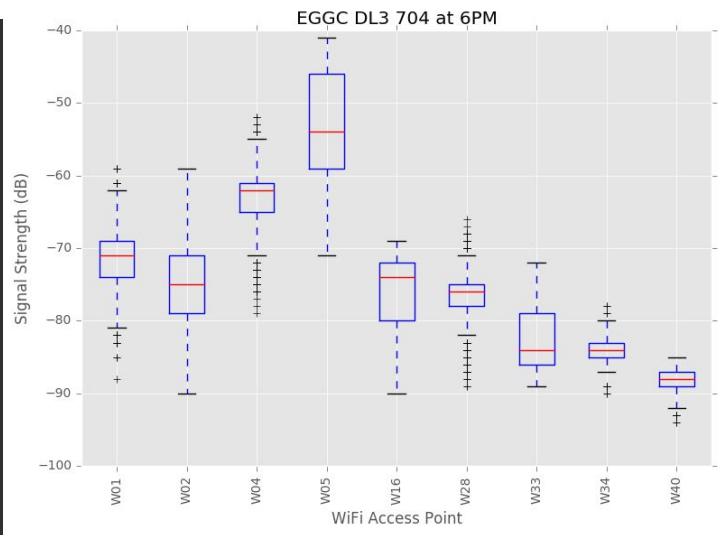
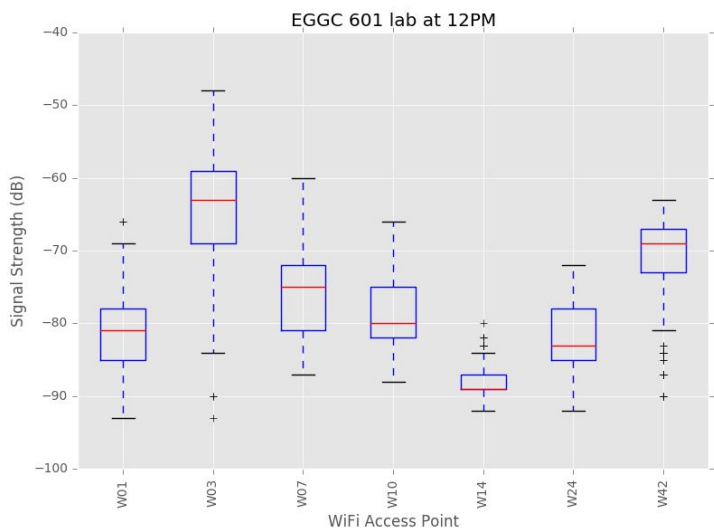
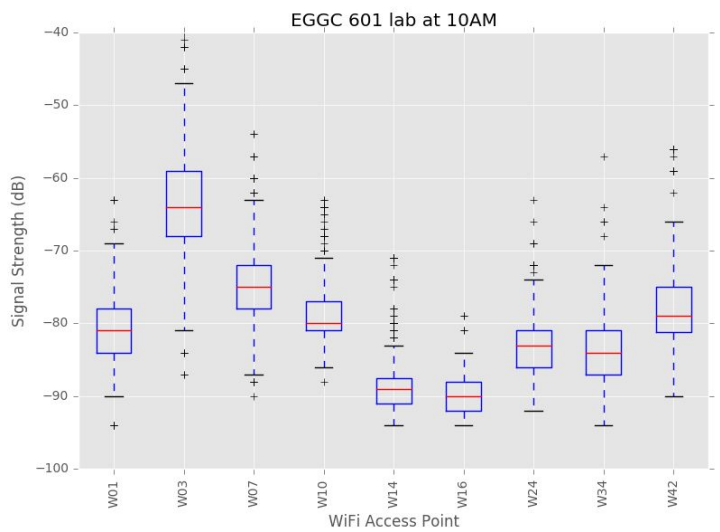
# Raw Record Counts for Locations and Times







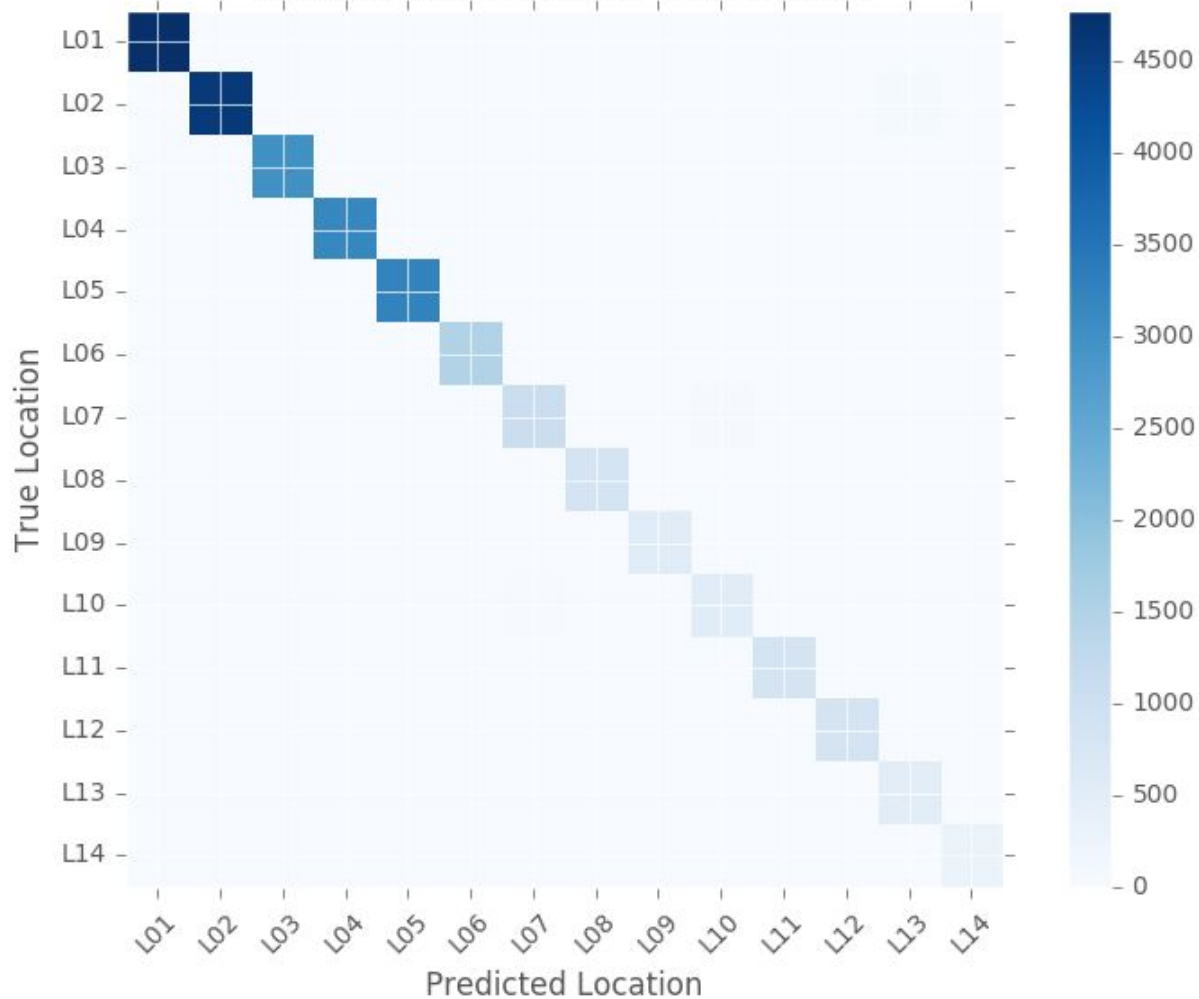


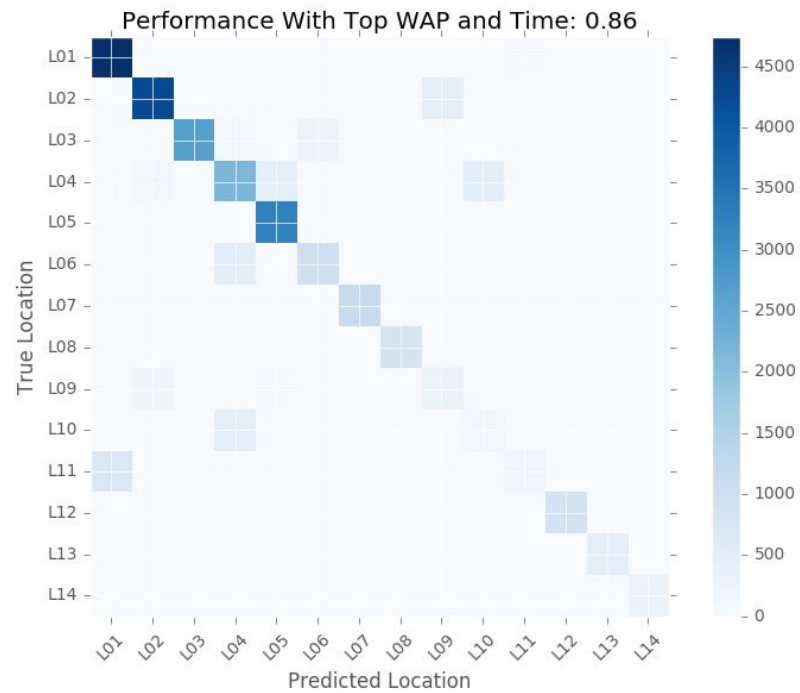
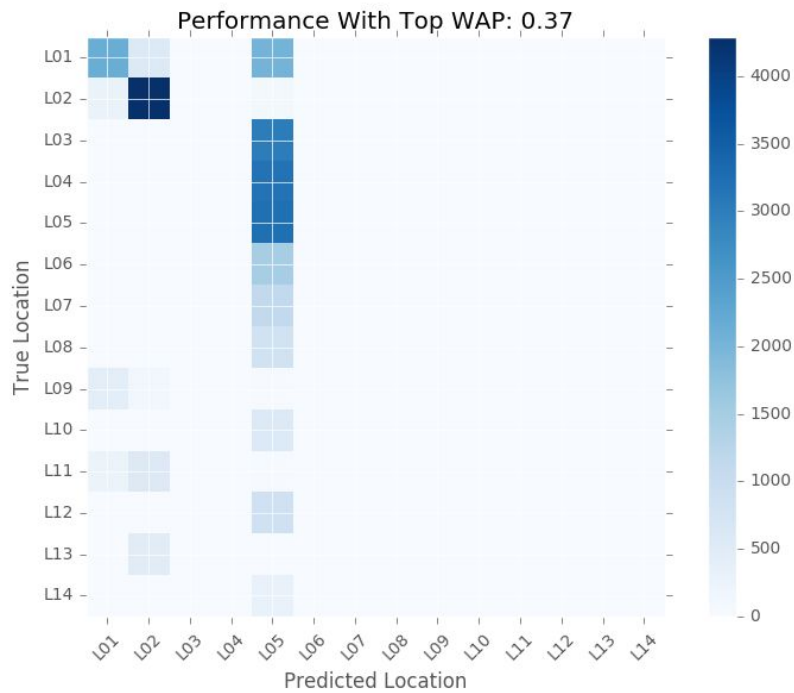


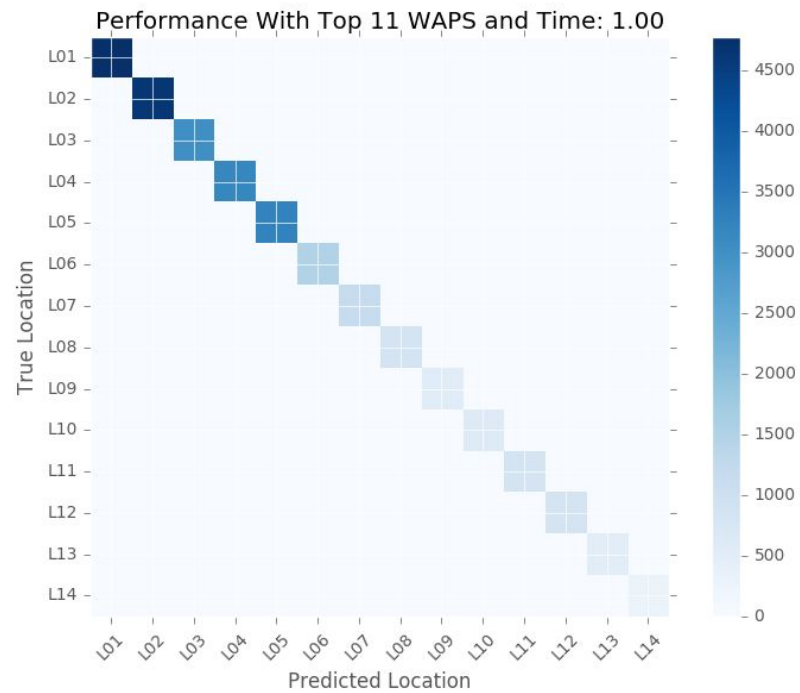
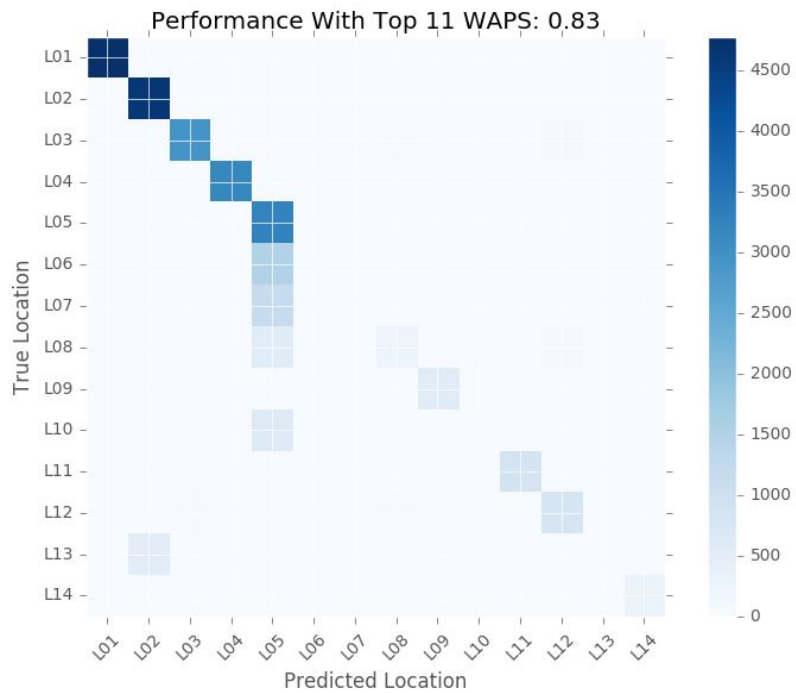
# Location Labels

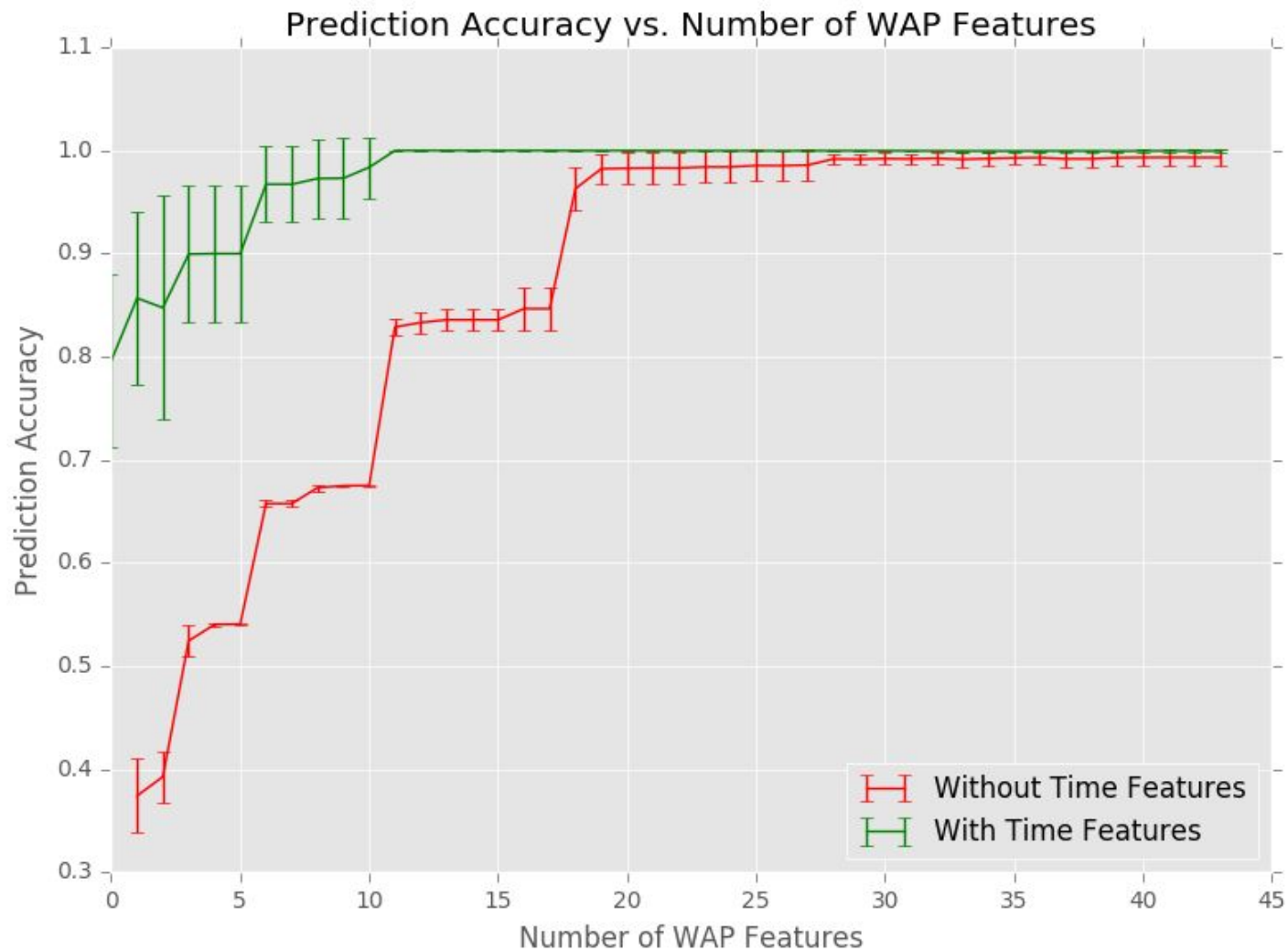
L01	EGGC 601		L08	MC16 624
L02	EGGC DL3		L09	EGGC 603
L03	MC16 723		L10	EGGC Library SA
L04	EGGC 903B		L11	EGGC 801
L05	MC16 924		L12	MC16 721
L06	Library Cubicles		L13	EGGC DL5
L07	Library Conference		L14	EGGC 904

Performance With All WAPS: 0.99









# **Conclusion**

*“Prediction accuracy is significantly improved by including time features in the classification algorithm.”*

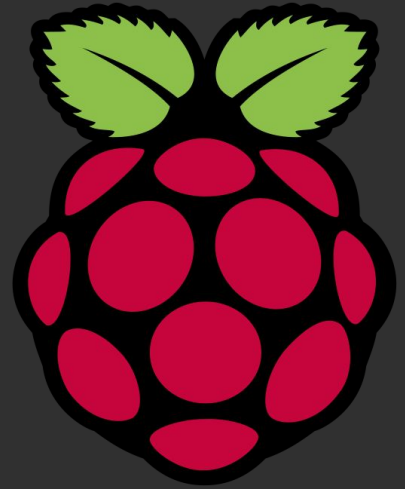


# Future Projects

Modify app to record phone's model number.

Program Raspberry Pi's to collect training data.

Explore regression based machine learning to predict distance to access point anchors.



# Learning Outcomes

<i>Server</i>	<i>Android</i>	<i>Machine Learning</i>
<i>Database</i>	<i>SQLite</i>	<i>Training Classifiers</i>
<i>REST API in Flask</i>	<i>Broadcast Receivers</i>	<i>Cross Validation</i>
<i>Apache with HTTPS</i>	<i>Background Services</i>	<i>Confusion Matrices</i>
<i>Sending Email</i>	<i>Making HTTP Requests</i>	<i>Matplotlib</i>
	<i>Notifications</i>	

Thank You

# References

1. [http://scikit-learn.org/stable/tutorial/machine\\_learning\\_map/](http://scikit-learn.org/stable/tutorial/machine_learning_map/)
2. <http://www.scipy-lectures.org/advanced/scikit-learn/>
3. <http://machinelearningmastery.com/classification-accuracy-is-not-enough-more-performance-measures-you-can-use/>
4. <http://www.nyit.edu/engineering/reu/>