

Wi-Pi: Distributed Wi-Fi Performance Assessment using Raspberry Pi

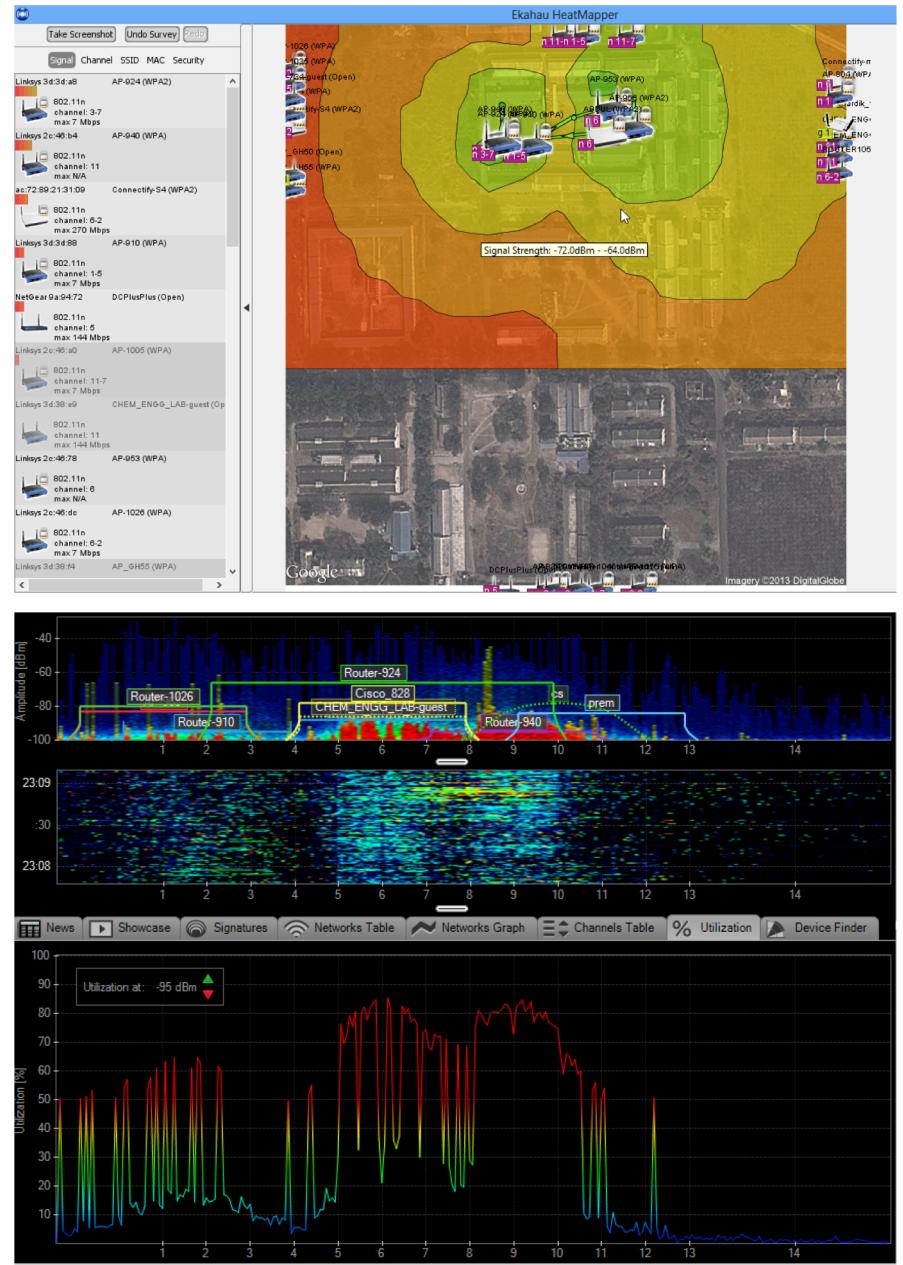
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Wi-Fi Related Problems Reported in IIT Hyderabad (Nov 2013 to Nov 2014)

- 56% (155 cases out of 276 total cases) is related to Wi-Fi connection in IIT Hyderabad
- What do they complain about Wi-Fi?
 - Signal
 - Speed
 - DHCP (rare)
 - Device Driver (rare)
 - Authentication (because of the new setup of Wi-Fi)
 - No comment

45 APs in Student Hostel in IIT Hyderabad (OLD)



Big Campus to Cover (Under Construction)

MASTER PLAN

Including

- Solar Farm
- The Commons
- The Mall
- Convention Village
- Tech. Incubation and Research Park



and

- Academic buildings
- Faculty and staff housing
- Hostels
- Research Centers
- International house
- Administration Building
- Sports facilities
- Auditorium
- Library
- Schools
- Medical facility
- Shopping

Tokyo Industry Meet 2014 08 01

Wi-Fi Monitoring in University Campus Network

- Large-scale
 - Number of equipment
 - Geographical distribution and coverage
- Performance fluctuation
 - Try and catch for optimization
 - Trouble shooting
- Motivation for Automating Wi-Fi Monitoring
 - Human Resource to move around in the campus
 - Persistence of problems
 - Continuous monitoring

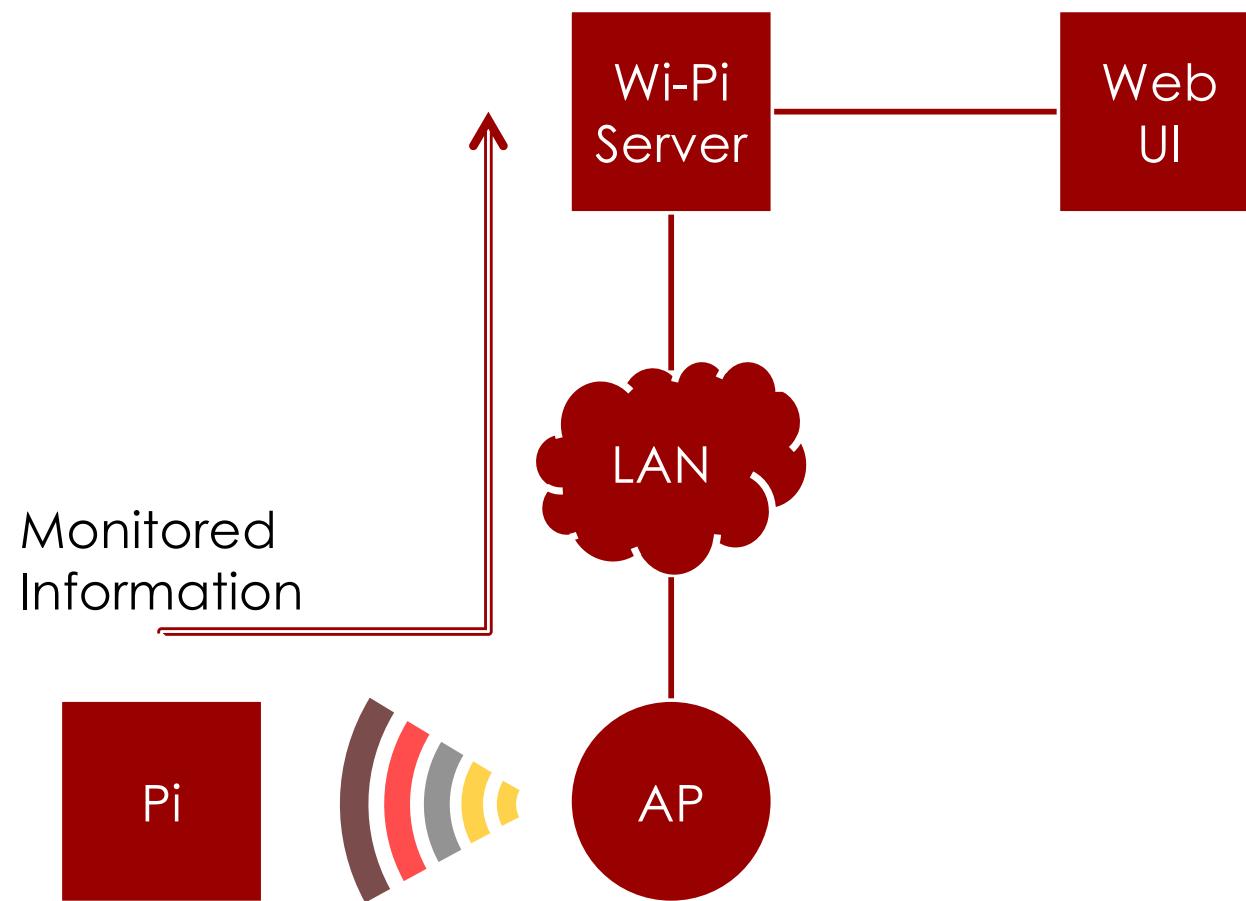
Parameters for Wi-Fi Performance Assessment

- Wi-Fi signal strength (RSSI)
- Packet Loss
- Round-trip delay time (RTT)
- (a lot of) Rogue Wi-Fi access points
- (almost always) Unplanned power-cuts

Wi-Pi

- Distributed Wi-Fi Performance Assessment using
Raspberry Pi
 - Scatter and leave them: No need to move around
 - Low-cost: Pi + USB Wi-Fi v.s Spectrum Analyzers
 - Stationary: Continuity of performance assessment
- Information from **Users' Perspective**
- Mode of **Visualization**
 - Heat Mapper
 - Performance Analysis in time-scale graphs

System Architecture



Database Schema in Server

- device info
 - Unique device id for each device
(covering both Pi and access point)
 - Location, Frequency band, ESSID
 - MAC Address, IP Address
- device data (for each Wi-Fi AP detected by Pi)
 - Time Stamp
 - RSSI, Channel
 - conductivity factor μ_1
 - Packet loss rate, latency to the pinger target

Web UI (1/2)

■ Device manager: Admin Panel

The screenshot shows the RPMS Admin Panel dashboard. On the left, there's a sidebar with a search bar, a dashboard icon, a 'Data Modification' dropdown, a 'Notification' icon, and a 'Settings' dropdown. The main area has a title 'Dashboard' and a breadcrumb 'Admin panel > Dashboard'. It features four toggle buttons: 'Toggle Heatmap' (selected), 'Change Gradient', 'Toggle between APs and their signal strength', and 'Change opacity'. Below these are two maps of a campus. The top map shows several green dots representing signal strength across different buildings, including 'IITH Girls Hostel', 'IITH Boys Hostel', 'IITH MTech Hostel', and 'Water Storage Tank'. The bottom map is a zoomed-in view of the 'IITH Boys Hostel' area. To the right of the maps is a sidebar with a red header 'DC:A5:F4:ED:F5:AE' and a yellow header 'Welcome ADMIN'. It lists various device MAC addresses and their status: 'IITH - 7C:95:F3:31:CF:5F' (not respond), 'IITH-1 - 7C:95:F3:31:CF:5D' (not respond), 'IITH-Guest - 7C:95:F3:31:CF:5E' (Update), 'IITH-Guest - 7C:95:F3:31:55:0E' (not respond), 'IITH-1 - 50:17:FF:3A:76:82' (not respond), 'IITH-1 - 7C:95:F3:31:55:0C' (not respond), 'Test1 - 7C:95:F3:31:55:0D' (not respond), 'IITH - 7C:95:F3:31:55:0F' (not respond), 'Test1 - 7C:95:F3:31:CF:5C' (not respond), 'IITH-1 - 7C:95:F3:31:D0:0D' (not respond), 'IITH - 7C:95:F3:31:D0:0F' (not respond), 'IITH-Guest - 7C:95:F3:31:D0:0E' (not respond), 'Test1 - 7C:95:F3:31:D0:0C' (not respond), 'IITH-Guest - 7C:95:F3:31:D0:06' (not respond), 'IITH - 7C:95:F3:31:D0:07' (not respond), 'Test1 - 7C:95:F3:31:D0:04' (not respond), 'IITH-1 - 50:17:FF:3A:53:62' (not respond), 'IITH-Guest - 50:17:FF:3A:4C:81' (not respond), and 'IITH-1 - EE:BB:41:13:F7:65' (not respond). At the bottom right is a teal footer box with the text 'Welcome to Raspberry-Pi Monitoring System Admin Panel! With great power comes great responsibility.' and a small info icon.

Web UI (2/2)

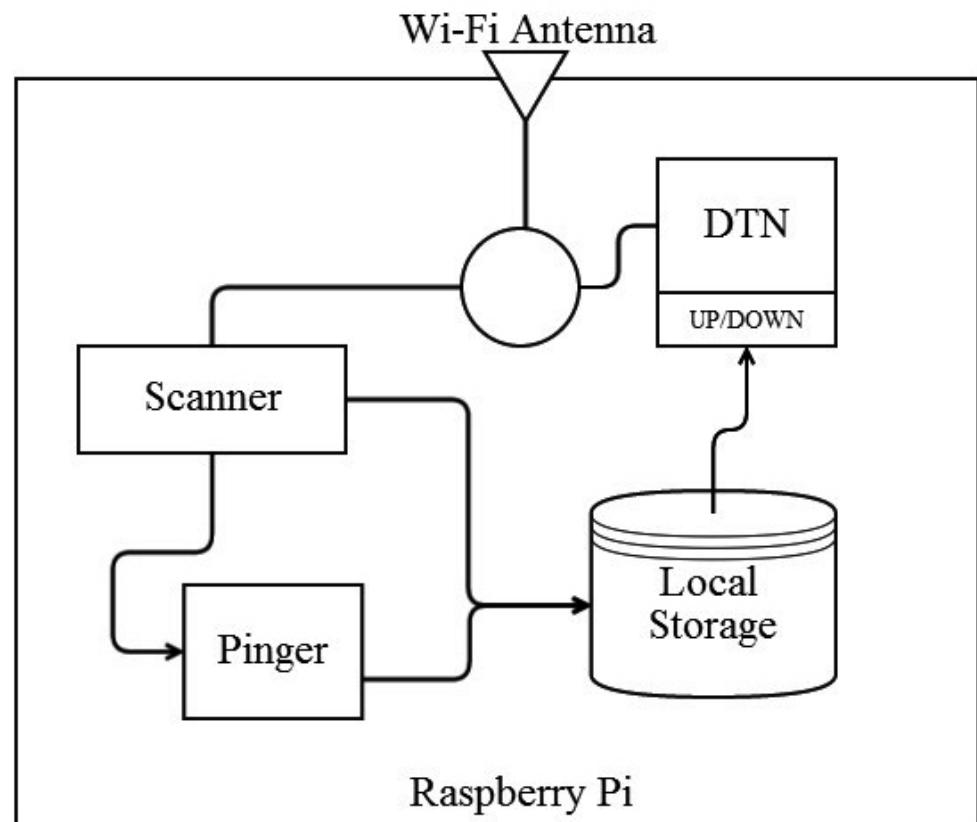
- List of Wi-Fi APs (Based on BSSID)

The screenshot shows the RPMS Admin Panel dashboard. The top navigation bar includes 'Welcome, ADMIN' with a notification count of 7, a 'Logout' button, and a search bar. The left sidebar has links for 'Dashboard', 'Data Modification', 'Notification', and 'Settings'. The main dashboard area displays a summary with three circular progress bars: 5% (4 APs not respond), 0% (0 PIs not respond), and 3.4% (3 Device loc. not set). Below this is a 'Delete Devices' section with a password input field. The main content is a table titled 'List of Devices' showing 11 rows of access point data:

Device Id	Mac	Essid	Frequency	Latitude	Longitude	Device
1	DC:A5:F4:ED:F5:A3	IITH-1	2.437	17.510806	78.140645	Access Point
2	DC:A5:F4:ED:F5:A1	IITH-Guest	2.437	17.510806	78.140645	Access Point
3	DC:A5:F4:ED:F5:A0	IITH	2.437	17.510806	78.140645	Access Point
4	7C:95:F3:C0:18:F1	IITH-Guest	2.462	17.510575	78.1405	Access Point
5	7C:95:F3:C0:18:F3	IITH-1	2.462	17.510575	78.1405	Access Point
6	7C:95:F3:C0:18:F0	IITH	2.462	17.510575	78.1405	Access Point
7	7C:95:F3:74:A0:23	IITH-1	2.412	17.510486	78.140737	Access Point
8	7C:95:F3:74:A0:21	IITH-Guest	2.412	17.510486	78.140737	Access Point
9	7C:95:F3:74:BD:43	IITH-1	2.462	17.511018	78.140625	Access Point
10	7C:95:F3:74:BD:41	IITH-Guest	2.462	17.511018	78.140625	Access Point
11	7C:95:F3:74:BD:40	IITH	2.462	17.511018	78.140625	Access Point

Data Handling at Pis

- Scanner
 - Scan and attempt to associate all available Wi-Fi APs
 - RSSI, Packet Loss Rate and RTT
- Handling disconnected situations using simple DTN
 - Pi will hold the monitored data in local storage
 - Whenever connection to server is available, Pi sends the file
- Some Pis are with battery
 - Sustain a bit after power-cut happens to store monitoring results in Local Storage



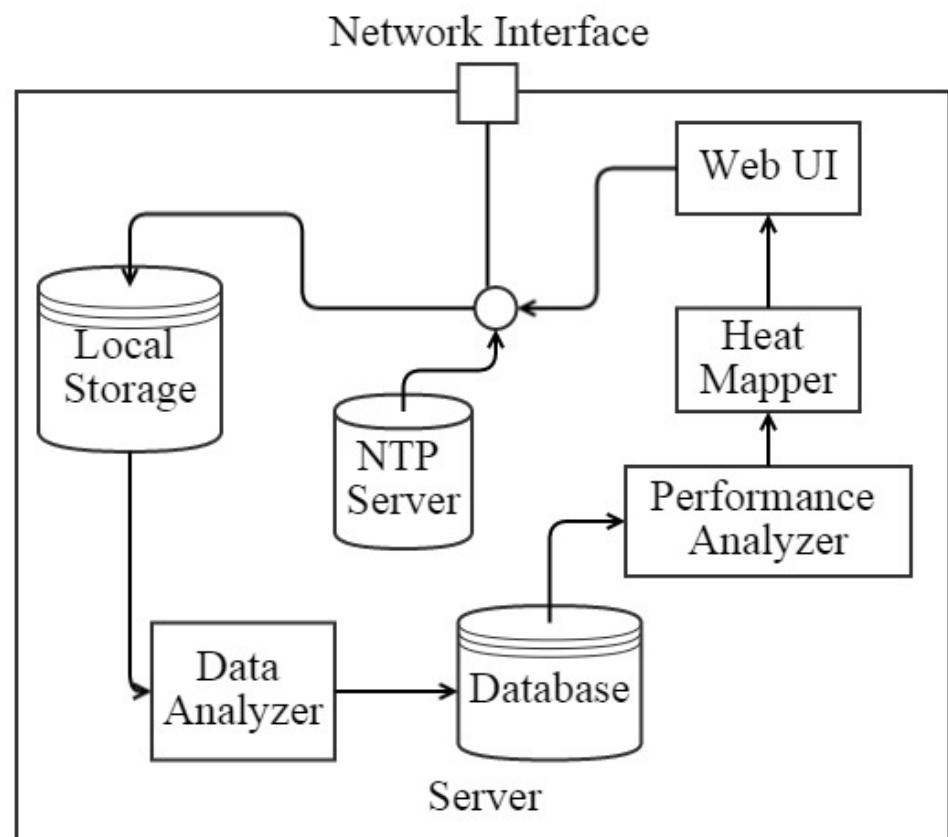
Raw Data Sent by a Pi

■ RSSI

f167ile1102-1.txt						
	Name	Address	Quality	Channel	Strength	Frequency
1	IITH-1	7C:95:F3:74:A0:23	86 %	6	-92	2.437
2	IITH-Guest	7C:95:F3:74:A0:21	76 %	6	-92	2.437
3	IITH	7C:95:F3:74:A0:2F	73 %	44	-92	5.22
4	IITH-Guest	7C:95:F3:74:A0:2E	73 %	44	-92	5.22
5	IITH-1	7C:95:F3:74:A0:2C	70 %	44	-92	5.22
6	Test1	7C:95:F3:74:A0:2D	70 %	44	-92	5.22
7	IITH-1	7C:95:F3:74:BD:62	42 %	11	-75	2.462
8	IITH-Guest	7C:95:F3:74:BD:61	39 %	11	-76	2.462
9	IITH	7C:95:F3:74:A0:27	39 %	44	-76	5.22
10	IITH-Guest	7C:95:F3:74:A0:26	39 %	44	-76	5.22
11	Test1	7C:95:F3:74:A0:25	37 %	44	-77	5.22
12	IITH	DC:A5:F4:ED:F5:AF	23 %	64	-76	5.32
13	Test1	DC:A5:F4:ED:F5:AB	10 %	64	-81	5.32
14	eduroam	DC:A5:F4:ED:F5:AA	7 %	64	-88	5.32
15	IITH-1	DC:A5:F4:ED:F5:AD	7 %	64	-88	5.32
16	MAC-AUTH	DC:A5:F4:ED:F5:A9	7 %	64	-89	5.32
17	IITH-Guest	DC:A5:F4:ED:F5:AE	7 %	64	-82	5.32
18	IITH	DC:A5:F4:ED:F5:A7	0 %	64	-95	5.32
19	MAC-AUTH	DC:A5:F4:ED:F5:A1	0 %	64	-93	5.32
20	Test1	DC:A5:F4:ED:F5:A3	0 %	64	-96	5.32

Data Handling at Server

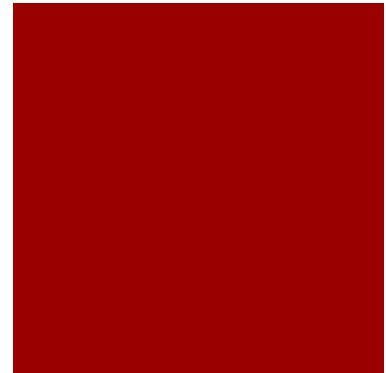
- Local Storage stores all the files containing relevant data sent by Pis
- Data analyzer analyzes the data contained in each file one-by-one and stores the information in the database
- Time Synchronization of Pis using NTP
- Performance analyzer queries the database for generating heat map and graphs



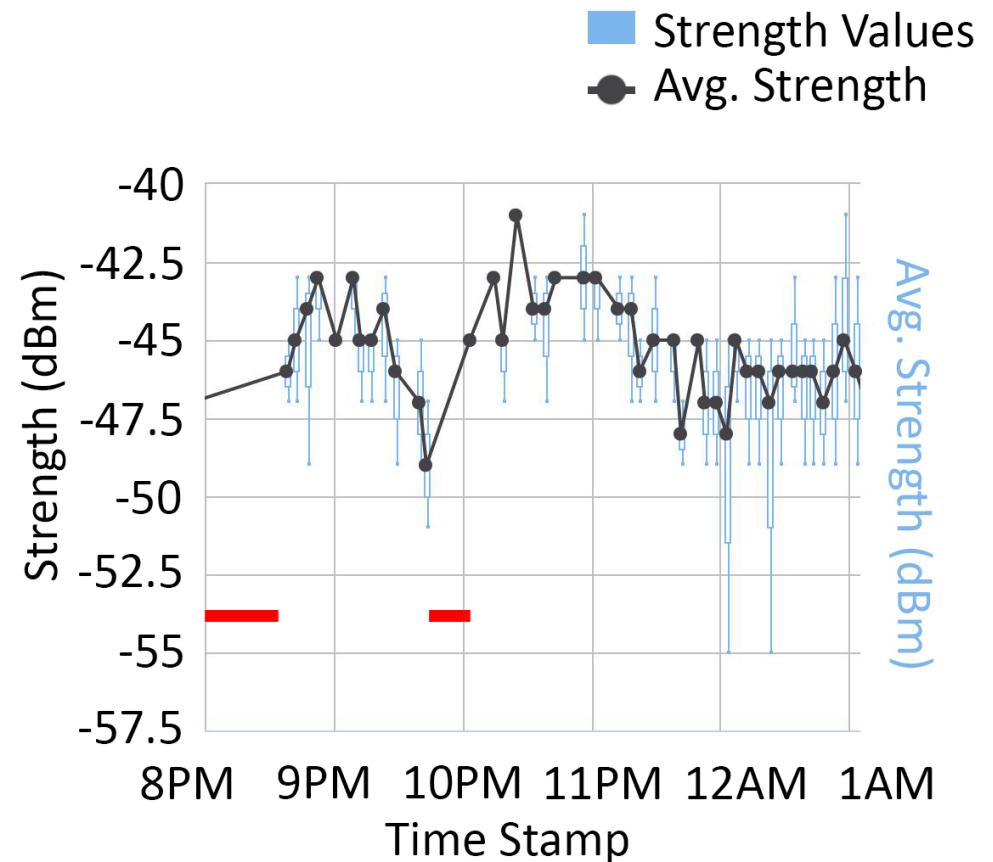
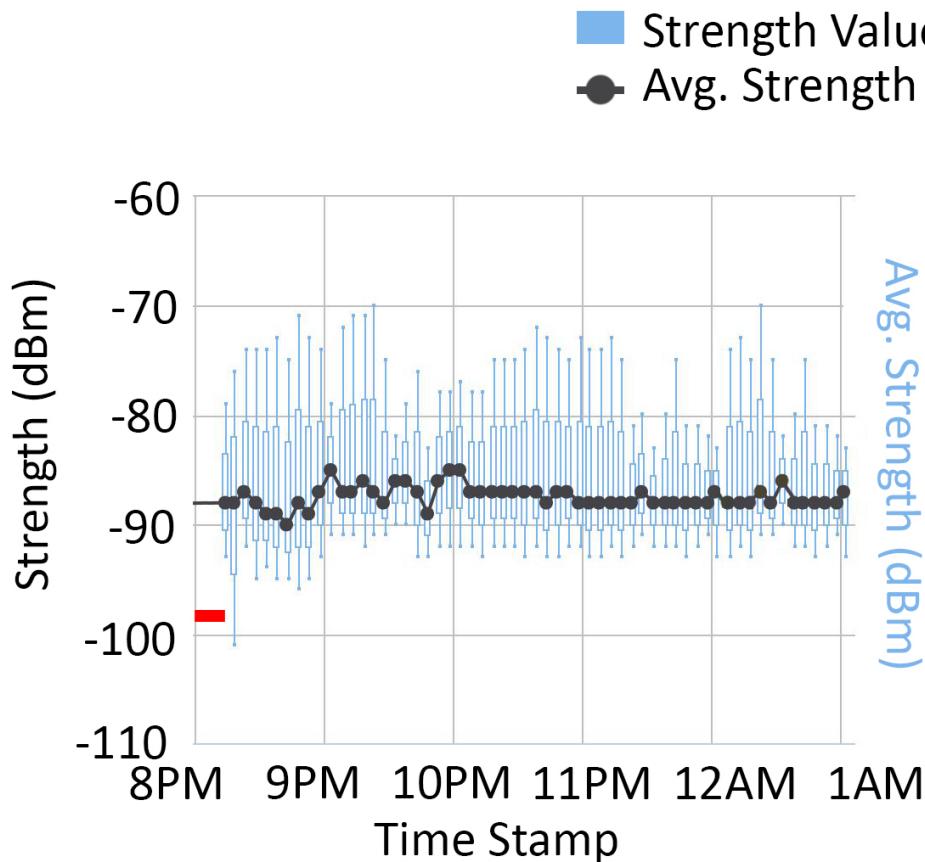
System Implementation

Device	HW Specs	SW Specs
Pi	<ul style="list-style-type: none">- Raspberry Pi (Type B)- Wi-Fi dongle and compatible drivers- 8GB Memory Card	<ul style="list-style-type: none">- Raspbian OS (version: July 2014)- SSH, SSHPASS, SCREEN - SCP packages- Python 2.7
Wi-Pi Server (VM)	<ul style="list-style-type: none">- 2GB RAM- 10GB storage space- 1 x CPU- 1GbE LAN Connection	<ul style="list-style-type: none">- Ubuntu 12.04.4 LTS- Apache Server- Python 2.7- MySQL connector module for python- SSH, SCREEN, SCP packages- Crontab

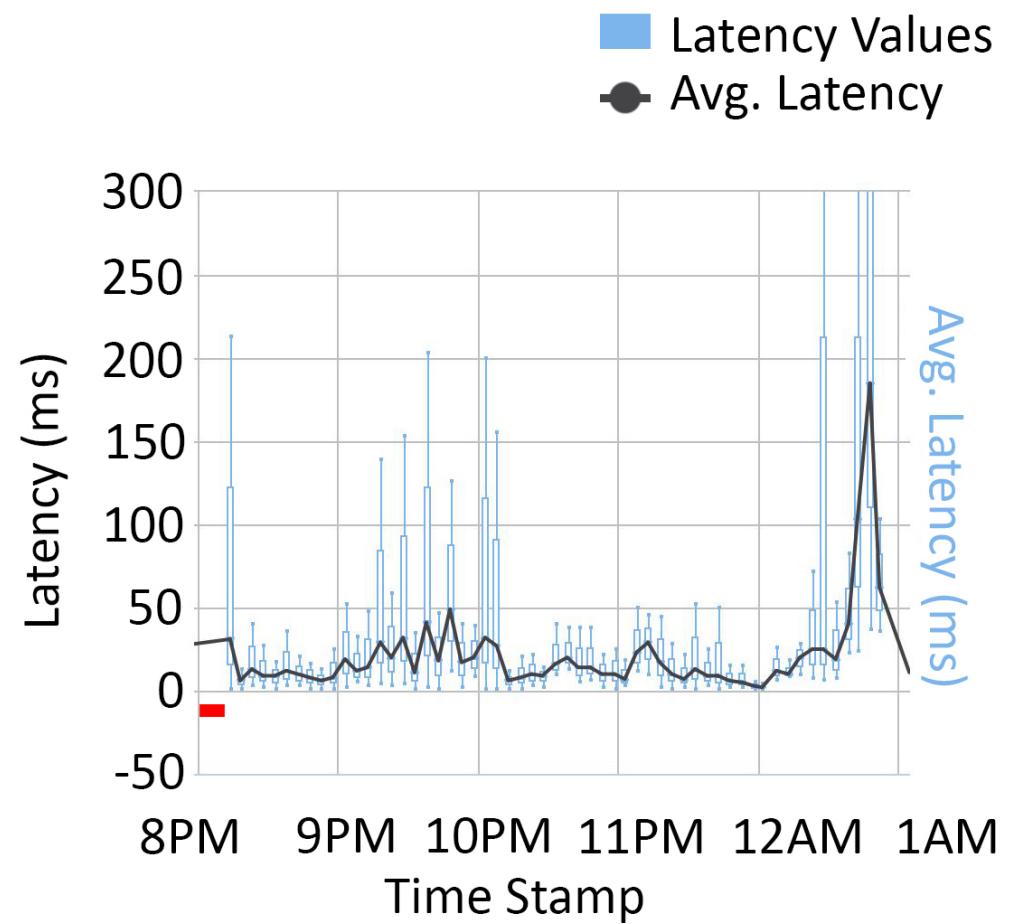
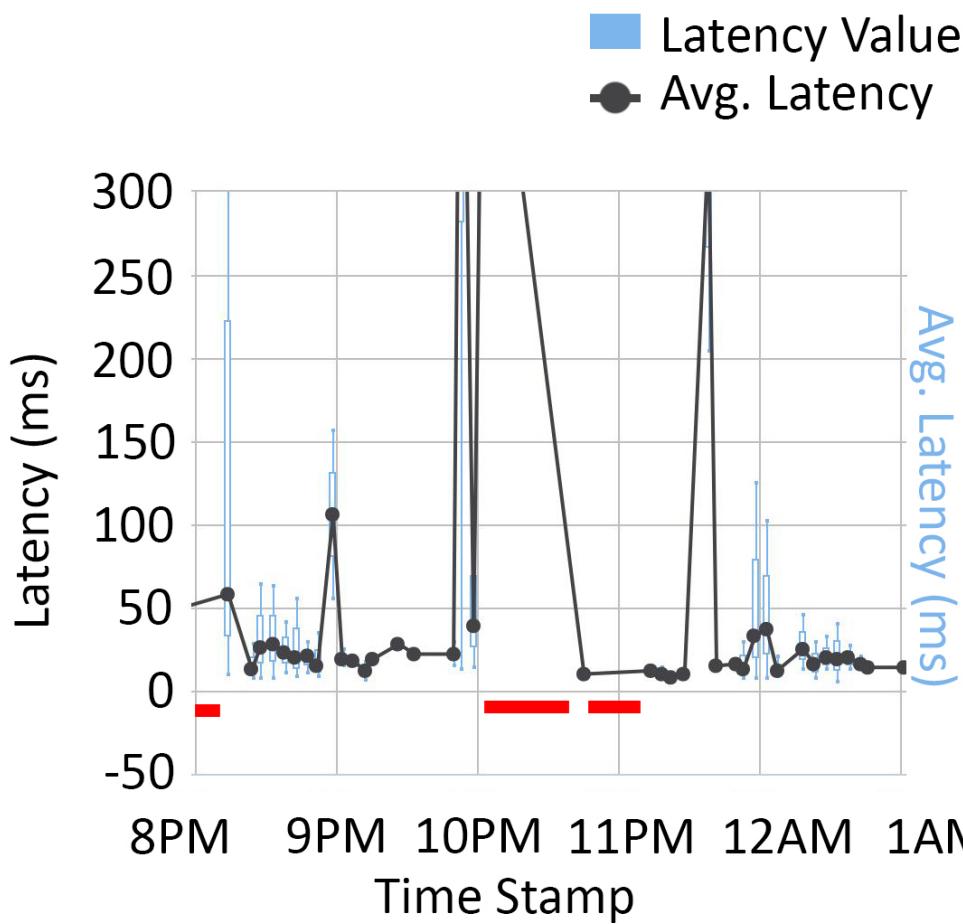
RSSI at two different APs, at the same time



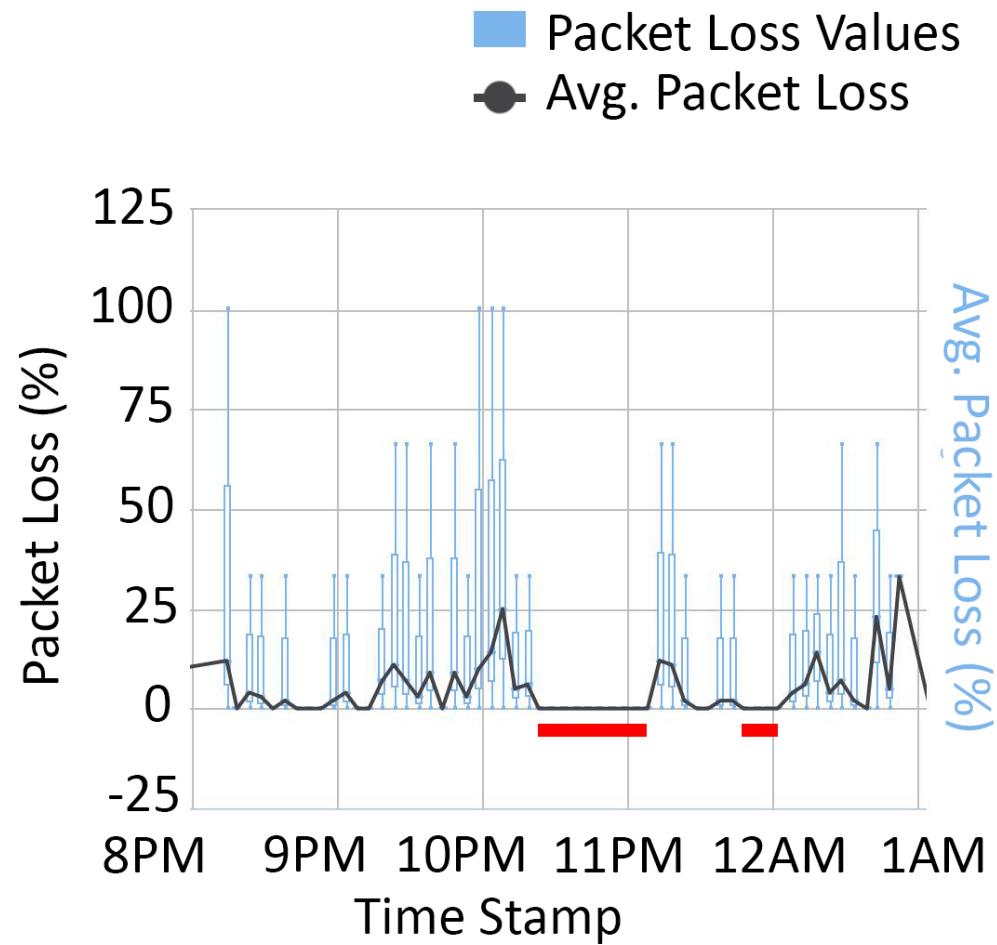
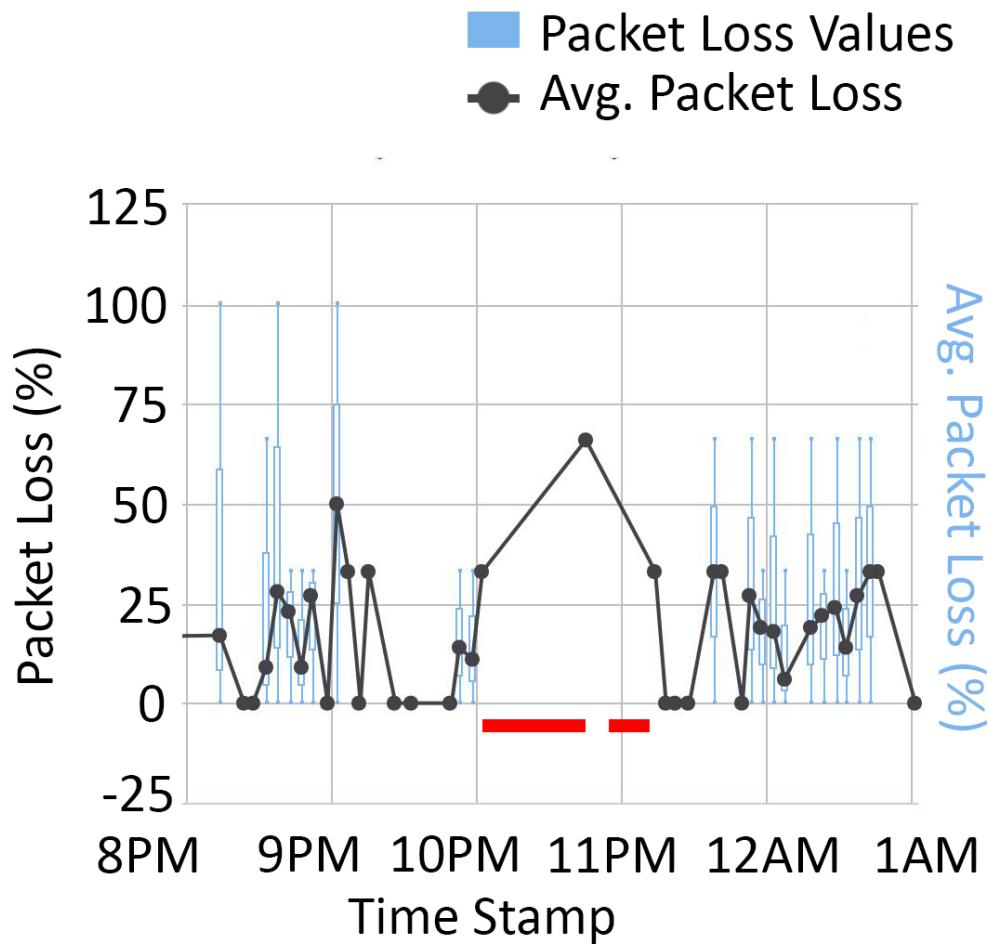
- Left: Low strength Right: High strength



RTT through two different APs, and at the same time

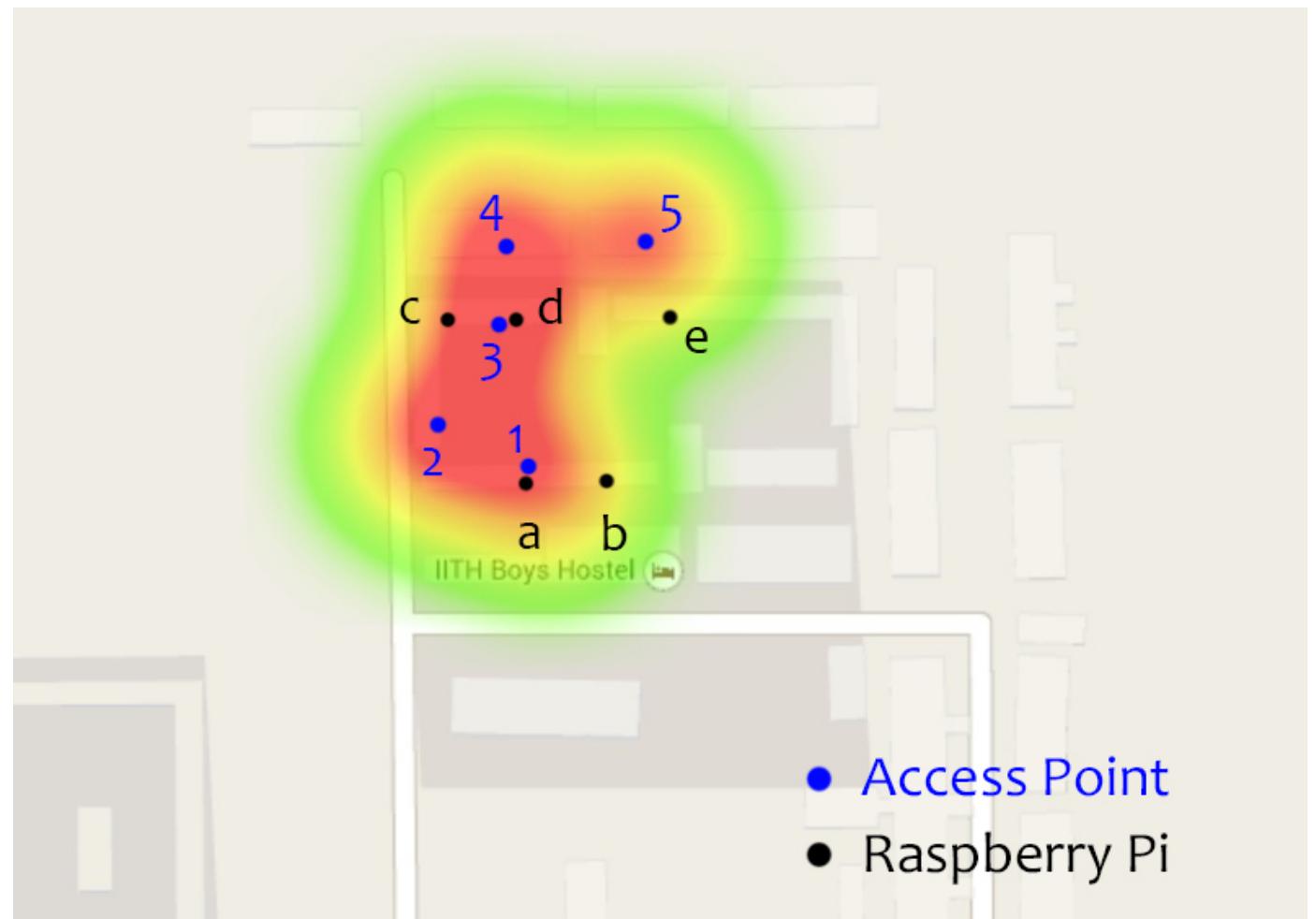


Packet Loss Rate through two different APs, and at the same time



Heat Map

- Simple FSPL
- Location of APs and Pis
- Too optimistic?



Discussions

- Good places to deploy Pis?
 - Reported points having poor quality?
(knowing cold places and their reasons)
 - Target locations in classrooms, canteen, hostel rooms and faculty cabins
 - Pathways in daily life
- Ready-made Wi-Pi OS image is available for clients
- FSPL is very basic one for plotting heat maps
 - Feeling like over-estimating the result
 - Need to improve accuracy

Conclusion and...

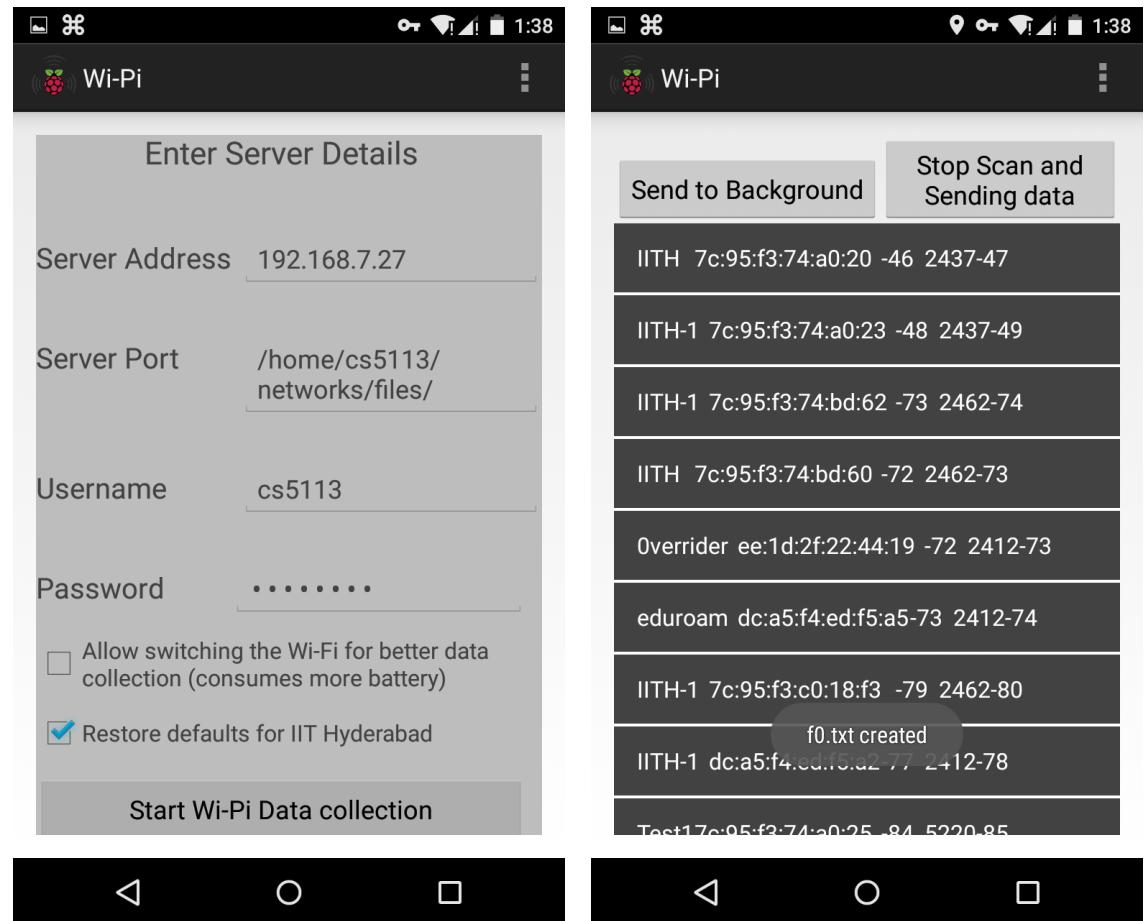
- Wi-Pi: a simple, static and cost efficient method of assessing Wi-Fi performance
 - Actual feedback from Wi-Fi client
 - Raspberry Pis: Low cost devices that used for carrying out computations
 - Can be customized easily to capture extra information like environmental information
- Small deployment in IIT Hyderabad campus Wi-Fi
 - Admin panel to locate and identify APs and Pis
 - Generating geographical heat maps
 - Visualization of RSSI, packet loss rate and RTT
- Making Wi-Fi performance assessment low-cost, continuous, doable and available

Future Work

- Improving visualization
 - Time-shift feature for animate heat map
 - Awareness of floors: Location including altitude or floor
- Improving accuracy of measured signal strength
 - Consideration to reflection and absorption of signals
 - Walls and other obstacles
 - Supporting CAD file?
- And some more but how?
 - More parameters like number of clients at each AP
 - Expanding the coverage
 - Reducing the cost aggressively

Wi-Pi Client as Mobile App

- Exporting Pi to Android
 - Can go where Pi can't go
 - Naturally location aware
 - Zero-cost client
- Implementation is ongoing





Thank you. Q&A