Wi-Fi NetMon :

Performance Observation, Anomaly Detection & Diagnosis in Long Distance Wi-Fi Networks

by

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under guidance of

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Outline

- Motivation
- Problem Statement
- Background
- Network Monitoring
- Wi-Fi NetMon Architecture
- Experiments for Performance Observation
- Possible Anomalies on link
- Anomaly Detection and Diagnosis
- Evaluation
- Related Work
- Take-aways

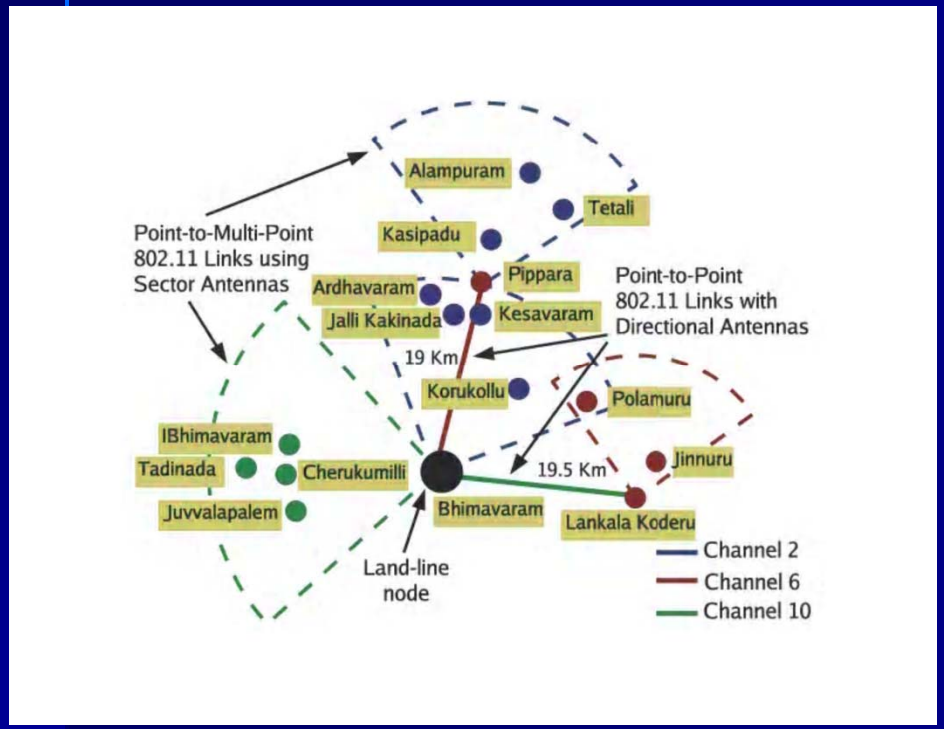
MOTIVATION

Motivation

Long Distance Wi-Fi Networks

- Providing network connectivity to rural areas at low cost
- Use of long distance Wi-Fi links
- Using off the shelf 802.11 equipments
- Using high gain directional and sector antennas
- Used for providing different services such as expert consultation, internet access etc.
- Some of the services require QOS
- Video conferencing requires at least 384 Kbps throughput

Motivation Contd....



Ashwini Network Deployment In Bhimavaram

- P2P links
- P2MP links
- Link length O(1 KM) to O(10 KM)
- Use of directional and sector antenna
- Land line internet connectivity at Bhimavaram

Motivation Contd…

- Difficult to conduct experiments on the links of long distance Wi-Fi networks.
- Poor results in experiments conducted on links of Ashwini Network deployment.
  - TCP and UDP throughput as low as 1Mbps with 802.11g.
- Problems listed in *Long Distance 802.11 Links: Performance Measurements and Experiences by K. Chebrolu, B. Raman and S. Sen* can be detected and corrected without visiting location of links.

PROBLEM STATEMENT

Problem Statement

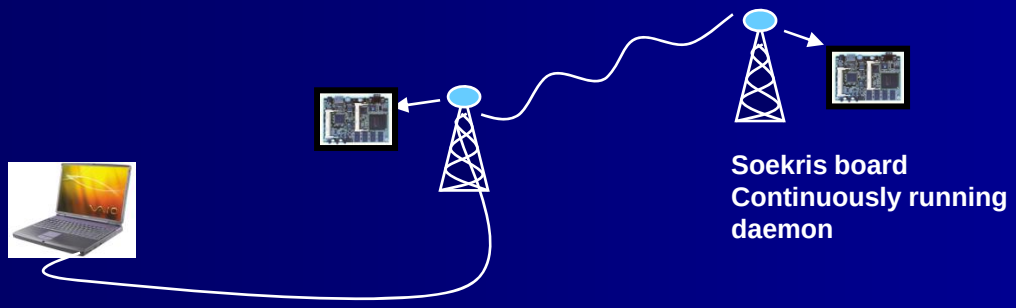
Design and Implement a Monitoring system for Long Distance Wi-Fi Networks which can

- help in conducting experiments from central location without going to location of links
- provide complete view of network at central location
- detect and diagnose the problems in the links of the network.
- rectify the problems, if possible, otherwise notify administrator.

BACKGROUND

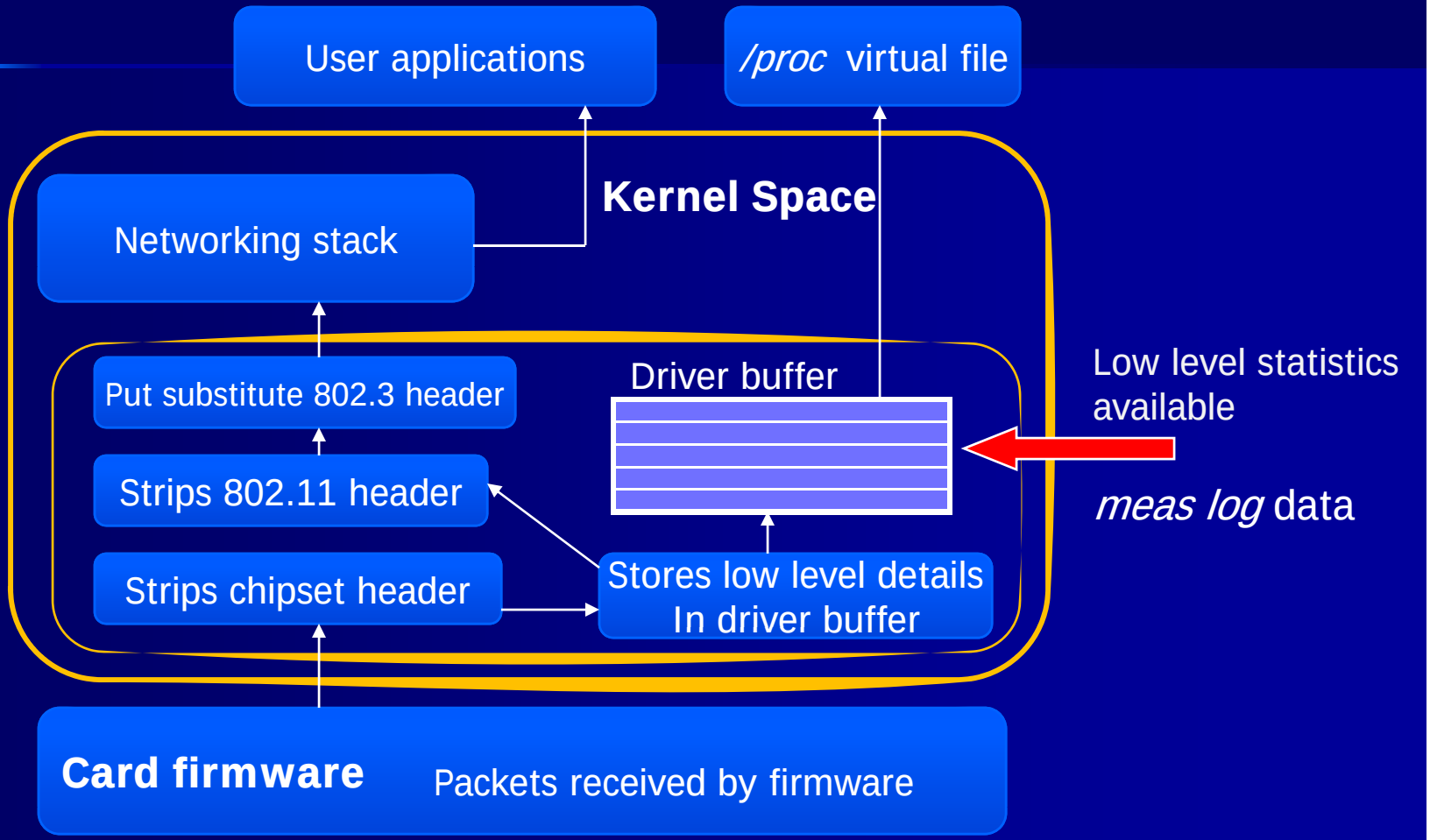
Background

- Rahul worked on a problem of running experiments between a link remotely



  - Experiment daemons running continuously at nodes.
  - Experiment parameters sent in form of xml document.

Background Contd...



Modification in Hostap driver

Image source: Defense Presentation by Akhilesh

NETWORK MONITORING

Network Monitoring

Design Choices:

- Active Monitoring

  Inject traffic in the link our self and observe performance.

- Passive Monitoring

  Observe performance without injecting traffic ourselves.

Network Monitoring Contd...

Other Dimension of design choices:

- Centralized
    1. Control remains at central node
    2. All decisions made by this central node
- Distributed

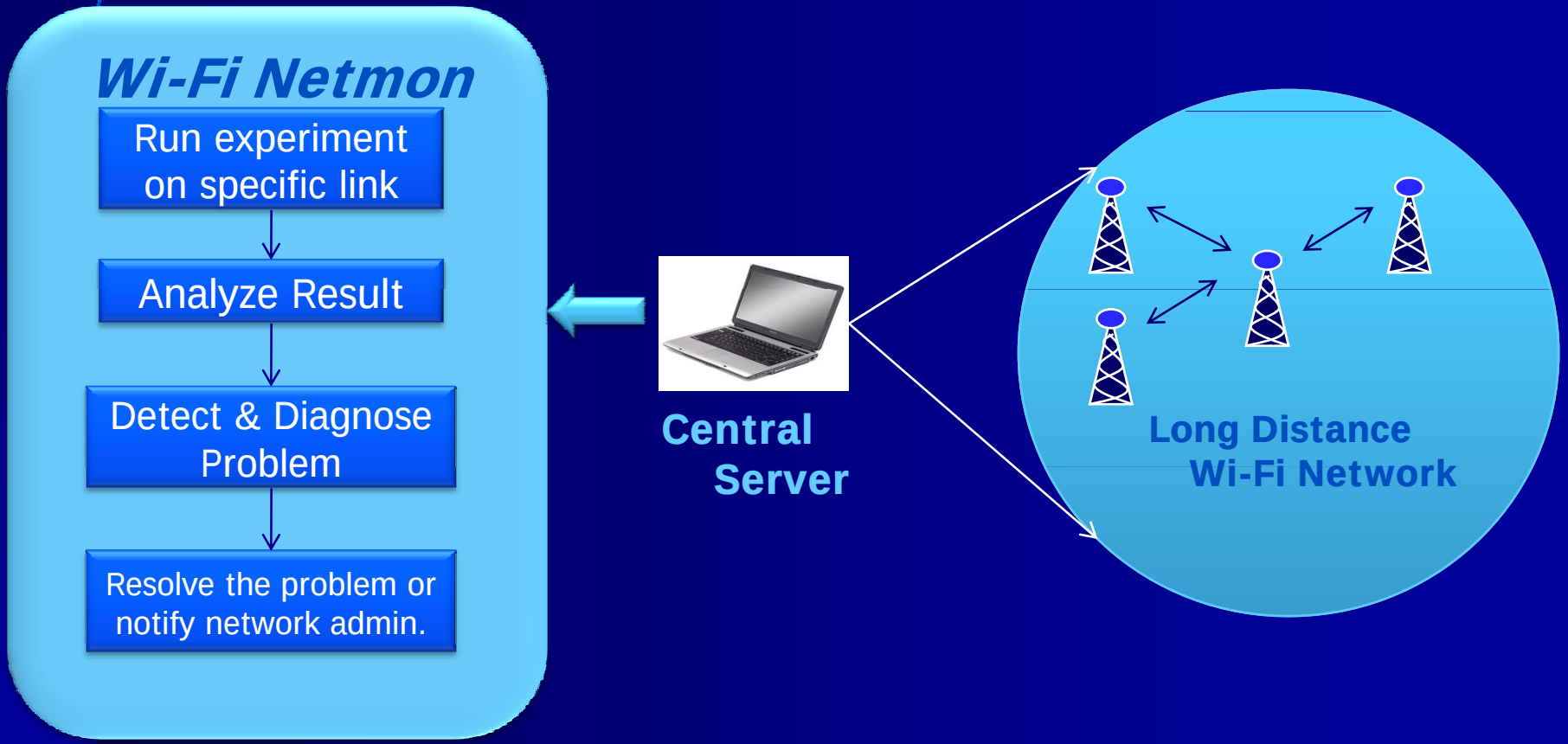
    Every node makes decision on its own

WI-FI NETMON ARCHITCURE

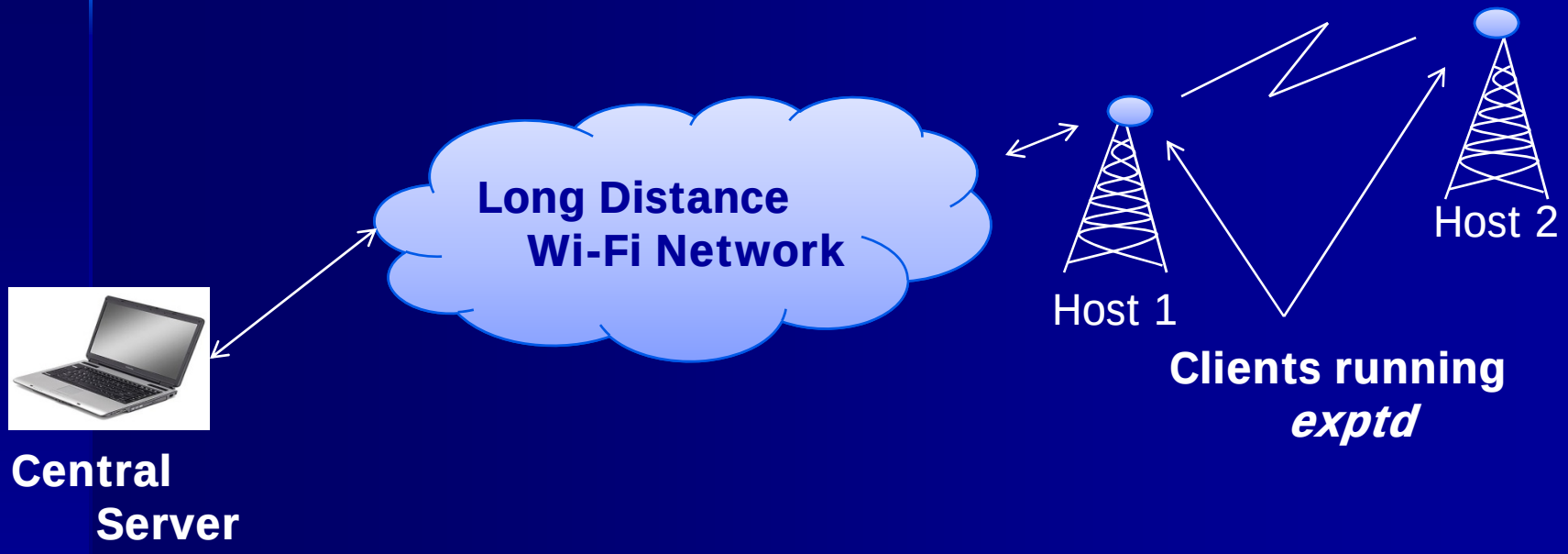
Wi-Fi NetMon Architecture

- Centralized Approach
- Client – Server Model
- One central node works as server
- All other nodes are client
- All decisions made by central server

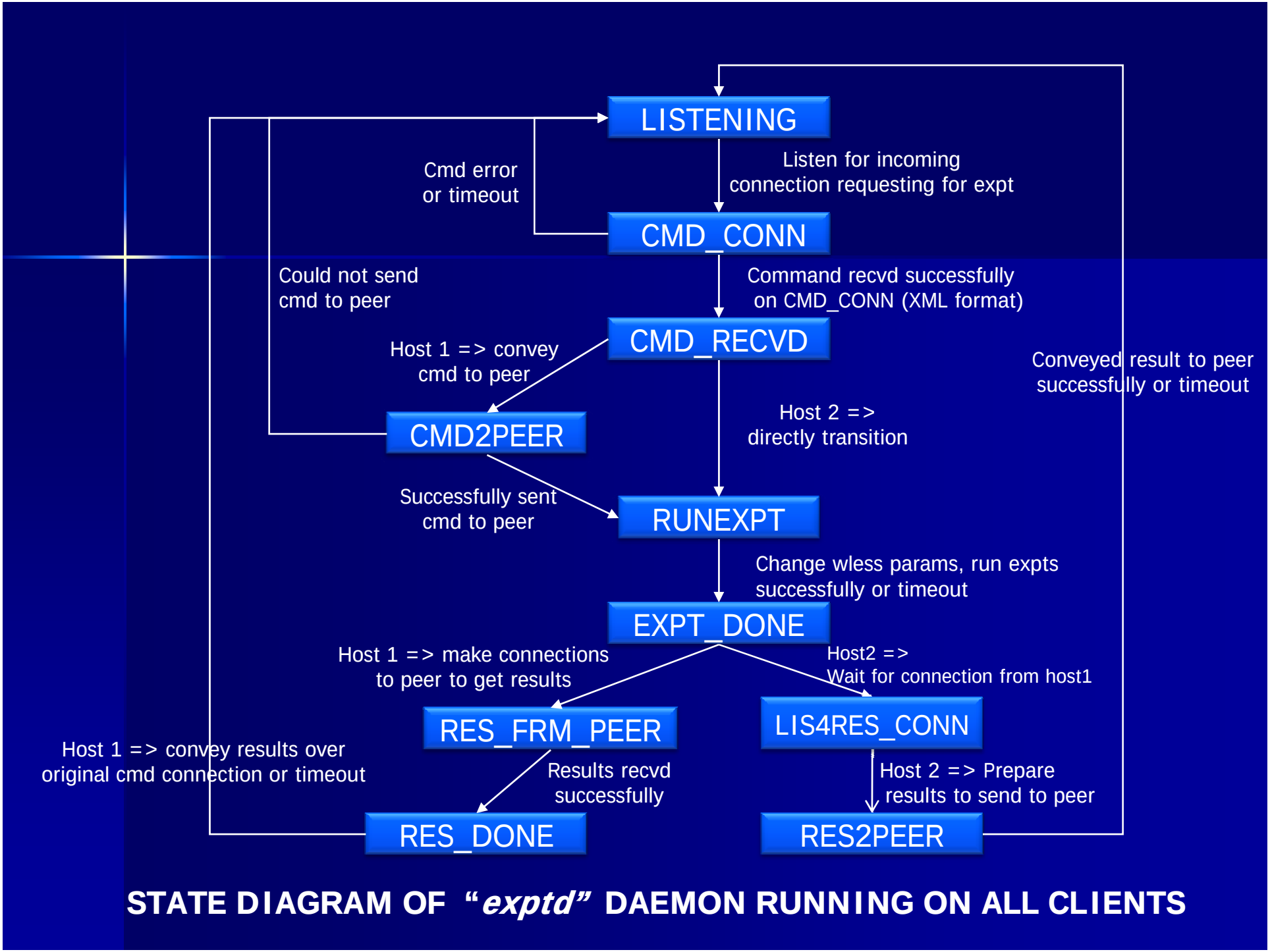
Wi-Fi NetMon Architecture Contd...



Wi-Fi NetMon Architecture Contd...



Function of Client-Server Model in Wi-Fi NetMon



STATE DIAGRAM OF "*exptd*" DAEMON RUNNING ON ALL CLIENTS

EXPERIMENTS FOR PERFORMANCE OBSERVATION

Experiments for Performance Observation

- Packet Error Rate
  - PER
  - Average RSSI, Average Noise
  - Monitor Mode:
    - MAC Addresses, Average RSSI, Average Noise
- UDP Throughput
  - UDP throughput achieved on a link in specified duration
- TCP Throughput
  - TCP throughput achieved on a link in specified duration

Experiments for Performance Observation Contd...

- Get Configuration
  - Retrieve value of different wireless parameters set on a link
  - Default configuration and current configuration
- Set Configuration
  - Set Value of different wireless parameters on a link as specified
- Parameters file maintained on all nodes
- Value of parameters always reflected in a file

POSSIBLE ANOMALIES IN THE LINK

Possible Anomalies on link

- Power Reset
  - Transmit power reset to default value
- Insufficient Transmit Power
  - RSSI at receiver is low
- Packet Dropping at Receiver
  - Processing Power of hardware not enough
  - Packets being dropped between hardware and driver

Possible Anomalies on link Contd...

- Interference
  - From Wi-Fi sources in vicinity working in same channel
  - From non Wi-Fi sources in vicinity
- Hardware Quirk
  - Even at high RSSI, packet error rate not zero
  - RSSI of CRC error packets are very low
- Link Misalignment
  - Antenna got misaligned

Possible Anomalies on link Contd...

- MAC level ACK timeout
  - Link length is very high
  - ACK timeout due to link length before packet reaches destination
  - Found only on longest link of length 37km

ANOMALY DETECTION & DIAGNOSIS

Anomaly Detection & Diagnosis

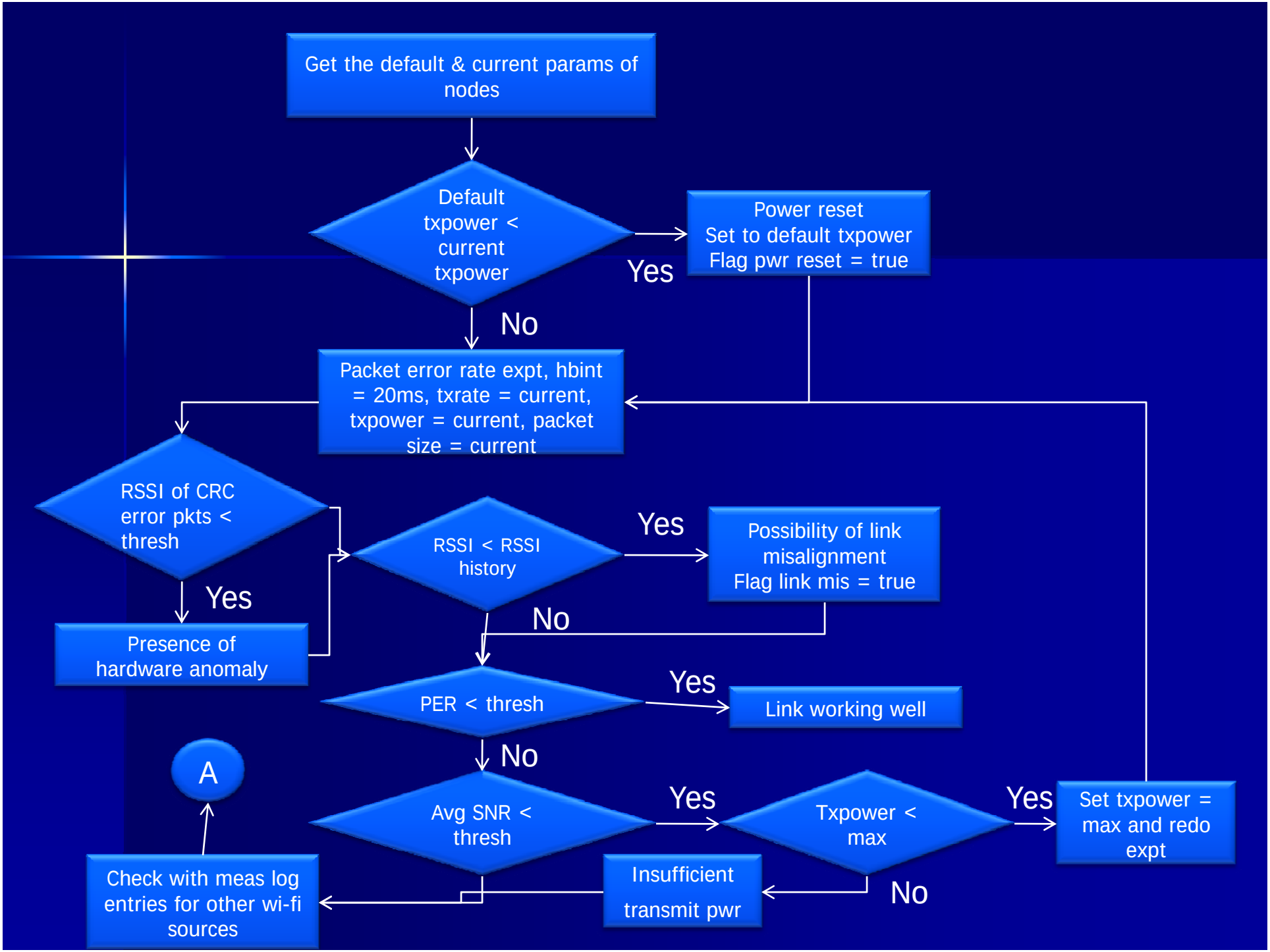
- Power Reset
  - Difference in current and default transmit power values.
  - Set back to default value
- Insufficient transmit power
  - Packet error rate with maximum transmit power
  - If PER with maximum transmit power is less than threshold then set transmit power to maximum.
- Interference from Wi-Fi sources in vicinity
  - Presence of other MAC addresses in results of monitor mode

Anomaly Detection & Diagnosis contd…

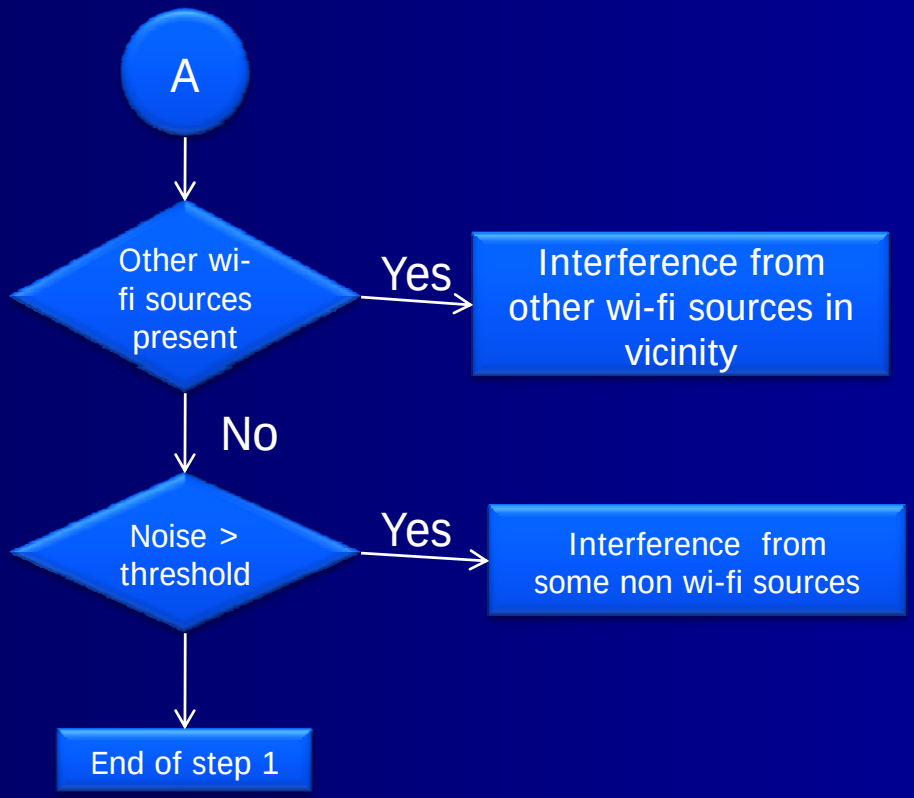
- Packet dropping at receiver
  - No. of packets received at meas log greater than no. of packets received at upper layer
- Link Misalignment
  - Maintain RSSI history at each node
  - If RSSI of packets received in PER experiment less than RSSI history than possibility of link misalignment
- MAC level ACK timeout
  - High no. of duplicate packets in meas log

Anomaly Detection & Diagnosis contd…

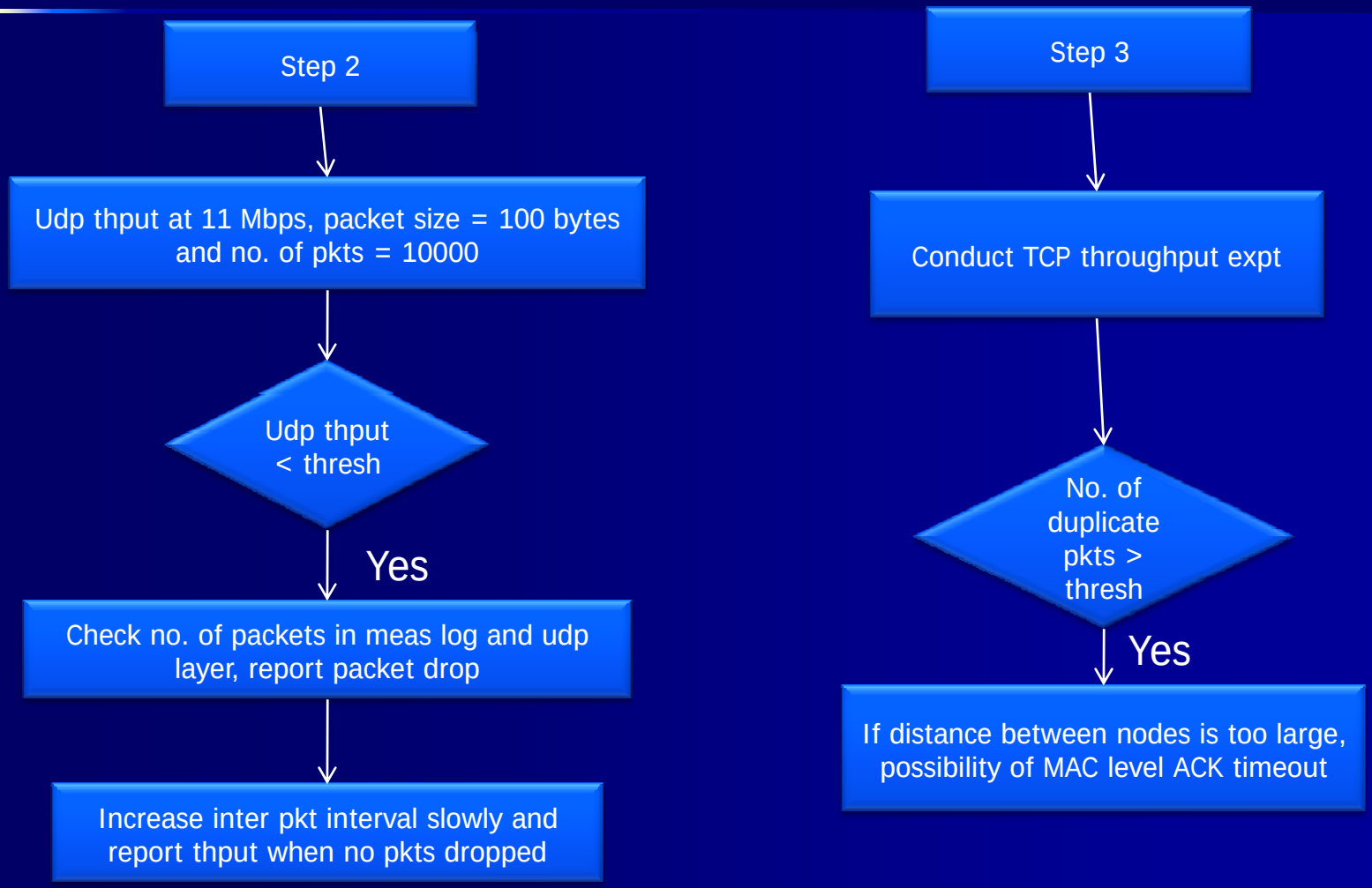
- Hardware Quirk
  - Check RSSI of CRC error packets
  - Hardware quirk present if RSSI of such packets very low


Get the default & current params of nodes
Default txpower < current txpower
Yes
Power reset
Set to default txpower
Flag pwr reset = true
No
Packet error rate expt, hbint = 20ms, txrate = current, txpower = current, packet size = current
RSSI of CRC error pkts < thresh
Yes
Presence of hardware anomaly
RSSI < RSSI history
Yes
Possibility of link misalignment
Flag link mis = true
No
PER < thresh
Yes
Link working well
No
A
Avg SNR < thresh
Yes
Txpower < max
Yes
Set txpower = max and redo expt
No
Insufficient transmit pwr
Check with meas log entries for other wi-fi sources

Anomaly Detection and Diagnosis Algorithm



Anomaly Detection and Diagnosis Algorithm Contd...



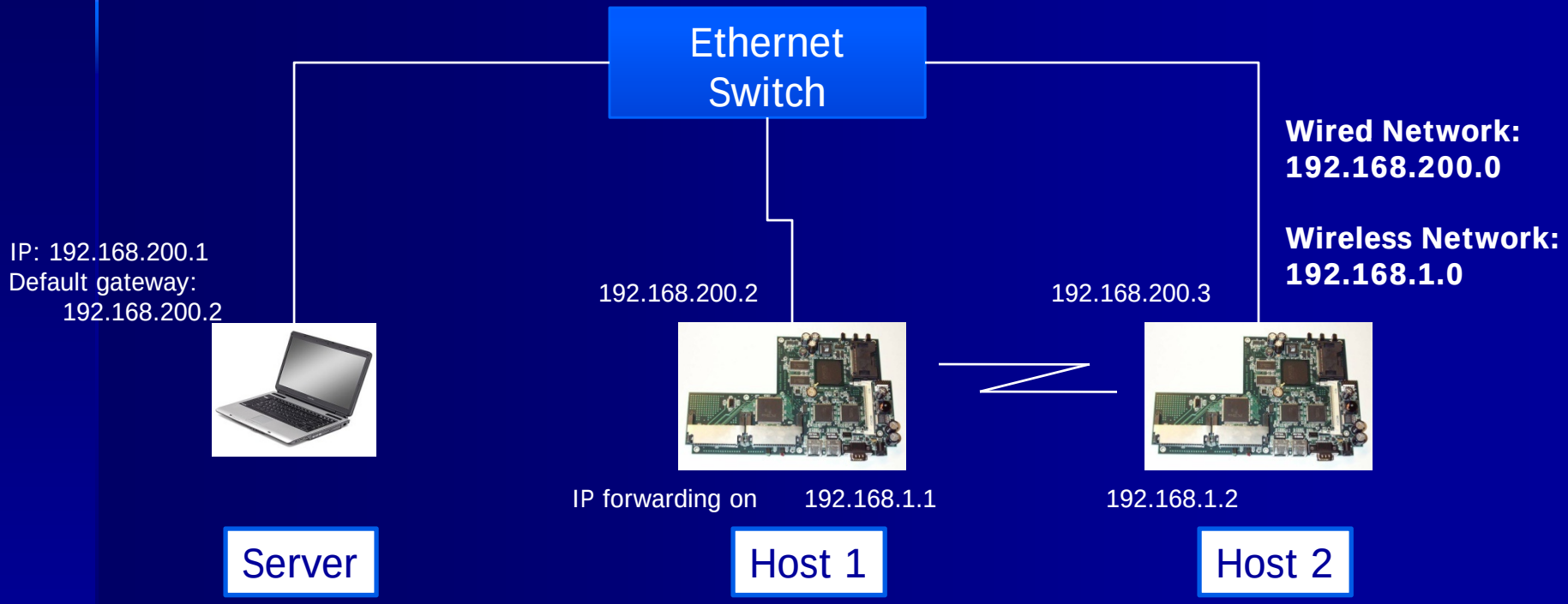
EVALUATION

Evaluation

Objective:

- Establish a wireless link in the lab
- Introduce anomalies in the link
- Detect and diagnose anomalies in the link through detection algorithm

Evaluation Contd...



Experiment Setup

Evaluation Results

- Power Reset
  - Set default transmit power to 20dBm
  - Vary current transmit power to various values
  - Power reset detected successfully in all the cases.

Evaluation Results Contd...

- Insufficient transmit power and link misalignment
  - Cover both soekris boards with thick clothes to attenuate the signal
  - Parameter values:
    - Mode : master – managed
    - Transmit power : -4 dBm
    - Inter packet interval : 20 ms
    - Packet size : 1400 B, no. of packets : 1000
    - Channel : 1,11
    - Transmit rate : 1, 2, 5.5, 11 Mbps
  - RSSI history set to -75 dBm

Evaluation Results Contd...

Parameters		Results							
Channel	Tx Rate	Default tx power				Insufficient transmit power	Max tx power		Link Misalignment
		RSSI (dBm)	Noise (dBm)	SNR	PER (%)		RSSI (dBm)	PER (%)	
1	11	-86	-96	10	7.78	Yes	-59	1.02	Yes
	5.5	-87	-94	7	6.65	Yes	-60	0.87	Yes
	2	-87	-95	8	32.67	Yes	-60	0.65	Yes
	1	-88	-96	8	29.50	Yes	-59	0.52	Yes
11	11	-87	-96	9	54.32	Yes	-60	0.71	Yes
	5.5	-90	-95	5	28.43	Yes	-60	0.40	Yes
	2	-90	-94	4	20.34	Yes	-61	0.52	Yes
	1	-90	-95	5	23.50	Yes	-61	0.84	Yes

Evaluation results for insufficient transmit power and link misalignment

Evaluation Results Contd…

- Both Link misalignment and insufficient transmit power detected successfully.
- Network administrator notified about the link misalignment.
- Transmit power set to maximum in presence of insufficient transmit power.

Evaluation Results Contd…

- Interference detection
  - Wi-Fi sources working in channel 6-11 in lab
  - Parameters:
    - Mode : master-managed
    - Transmit power: 20 dBm
    - Inter packet interval: 20ms
    - Channel: 1, 11
    - Transmit Rate: 1, 2, 5.5, 11 Mbps
  - Interference reported in channel 11
  - No interference in channel 1

Evaluation Contd...

Parameters		Results			
Channel	Tx Rate	RSSI (dBm)	PER (%)	Interference	Interferers (RSSI)
11	11	-56	4.6	Yes	A(-82), B(-85), C(-76), D(-86)
	5.5	-55	3.5	Yes	A(-85), K(-86), C(-76), G(-83), L(-88), M(-88), B(-91)
	2	-56	3.4	Yes	A(-85), B(-90), C(-75), G(-83)
	1	-55	0.8	Yes	P(-89), A(-83), B(-91), C(-75), G(-83)
1	11	-54	3.5	No	-
	5.5	-54	0.6	No	-
	2	-54	3.5	No	-
	1	-54	0.5	No	-

Evaluation results for interference detection

Evaluation Contd...

- Packet dropping at receiver
  - Packets are dropped when transmitting at 11 Mbps with very small inter packet interval
  - Parameters:
    - Mode: master-managed
    - Transmit power: 20 dBm
    - Transmit rate: 11 Mbps
    - Packet size: 100 bytes
    - No. of pkts: 10000
    - Channel: 1, 11
    - Inter packet interval: 0, 2, 4 ms

Evaluation Contd...

Parameters		Results				
Channel	Inter pkt interval	RSSI (dBm)	PER (%)	No. of pkts at UDP layer	No. of pkts at meas log	Packet drop detected (yes/no)
11	0	-51	86.58	1342	1496	Yes
	2	-52	33.04	6696	6025	No
	4	-51	0.01	9999	9458	No
1	0	-52	86.62	1338	1497	Yes
	2	-53	27.78	7222	6501	No
	4	-53	1.33	9867	9337	No

Evaluation results for packet dropping at receiver

RELATED WORK

WORK	NETWORK	METHODOLOGY	FAULTS CONSIDERED OR METRICS MONITERED	ARCH / SIMULATION / IMPLEMENTATION
MOJO	WLAN	Sniffers	➢Hidden terminal ➢Capture Effect ➢Signal Strength Variation ➢Noise	Architecture
VISUM	WLAN	AP	N/A	Architecture / Implementation
Arch and tech for diagnosing faults	WLAN	Client	➢Locating disconnected clients ➢Rogue AP detection	Architecture / Implementation
Troubleshooting WMN	WMN	Client	➢Pkt dropping ➢Link congestion ➢External noise ➢MAC misbehavior	Architecture / Simulation
Wi-Fi NetMon	Long Distance WMN	Client-Server	➢Power reset ➢Pkt dropping at receiver ➢Interference detection ➢Insufficient transmit power ➢Link Misalignment ➢MAC level ACK timeout	Architecture / Implementation

CONCLUSION
OR TAKE-AWAYS

Take-Aways

- Network monitoring tool for long distance Wi-Fi networks
- Centralized approach and client-server based model
- Decisions made by central server
- Performance related experiments: pkt error rate, UDP throughput, TCP throughput, get config, set config
- Anomaly detection and diagnosis for problems such as power reset, link misalignment, insufficient transmit power, interference detection, packet dropping at receiver, MAC level ACK timeout and hardware quirk

Take-Aways Contd…

- Power reset, link misalignment, insufficient transmit power and interference detected successfully
- Detecting packet dropping at receiver partially successful, bug found in code.
- No hardware quirk found in DLink cards
- Evaluation for MAC level ACK timeout not done

Questions ?