



Automated Root Cause Analysis in Wireless Networks

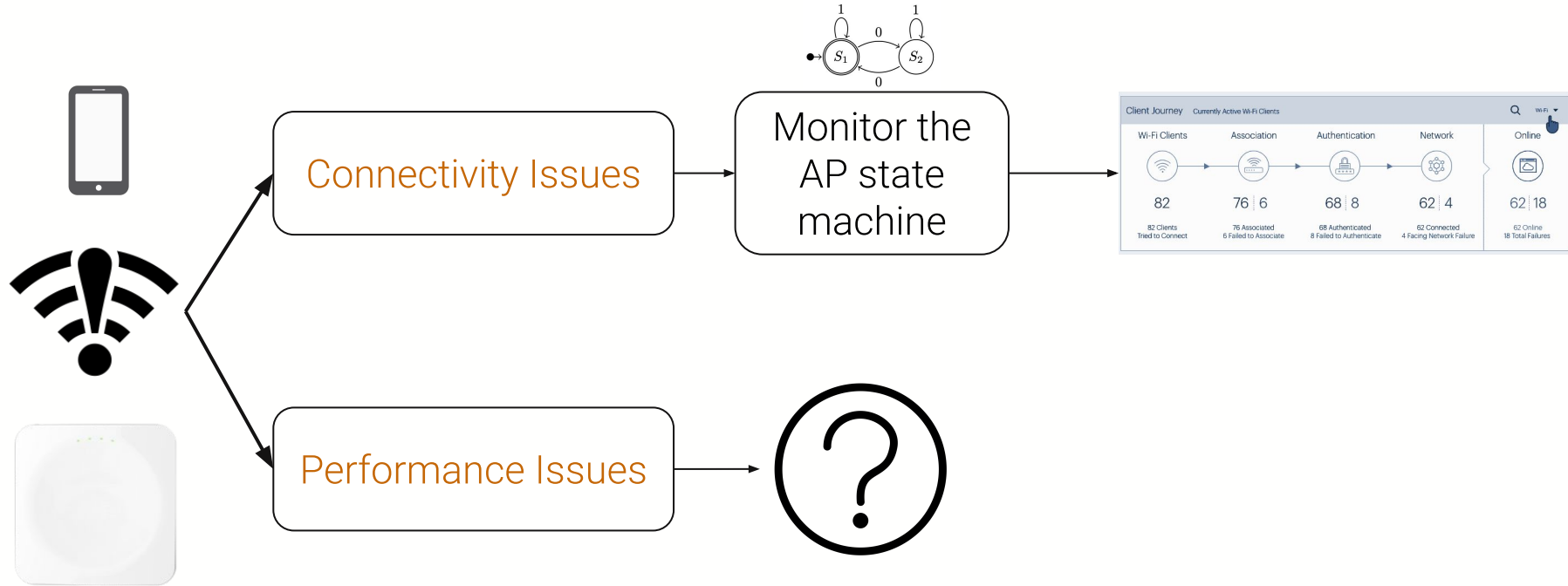
#WiFiDesignDay, 2020

Karan Gupta

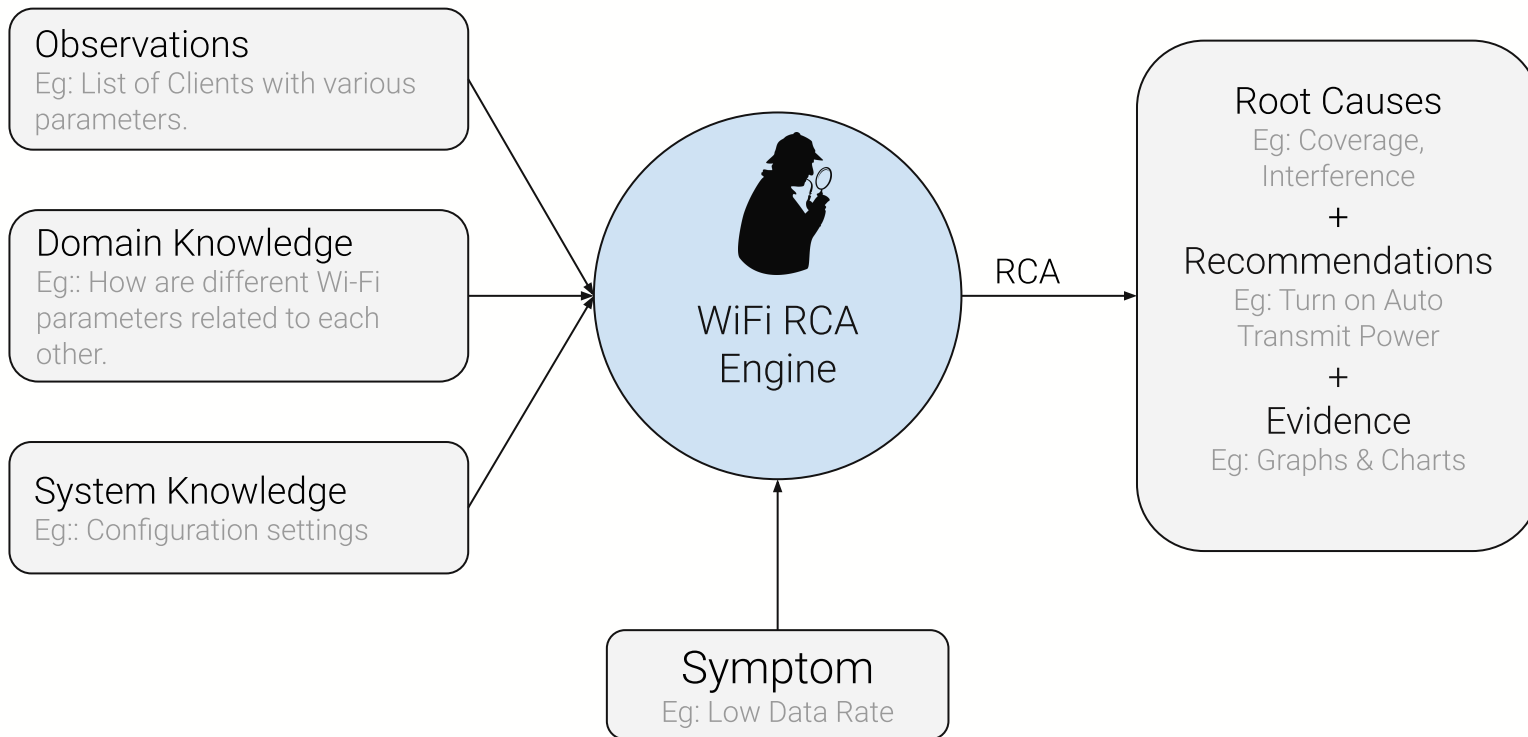
Manager, Software Engineering
Arista Networks

 @karanghz | karan.gupta@arista.com

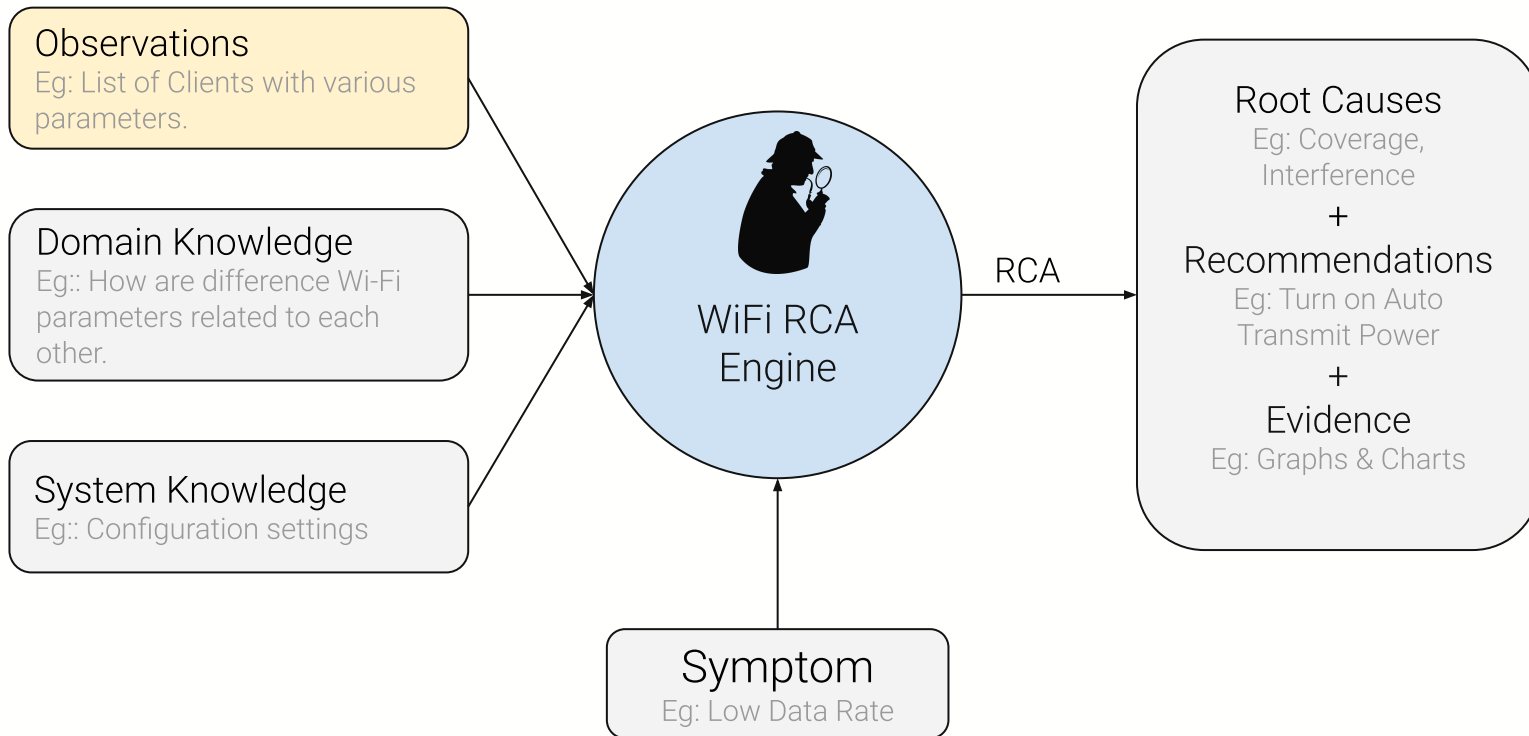
Why do we need Automated Root Cause Analysis (RCA)?



What is an RCA Engine?



For a detailed analysis of this space, please refer: ['Survey on Models and Techniques for Root-Cause Analysis'](#).



Observations



Network level RCA: A list of *all* the clients along with their respective Wi-Fi parameters.

Single Client RCA: All parameters of the client.

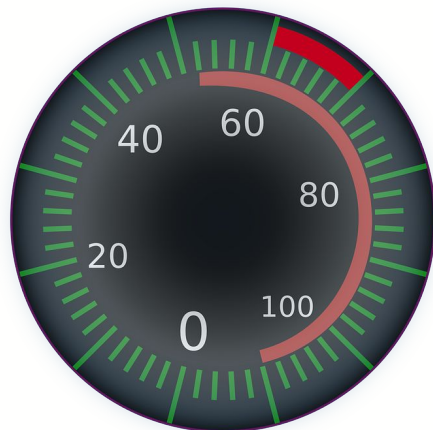
Client MAC	High Retry Rate	Low RSSI	Capability Issue	Sticky	Poor Coverage	High Contention	Interference	Band Issue	Location	Vendor / OS	AP	SSID	Low Data Rate
...	Yes
...	No
...	No
...	Yes
...	Yes
...	No

Observations - More about Client Parameters

For simplicity we consider each performance parameter to be a boolean flag. The value of the flag is determined by the system.

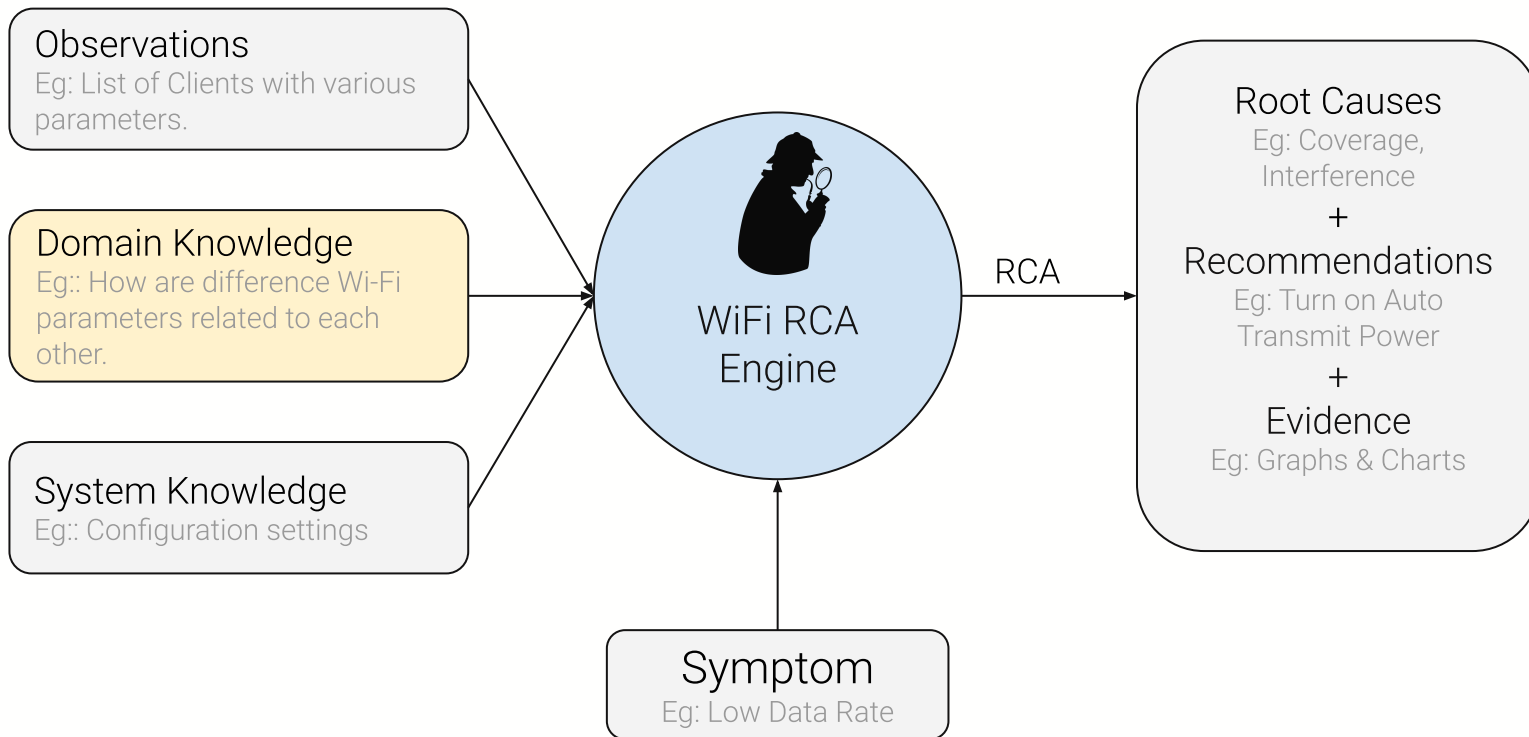
PERFORMANCE PARAMETERS

Low Data Rate
High Contention
Client doesn't support 5GHz band
WiFi Interference
Poor Coverage
Low SNR
....

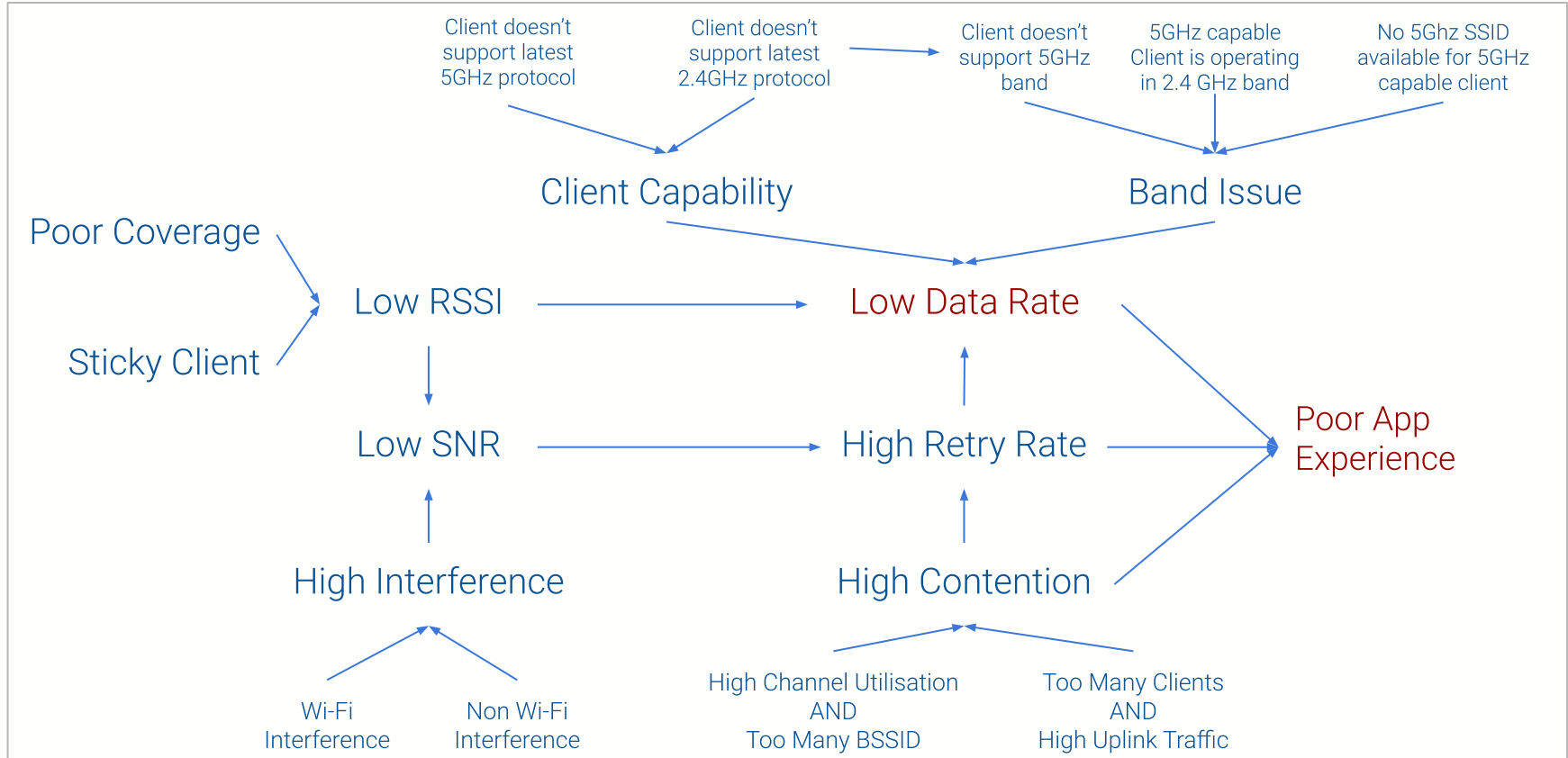


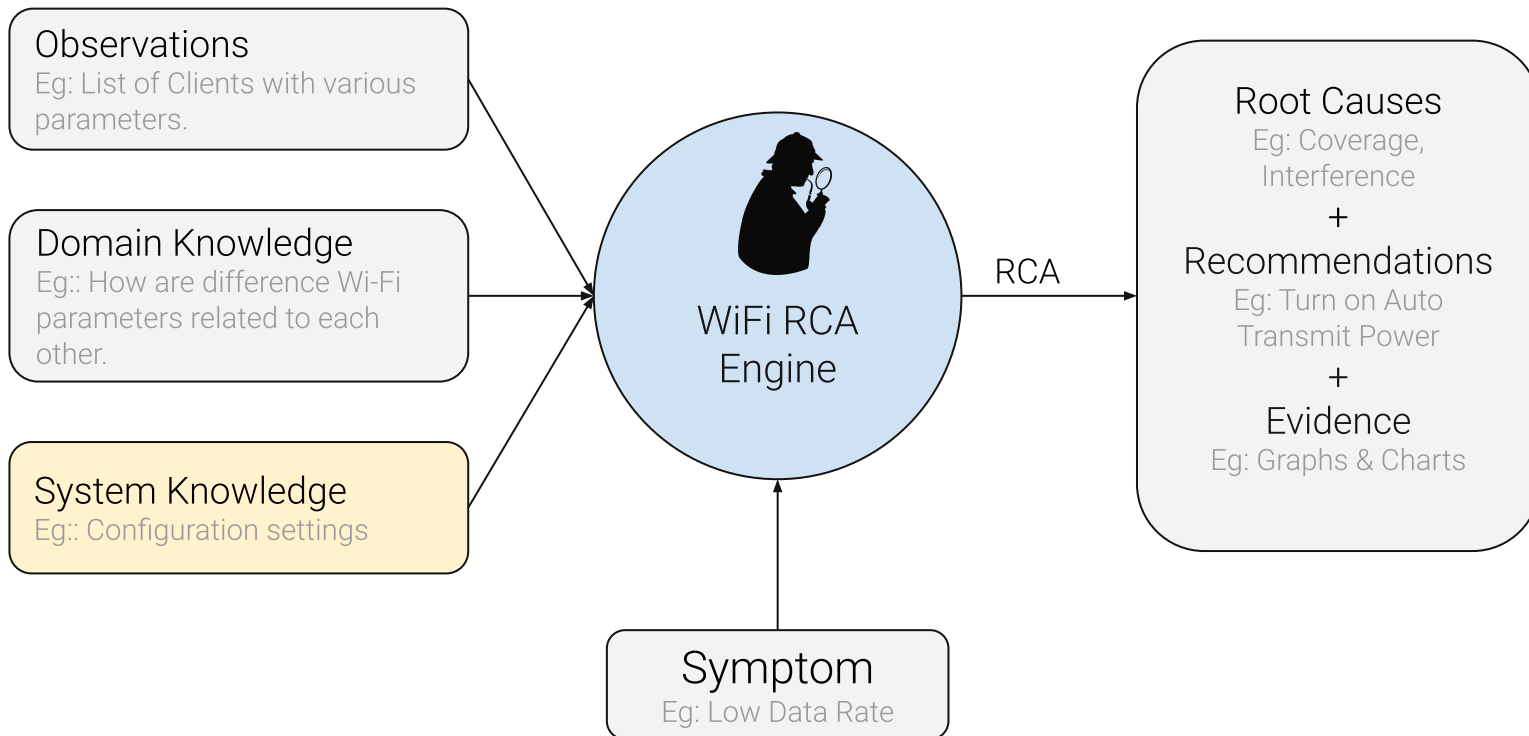
OTHER PARAMETERS

Location
Vendor
OS
AP
SSID



Domain Knowledge



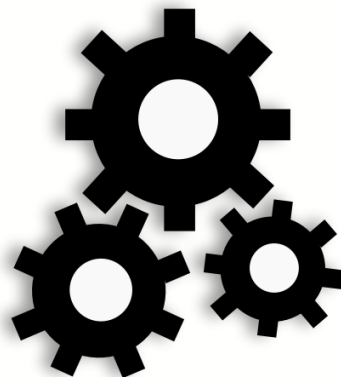


System Knowledge

Parameters that capture the state of the Wi-Fi system.

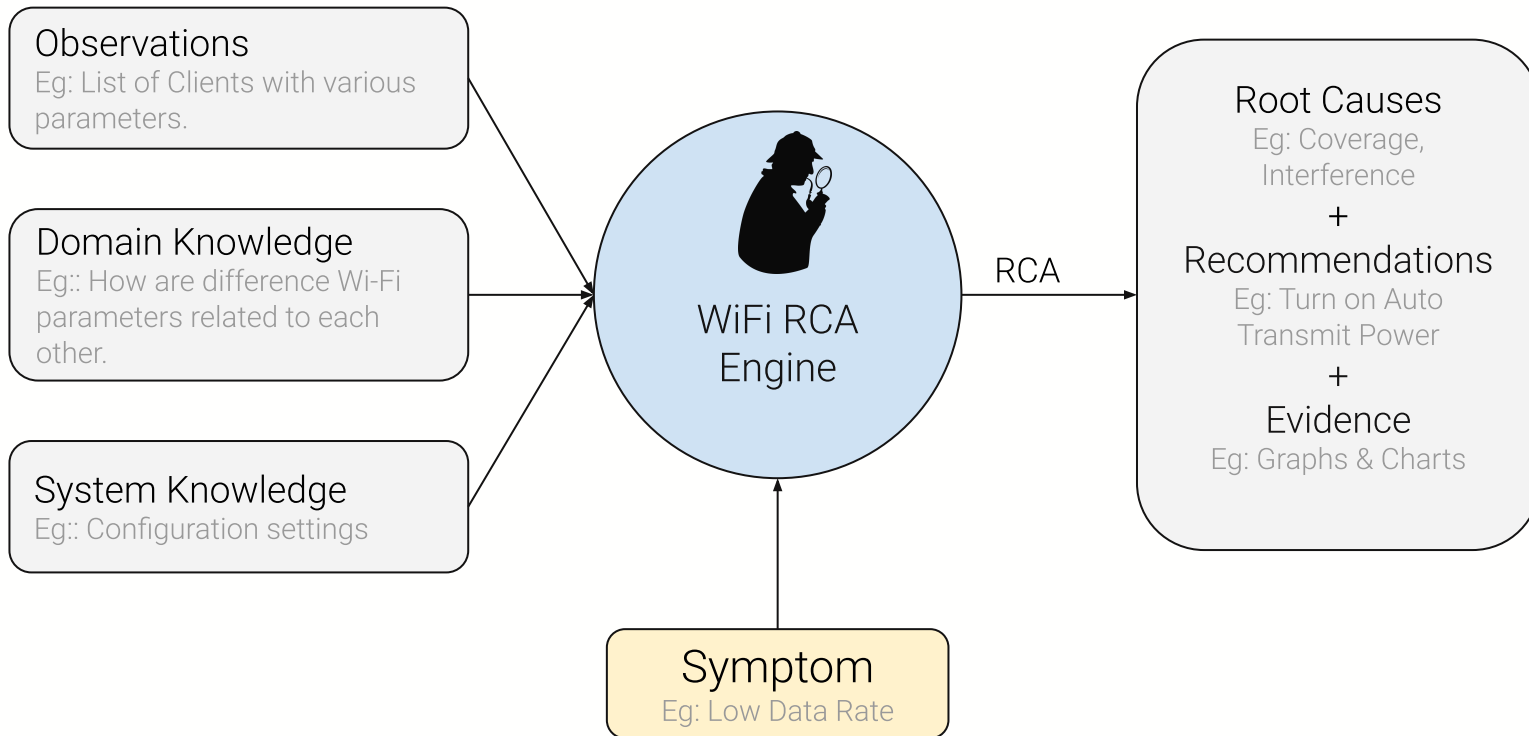
CONFIG PARAMETERS

Is Auto Transmit Power on?
Is DCS on?
Is Captive Portal on?
Is 5Ghz being used?
...
...



OTHER PARAMETERS

Location Tree
AP List
...
...



Symptom(s)

“A Symptom is an external manifestation of failures^{}. This includes direct observations of failures themselves and externally visible indicators that a failure happened that are not failures themselves, like alarms raised by anomaly detectors”.*

In case of Wi-Fi, we can define the following *Symptoms*:

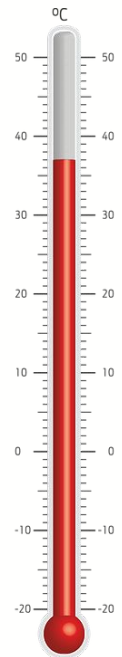
- **Poor App Experience**

This is true if a client is experiencing sub-optimal app experience for one or more apps.

- **Low Data Rate**

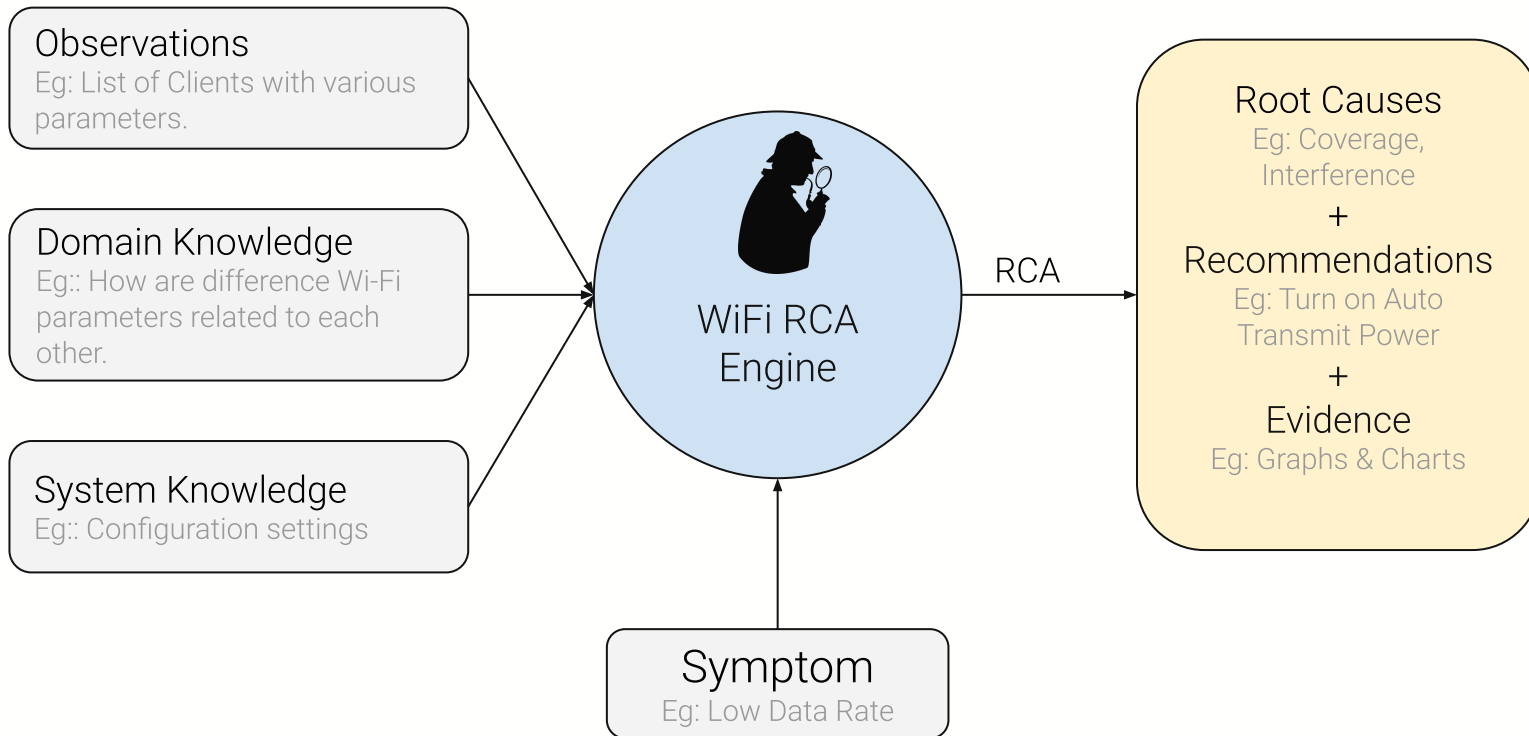
This is true if a client is operating at a data rate less than the expected value.

The RCA engine is supposed to look at the observations and infer which of the many root causes are responsible for one or more of the above symptoms.

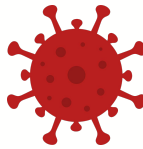


^{*} A Failure is an Error^{**} that is observable from outside the system.

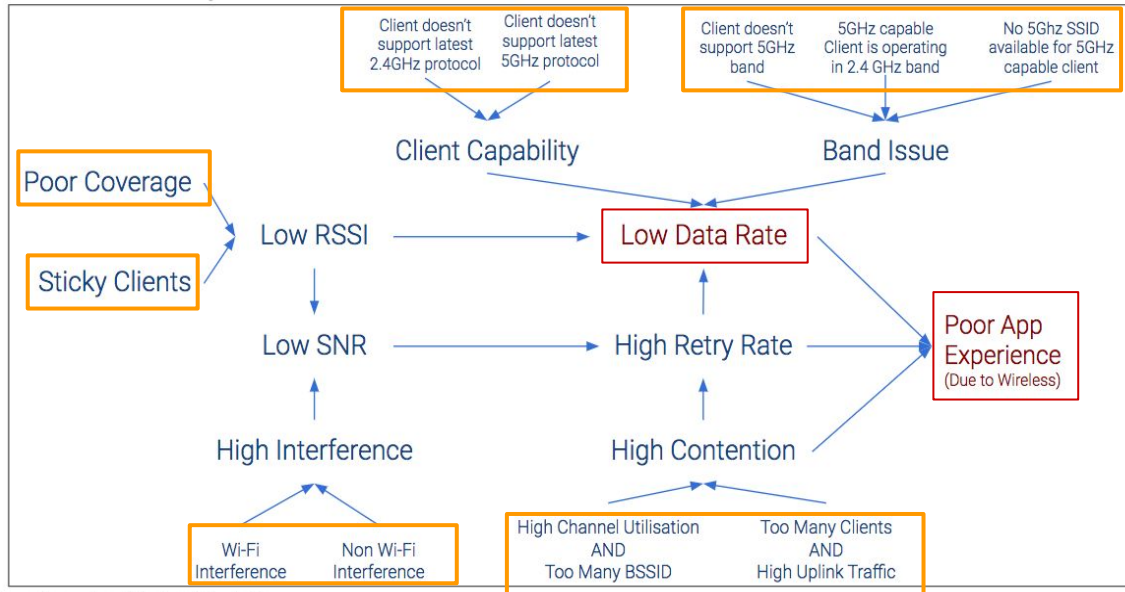
^{**} An Error is caused by one or more faults and is the discrepancy between a condition of the system and its theoretically correct condition.



Root Causes



“Root Causes are events* that can cause other events but are not themselves caused by other events.”



Additional root causes:

Location
Vendor
OS
Access Point

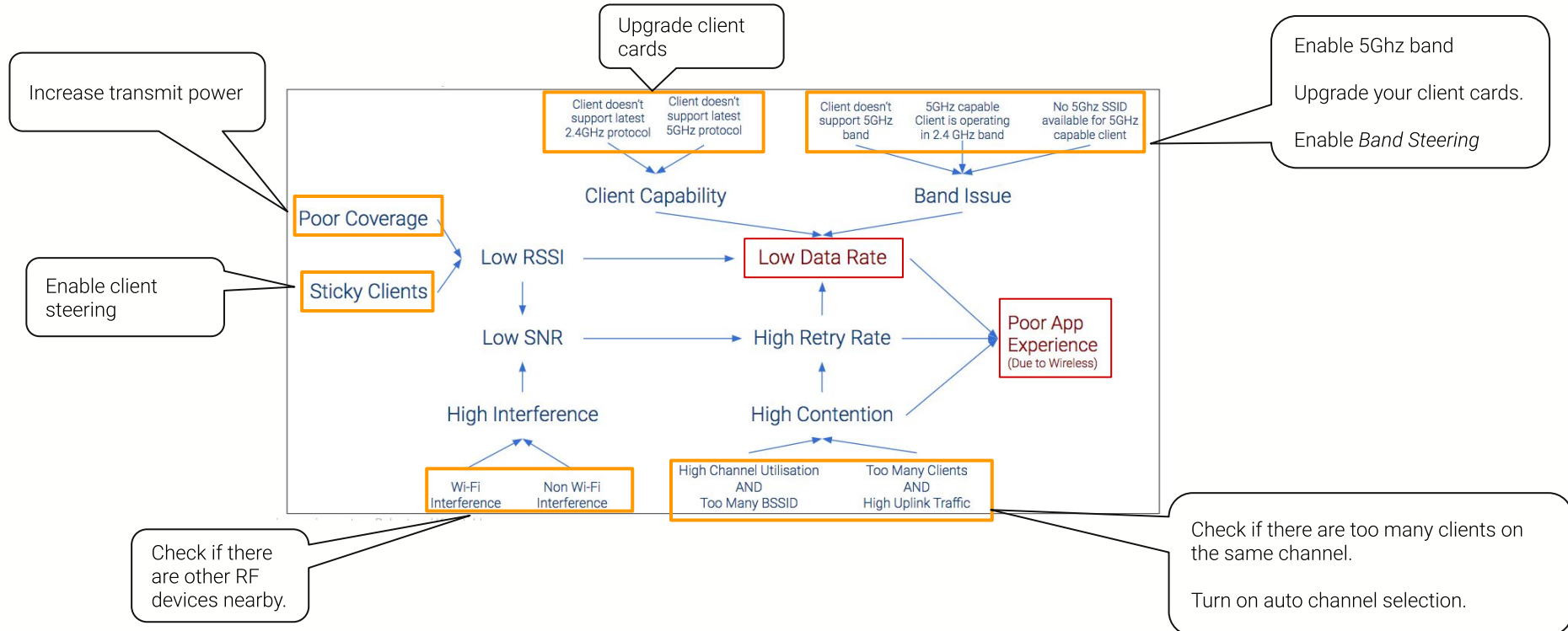
Though these are not *root causes* in the true sense of the term, treating them as root causes can result in valuable analysis.

For example, it can be useful to know if *Symptom* is seen mostly at a specific location or with a specific vendor

* Event is an exceptional condition occurring in the operation of a system (refer [this paper](#).)

Recommendations

Recommendations are actions suggested by the system that can help the user mitigate the *Root Cause*.



Types of RCA Engines



SINGLE CLIENT

RCA is done for each client individually

The number of features can be more than those for the MULTI-CLIENT version.

Useful when debugging an issue with a specific client

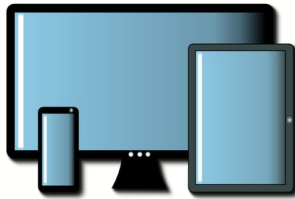


MULTI CLIENT

RCA is done across a list of clients connected to the network

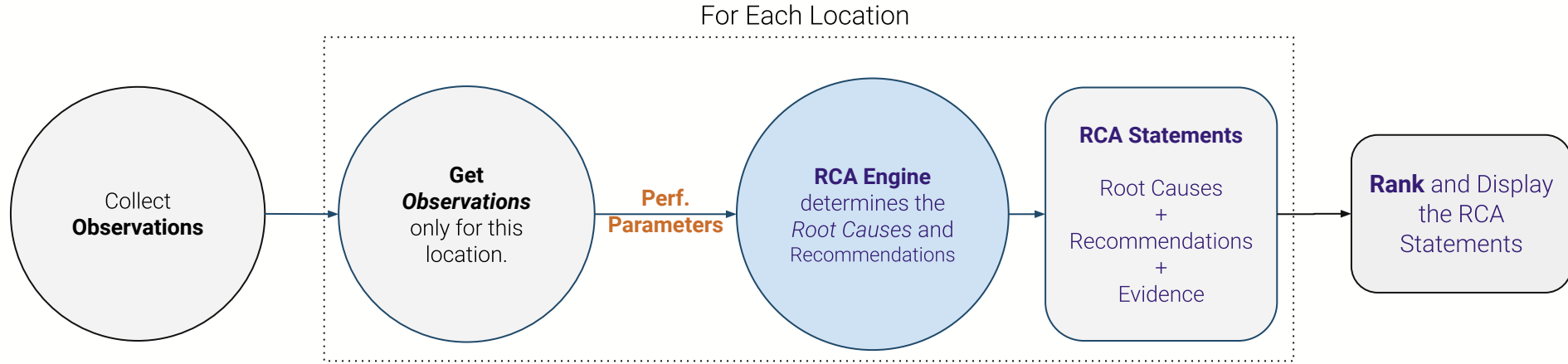
The number of features are limited. Location is a very important feature here.

Useful when debugging a network wide issue



Multi-Client RCA Engine

RCA Process



Using Decision Tree Algorithm for Root Cause Analysis

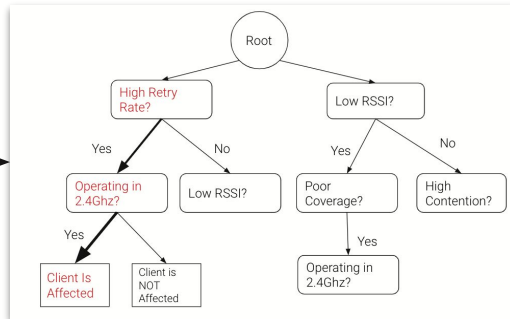
Data

(Observations: All Clients)

Features				Target
High Retry Rate	Non-Wifi Interference	...	TCP/	Low Data Rate
...	...	...	...	True
...	...	...	...	True
...	...	...	...	False
...	...	...	...	False

Train a Decision Tree Model

Decision Tree



Read the Generated Decision Tree

RCA Statements

This RCA approach is based on the heuristics mentioned in the following paper: ['Failure Diagnosis Using Decision Trees'](#)

Data (Observations)



A list of **all the clients** along with their respective Wi-Fi parameters.

	Features (Root Causes)							Target (Symptom)
Client MAC	Sticky	High Contention	Interference	High Retry Rate	Capability Issue	Poor Coverage	...	Low Data Rate
...	Yes			...	Yes
...	No			...	Yes
...	Yes			...	Yes
...	No			...	Yes
...	Yes			...	No
...	No			...	No
...	Yes			...	No
...	No			...	No

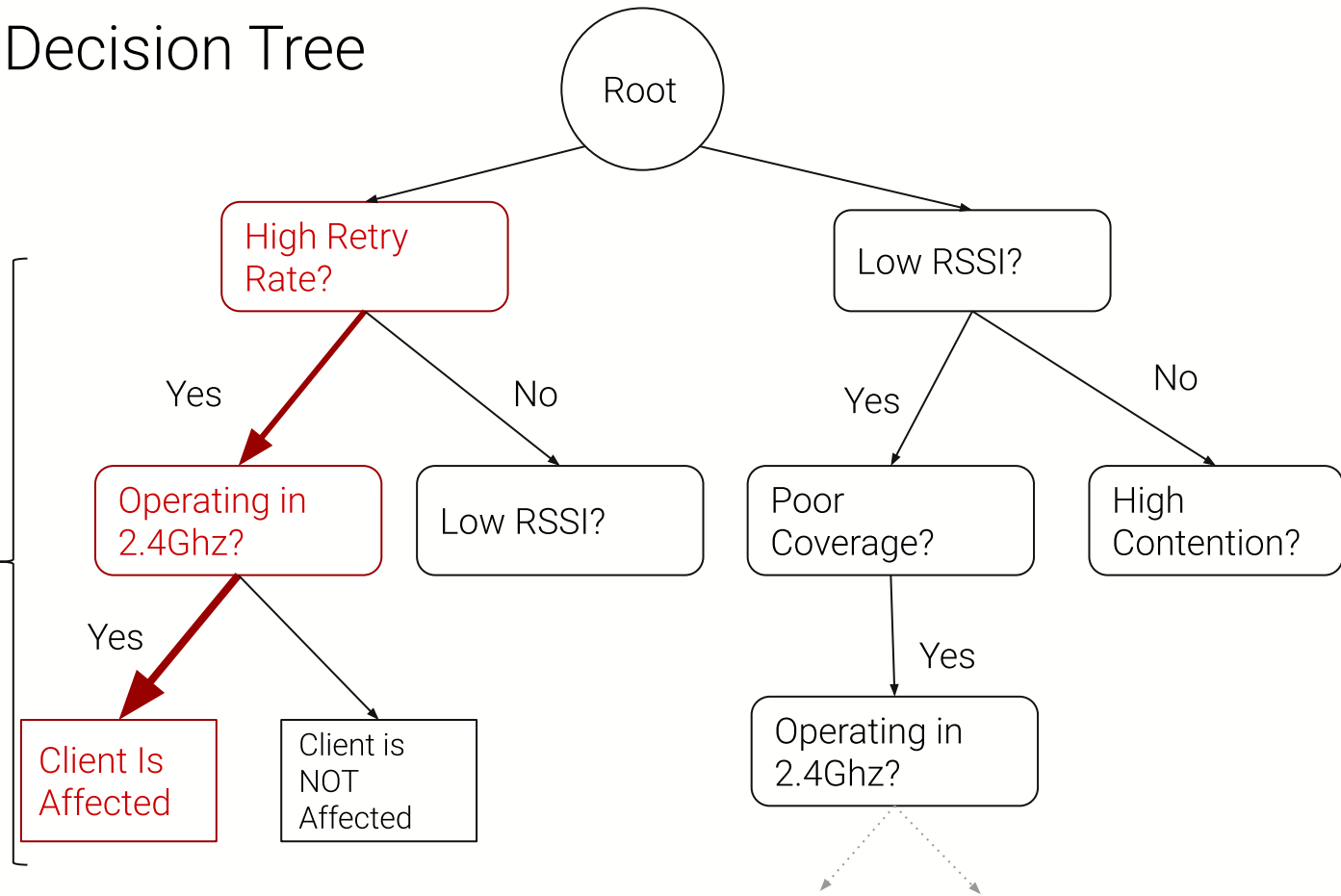
Observations



A list of **all the clients** along with their respective Wi-Fi parameters.

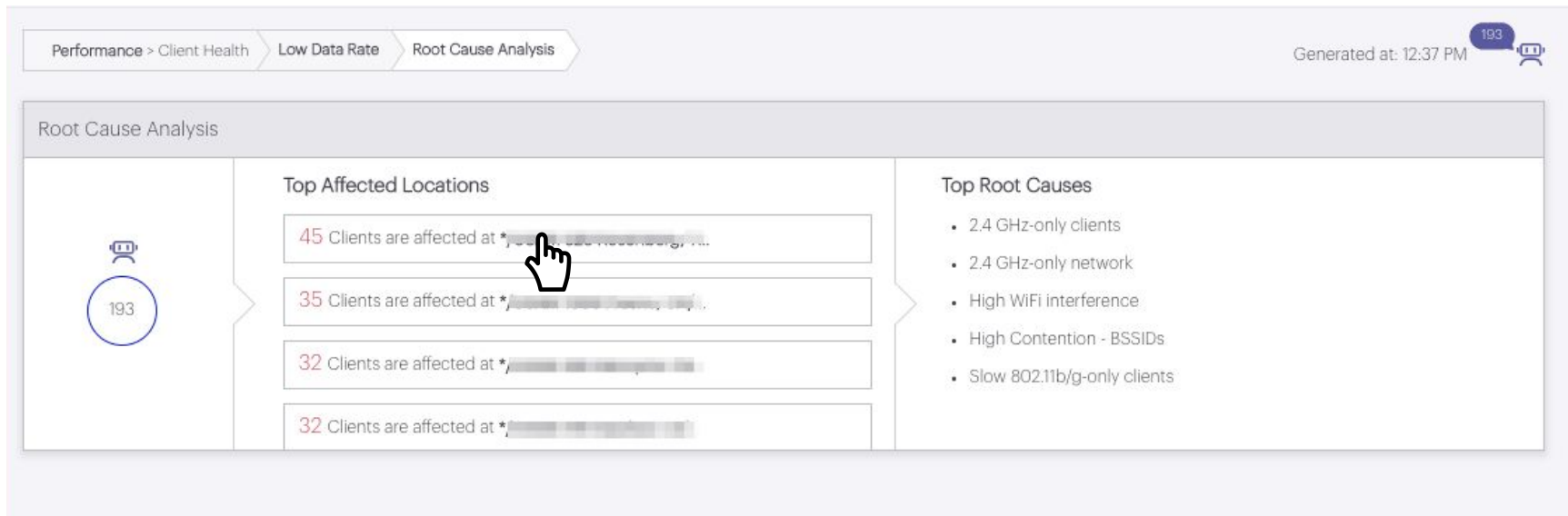
	Features (Root Causes)							Target (Symptom)
Client MAC	Sticky	High Contention	Interference	High Retry Rate	Capability Issue	Poor Coverage	...	Low Data Rate
...	Yes	Yes	Yes	...	Yes
...	No	Yes	Yes	...	Yes
...	Yes	Yes	Yes	...	Yes
...	No	Yes	No	...	Yes
...	Yes	Yes	No	...	No
...	No	Yes	No	...	No
...	Yes	Yes	No	...	No
...	No	Yes	Yes	...	No

Sample Decision Tree




Root Causes
- High Retry Rate
- Op. in 2.4Ghz

RCA In Action - Top Locations and Root Causes



RCA In Action - Statement 1

Performance > Client Health > Low Data Rate > Root Cause Analysis See All Root Causes



Location Name: [Redacted]
Total Clients at this Location: 66
Clients Analyzed at this Location: 45

Results

32 Clients at location [Redacted] faced all these issues.


2.4 GHz-only network - Clients have 5 GHz capability but the WiFi network is available only in 2.4 GHz.

32 Clients Filter Expand Refresh

Statu...	Name	MAC Address	Associated Access Point	Avg. data rate	Associated SSID	OS	Vendor Name	Location
	[Redacted]	[Redacted]	[Redacted]	9.69 Mbps	[Redacted]	--	[Redacted]	[Redacted]
	[Redacted]	[Redacted]	[Redacted]	1.78 Mbps	[Redacted]	--	[Redacted]	[Redacted]
	[Redacted]	[Redacted]	[Redacted]	2.05 Mbps	[Redacted]	--	[Redacted]	[Redacted]
	[Redacted]	[Redacted]	[Redacted]	4.61 Mbps	[Redacted]	--	[Redacted]	[Redacted]
	[Redacted]	[Redacted]	[Redacted]	17.25 Mbps	[Redacted]	--	[Redacted]	[Redacted]

RCA In Action - Statement 2


Performance > Client Health > Low Data Rate > Root Cause Analysis See All Root Causes








Location Name: [Redacted]
Total Clients at this Location: 66
Clients Analyzed at this Location: 45

Results

13 Clients at location [Redacted] faced all these issues.

- High Contention - BSSIDs - These clients used channels with too many BSSIDs and high utilization. 

13 Clients Filter, Expand, Refresh icons

Statu...	Name	MAC Address	Associated Access Point	Avg. data rate	Associated SSID	RSSI - Associated ...	Channel	Retry Rate (%)	Contending Access Point...	Location
	[Redacted]	[Redacted]	[Redacted]	6.91 Mbps	[Redacted]	-55	1	0	11	[Redacted]
	[Redacted]	[Redacted]	[Redacted]	1.82 Mbps	[Redacted]	-49	1	0	10	[Redacted]
	[Redacted]	[Redacted]	[Redacted]	2.88 Mbps	[Redacted]	-43	1	0	10	[Redacted]
	[Redacted]	[Redacted]	[Redacted]	2.03 Mbps	[Redacted]	-53	1	0	10	[Redacted]
	[Redacted]	[Redacted]	[Redacted]	5.58 Mbps	[Redacted]	-43	6	0	10	[Redacted]

RCA In Action - Statements Across Locations

Search for MAC/ IP Address/ User Name/ Device

Performance > Client Health > Low Data Rate > Root Cause Analysis

Location Name: [Redacted]
Total Clients at this Location: 66
Clients Analyzed at this Location: 45

Results

32 Clients at location [Redacted] faced all these issues.

2.4 GHz-only network - Clients have 5 GHz capability but the WiFi network is available only in 2.4 GHz.

32 Clients

Statu...	Name	MAC Address	Associated Access Point	Avg. data rate	Associated SSID	OS
	[Redacted]	[Redacted]	[Redacted]	9.69 Mbps	[Redacted]	--
	[Redacted]	[Redacted]	[Redacted]	1.78 Mbps	[Redacted]	--
	[Redacted]	[Redacted]	[Redacted]	2.05 Mbps	[Redacted]	--
	[Redacted]	[Redacted]	[Redacted]	4.61 Mbps	[Redacted]	--
	[Redacted]	[Redacted]	[Redacted]	17.25 Mbps	[Redacted]	--
	[Redacted]	[Redacted]	[Redacted]	15.47 Mbps	[Redacted]	--
	[Redacted]	[Redacted]	[Redacted]	3.41 Mbps	[Redacted]	--

Root Causes

Top Affected Locations

32 Clients at location [Redacted] faced all these issues.

2.4 GHz-only network - Clients have 5 GHz capability but the WiFi network is available only in 2.4 GHz.

13 Clients at location [Redacted] faced all these issues.

High Contention - BSSIDs - These clients used channels with too many BSSIDs and high utilization. ⓘ

35 Clients at location [Redacted] faced all these issues.

2.4 GHz-only clients - There are 2.4 GHz-only clients in the network. They are unable to use the faster 802.11ac protocol. ⓘ

18 Clients at location [Redacted] faced all these issues.

High WiFi interference - Access points serving these clients experienced high WiFi interference from other WiFi networks. ⓘ

2.4 GHz-only clients - There are 2.4 GHz-only clients in the network. They are unable to use the faster 802.11ac protocol. ⓘ

RCA In Action - Recommendations

The screenshot displays the RCA In Action interface. At the top, there is a search bar and navigation tabs for Performance, Client Health, Low Data Rate, and Root Cause Analysis. The main content area shows a location summary with a location icon and statistics: Total Clients at this Location (66) and Clients Analyzed at this Location (45). Below this, a list of issues is shown, with 'High Contention - BSSIDs' highlighted by a hand cursor. To the right, a 'Recommendations' panel provides detailed advice for this issue, including instructions on setting Transmit Power Selection to 'Auto' and enabling Dynamic Channel Selection. At the bottom, a table lists 13 clients with columns for Name, MAC Address, Associated Access Point, Avg. data rate, Associated SSID, and RSSI - Associated Access Point.

Search for MAC/ IP Address/ User Name/ Device ID

Performance > Client Health > Low Data Rate > Root Cause Analysis

Results

Location Name: *XXXXXXXXXX
Total Clients at this Location: 66
Clients Analyzed at this Location: 45

13 Clients at location *XXXXXXXXXX faced all these issues.

High Contention - BSSIDs - These clients used channels with too many BSSIDs and high utilization.

Recommendations

High Contention - BSSIDs
These clients used channels with too many BSSIDs and high utilization.

In Radio Settings, set Transmit Power Selection to 'Auto' and enable Dynamic Channel Selection at location *XXXXXXXXXX. If you are using dual-radio access points, make sure Background Scanning is enabled in Device Settings.

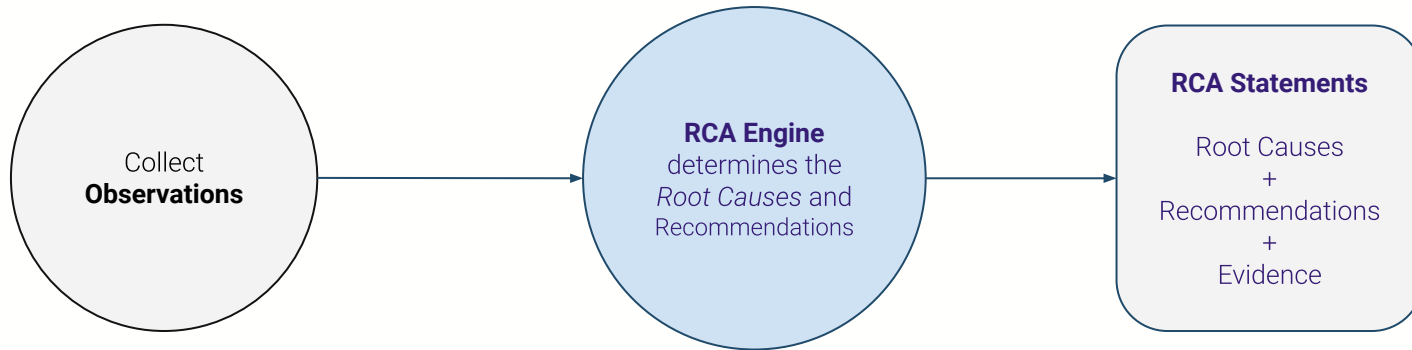
13 Clients

Statu...	Name	MAC Address	Associated Access Point	Avg. data rate	Associated SSID	RSSI - Associated Access Point
📶	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	6.91 Mbps	XXXXXXXXXX	-55
📶	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX	1.82 Mbps	XXXXXXXXXX	-49



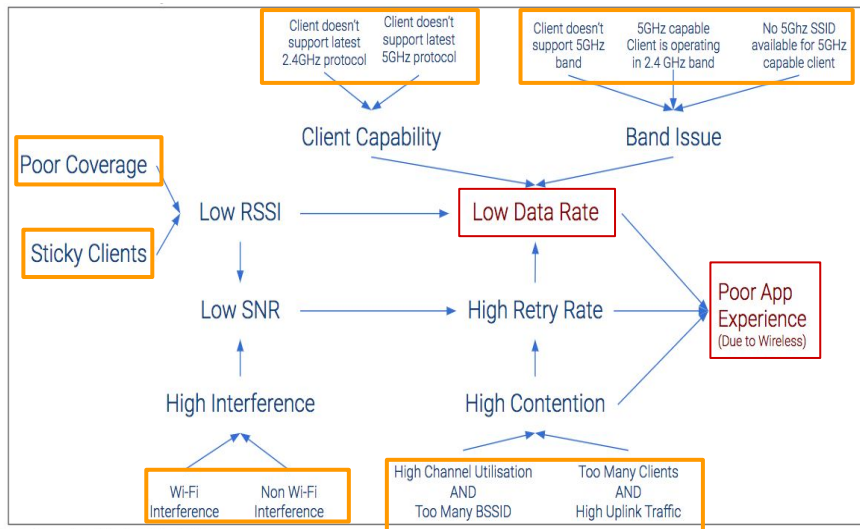
Single-Client RCA Engine

RCA Process



Observations and Rule Based RCA

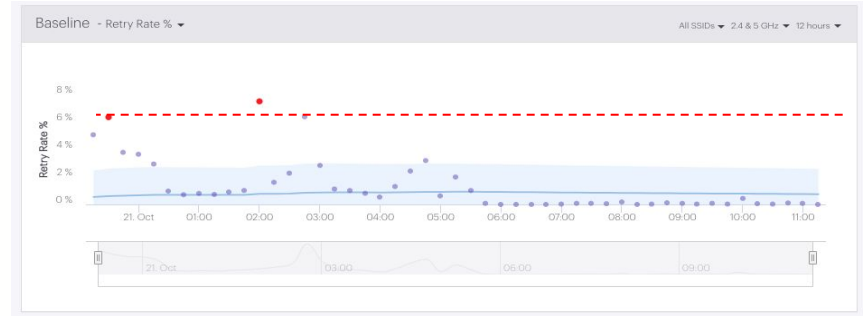
Performance Issues



Connectivity Issues

Roaming aggressively
Trying to connect to too many SSIDs
Frequent fast roaming failures
High DHCP/AAA/DNS latency
...

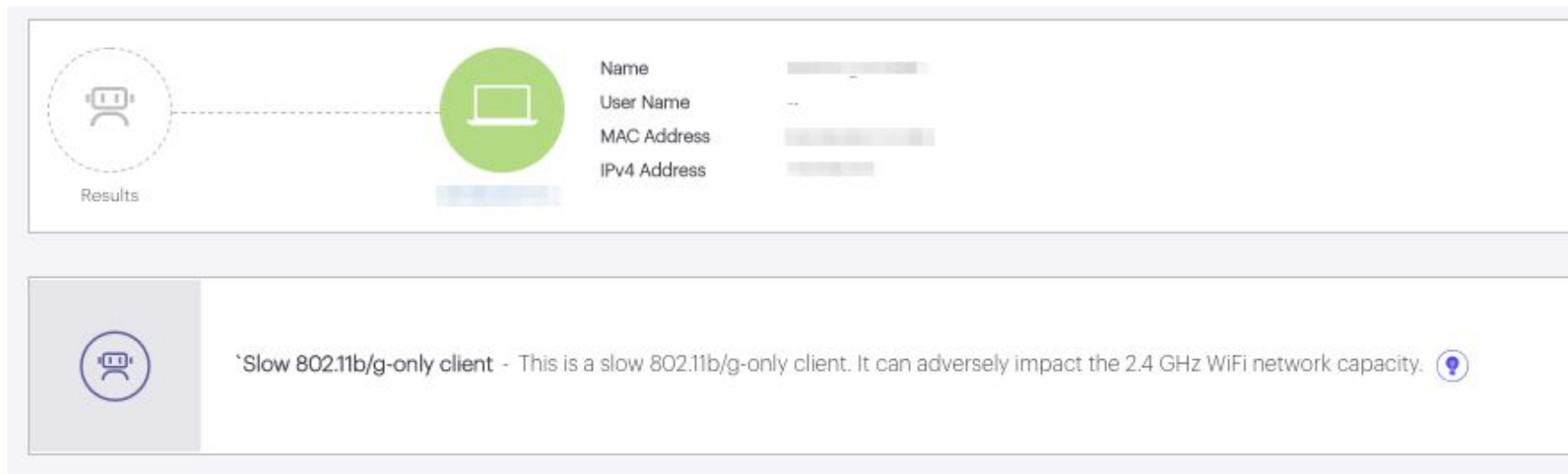
RCA Statement



The client is facing **Low Data Rate** & **High Retry Rate** because of the following reasons:


- **High Channel Utilisation**
- **High WiFi Interference**

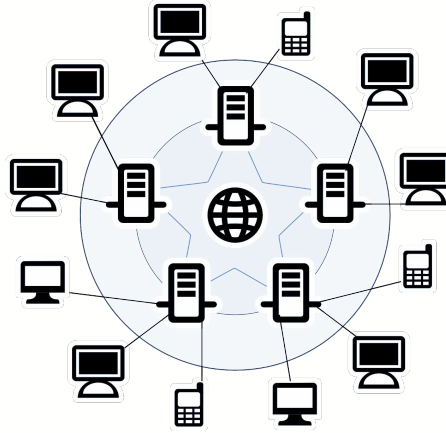
RCA In Action



The interface displays a results section on the left with a robot icon and the word "Results". A dashed line connects this to a green circle containing a laptop icon. To the right of the laptop icon is a table with the following data:

Name	[REDACTED]
User Name	--
MAC Address	[REDACTED]
IPv4 Address	[REDACTED]

Below this is a warning message in a grey box, featuring a robot icon and the text: **'Slow 802.11b/g-only client** - This is a slow 802.11b/g-only client. It can adversely impact the 2.4 GHz WiFi network capacity. 



Network Assurance

Automatically Trigger on Anomaly Detection



.... or on a predefined schedule.

Thanks!

Questions?



That's all Folks!