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Wireless Access Network

The Wi-Fi Happiness Index

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- Introduction
- Algorithm Overview
- Telemetry data used by WHIX
- Training the Machine Learning Model
- How WHIX uses the Machine Learning Model
- Benefits of WHIX

Problem Statement:

- Wi-Fi is complex
- Wi-Fi is affected by multiple different Wi-Fi conditions, occurring simultaneously.
- Even a Wi-Fi subject matter expert can find it difficult to consider all the various Wi-Fi conditions, assess the health of the Wi-Fi network and determine how these conditions interact to affect the user experience.

The Wi-Fi Happiness Index (WHIX) Concept:

- It can make it easy to understand if a customer has good or bad Wi-Fi
- It can provide lot of details on specific Wi-Fi conditions and why Wi-Fi is good or bad.

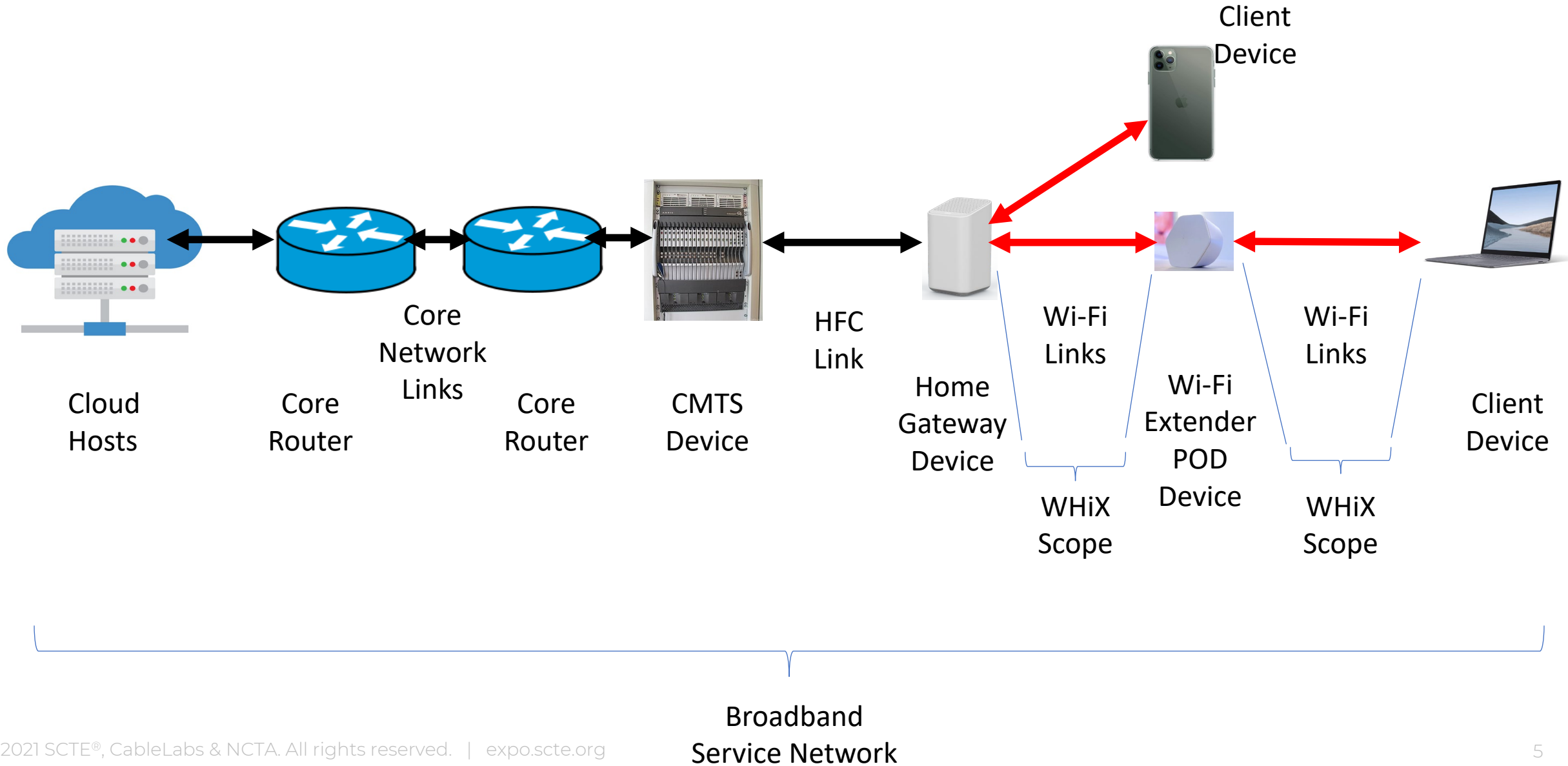
WHiX may measure Wi-Fi for:

- Every client device in every account, every hour
- At the account level, for every account, every hour

WHiX is an API based software

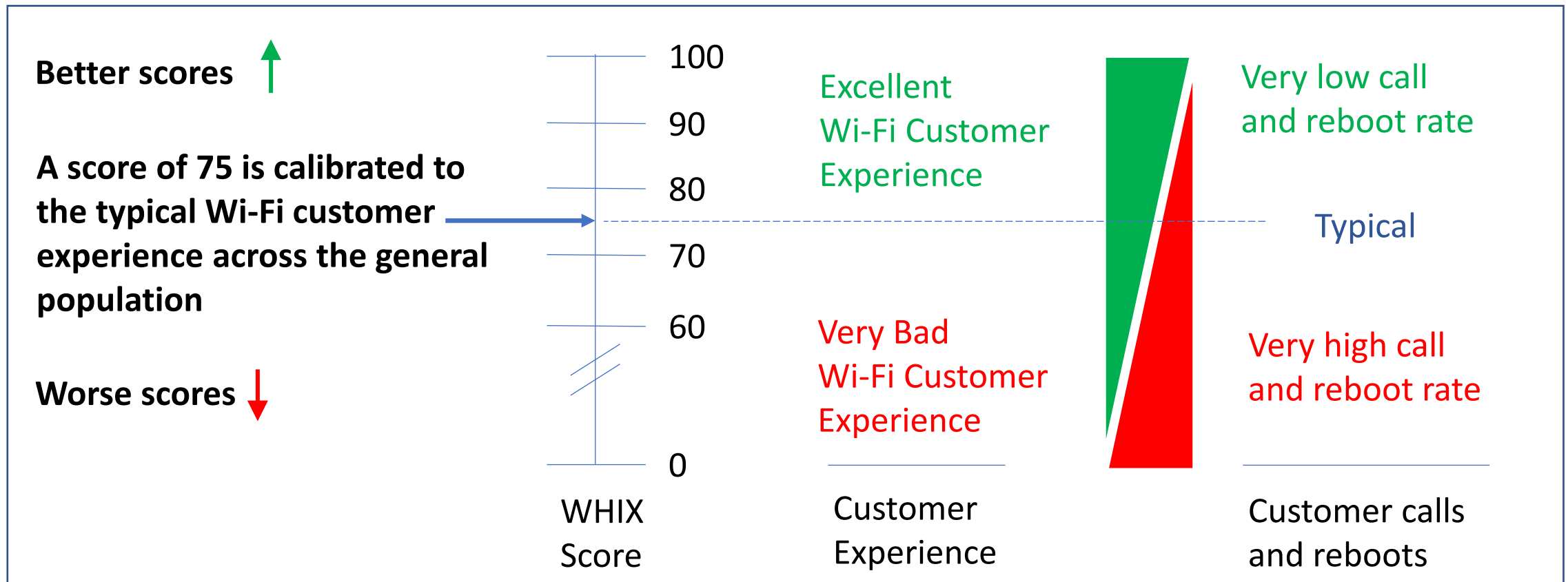
- It may run in the cloud
- It's may integrate into other tools / UIs.
- Dashboard views can be created to view the data gathered by WHIX
- Recommendations such as adding or moving POD extenders or moving the home gateway device can also be given as a part of the Wi-Fi recommendation solution.

WHiX scope in end to end broadband path



WHIX scores may be reported on a scale of 0 to 100.

- A score may be reported for every account each hour.
- A score may be reported for every client device in each account each hour.



The WHIX algorithm is based on Machine Learning

- It may use a supervised training model based on Wi-Fi related customer behavior/feedback
- Data from 18+ million homes and businesses can be used to train the model.
- Telemetry data can be collected from both gateways and PODs.
- This training model may look at over 4000 specific Wi-Fi conditions in combination with 9 different Wi-Fi client type categories.
- Customer calls and unscheduled reboots can be used to train the model
- Anonymized device fingerprint data can be used to determine each client Wi-Fi device type. WHIX uses nine client Wi-Fi device types
 - Broadband Devices: Smartphones, laptops, tablets
 - Media Players: Smart TVs, streaming video devices, streaming dongles
 - Media Sources: Cameras, streaming servers
 - IoT / Printers: Thermostats, lightbulbs, sensors, and networked printers
 - Managed Set-tops
 - Managed Wi-Fi Extender PODs
 - Audio Devices: Smart speakers, connected audio devices
 - Network Devices: Customer-owned Wi-Fi extenders, etc.
 - Game Consoles
- The training model may control the Wi-Fi analysis and feeds the API output

Telemetry data collected from the devices.

50 different parameters can be obtained using telemetry data from the Home Gateway Device and the POD. Some of them are listed here...

- downlink and uplink PHY rates,
 - MCS (Modulation and Coding Scheme) levels
 - background RF level (also called the “noise floor”)
 - Signal to Noise Ratio (SNR)
 - rate of packet re-transmissions on each client device
 - rate of lost packets on each client device
 - service availability of the access points in the Wi-Fi network
 - the ability (or inability) of Wi-Fi clients to sustain the Wi-Fi connection (measured as “rapid reconnects”)
 - total number of Wi-Fi clients on each Wi-Fi channel
 - rate of Wi-Fi password failures
 - the configured maximum channel width,
 - the operating channel width for each client device
 - media access delay for transmitted packets
 - the ability (or inability) of the network to steer each client device to a closer AP or steer that client device to a better Wi-Fi band,
- and more

Two feedback mechanisms may be used:

- User Contact Rate for connectivity-related issues
- Unscheduled Reboot Rate.

User Contact Rate:

- Higher rate of connectivity-related contacts is associated with a poorer Wi-Fi experience.
- Lower rate of connectivity-related contacts is associated with a better Wi-Fi experience.

Unscheduled Reboots:

- power outages
- software “self-heal” mechanisms
- A customer reboots the device.
 - Customers reboot their Wi-Fi gateway when experiencing a Wi-Fi related problem.
 - A higher rate of unscheduled gateway reboots is associated with a poorer Wi-Fi experience.
 - A lower rate of unscheduled gateway reboots is associated with a better Wi-Fi experience.

Each Wi-Fi-related condition (Wi-Fi criterion) may be mapped into a range of values called a “bin”.

- Bins are constructed based on the distribution of telemetry data, so that enough Boolean “matches” may occur within a bin range (where possible) to have sufficient data to avoid noise.

Correlation may be measured for each Wi-Fi criteria bin with customer contacts related to connectivity.

- For each bin (range of values for a single Wi-Fi criterion), the percentage match rate in the population that made contact with the service provider for connectivity-related issues within the previous 24 hours is calculated.

The “Criteria Match Difference” (CMD) is calculated to compare this match rate by this criteria match rate in the total general population.

This may be repeated for correlation with Unscheduled Reboots.

Based on this correlation data, an algorithmic weight can be calculated for each of the 4,000 Wi-Fi criteria bins.

- Positive weights may indicate Wi-Fi conditions that correlate to Wi-Fi user happiness that is better than the general population.
- Negative weights may indicate Wi-Fi conditions that correlate to Wi-Fi user happiness that is worse than the general population.
- Zero weights may be used to indicate correlation with the typical Wi-Fi user happiness level (same user happiness as the general population).
- For each Wi-Fi criteria, the weights for all bins in the ML model may be normalized such that positive weights offset (balance) negative weights across the total population.

This may be repeated for correlation with Unscheduled Reboots.

How WHIX uses the machine learning model

- On each telemetry interval (currently each hour), WHIX may use the ML model to assess the Wi-Fi conditions for every client device in every home.
- All available Wi-Fi telemetry can be collected from the Wi-Fi gateway and from all extender PODs in that home. It may be compared to the bins defined in the ML model.
- The process may be repeated for all other telemetry data that can be collected on all Wi-Fi link(s) used for the end-to-end path to each client device . Each additional telemetry data value is processed by the ML model to add an additional weight for each Wi-Fi criterion.
- All weights for all criteria matches for each client device may then be summed and added to a value of 75 that normalizes the WHIX score to the typical score in the general population.
- If the WHIX score is less than 75, it may indicate that Wi-Fi conditions may provide a worse-than-typical user experience. Previous scores may be retained to support historical views and trend analysis for this client device.
- The WHIX client devices scores may be rolled up to create a WHIX score for that home as a whole (WHIX account score). The worst performing client device scores may be used to calculate the WHIX account score. An adjustment may be applied to normalize the account scores to a median value of 75.
- The collection of individual hourly scores can be analyzed over time provides provides higher level statistics that can be used to characterize the Wi-Fi user experience over time.
- The WHIX-adjusted worst hour score may be the best indicator of user happiness and the best predictor that the customer will/will-not contact the service provider and/or reboot their gateway device within the next 24 hours.

Customer Wi-Fi quality

- enables us to determine the quality of each customer's Wi-Fi experience, per connected device and for every customer's account as a whole.
- facilitates us to see the most recent hour (based on available telemetry data) and also see a timeline that shows historical views, including any times when the customer's Wi-Fi experience was materially better or worse.
- Data may also be provided that shows exactly what caused the customer's Wi-Fi experience to be better or worse for each hour. Indicates affected the customer's Wi-Fi experience and can be used to troubleshoot and remediate any problems.

Determine the impact on Wi-Fi due to incremental software upgrades dispatched to Home Gateways

- The change in WHIX scores due to the upgrade would help in troubleshooting issues seen in the field.

Impact of addition of new clients to the Wi-Fi network

- The WHIX score of the new device may help to determine how different clients react to the Wi-Fi network.
- Impact of the addition of the new device to the network.

Monitoring the Wi-Fi Happiness Index may help in troubleshooting difficult issues that normally surface over time

- May help to narrow down if problems are intermittent or persistent.

Additional cloud-based tools were developed to recommend specific actions to improve the Wi-Fi user experience for each home. These may be used with WHIX and may include:

- Automated recommendation to install Wi-Fi extender PODs;
- to move Wi-Fi extender POD(s) to a better location;
- to move the main gateway, among other automated recommendations.

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Thank You!

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