



Mesh Kick-Off Q4 2023

Agenda

- Overview
- Hybrid Comcast Mesh (HCM)
- The Future – Roadmap Review
- Q4 2023 Focus Areas
- Spotlight: DFS+OCS Hybrid Solution



Overview

Lots of innovative stuff we are working on

- Cujo DI for Mesh Cloud – better steering, consistency
- 5GHz OCS + DFS Hybrid solution
- 6E backhaul for the future
- Hybrid Comcast Mesh (HCM)

And these are just a few highlights....

Hybrid Comcast Mesh (HCM)

What is HCM?

Objective: We are replicating Mesh logic on the CPE to enable tighter integration, gain efficiencies, and alleviate Cloud costs

Why?: Mesh Cloud is extremely expensive. It generates a LOT of data and CPU and storage. We are looking to replatform in order to optimize.

Goal: Move Steering/Optimizer logic from the Cloud to the Gateway for gateway-only homes and non-high-density environments.

What is changing: From a user experience perspective, nothing really changes. We are replicating the current Mesh logic in the cloud where it makes sense to do so, and not inherit any major flaws to give us the best foundation to build on top of going forward.

Benefits

- Ability to know what is enabled for which partner and region
- Tighter integration with RDKB stack and requirements for extensibility
- Supports longer term Mesh Metrics strategy

Timing

Development Phases

Both phases will be Dev-Complete before the end of Q2 2024'



Phase 1 TOS Steering for lead platform(TCXB7), monitor mode



Phase 2 Channel selection (Optimizer), monitor mode

Both phases pass, then slow rollout to customers on lead platform as early as Q1 (FCS), then Q2 will focus on scaling other platforms and expanding deployment on lead platform.

**Now is when we stop simply managing
Mesh, and begin to move Mesh forward**

The Future - Roadmaps

WiFi Feature Roadmap

Legend: Impacted by Hybrid Comcast Mesh (HCM)

Category	Target deliverables					Exploratory
	Q3 '23	Q4 '23	Q1 '24	Q2 '24	Q3 '24	
WiFi Technology	WiFi7 Feature Characterization WiFi6E SP / AFC v2 Eval (320MHz/80MHz) BSS Coloring (MDU PoC)	WiFi7 Feature Characterization (Puncturing)	WiFi7 Feature Characterization (MLO) AFC LoE WiFi Motion MVP	WiFi7 Feature Characterization (MLO) AFC Architecture		Distributed architecture (virtual or physical) WiFi7 MLO Adaptations AFC POC
WiFi Optimization	5GHz OCS WPA3 on Pods Secure Backhaul	DFS 160MHz HighDensity Neighborhoods Edge Optimization(-1)	Edge Optimization	Throughput prediction autocalibration Pre-Association Re-Arch (BS) 4-Addr Mode (WDS)(+2)	Dynamic Watermarks(+2) Dynamic Profile Identification (+1) Mesh on OG Hotspots(+1) Post-Auth Steering Re-Arch (+2) SmartDFS (+2)	Load-based network steering Optimization Output Prediction (AI/ML) Optimization Trigger Prediction (AI/ML) Dynamic Onboarding (VAP)
Cloud	Fleet Management (Controller) IPv6 for Mesh Cloud OpenSync 4.4	Database Resilience Metrics Improvements	Cujo for Mesh Cloud	Multi-Region Active/Active		Protocol Optimizations
Data Analytics	ERN - Equipment Recommendation Engine Mesh Foundational Dashboards	WiFi7 Interpretations	Realtime WHIX (v2.0)			XM devices real-time telemetry
		WiFi QoE	WPA3 Secure B-haul	Gaming MVP+		AP Clusters with Hotspots

Optimizer Roadmap

Legend: Impacted by Hybrid Comcast Mesh (HCM)

Product Phase	Target deliverables				
	Q3 '23	Q4 '23	Q1 '24	Q2 '24	+Q3 '24
FCS	20Mhz-only for 2.4G band 5GHz OCS (XB8)	DFS* (+1)	Edge Optimizations (XB7)	Edge Optimizations (XB6) Edge Optimizations (XB8) DFS+OCS Hybrid High Density Optimizer (PoC)(+2) Mesh Model v2 (Trial)(+2) 160MHz + XLE Support(+1)	
Discovery	New Optimization triggers for XLE Proactive Prediction (AI/ML)	DFS+OCS Hybrid Edge Optimizations(+1) High Density Optimizer(+1) 160MHz + XLE support (+1)		Kubernetes Deployments(+3) Move Optimizer to Python3(+2)	
Development		Proactive Prediction (AI/ML) Edge Optimizations Optimizer platform upgrade S108 (+1)	DFS+OCS Hybrid Edge Optimizations (XB7)(+1) High Density Optimizer(+1) MeshModel v2 (XB7)(+2) 160MHz + XLE Support(+1) New Optimization triggers for XLE (+1)	Edge Optimizations (XB6)(+1) Edge Optimizations (XB8)(+1) MeshModel v2 (XB6)(+2) MeshModel v2 (XB8)(+2)	Kubernetes Deployments(+3) Move Optimizer to Python3(+2) Device Driven channels (+4)
Optimization	20Mhz-only for 2.4G band 5GHz OCS			160MHz + XLE support(+2)	

Optimizer Dictionary

Product Feature	Description
160MHz + XLE Support	Support 160MHz wide channels for Gateways and XLE - backhaul and fronthaul
Device Driven channels	<p>Currently the channels + channel-widths supported for each GW/extender are static configurations in the controller and optimizer based on regulatory domain. This leads to distributed and potentially out-of-sync channel configs. Also needs work in multiple places before a device model can start working as intended in the Cloud. Any changes also need to be done in both places.</p> <p>The solution that was proposed by Plume was to have each device publish allowed/supported channels and widths per radio and that would be the source of truth for the controller to use and then pass to the Optimizer to carry out optimizations.</p>
DFS	Enable DFS in Mesh cloud. Provides additional channels to recommend and the ability to use a 160MHz channel width
High Density Optimizer	Cohort Management. HD v/s Current Location Optimizers
Kubernetes Deployments	Move from the current EC2 hosts to EKS hosts for Optimizer. Gives the ability to scale up or down in a much more granular way.
MeshModel v2	Introduce Meshmodel v2 for XB6/7/8 optimizations. Meshmodel v1 is no longer supported. Meshmodel v2 offers improved speed of optimizations
Move Optimizer to Python3	The Optimizer was developed using Python2 which was declared unsupported and EOL in 2020. If any vulnerabilities are reported or new python packages are to be updated, this becomes a roadblock.
New Optimization triggers for XLE	XLE locations have additional transition states that required triggering the Optimizer: CableWAN Failover recognized, CableWAN restored
5GHz OCS	Active channel scanning in 5G band. Provides Optimizer with interference data of other channels when making its recommendation
Edge Optimizations	For single node(Gateway-Only) locations use device-compute in lieu of cloud-compute on XB6/7/8 class devices
Optimizer platform upgrade S108	Update to Plume's 108 Optimizer platform. Since the Controller is on 108, this will standardize our ecosystem and allow for new data to be processed
AI/ML for Optimizer	Three phase initiative to increase effectiveness and efficiency of the Optimizer
Proactive Prediction	Prior to an optimization running, utilize AI to analyze the request payload and only execute the Optimization if it is highly likely to cause a topology change. This reduces the total number of executed optimizations and increases ROI per optimization
Trigger Reevaluation	Using data from Proactive Prediction, reevaluate Optimizer triggers so it is only executed when a topology change is likely. Enhances the Optimizer by having triggers that would optimize the network in real time as needed
AI Driven Solver	Use AI to make decisions on topology recommendations based on the data in the request payload
20MHz and 30MHz for 2.4GHz	Moving to 20MHz on the 2.4GHz. This will help reduce the number of channels and distribution on 2.4GHz

Steering Roadmap

Legend: Impacted by Hybrid Comcast Mesh (HCM)

Product Phase	Target deliverables				
	Q3 '23	Q4 '23	Q1 '24	Q2 '24	+Q3 '24
FCS	Cujo for Mesh Cloud		Post-Association Re-Arch (BS) Managed Device-Specific Profiles	Pre-Association Re-Arch (BS) Dynamic Device Watermark WiFi 7 (MVP) TOS SNR-to-Datarate	Dynamic Profile Identification
Discovery	Pre-Association Re-Arch (BS) Dynamic Device Watermark(+2) WiFi 7 (MVP)(+2)	Dynamic Profile Identification(+2) Latency-Aware Steering(HCM?)	TOS SNR-to-Datarate(+2)	Throughput prediction(+2) autocalibration	
	Steering efficiency metrics(+2)			Load-based Band Steering(will be covered in HCM ?)	
	Managed Device-Specific(+2) Profiles				
Development	Post-Association Re-Arch (BS)(+1) Cujo for Mesh Cloud(+2) Client Anchoring? MLO Steering (MLO- post WiFi7 MVP Phase)(+3)	Dynamic Device Watermark(+2) WiFi 7 (MVP)(+1) Steering efficiency metrics(+1)	Pre-Association Re-Arch (BS)(+1) Integration with RF/Troubleshooting(+1)	Dynamic Profile Identification(+1)	Throughput prediction autocalibration(+1)) Load-based Band Steering(HCM?)
Optimization	Default Profile			TOS SNR-to-Datarate(+1)(HCM?)	

Steering Dictionary

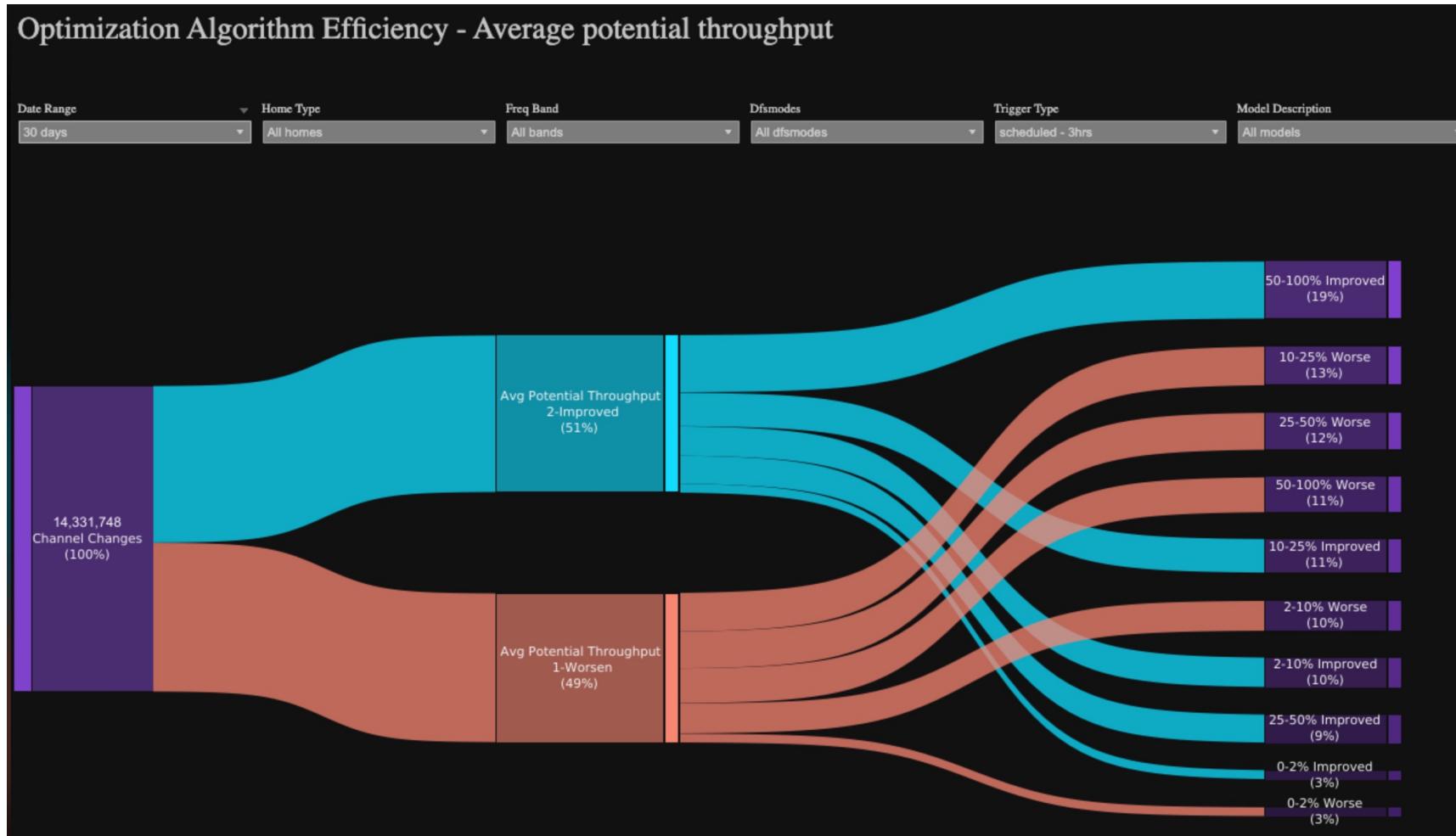
Product Feature	Description
Post-Association Re-Arch	Redesign band steering architecture for associated clients
Pre-Association Re-Arch	Redesign band steering architecture for unassociated clients
Client Anchoring	Anchor clients to a band once optimally steered to avoid churn
MLO Steering	Develop algorithms to optimally steer across 2.4/5/6 GHz bands
Integration with RF/Troubleshooting	Incorporate real-time RF and diagnostic data to inform steering
Machine Learning Optimization	Apply ML techniques to analyze and optimize steering decisions
Load-based Steering	Steer clients based on real-time load and congestion conditions
Latency-Aware Steering	Steer clients based on application latency requirements
Dynamic Device Watermark	Customize steering based on individual client capabilities
Managed Device Profiles	Create groups of steering profiles for classes of devices
Dynamic Profile Identification	Automatically identify and classify devices to steer them appropriately
SNR-to-Datarate Mapping	Build AP intelligence to map SNR to expected throughput
Throughput Prediction	Predict expected throughput for a client when making steering decisions
WiFi 7 MVP Support	Develop initial algorithms and capabilities to steer WiFi 7 clients

2023 Highlights

- Launched 5GHz OCS for Comcast
- SkyUK Launched with DFS enabled
- Implemented processes between Product/Engineering which enables Discovery and Development Phases, which will make WiFi Roadmaps more predictable.
- Mesh Foundation Metrics created, now looking to build on top of it
- Established Steering and Optimizer roadmaps to show how we will evolve our product

Mesh Metrics and Opportunities

New Metrics have revealed opportunities where we can improve and feed our roadmap



Q4 2023

- Plume Shutdown
 - Knowledge Transfers items from Plume
 - Repo and Access management activities
- Hybrid Comcast Mesh(HCM) – Ramp up and get that off to a great start
- Pods: WPA3 on XE2's, add 6E Backhaul support in Optimizer and Steering
- Roadmaps – align on Q1 efforts committed for **Definition** and **Development**

Spotlight: DFS+OCS Hybrid Solution

OCS + DFS Hybrid Implementation

Problem

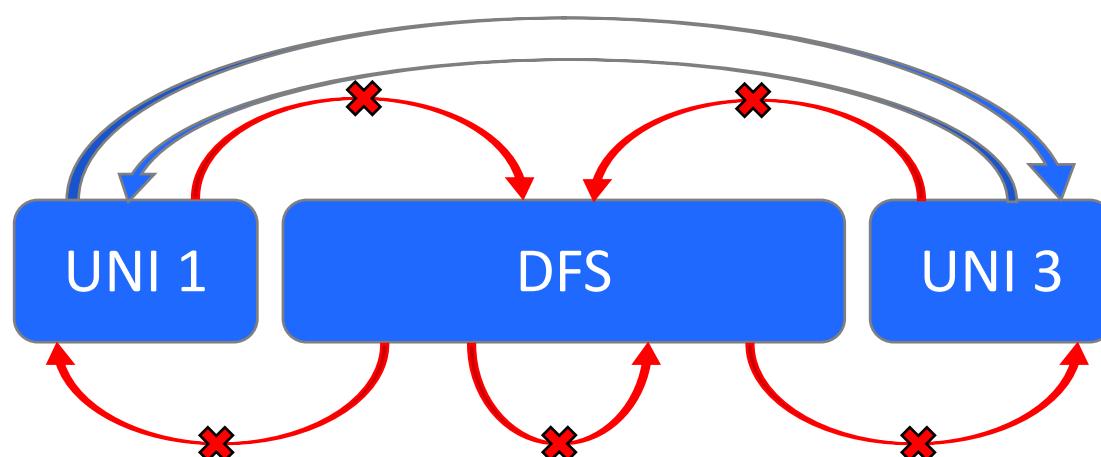
Due to regulatory restrictions on the DFS spectrum of the 5GHz Wi-Fi band, additional logic is needed to get value out of both in parallel.

- When DFS bandwidth is in use, it needs to be *constantly* monitored for radar events
- Before sending a single packet on a DFS channel, a full CAC must be performed. This means DFS channels would need to be passively scanned, leading to longer time off channel and likely causing more user interruption

Solution

DFS channels will always be enabled and available
Off-Channel Scanning will be conditionally enabled:

- When the AP is using any part of the DFS spectrum, OCS is disabled. This means when the channel with is fully or partially within the DFS spectrum
- When the AP is NOT using any part of the DFS spectrum, OCS is enabled for UNI 1 and UNI 3. It will not scan DFS channels to avoid having to perform a CAC each time



Start of arrow: Channel AP is on
End of arrow: Channel being scanned
RED: Scan not allowed
BLUE: Scan allowed

OCS + DFS Timeline

	'23 Q3	'23 Q4	'24 Q1	'24 Q2
OCS + DFS Hybrid Implementation	Solution	Definition/Architect	Development	FCS
OCS Standalone	50% -> 100% GA XB8	100% GA XB8	TBD based on Q4 results	N/A
DFS Standalone	Plan/Develop	Rollout on TCH XB7	TBD based on Q4 results	N/A

While planning and developing the hybrid approach, we will aim to get as much value to our customers as possible in the short term. This will start by rolling out 5G OCS standalone to all XB8s. In Q4, we gradually rollout DFS standalone to TCH XB7s until we hit 1.5M accounts. With equally sized data pools, we can then compare the value each feature is bringing to the customer and make a decision on which one will be fully deployed until the hybrid approach is ready.

End