

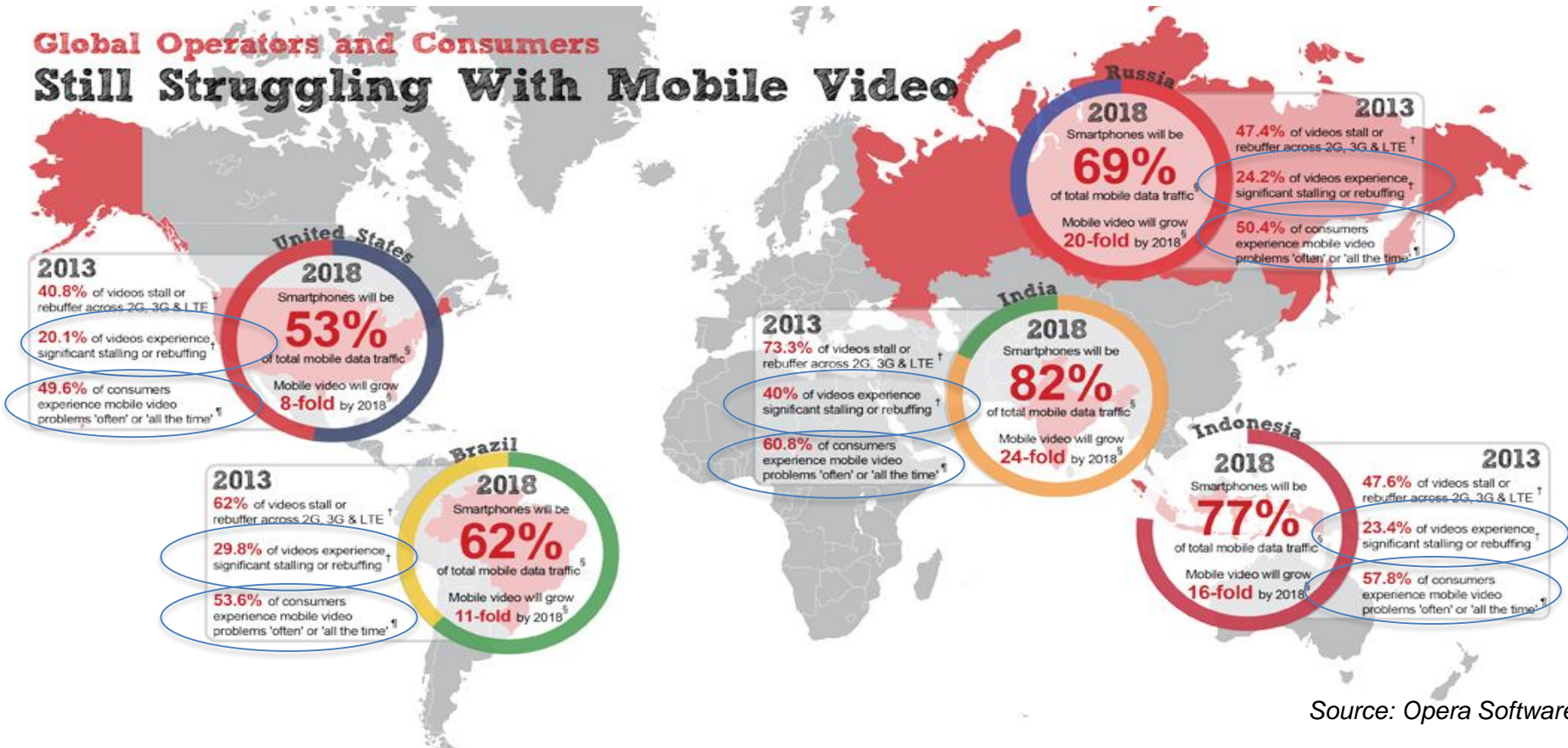


Reimagine Mobile Edge Computing Content Delivery

Eliminating Backhaul Bottleneck
Creating Additional Bandwidth
Adding Resilience

Mobile Video Delivery Struggles

Global Operators and Consumers Still Struggling With Mobile Video



Source: Opera Software

Challenges in Mobile Content Delivery

- Majority of mobile video traffic (YouTube, Netflix) is unicast (personal) in nature;- multi-cast is not going to help with this type of content
- Content delivery/caching needs to address encrypted videos as well
 - Need to work with a provider to enable caching of encrypted videos
- MEC caching content and delivery/acceleration (even close to the user) gets affected by backhaul bottleneck

Our Solution

Enhanced MEC Content Caching

The logo for Saguna, featuring the word "Saguna" in a blue, sans-serif font.The logo for PeerApp, featuring the letters "PA" in a stylized, colorful font (green and blue) followed by the word "PeerApp" in a grey, sans-serif font.The logo for Parallel Wireless, featuring the word "Parallel" in a bold, black, italicized font with a green graphic element to the left, and the word "Wireless" in a bold, orange, italicized font below it.

- Mobile Edge Computing Platform → bringing content and services closer to the user, while maintaining mobile NW functionality
- Mobile-Edge Content Accelerating → MEC product for hosting and accelerating content closer to the user. Promoting content and CDN caching, and MEC vCDNs
- **NEW:** License assisted backhaul enabled by SDN wireless mesh → solving backhaul bottleneck for delivering MEC Content to the end user

Mobile Edge Computing & Mobile Edge Caching were already announced. What is New?

- **CWS base station (3G, 4G, Wi-Fi + integrated backhaul)**

- 1
 - 2X GigE, 2X built-in mesh radios, LTE macro backhaul, custom
 - Full-featured **third generation mesh technology**

- **Two Solution Modes**

- 2
 - **License assisted backhaul (LAB)** enabled by SDN wireless mesh backhaul

- Similar to LAA
- Aggregates LTE and unlicensed spectrum for backhaul and makes decisions as to what spectrum to use to deliver guaranteed Quality of Service for different types of applications (VoLTE, mobile video, etc.).
- Enhances existing MEC Content-caching solution:
 - Enhances existing MEC Content-caching CDN and accelerating solution
 - Opportunity to host future existing additional MEC applications
 - Additional capacity and efficiency, additional bandwidth savings as one content caching solution can serve a whole mesh cluster
- Dynamic content routing

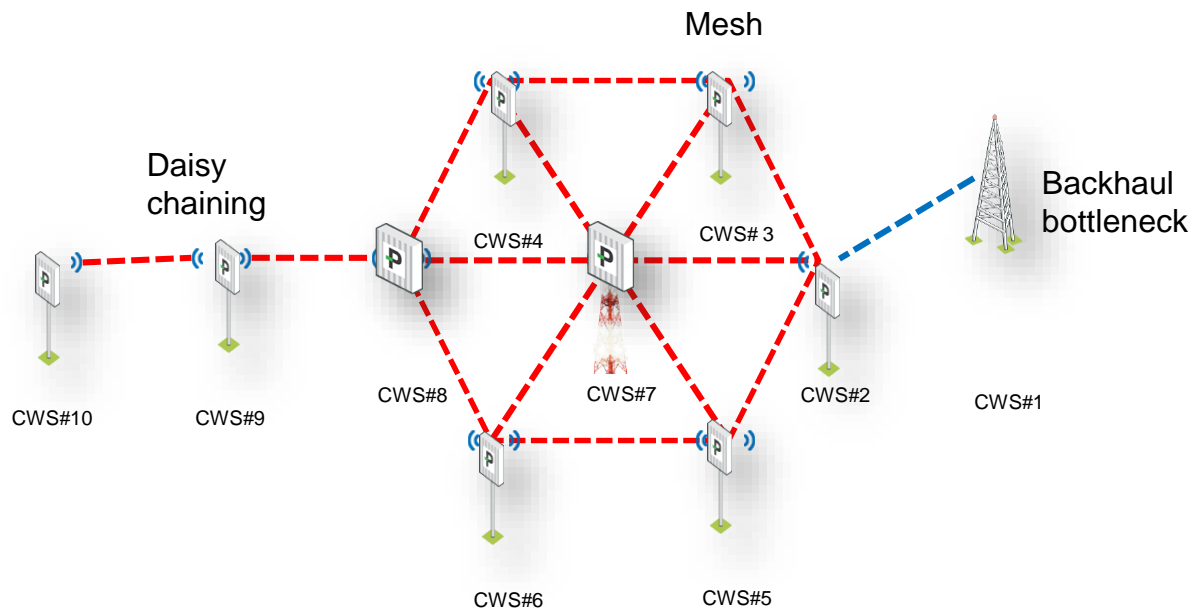
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 - **Unlicensed Assist Backhaul (ULA)**

- ULA works with unlicensed spectrum
- Complements existing wired backhaul to provide additional backhaul capacity
- Software-Defined Networking (SDN)-enabled resilience.
- Dynamic content routing

Multi-Radio Elastic Mesh Backhaul

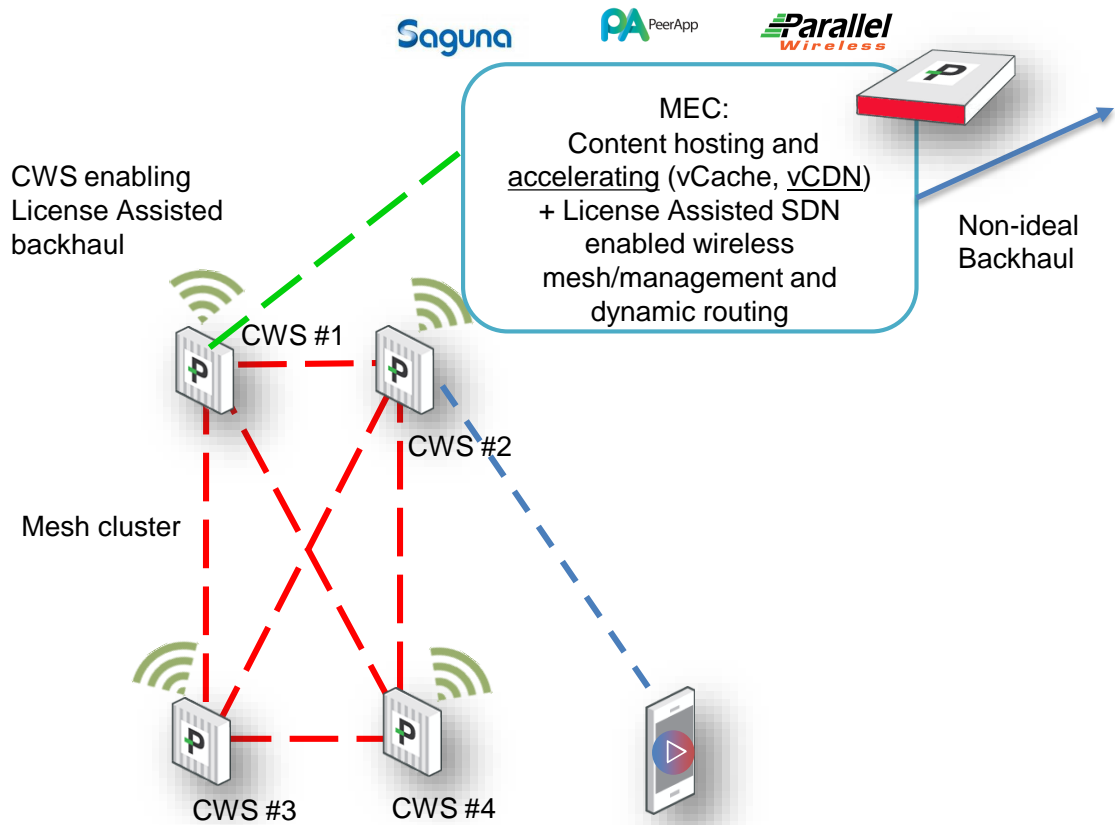
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- SDN mesh backhaul links can be configured for mesh deployment multi-point to multi-point scenarios or long haul point to point links
- Only few CWSs need wired backhaul or LTE backhaul from macro
- Can be extended with linking and daisy chaining
- Creates “free” backhaul and eliminates a bottleneck



Caching Solution Detailed Architecture

License Assisted Backhaul



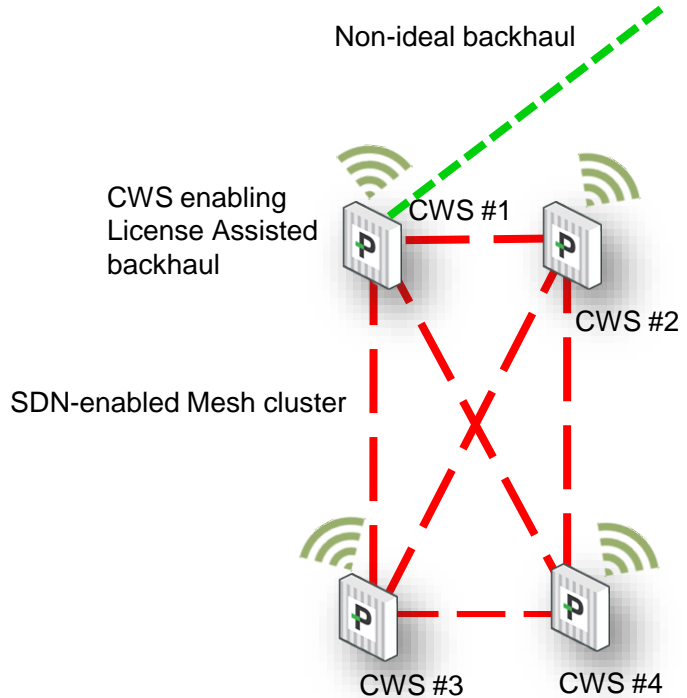
- CWS provides backhaul incl. mesh
- HNG runs on COTS server
- HNG manages SDN mesh fabric and aggregates backhaul, enables:
 - License Assisted backhaul to eliminate backhaul bottleneck and add backhaul capacity
 - Dynamic content re-routing based on mesh conditions
- Multi-point-to-multi-point mesh within the cluster with ideal backhaul for each node → same user experience on each node/no latency or delay
- Signaling handoff optimization
- Bandwidth savings and better user experience

Solution Detail: LAB

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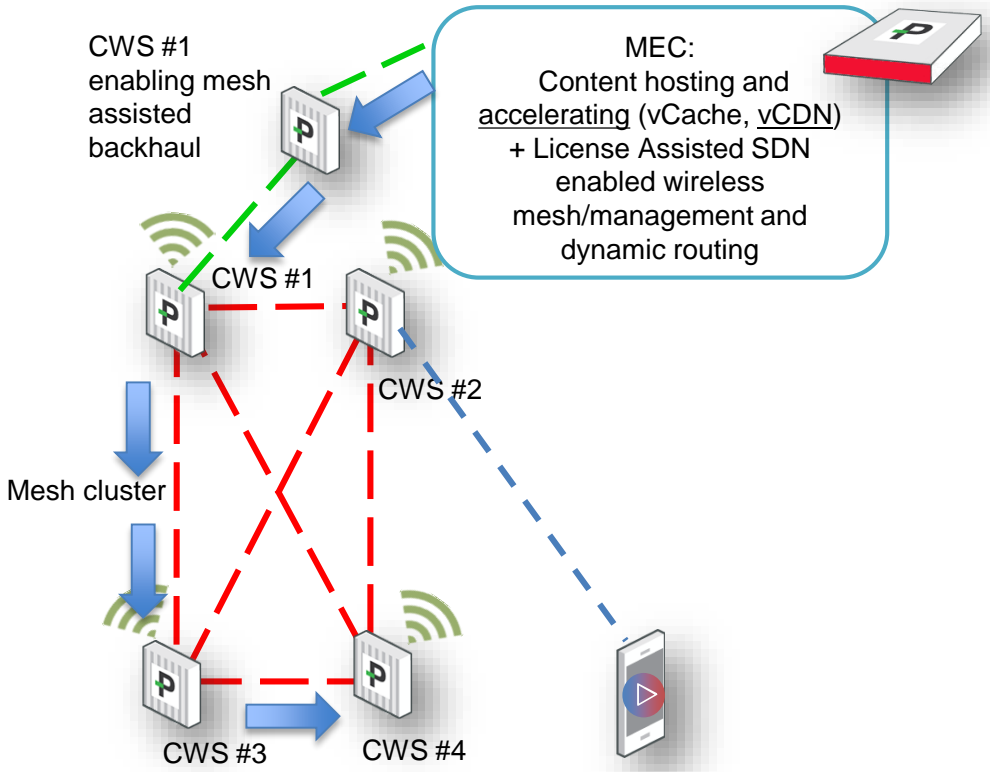
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Eliminating a Bottleneck/Creating Backhaul Capacity



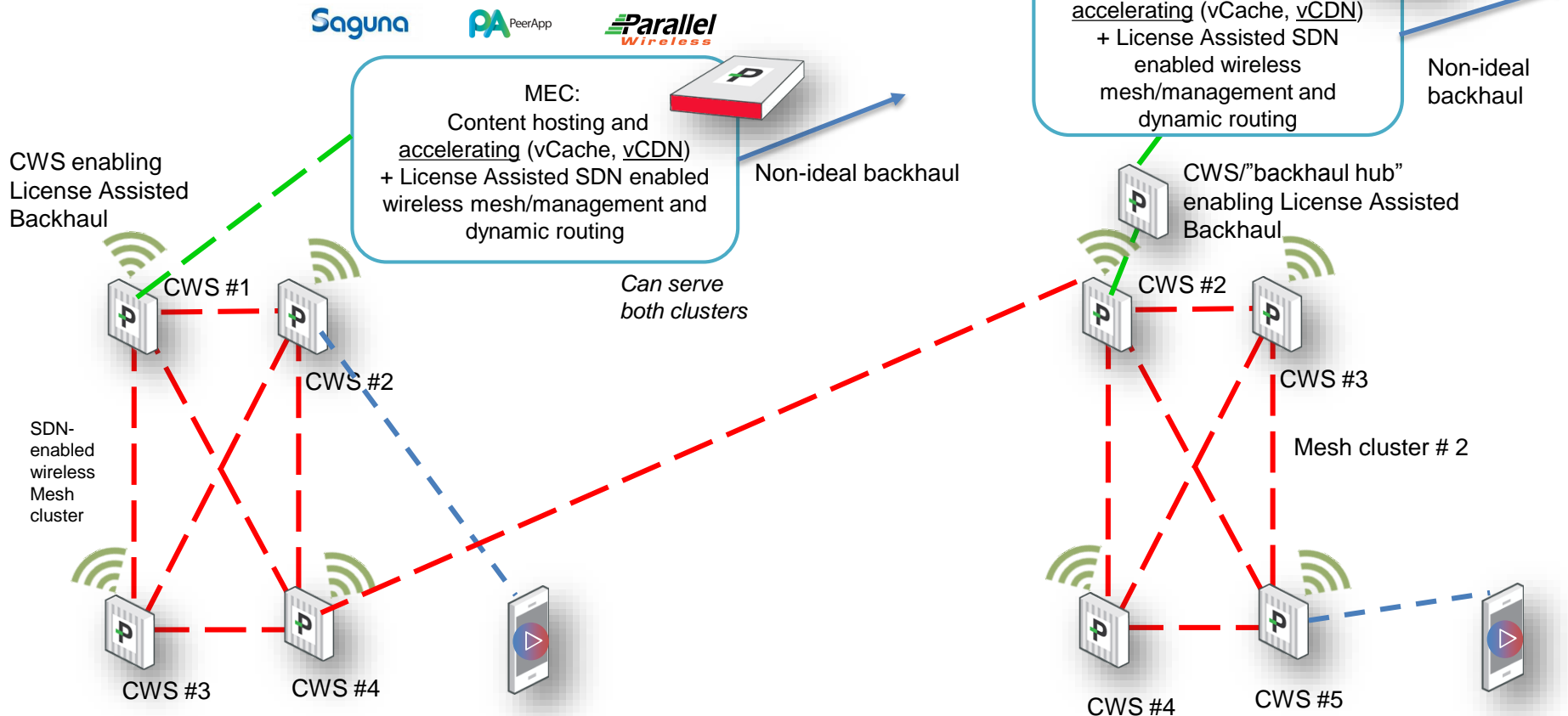
- Non-ideal backhaul **is not** a choke point
- Each CWS:
 - Capable of up to **450** mbps capacity
 - Creates more backhaul capacity over licensed spectrum that is not used or unlicensed
 - Transport pipe becomes **much larger**
- Cached content delivery improves
 - No latency
 - More available capacity
- Dynamic Content Routing
 - Resilience
 - QoS

Dynamic Content Rerouting



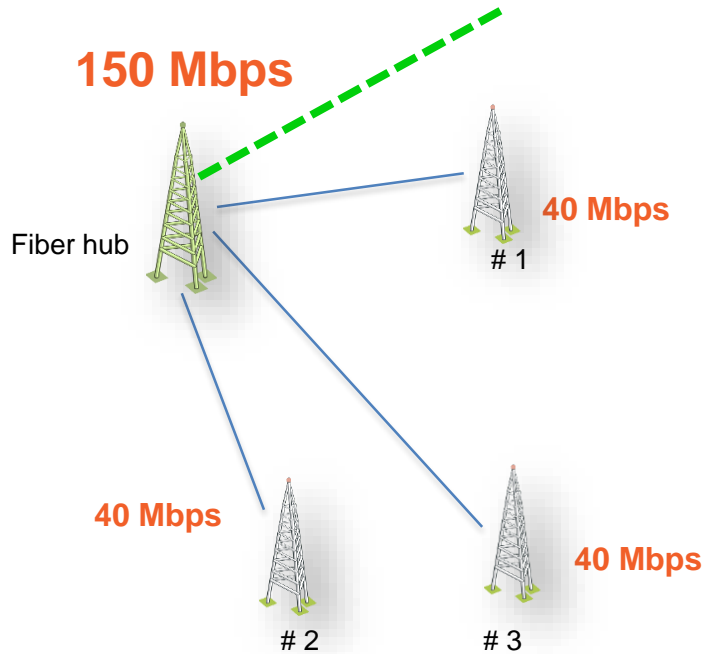
- Multi-point to multi-point mesh
- HNG manages:
 - SDN mesh fabric
 - SDN-based dynamic content rerouting based on mesh conditions
 - On downlink → pushes routes for certain type of traffic
 - On uplink → manages CWS profiles to route in resilient and most cost-effective way
 - Most direct path might be not the best quality one
 - Rerouting in case of failure
 - In traditional scenario if backhaul is compromised content is not delivered
- Result: Caching + optimization

Multiple Mesh Clustering



Traditional Macro Solution

Not Enough To Share ...



Non-ideal backhaul creates a choking point/bottleneck at fiber hub

i.e. **150 Mbps** has to be shared between each node (in this picture: between 3 nodes)

Each node ends up with barely **40 mbps** to provide capacity

If node is sectored, each sector gets one third of the 3rd (barely **15 mbps**)...

Backhaul to cache content is constrained

Content delivery gets compromised

Latency increases

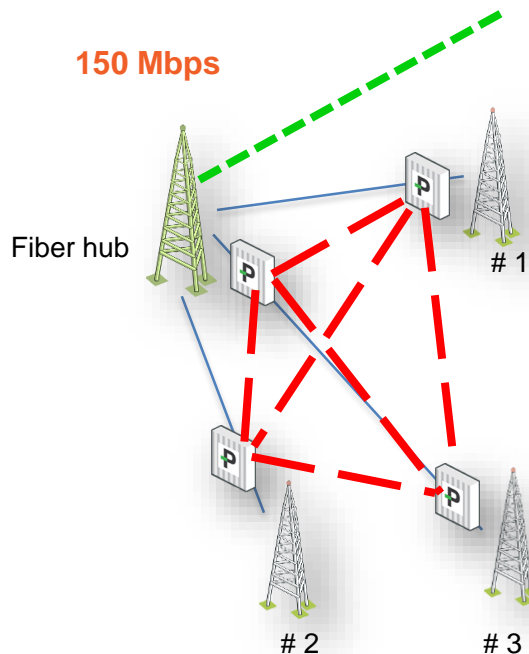
QoS gets reduced

Our Solution

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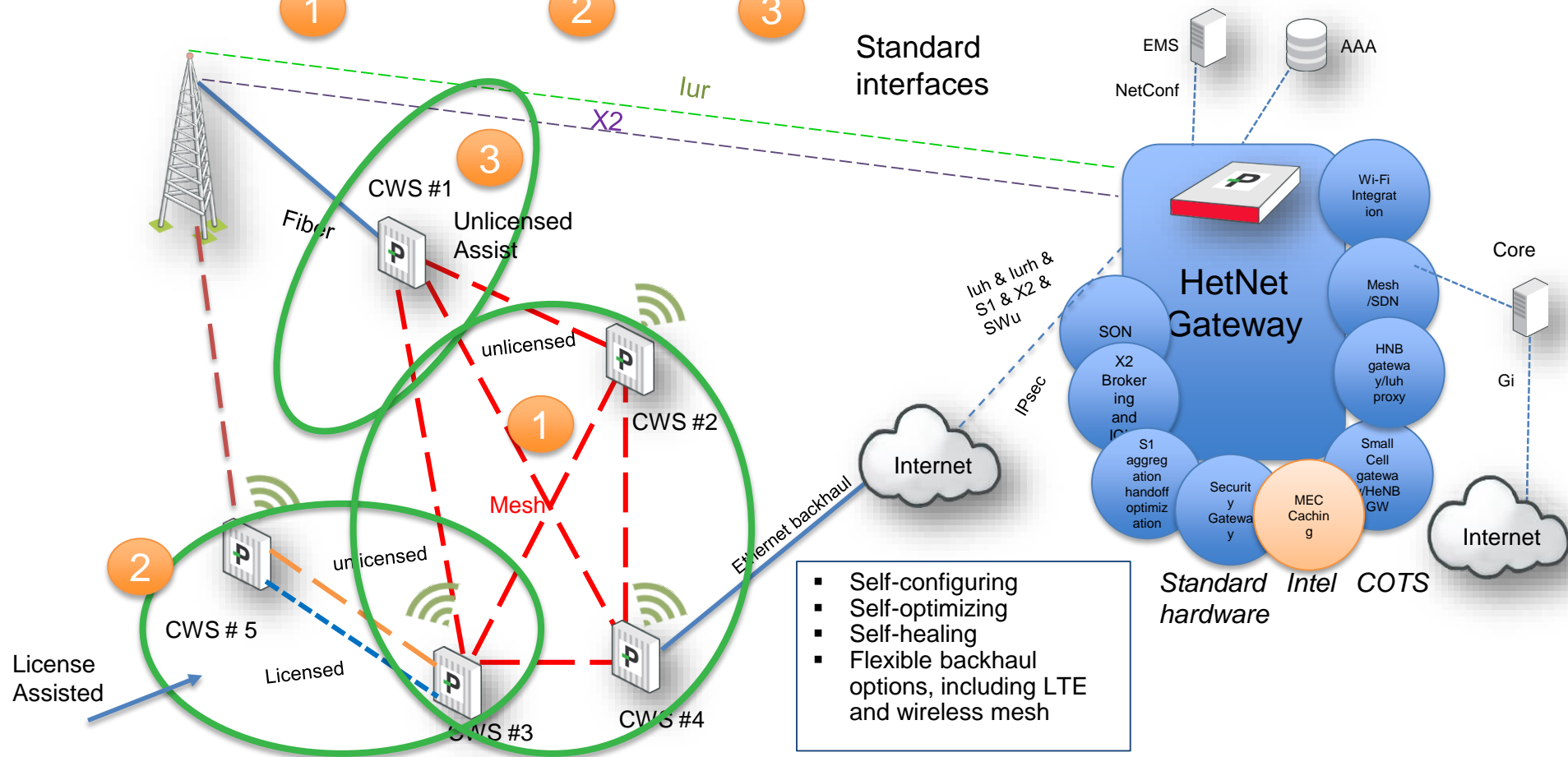
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Mesh Fabric/Unlicensed Assist as Alternative Backhaul



- Adding unlicensed spectrum to existing framework
- CWS = backhaul provider
- Each CWS:
 - Capable of up to **450** mbps capacity
 - Creates more “**free**” backhaul capacity over unlicensed spectrum
 - Transport pipe becomes much larger
 - Enables resilience in case of fiber cut
 - Can be primary or back up
 - HNG can enable dynamic routing over fiber or mesh backhaul
- Can be used in caching to optimize delivery
- Helps with constrained spectrum

NEW: Mesh Fabric, LAB and ULA



Converged Wireless System

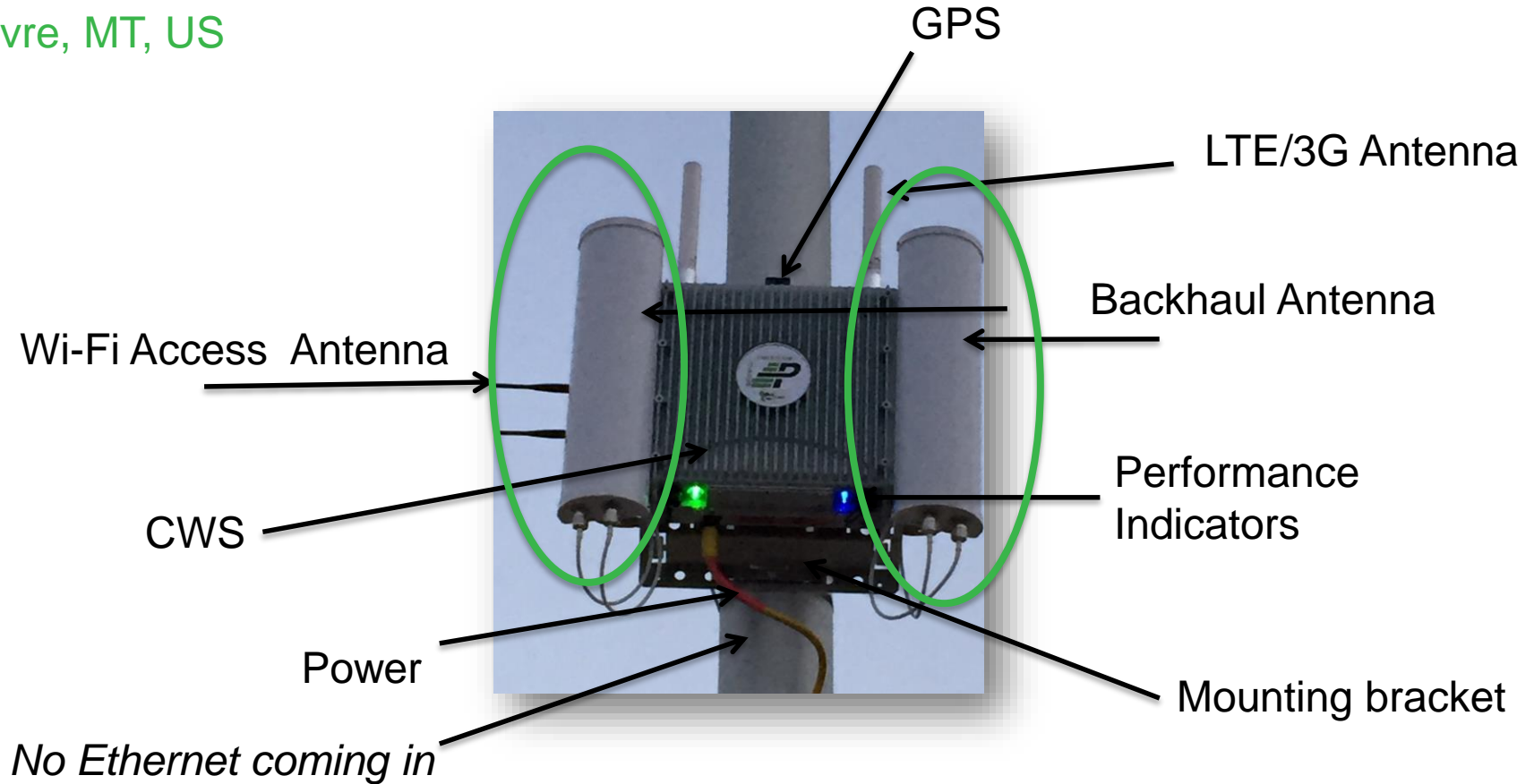
Software-defined, Multi-mode, Multi-band

- More functionality in one unit
 - Integrated: 3G, 4G, Wi-Fi Access and flexible backhaul (LTE, wired, NLOS/LOS mesh, Wi-Fi)
 - Combines NodeB/RNC for 3G Functionality, eNodeB for 4G
 - Solves backhaul challenges: only a few nodes require wired backhaul
 - RAN simplification
- Leverages latest silicon
- Reduced network costs and operations with integrated access/backhaul design
- Backhaul Capabilities
 - Each integrated 40 MHz Mesh Radio delivers ~200Mbps capacity using 2X2 MIMO. Capable of 450Mbps capacity with 3X3 MIMO.
 - “Multi-point” to “multi-point” (no server node or client node)
 - Multi-homed – any egress (wired or LTE) on a given node is available to full mesh cluster. E.g. 10 meshed cluster of CWS has 3 Ethernet backhaul that terminates on 3 of the 10 CWS, this backhaul is shared among all 10 nodes.
 - CWS can provide Ethernet backhaul to external devices: external Access Points, traffic camera, etc.
- Reduced CapEx with commodity components and flexible backhaul
- Install, power-up and go with zero touch configuration via HNG
- Reduced Opex with resource optimization and traffic mitigation via HNG
- Seamless user experience between 3G/4G/Wi-Fi technologies
- Secure, carrier-grade
- Standards-based



Example CWS Install

Havre, MT, US



Deployment and Business Cases

One Solution – Many Use Cases

- Content Caching + Optimization
- Retrofitting an existing network for additional level of resilience:
 - For Public Safety Grade networks
 - To create “free” bandwidth for offloading where it is cost-prohibitive or logistically difficult to install more fiber or fixed backhaul
- Greenfield deployments
- Backhaul only

Summary

- 2 solution modes: Licensed Assisted and Unlicensed Assist backhaul on CWS + HNG providing SDN-enabled routing
- 3rd generation mesh
- Solves latency and backhaul bottleneck
- Content caching and delivery benefits from improved backhaul capacity
- Unlicensed Assist Backhaul on CWS can be retrofitted over existing macro for additional free capacity and resilience

Thank You