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Inside DOCSIS 4.0

The technology enabling reliable 10 Gbps over cable

Cornel Ciocirlan
CTO EMEA, Aurora Networks

The DOCSIS bandwidth challenge

Four generations, each adding capacity on the same coax

DOCSIS 1.0 / 1.1 / 2.0

One channel

One downstream channel, up to 50 Mbps.

Several upstream channels.



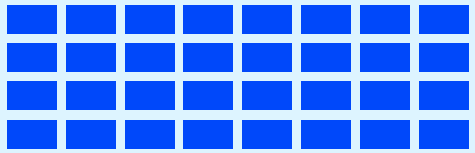
1 channel

DOCSIS 3.0

Bonding

8 to 32 bonded downstream channels.

Up to 8 bonded upstream.



up to 32 bonded channels

DOCSIS 3.1

OFDM blocks

OFDM downstream, OFDMA upstream.

2 blocks each way per modem.



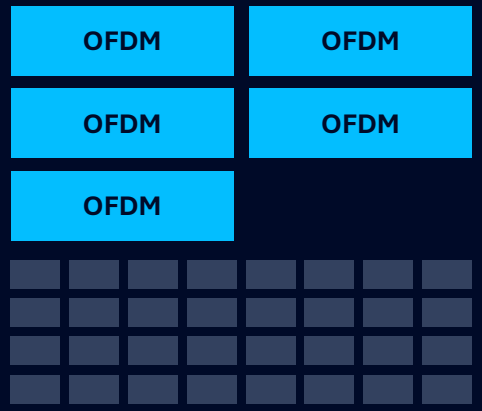
2 OFDM blocks, plus SC-QAM

DOCSIS 4.0

10 Gbps

Adds Full Duplex, Extended Spectrum and FlexBand.

The three flavours this talk explains.



5 OFDM blocks, plus SC-QAM

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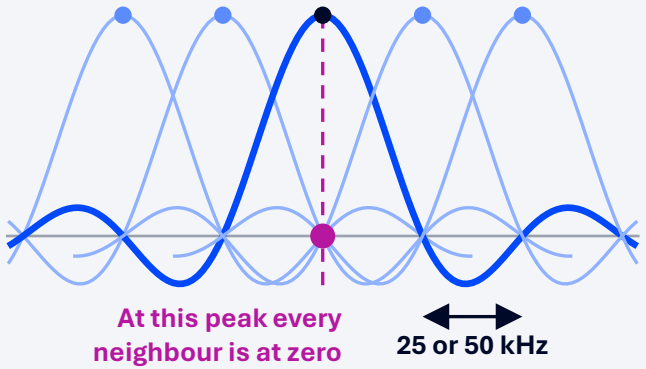
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How OFDM and OFDMA work

Many narrow subcarriers instead of one wide carrier; in the upstream, shared between modems

THE PRINCIPLE

Orthogonal subcarriers

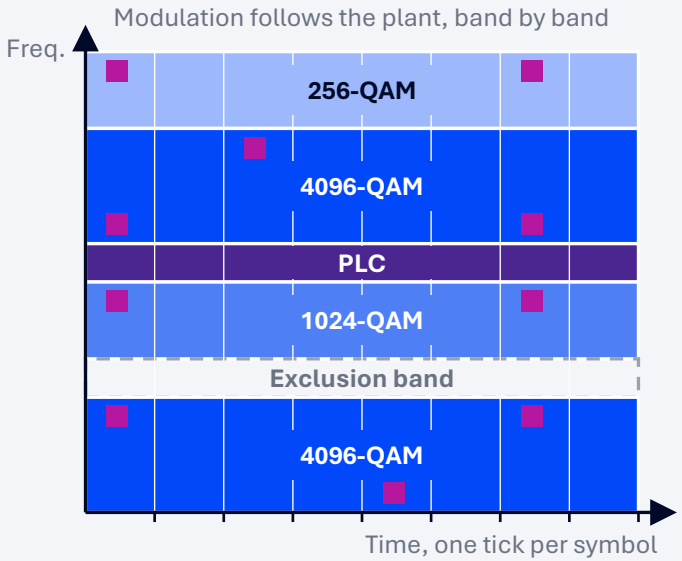




A cyclic prefix (CP) before each symbol absorbs short echoes.

DOWNSTREAM

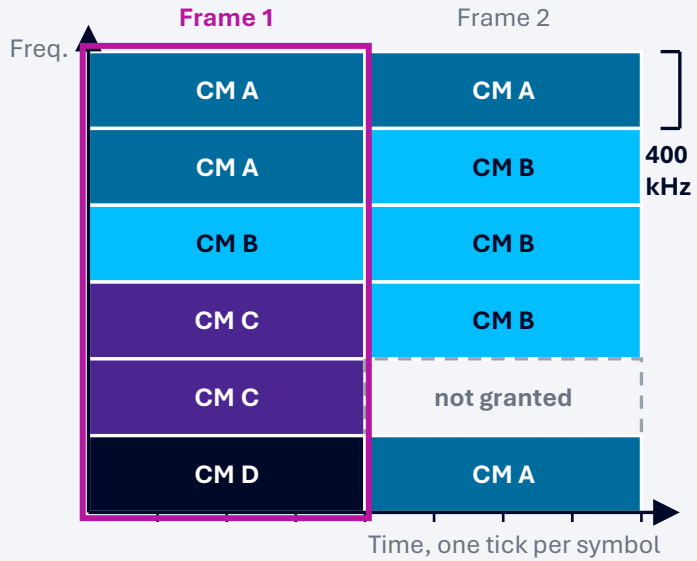
OFDM: one transmitter, bit loading



■ Pilots. Every symbol goes to all modems.

UPSTREAM

OFDMA: the grid is shared



Frame 1: modems A, B, C and D transmit at once.

THE TRANSMIT CHAIN, BOTH DIRECTIONS



Parameters	Channel width	Spacing	FFT size	Shared out as
Downstream OFDM	up to 192 MHz	25 or 50 kHz	8K or 4K	Profiles
Upstream OFDMA	up to 96 MHz	25 or 50 kHz	4K or 2K	400 kHz minislots

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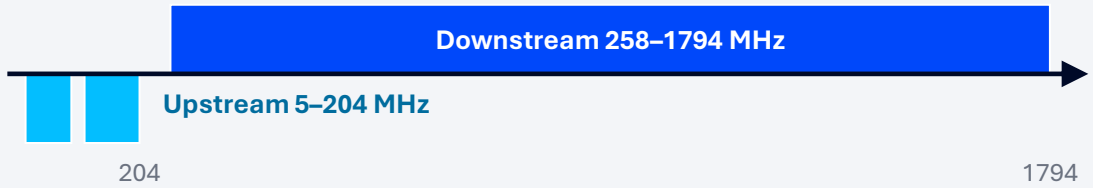
DOCSIS 4.0 in three flavours

Extended Spectrum, FlexBand and Full Duplex: example splits, other configurations are possible

SPECTRUM IN MHz, TO SCALE — Downstream — Upstream — CAPACITY AT ABOUT 7.5 bps/Hz

Extended Spectrum (ESD)

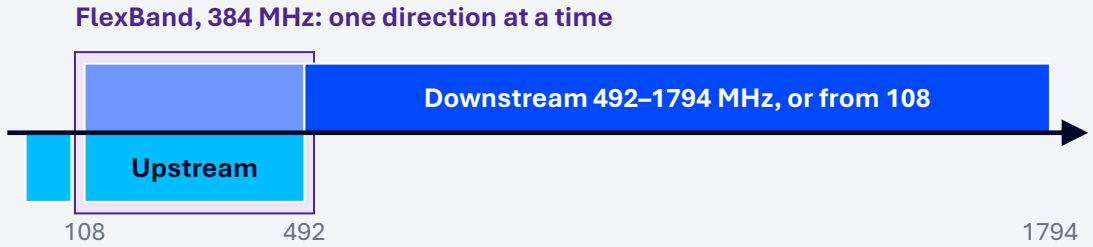
FDD to 1.8 GHz. Both directions get more spectrum, and diplexers fix the split.



12 Gbps down — **1.5** Gbps up

FlexBand (flexi-split)

Extended Spectrum plus a band whose direction the scheduler switches. Echo cancellers replace the diplexer.

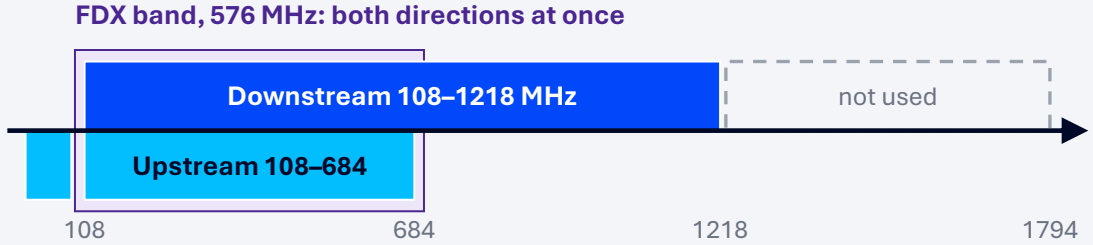


12.6 Gbps down — **3.5** Gbps up

each at most, not together

Full Duplex (FDX)

The plant stays at 1.2 GHz. Upstream and downstream share 108–684 MHz at the same time.



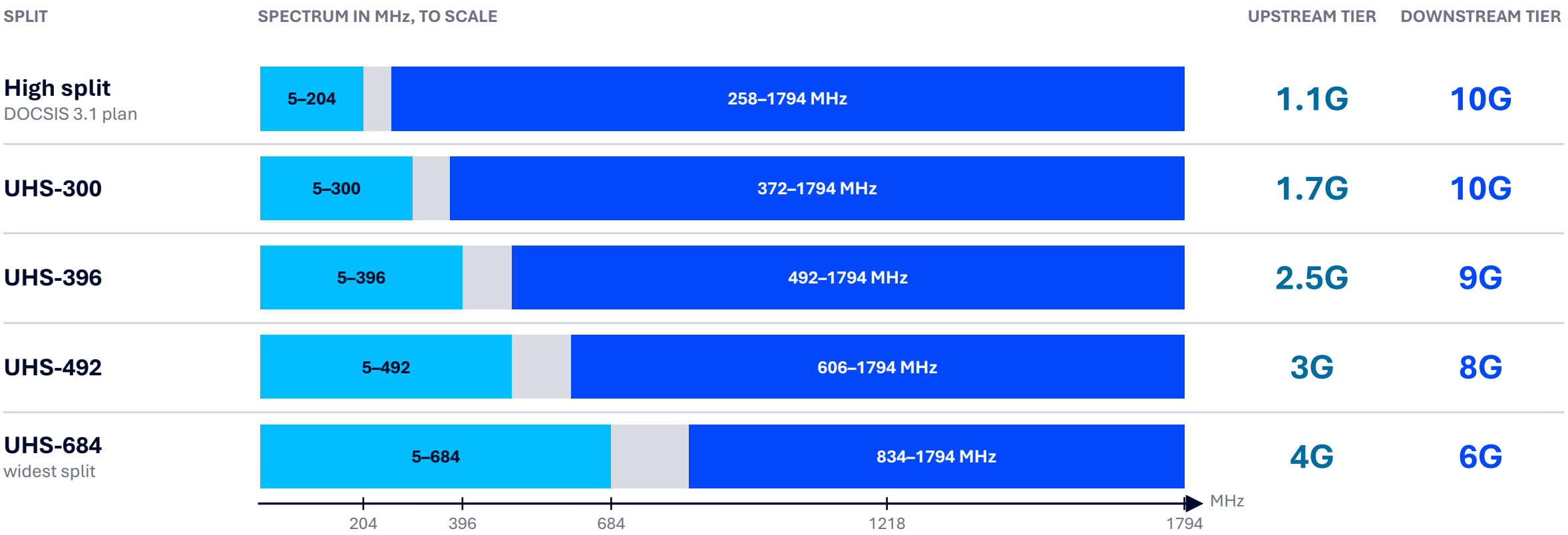
8.3 Gbps down — **5** Gbps up

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FDD band plans up to 1.8 GHz

Ultra-high splits move the diplexer, not the physics



Illustrative service tiers: every megahertz moved upstream is taken from downstream. The spec also assumes 1.8 GHz ends on a single point-of-entry device in the home.

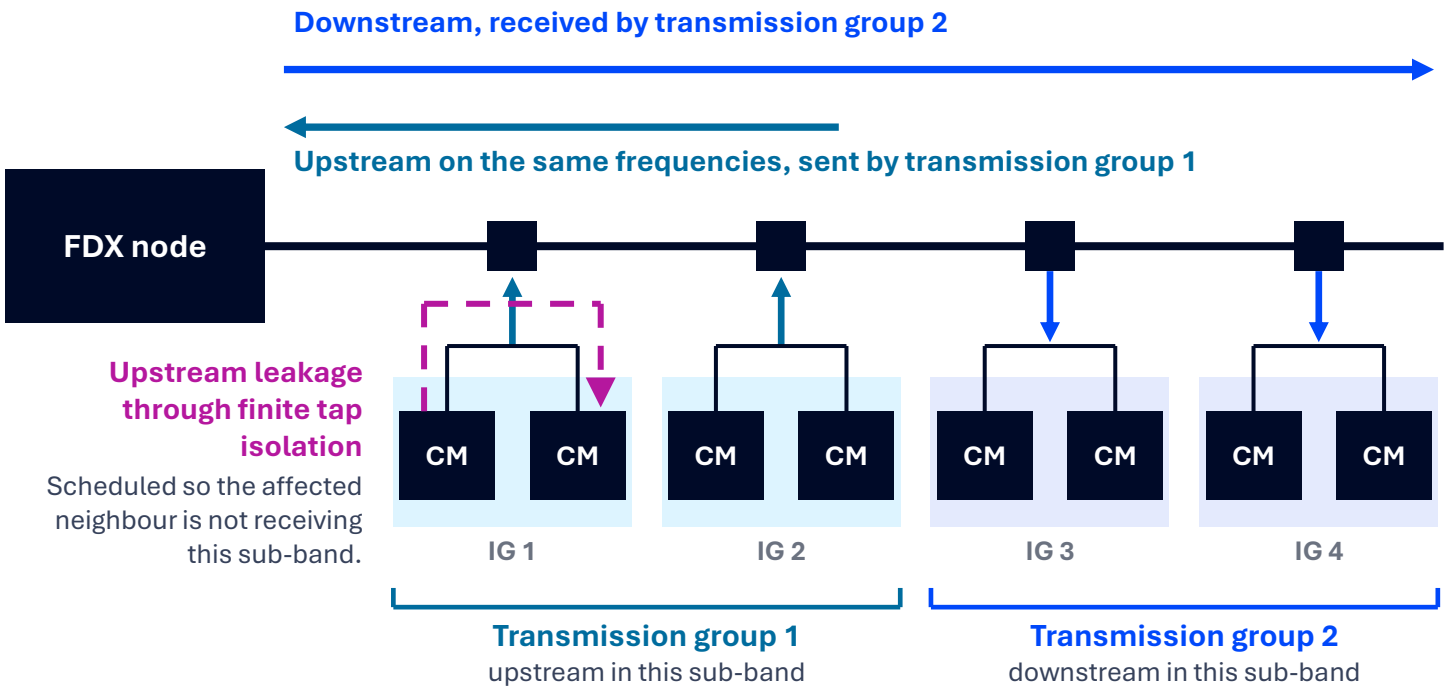
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FDX: one band, both directions

Full duplex at the node, FDD at each modem, and scheduling between neighbours

ONE MOMENT IN SUB-BAND 1, 108–300 MHz



Upstream leakage through finite tap isolation

Scheduled so the affected neighbour is not receiving this sub-band.

Example resource block assignment

Sub-band, MHz	108–300	300–492	492–684
Node	Both	Both	Both
TG 1	Up	Down	Down
TG 2	Down	Up	Down

the moment drawn on the left

The CMTS sends these assignments to the modems and changes them as demand shifts.

At the node

True full duplex. It knows its own downstream, so it can cancel the echo of it.

At the modem

Each sub-band is upstream or downstream at any moment, never both.

Between modems

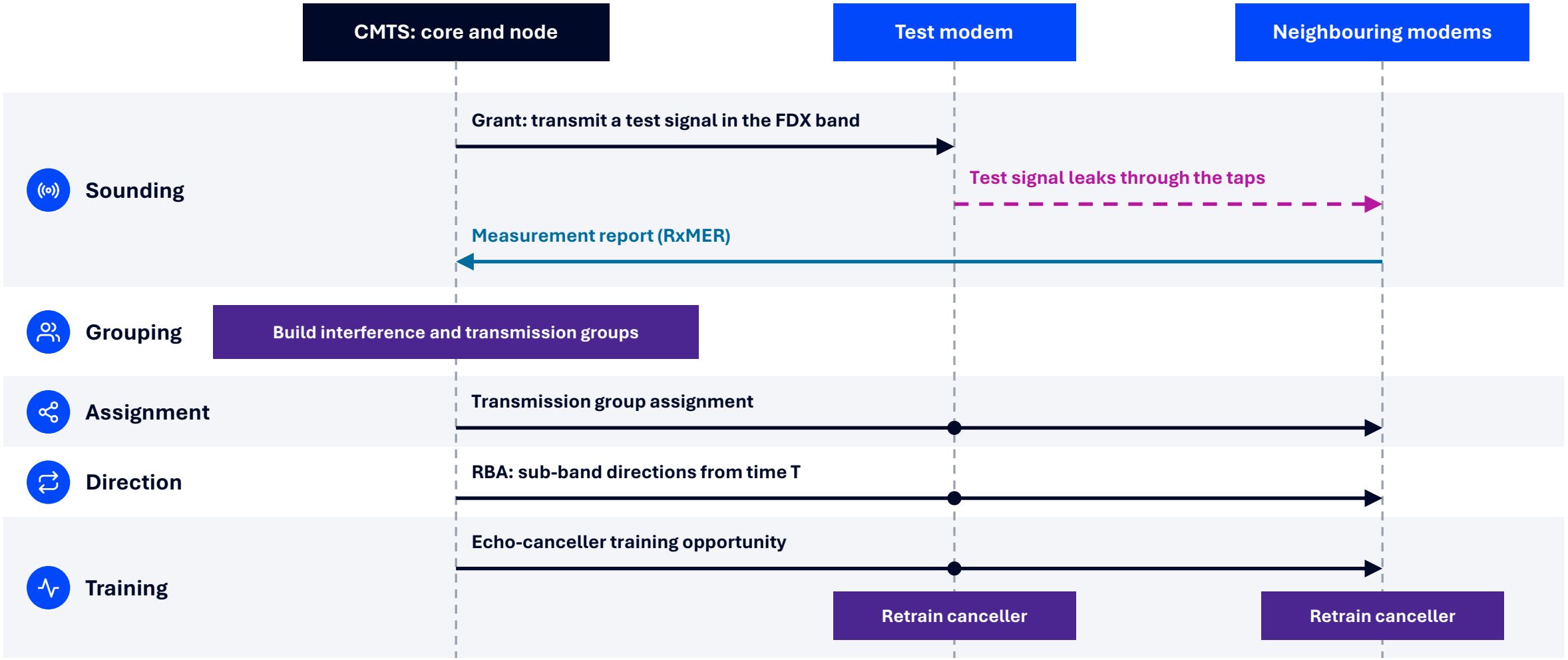
A neighbour's signal cannot be cancelled, so the CMTS schedules around it.

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FDX procedures in the MAC

Conceptual sequence; protocol message names simplified

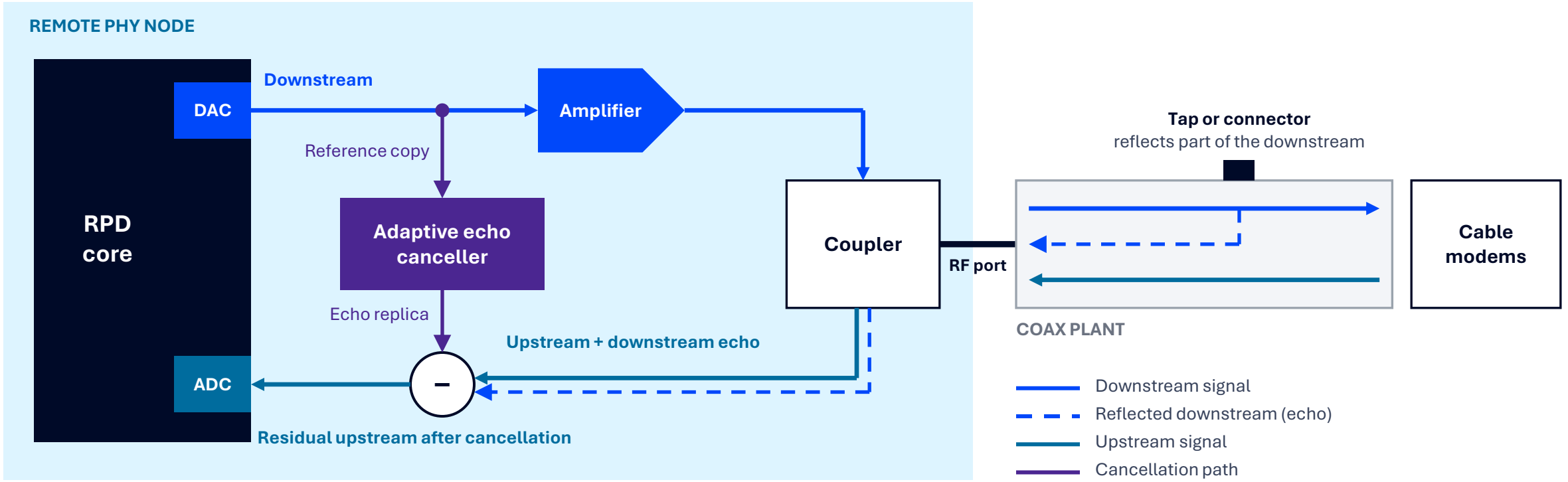


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FDX key technology: echo cancellation

How a Remote PHY node receives upstream on the frequencies it is transmitting on



One band, one port

In the FDX band the node transmits downstream and receives upstream at the same time.

Its own echo comes back

Reflections of the downstream return with the upstream, and can be far stronger than it.

Subtract what it knows

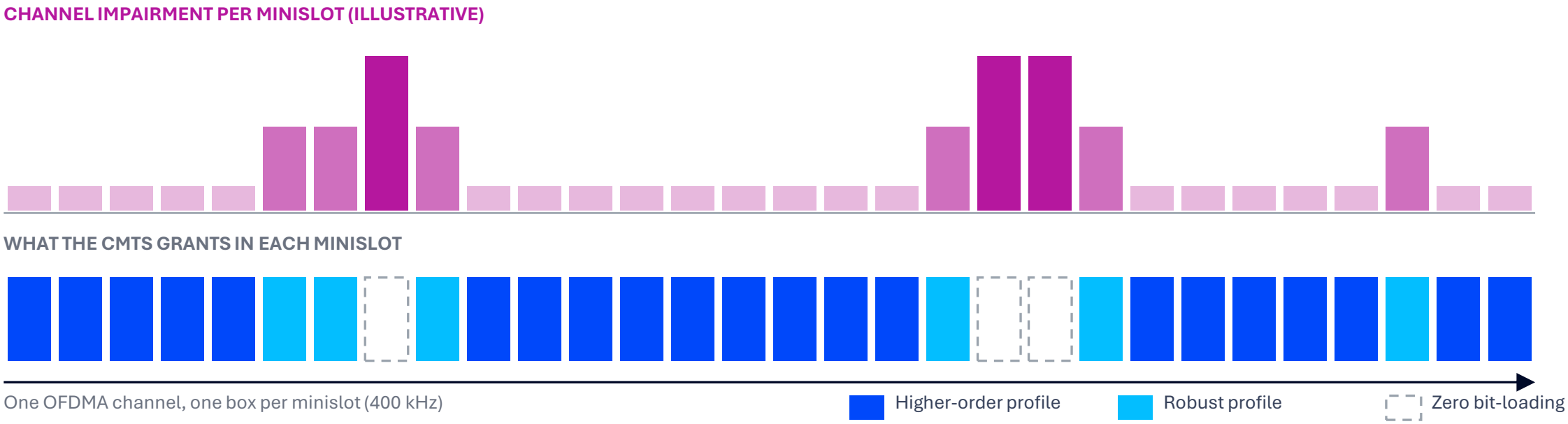
The node knows what it sent, so it removes a replica of it. A modem cannot do that for a neighbour.

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Upstream resilience: Dynamic IUC

Per-minislot adaptation inside the CMTS, within seconds



Fast
Reacts within one or a few seconds, where profile management cannot follow short noise bursts.

Fine-grained
Chooses between two data IUCs and zero bit-loading for each minislot.

Local
Decided in the CMTS from per-minislot metrics, with no message to the modem.

It works alongside profile management, and the same metrics let the CMTS place ranging in a noise-free part of the channel.

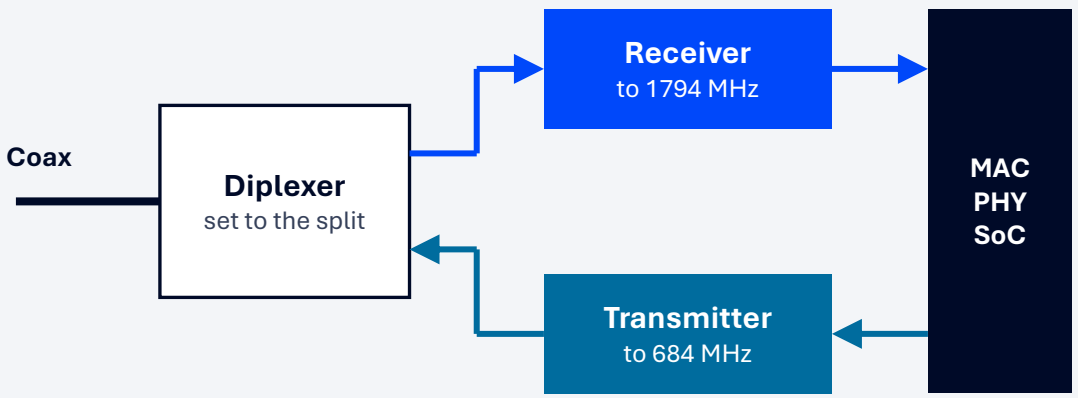
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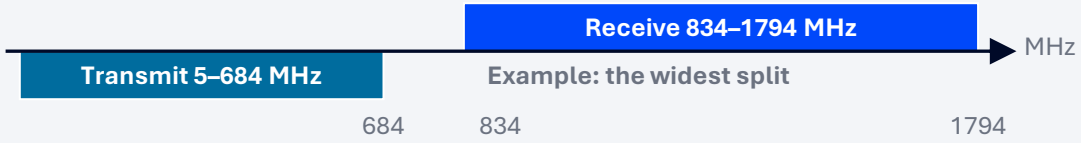
Cable modem RF front end

Two designs behind one specification

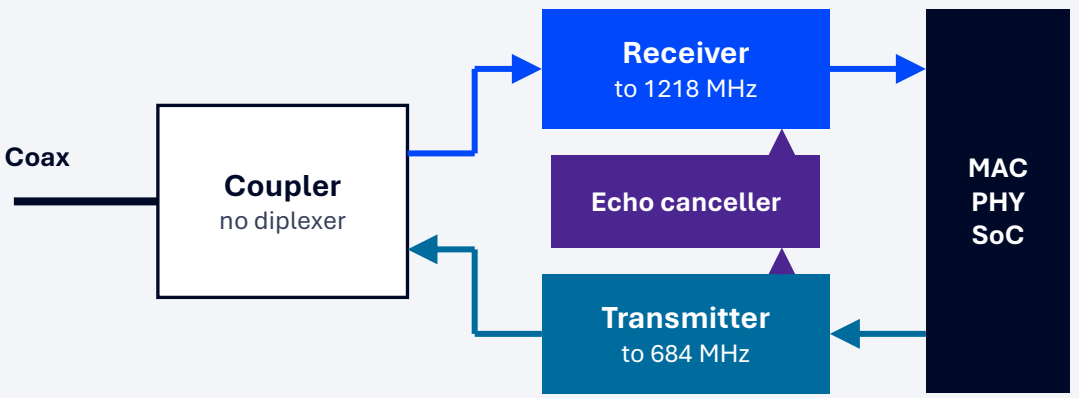
FDD modem



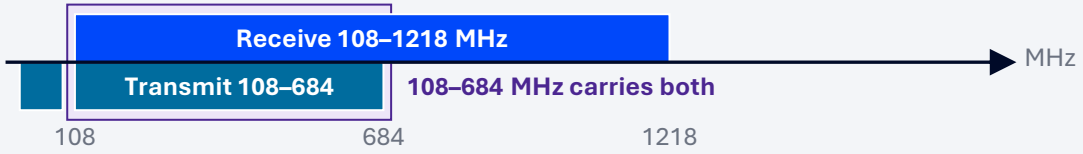
The diplexer keeps transmit and receive in separate bands.



FDX modem



Different FDX sub-bands can use opposite directions; each sub-band is one direction at a time.



Common to both

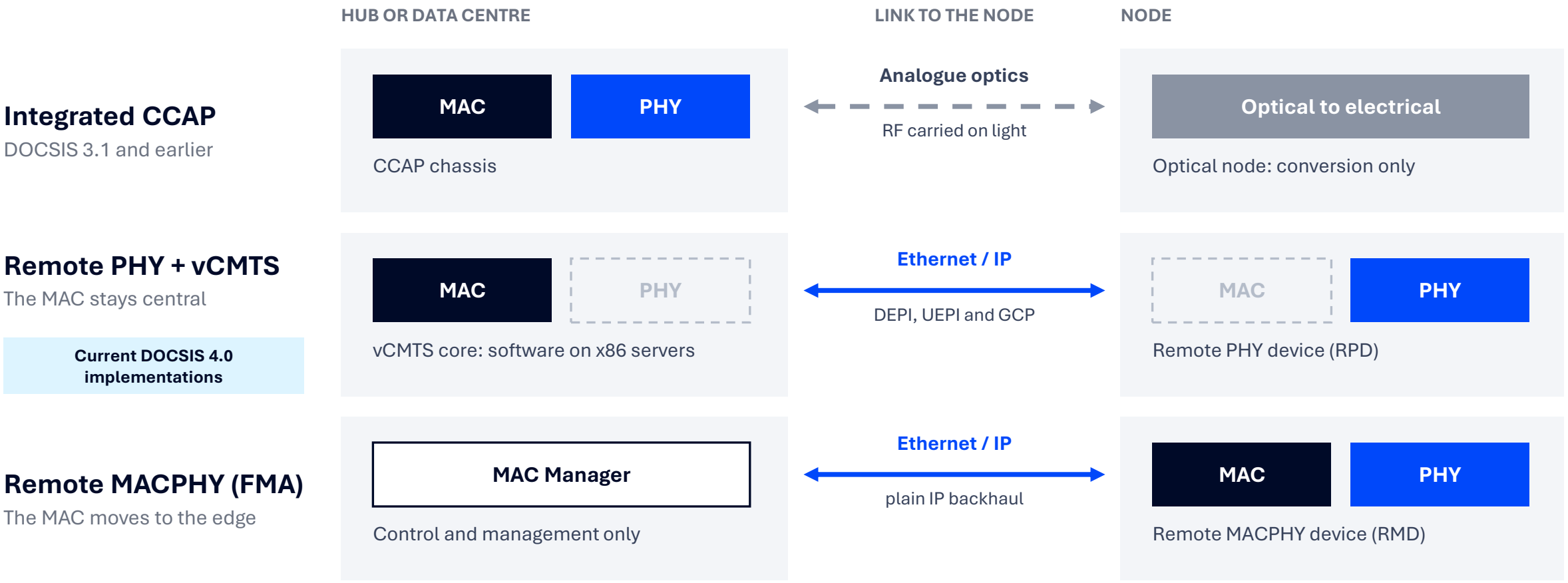
At least 5 OFDM and 7 OFDMA channels. Backward compatible with DOCSIS 3.1 and 3.0. Unified chipsets now build both front ends into one device.

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Three places to put the MAC and the PHY

Integrated CCAP, Remote PHY with a virtual core, Remote MACPHY



DOCSIS 4.0 fit: FDX was specified for a node that holds the PHY, an RPD or an RMD.

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A virtual CMTS implementation example

Aurora vCCAP Evo: control and data planes scale independently

Kubernetes and automation

Runs every control and data plane; several instances can share one cluster. gNMI, RESTCONF and CLIPS for orchestration

Control plane: up to 2, redundant 1+1

DOCSIS control, GCP to the RPDs, routing and addressing, CLI, SNMP, NETCONF and gNMI

Data plane: up to 16 per instance, redundant N+M

All customer traffic: forwarding, DEPI and UEPI tunnels, BPI+ encryption, DOCSIS scheduling

Servers and switches of the operator's choice

Intel Sapphire Rapids with QAT; 100 GbE for data planes; PTP boundary clock, grandmaster optional

Converged interconnect network

To Aurora or third-party Remote PHY devices, such as Vecima, Teleste and HUBER+SUHNER

192 Gbps per RU

of customer traffic (96 Gbps per data plane, with AES encryption, 192 Gbps with dual NUMA)

252 RPDs per instance

and 65,536 cable modems per instance, with 252 MAC domains and 504 upstream service groups

2 + 16



control and data planes per instance, scaled independently. Outlined: the standby.

Source: Aurora Networks vCCAP Evo solution review, October 2026. Scaling figures are release- and deployment-specific.

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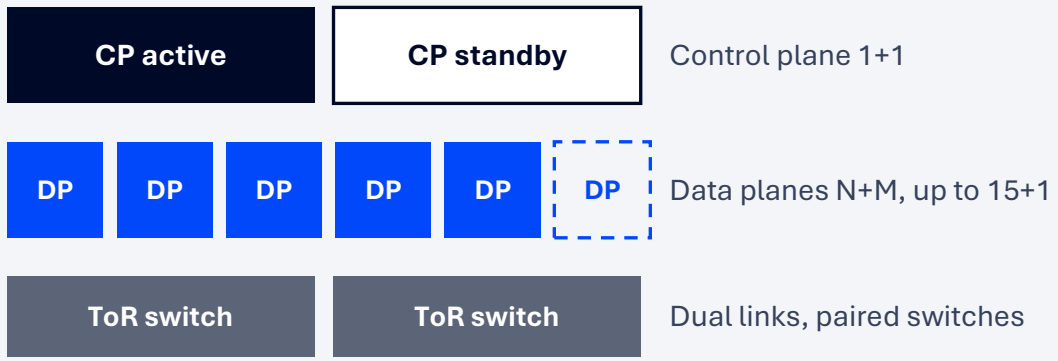
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Resilience in a virtual CMTS

Two layers: inside the cluster, and between sites

LAYER 1

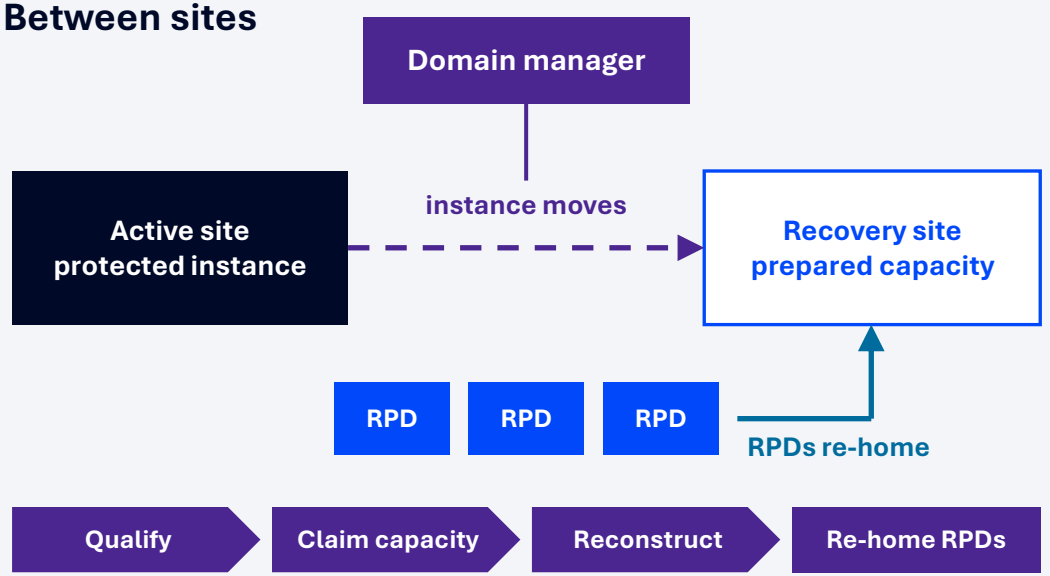
Inside the cluster



Service stays at the active site.

LAYER 2

Between sites



Distributed instance

One instance across two data centres: each RPD is served locally and taken over by the other site if one fails.

Sized to the hub

From a single converged server for a lab to 2 control and 16 data planes, expanded in live operation.

Planned or unplanned

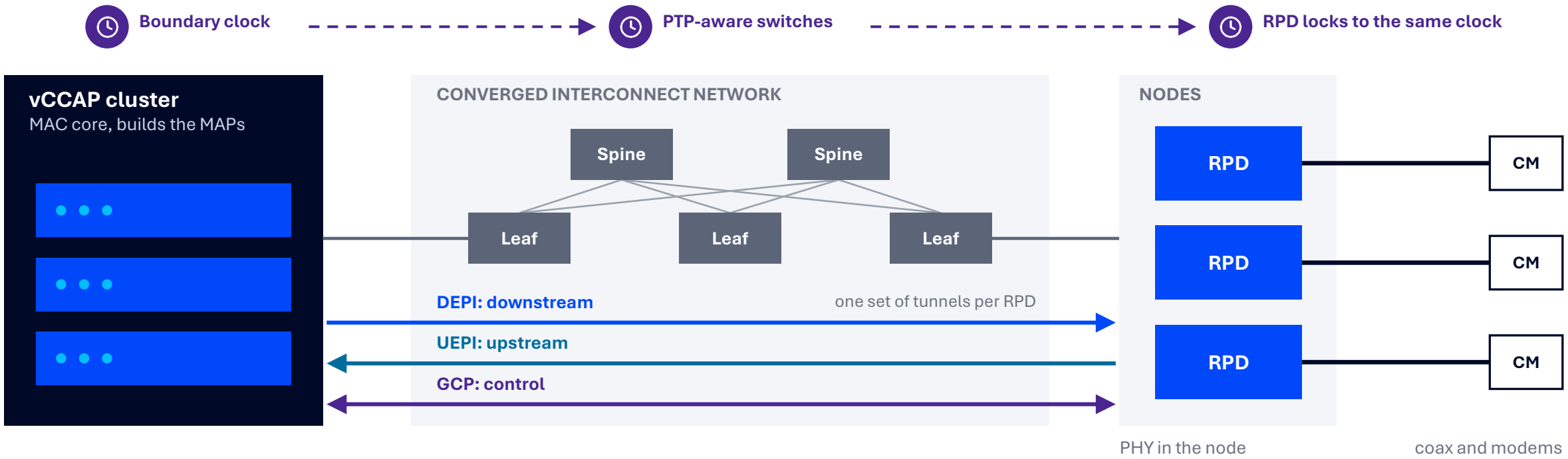
The same recovery sequence serves automatic, scheduled and manual moves.

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The CIN and timing

The network between core and node becomes part of the DOCSIS MAC



Request-to-grant path (conceptual, not to scale)



CIN latency consumes part of the scheduler's request-to-grant timing budget, so it influences core placement, MAP advance and system responsiveness. Design for redundant paths, end-to-end PTP and uplinks sized to aggregate throughput.

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Operating the distributed DOCSIS network

AI-assisted correlation and closed-loop automation

SENSE

Collect and normalise

- DOCSIS and PON telemetry
- RF performance, alarms, modem state
- Topology, call history, past tickets

REASON

Correlate and explain

- Group related alarms
- Trace faults across the topology
- Rank causes with a confidence score

ACT

Prioritise, recommend

- Severity P0 to P3 by customer impact
- Recommended action or dispatch
- Staff approve operational changes

LEARN

Close the loop

- Verify the repair with telemetry
- Learn from resolved incidents
- Tune the prioritisation

Outcomes feed back into the next round

ONE OPERATING LOOP, BUILT ON A COMMON DATA LAYER

RF and modem telemetry
RxMER, profiles, alarms and modem state

Topology and service groups
RPD, CIN, plant relationships and utilisation

Incidents and workflows
Tickets, work orders, history and outcomes

Customer experience
Impact, call signals and service performance

Bounded automation today: people approve consequential changes; TM Forum Level 4 remains the ambition.

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The agents: one for each operations team

How the same data layer serves different teams

Network operations
Navigator

ASKS

Which incident matters most, and what should we do first?

DRAWS ON

Alarms, topology, service metrics, incident history

DOES

Groups alarms, ranks causes with a confidence score, drafts the runbook

HUMAN CONTROL

NOC staff approve every change

Field
Engage

ASKS

What should I test first, and which parts will I need?

DRAWS ON

Work orders, asset records, remote tests, field photos and notes

DOES

Builds the pre-visit brief, picks the next test, verifies the repair

HUMAN CONTROL

The technician validates on site

Customer care
Call Center Triage

ASKS

Why is service slow, and which fix is most likely to work?

DRAWS ON

Telemetry, CRM and tickets, outage history, the live conversation

DOES

Separates home faults from network faults, prepares the case notes

HUMAN CONTROL

The representative confirms any action

Profile optimisation
Profile IQ

ASKS

Which profiles should each channel run now?

DRAWS ON

OFDM and OFDMA RxMER for every channel

DOES

Generates profiles, schedules them, pushes to the CMTS, validates

HUMAN CONTROL

Runs within set limits, with rollback

One data layer, deployed on-premises

Network telemetry, subscriber experience, tickets and workflows, service profiles. Operator data stays under operator control.

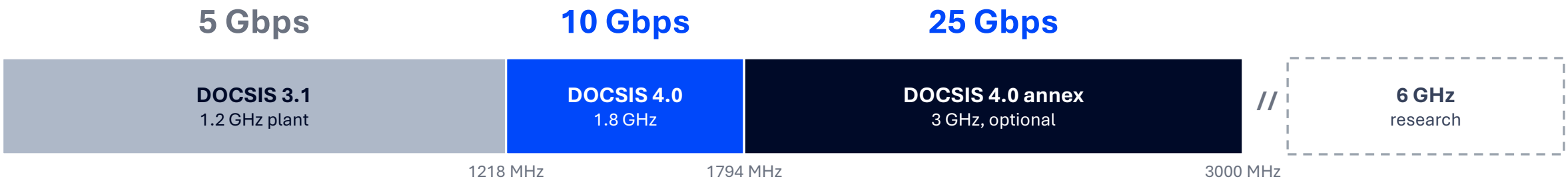
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What comes next

More spectrum increases capacity; automation must keep the distributed network operable

DOWNSTREAM SPECTRUM AND APPROXIMATE HEADLINE CAPACITY



The 3 GHz annex extends the downstream only, and node amplifier technology for it is still in development.

Spectrum becomes flexible

FDD to 1.8 GHz or FDX within 108–684 MHz; unified silicon supports multiple deployment paths.

The CMTS becomes distributed

The MAC core, CIN, timing, RPD and cable modem operate as one coordinated system.

Complexity moves into software

Profiles, sub-bands, interference groups, scheduling, redundancy and telemetry are managed continuously.

The next step: bounded AI automation

AI agents correlate RF, topology, incidents and subscriber experience; recommend actions within policy; and verify outcomes.

Faster diagnosis, safer changes and a progressively closed operational loop.

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