UNLEASH THE POWER OF LIMITLESS CONNECTIVITY
Wireline Access Network

Extended CIN

Deepa Phanish, Ph.D.
Network Planner/Technical Analyst
Cox Communications
Collaborations

Alan Skinner, Principal Engineer, Cox Communications
John Huang, IP Engineer, Cox Communications
Igor Tavrovsky, Reliability Engineer, Cox Communications
Ernest Fabre, Design Engineer, Cox Communications

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INTRODUCTION

Remote PHY Core

• Remote PHY enables cable operators to deliver Gigabit service
• CCAP Chassis in every facility
• Substantial amounts of rack space, power, and HVAC
• Non-feasible/cost intensive facility augments

Network design to deploy CCAP chassis non-locally?

Cisco cBR8 CCAP

Weight: 429 lb. (195 kg) max
Height: 13 RU (22.75 in)
Width: 17.45 in no rack mounts, 17.65 in with rack mounts

- Lifetime Facility Power: 9000 W
- Hardware Facility Power (D3.0): 7300 W
- Hardware Facility Power (D3.1): 7900 W
- Average fully loaded: 4500 – 5200 W
INTRODUCTION

Agenda

1. Network Design
   • Topology
   • Reliability Analysis
2. Implementation
   • Networking
   • Video support
3. Performance – Latency, Throughput, Distances
4. Business Impact
   • Capacity planning
   • Cost Estimate
5. Conclusion
Topology

FULL CIN VS E-CIN

• In standardized full CIN solution, hub routers uplink to the backbone over metro DWDM
• "Remote site": E-CIN edge facility
• "Host site": CCAP core facility

• What are the topological solutions for E-CIN?
• How to chose an optimal host?
**Topology**

**E-CIN SOLUTION 1**

- Direct DWDM links between remote access aggregation device and host hub routers

- **Pros:** Least hops, low latency
- **Cons:** Not scalable
- **Use case:** No growth small site
**Topology**

**E-CIN SOLUTION 2A**

- Route via remote hub routers with direct DWDM links to host hub routers

- **Pros:** Scalable, few hops
- **Cons:** Hybrid topology, non-optimal DWDM aggregation
- **Use case:** Direct fiber pair to subtended site
E-CIN SOLUTION 2B

- Route via remote hub routers and DSRs back to host hub routers over DWDM links

- **Pros:** Scalable, standardized topology, optimal DWDM aggregation
- **Cons:** More hops, higher latency, lower reliability
- **Use case:** Generic, performance dependent on host selection
Reliability Analysis

**2B CASE STUDY**
- Metro optical ring spanning ≈1300km, 18 sites
- Individual distances for metro and long-haul

**MODELING**
- ReliaSoft BlockSim package
- MTTR = 4hrs for comparison, log-normal for last mile with $\mu = 3.3.4576$ and $\sigma = 0.5287$
- Last mile simulation with hardware, software, human factor, and power outages, > 1000 blocks, 5 yrs of operation, 5000 iterations
Reliability Analysis

SIMULATION RESULTS – METRO CORE

Ex: For “Last mile” drop by 0.00028, customer site J with cBR8 in RDC A has a mean availability of 99.964%. Does it qualify SLA?
Topology Selection

SUMMARY

Priority 1: **Subtended hub-hosted** (Solution 2a)
- Another hub site as host with direct fiber pair links

Priority 2: **RDC-hosted** (Solution 2b)
- RDC as host with standard L3 hub-and-spoke topology

Priority 3: **Hub-hosted** (Solution 2b)
- Another hub site, preferably of highest reliability, as host with standard L3 topology
IMPLEMENTATION

Networking

- CIN routing policies apply
- IP addressing and route advertisement updates for reachability between RPA, CCAP core, and boundary clocks (BCs)
- Remote edge leverages host site BCs for timing
- BC preference set by the R-DTI profile
Video Support

• Increased operational complexity
• Additional CCAP configurations when channel lineup, ad zones, DSG tunnels, OOB, and PEG channels differ between remote and host sites
• CCAP configuration best practices
  • No more than 6 full BSGs per CCAP
  • No more than 12 BSGs per CCAP including PEG
  • One Conditional Access System per CCAP
  • One main SDV lineup on a CCAP

Multiple remote site hosting options:
1. All remote sites on all CCAPs - Most flexible, high complexity, potentially reduced DOCSIS SG capacity
2. Segregation of CCAPs by serving footprint – optimal configuration, requires tracking of RPD mapping
3. Standalone dedicated video core – Full CCAP utilization for DOCSIS, only DSG tunnel configurations
DOCSIS Request/Grant Cycle

**Legend:**
- **RPC** = Remote Phy Core
- **RPA** = Remote Phy Aggregator
- **RPD** = Remote Phy Device
- **CM** = Cable Modem
- **CPE** = Customer Premises Eqpt

**Bandwidth request**
- RTT = base DOCSIS delay (5ms) + 4 km HFC + 40 km CIN
- 6 ms

**Ping request**

**Bandwidth grant**

**Ping reply**

**Ping reply**

**400km (2 ms of light)**
- Extended CIN

**Bandwidth request**
- RTT = base DOCSIS delay (5ms) + 4 km HFC + 40 km CIN + 1600 km E-CIN
- 14 ms

**Ping request**

**Ping reply**
PERFORMANCE

Latency, Throughput, Distance

• Full downstream and upstream throughput, even on the Gigabit tier, up to 320km
• Exact distance limitation to preserve full Gigabit downloads is still TBD
• During path failover, worst-case at 1200km, downstream throughput inconsistent, not gigabit-class. RPDs and modems remain online and providing service in a degraded state

It is essential to maintain optimization - preferring the shortest path (in steady state) and ensuring symmetrical (forward & return) traffic flow
BUSINESS IMPACT

Capacity Planning

A) \( \max(Td_H + TCI_{R}/2, M \times (Tu_H/2 + TCI_{R}/2)) \]

B) \( Td_H/2 + M \times TCI_{R} \]

C) \( \max(Td_R, \frac{M}{2} \times (Td_R + TCI_{R})) \]

D) \( Td_R + TCI_{R} \]

\( T_{xy} \): Total \( x \)-stream traffic at \( y \)-site

\( M \): Bandwidth margin on the router uplinks, required for heathy tunneled traffic flow

\( M = 1.5 \) ensures steady state below 66.66%
Conclusion

- E-CIN is novel to geographically de-couple Remote PHY core from edge
- Useful in reducing footprint at a facility and consolidating resources
- Cost benefit from deferred facility augments and shared core resources

- Unique challenges with reliability, latency, and operational complexity
- Cost expenditure on additional metro-core augments

- Apply E-CIN only where optical separation is low (< 320 Km) and cost benefit is high.
- Pending evaluation within the context of Remote MAC-PHY and virtual CCAP
Thank You!

Deepa Phanish, Ph.D.
Network Planner/Technical Analyst
Cox Communications
+1 404-664-8816
deepta.phanish@cox.com