Modern Cable Networks

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Base Principles

- Let’s define ‘architecture’
- Fundamentals of modern SP & cable networks
  - Automation
  - Routing systems
  - Network discipline
- Modern Cable Networks
  - Metro networks & pluggable optics
  - CIN and a rapidly diversifying last mile
- Major decision points

/ˈärkəˌtek(t)SHər/

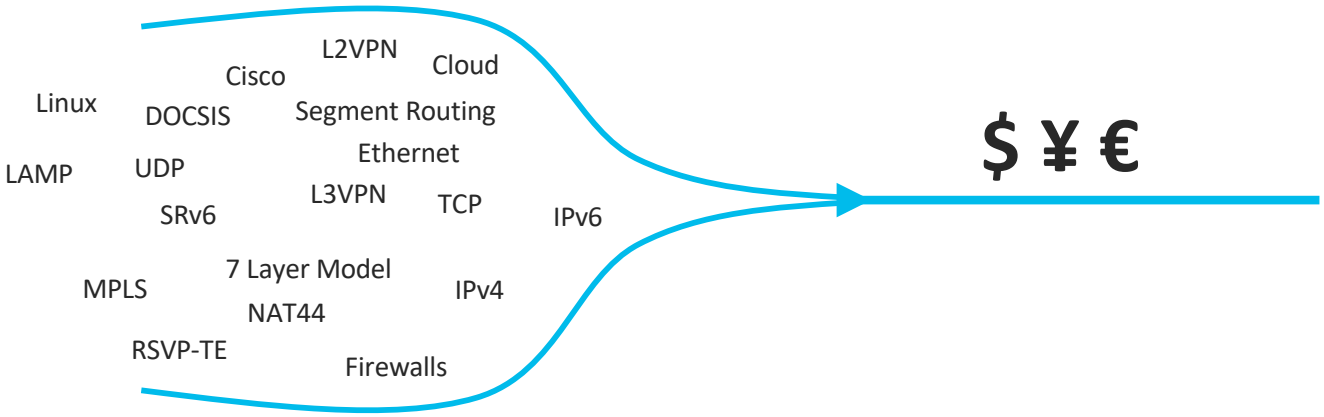
- What does “network architecture” really mean?
- What or who is a ‘network architect’?
- What is a successful network architecture?

Differing views of Cloud Computing

An architecture can be as simple or as complex as you want to make it.

/ˈärkəˌtek(t)SHər/

- Architecture means **consensus** in how to achieve the goal.
- In Service Provider, the goal is to **make money**
- Technology enables the goal. **Technology isn't the goal itself.**



Network Architecture drives technology to the goal

The Cable Internet Environment

Essentially all core and metro traffic is IP over Ethernet

- That which isn't (less than 1%) will be soon

Essentially all last mile traffic is IP over DOCSIS

- DAA extends this to IP-over-Ethernet-over Fiber + DOCSIS

Essentially all network traffic begins and ends at a machine

- Data Center is the root of cable (new satellite receiver), IP-only video players
- Cameras and production facilities migrating to IP
- Much more dynamic traffic patterns than other forms of networking. Residential internet is an inherently bursty service
- As computational power grows, so will traffic demands. Fuels high growth of networks.

Therefore, all cable networks need routers and routing

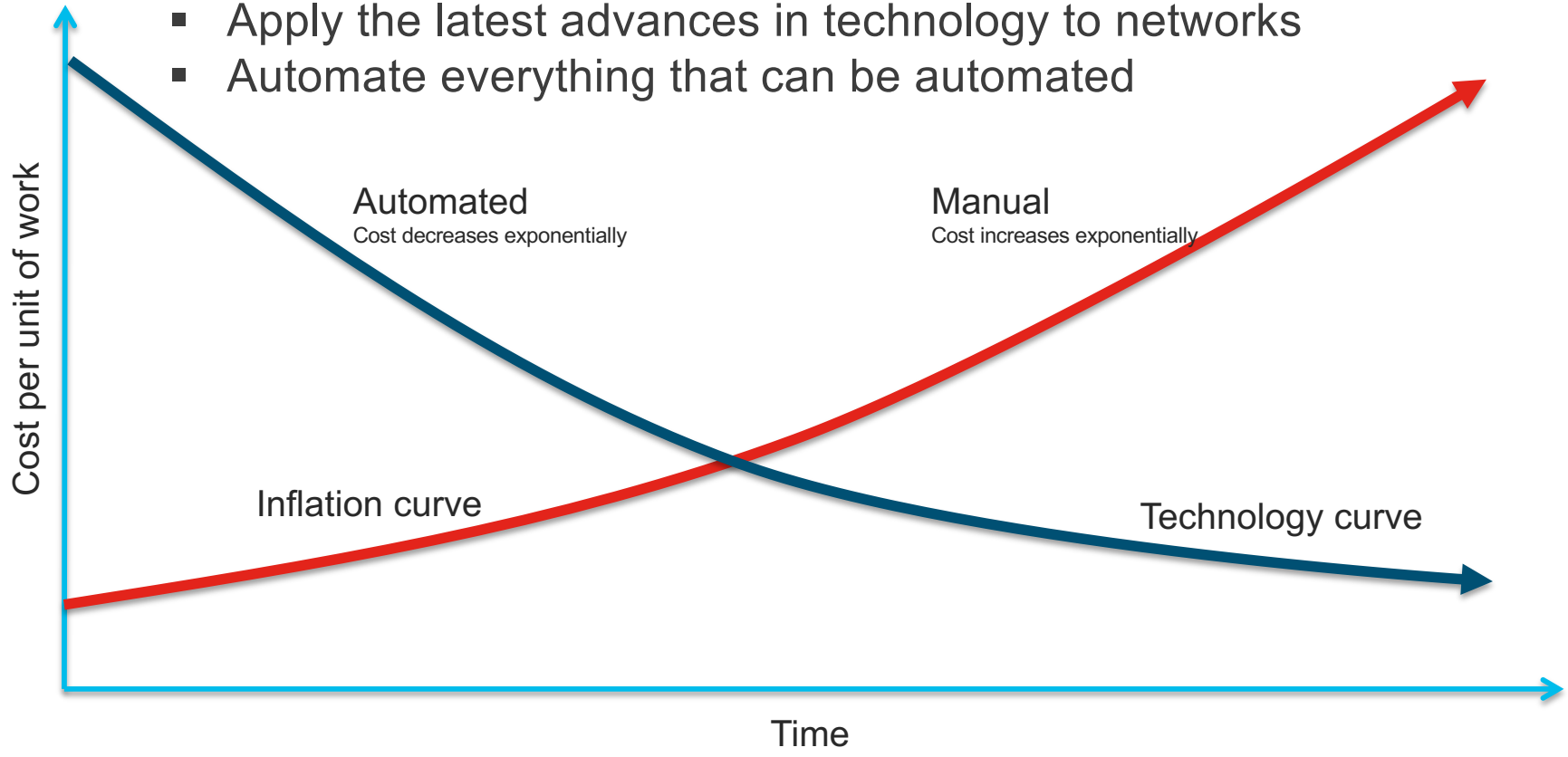
These are fundamental, base principles

What cable operators demand

- All large networks – Cable, SP, Web, Financial, Government… all have similar macro demands
- Among the largest and most demanding Internet networks
- Most common asks are:
  - Help us reduce **opex**
  - Help us become **agile and efficient**
  - Help us reduce **capex**
- Cable and SP specifically:
  - Help us **monetize** our networks

Fundamental Economics of Technology

- Apply the latest advances in technology to networks
- Automate everything that can be automated



Fundamentals of Networking

- Most significant advances in the last 40 years:
  - Packet switching increased efficiency
  - Routing (dynamic topology discovery) automated network operations
- The next advances will be in:
  - SDN – Logically centralized functions
  - NFV – Stateful (L4-L7) functions
    - Cloud native networking – Ensemble of stateless network software components

These advances will be in addition to, not instead of, packet switching and routing.

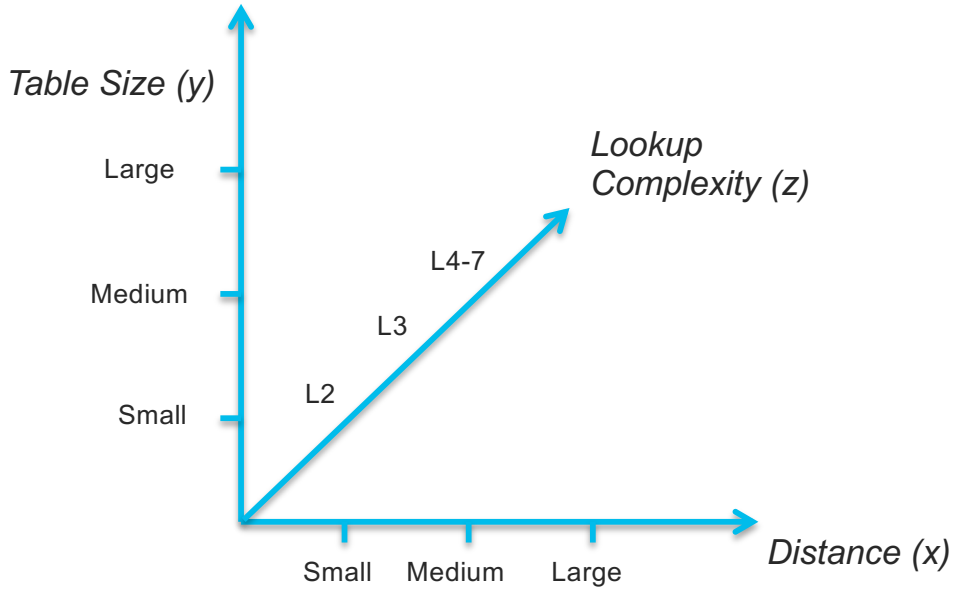
Fundamentals of Routers

- Routers have five crucial properties:
  - Dynamism
  - Stat-Mux Gain

  } Quintessential properties

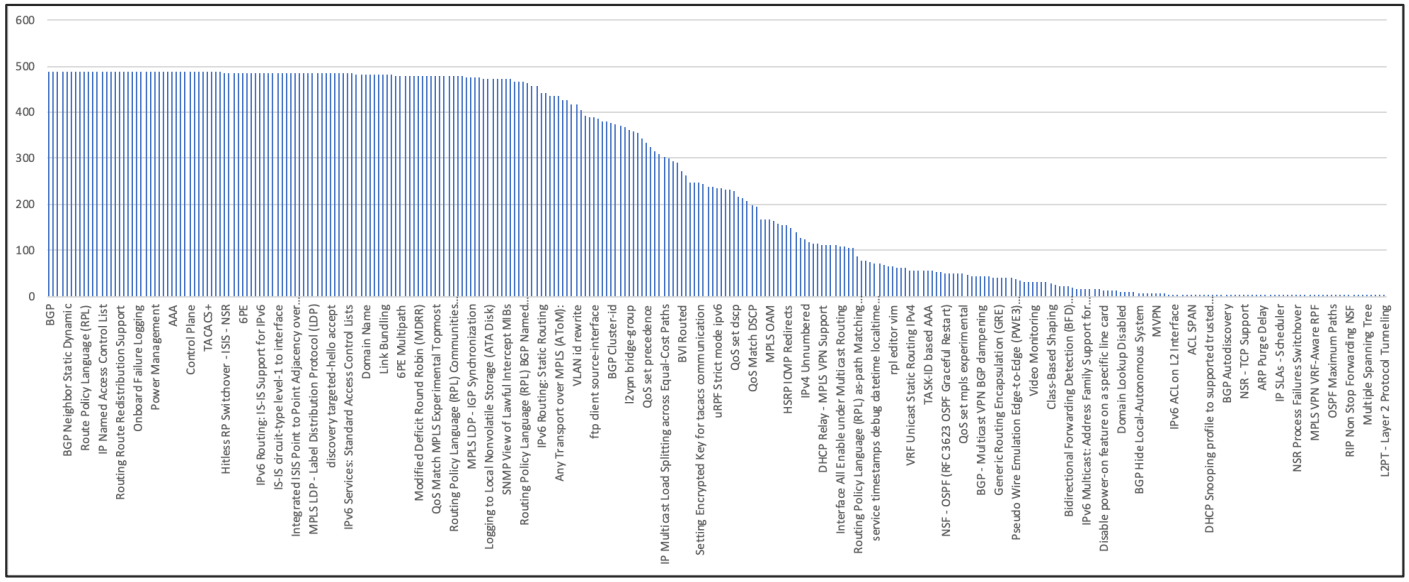
  - Distance
  - Table Size
  - Lookup Complexity

  } Variable properties



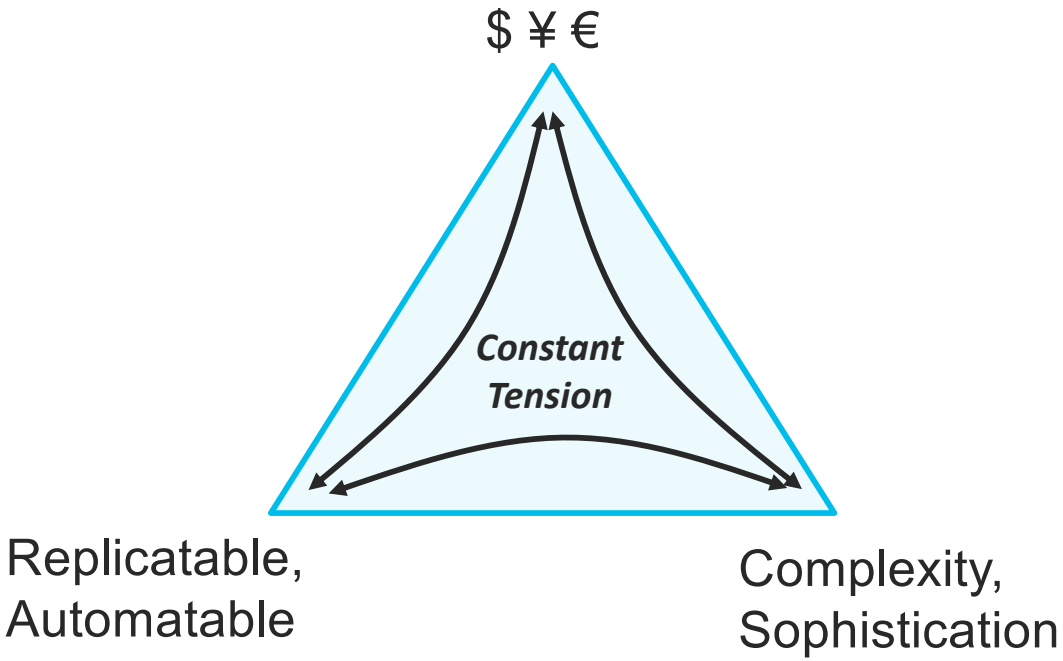
When one or more of these properties can be relaxed, a router can be delivered of lower cost.

Discipline in Network Architecture



- Network architecture is as much about what is turned off, as well as what is turned on
- One off configs can solve problems and apply agility to business, but at a cost of complexity and compounded hardware/software interactions
- Actual distribution of features enabled on 488 ASR9k routers in a major cable environment

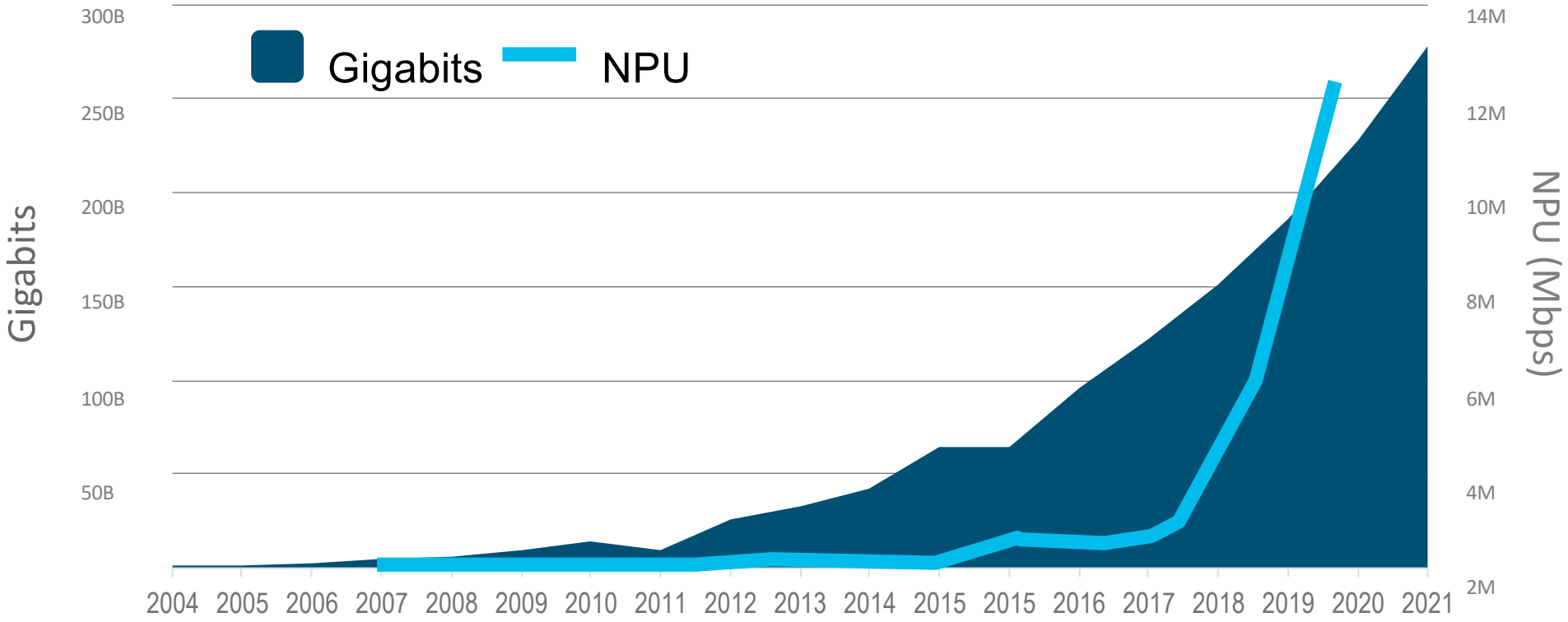
The SP Network Triangle Conundrum



- Making money – always in tension with network ability and network efficiency
- Regardless where value is added in the network – edge/PE, app, last mile, will still find this pattern
- The art of SP network architecture is in finding the balance to deliver an acceptable result

The World of Bandwidth

Gigabits per Month vs. NPU (Mbps)



Modern Cable Metro Networks

An old {debate, argument, contest, fight}

Circuit switching architectures	Packet switching architectures
~~Connection oriented~~	~~Connectionless~~
~~ATM~~	~~IP~~
~~Fast~~	~~Slow~~
~~Reliable~~	~~Unreliable~~
“Cheap” (OTN)	“Expensive” (MPLS)

- Packet switching has consistently proven to be superior to circuit switching in all types and sizes of networks
- OTN / Optical architecture’s last argument is cost
- Emergence of next gen silicon, systems, and **400G ZR** will settle this for high growth metro networks

Packet switched metro transport networks

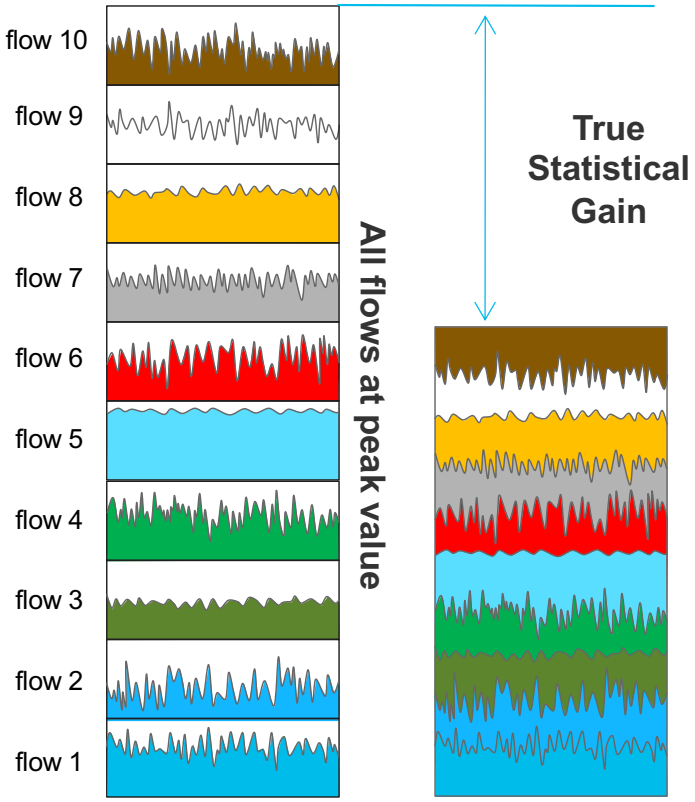
Base principles:

- Statistical multiplexing creates efficiency (pooling) – circuit switching loses this
- Routing automates fundamental operations, enables scale

Add to the recipe:

- High order automation via API's and industry consensus
- Scalable control and data planes with MPLS and Segment Routing
- Extremely high capacity, low latency, clean slate silicon technology
- Low power, interoperable, high capacity pluggable optic. **400G ZR and ZR+ is the major inflection point!**

400G ZR Packet Transport in the Metro



- Metro-distance networks will have the highest growth rate in the coming years
- 400G ZR and modern ASICs dramatically improves efficiency, scale and automatability of this network
- Bandwidth may no longer be the scaling factor – **latency will mater more**

Traffic Moving Closer to End User

Cross-country Delivered
58% in 2016
41% by 2021

Regional Delivered
20% in 2016
23% by 2021

Metro Delivered
22% in 2016
35% by 2021

Modern Cable Access Networks

The Big Changes with DAA & CIN

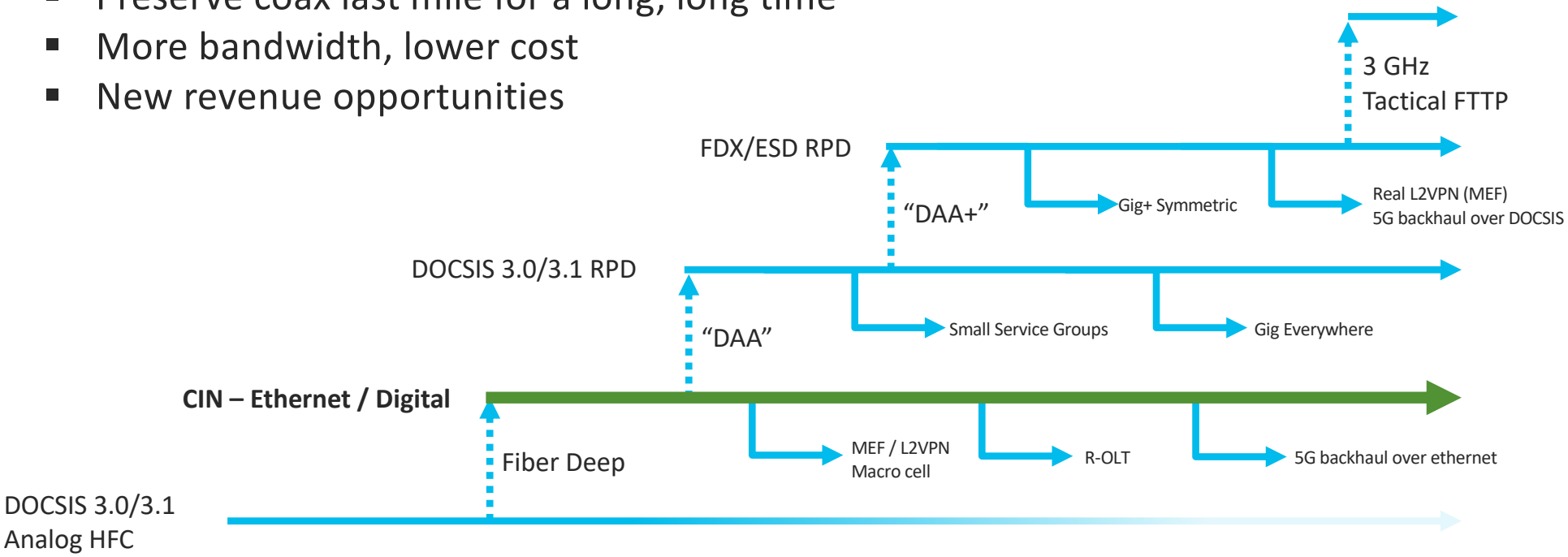
The Cable HFC transition from “analog” p2p optics to modern IP-over-Ethernet enables new, fundamental base principles in this portion of the network:

- Dynamic topology discovery
  - Routing, for the first time, is applicable here
  - An arbitrary topology is possible (p2p, ring, tree, etc)
- Packet switching stat-mux
  - Massive increase in efficiency and capacity
  - Creates entire new platform for multiple service delivery
- Automation and software control
  - Transition from hands-on black art of analog to fully automated packet networks
- Economic advantages
  - Adopting standard SP technology sets a new standard for investment & return

CIN is the inflection point

The big goals:

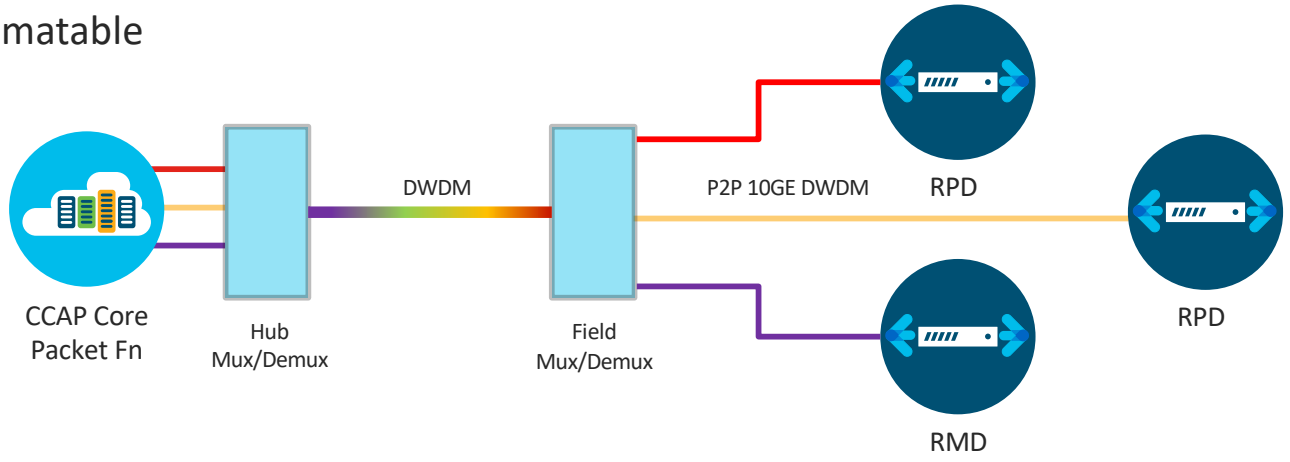
- Preserve coax last mile for a long, long time
- More bandwidth, lower cost
- New revenue opportunities



Not to scale

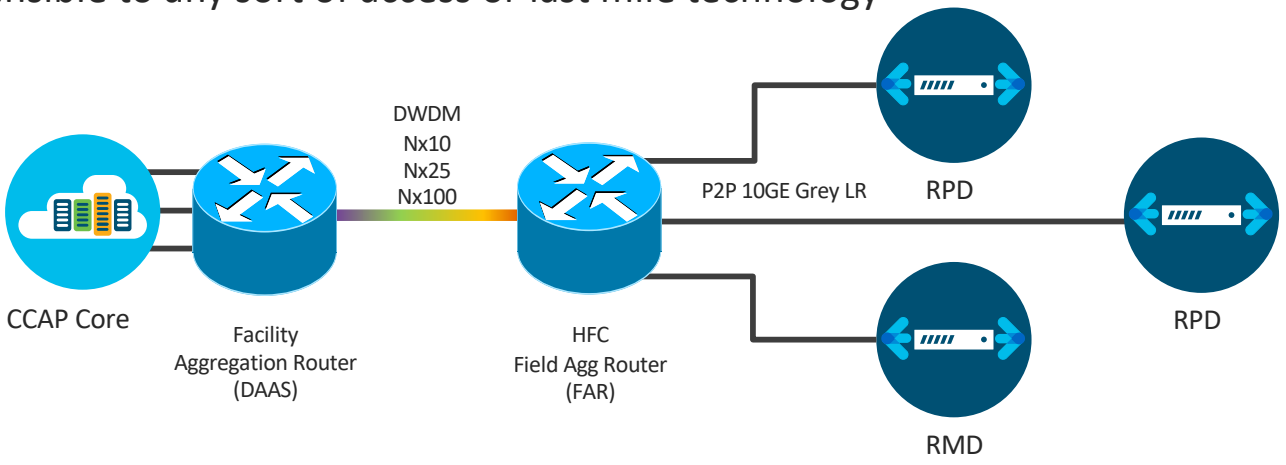
Typical DAA Plan of Record

- Leverage 10GE colored optics in a facility/field mux/demux architecture
- Discrete P2P ethernet & IPv6 from CCAP Core to each RPD
- Stable and predictable access network, but:
  - Consumes high number of DWDM 10G optics ($)
  - Long term inefficient use of fiber assets (no statmux)
  - Un-automatable



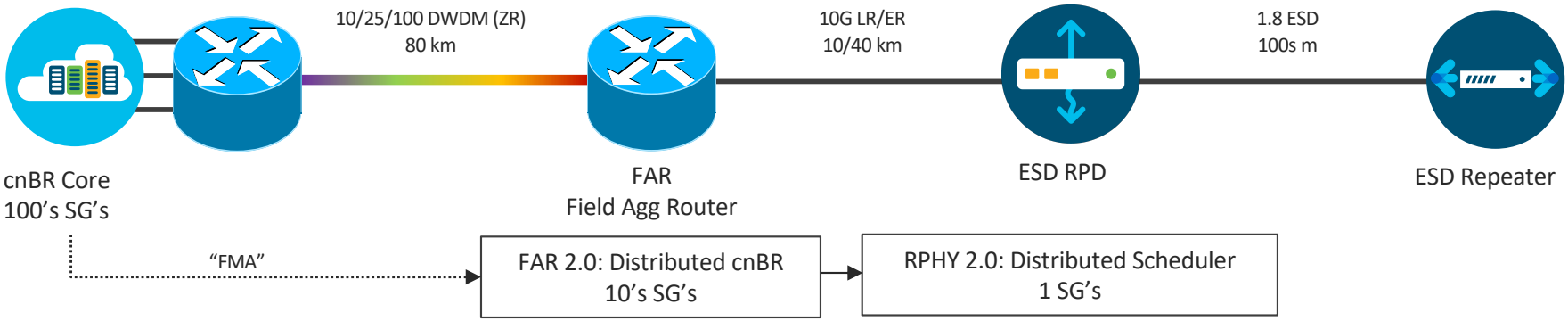
CIN with a Field Aggregation Router

- Placement of a router in the outside plant enables:
  - Highest use of low-cost, <= 40km 10G LR grey ethernet optics between FAR and RPD
  - Tactical use of 10/25/100GE transport links as bandwidth demands and economics permit
  - A fully automated system, minimal labor to enable new RPD's
- FAR keeps fiber within the dimensions of the CIN -- packet is the building block
- Fully extensible to any sort of access or last mile technology



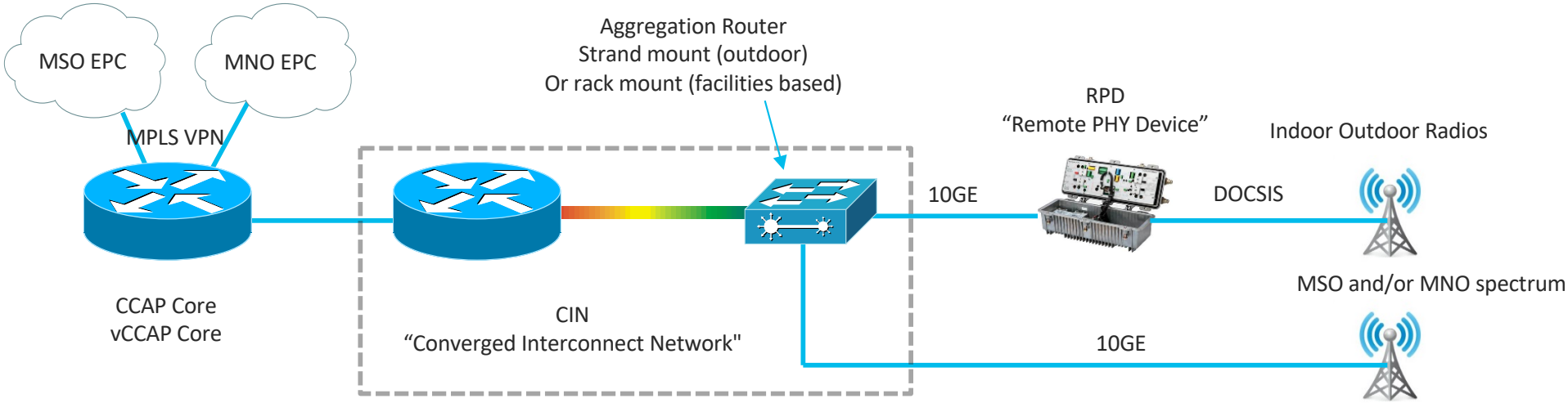
Cable as a System

- Consider the life of a packet, inclusive of FAR, ESD RPD and ESD AMP
- Optimal placement of technology, optics, automation, capital efficiency
- DOCSIS Scheduler can be distributed or centralized
- Platform for potential cable evolution: 5G, vOLT, FMA
- Replicable architecture in a variety of footprints



Cable Access & 5G xHaul

- Investment in Remote PHY enables 5G xHaul over Ethernet and over DOCSIS. Leverage capacity, power, ubiquity of coax
- True multi-purpose, multi-tenant, carrier aggregation network
- Synchronize the LTE and DOCSIS scheduler (BWR), provide 1588



Final thoughts

Cable and Networking: Major Decisions

DAA CIN

- Single or multi purpose?
- Larger strategy or tactical deployment
- Targeted placement of optical technology for a topology

PACKET OPTICAL TRANSPORT

- It's going to happen
- Interop, efficiency, automation, simplicity all driving forces
- Find a small use case and drive it – get experience with it

NETWORK ARCHITECTURE

- Is it a surplus of bandwidth?
- Milliseconds will matter more than megabits
- Can be a little less precise with how we operate

AUTOMATION

- Layered building block approach
- It is a journey not a destination
- Close, intimate relationship with operations

PEOPLE

- Learn new skills or perish
- config term vs int main void()
- Organizational structure and behaviors biggest challenge
- Standards participation

PROTOCOLS

- Treadmill to lock-in
- Industry agreement more important than standards body agreement
- Cablelabs, IETF & consensus


CISCO