

A decorative graphic of a white circuit board pattern is positioned on the left side of the slide. It consists of numerous white lines of varying thicknesses, some straight and some curved, connecting to small white circles of varying sizes, creating a complex, interconnected network structure.

CRISIS IN TRANSPORT (Moving the Purple Line)

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Three Trends in Networking

1. TDM is past its prime

- A major component of Next Generation Networks is the migration from TDM voice to VoIP and from TDM and ATM circuits to Ethernet; this trend progressively reduces the value of fine-grained TDM in NGNs
- TDM is also very expensive on a cost/Gbps basis

2. Packet transport is on the rise

- There is recognition that transport must focus on packets, not bits
- There are multiple approaches, and a lot of confusion out there

3. Interest in the Packets+Photons Phenomenon is growing

- There is also recognition that the worlds of packets and of optical transport must come together
- Again, there are several approaches, and no clear way forward

What Should Be Done?

1 TDM is Past Its Prime

- **Let's look at a brief history of TDM (especially SONET/SDH): where it started and where it is now**
- **The idea is to get a sense of the value of TDM networks, what the issues are, and how this should evolve going forward**

The “Legacy” Picture

SONET/SDH

Deep Channelization: down to VT1.5

⇒ **remove**

Framing: carry bits/cells/packets/frames

⇒ **simplify**

Overhead: OAM: liveness, management

⇒ **split**

Fast Restoration (1+1, ring-oriented)

⇒ **move**

Traffic Engineering (path and capacity mgmt)

⇒ **move**

Timing (clock/frequency synchronization)

⇒ **remove/replace**

Main Function
Responsible for a
fair chunk of cost.
Limited utility
going forward

Suggestion: Transition to Ethernet

Migrate from SONET/SDH to Ethernet + “magic layer”

SONET/SDH

- Deep Channelization: down to DS0
- Framing: carry bits/cells/frames/packets
- Overhead: OAM: liveness, management
- Fast Restoration (ring-oriented)
- Traffic Engineering (path and capacity mgmt)
- Timing (clock/frequency synchronization)

Ethernet

- Magic layer (PBT/TMPLS/MPLS)
to recapture TE, FRR, packet OAM, etc.
- Framing: to carry packets
- G.709: optical OAM, FEC, coarse chan, framing
- Timing (synchronous Ethernet, *if needed*)

DWDM

Fiber

Removing functions that are no longer required leads to savings

Drivers

The primary driver for the transition from TDM to Ethernet-based packet transport is: **COST, COST, COST!**

- 1. New way to “fill pipes”:** statistical multiplexing of packets more efficient than time-division multiplexing of circuits
- 2. Reallocation of functions**
 - Move OAM, Traffic Engineering, and Fast Restoration into the “magic layer”; use Synchronous Ethernet and/or IEEE1588v2
- 3. Elimination of a whole range of infrastructure interface types and link layers in favor of just Ethernet**
- 4. Convergence of services onto a single, purpose-built network for packet transport**

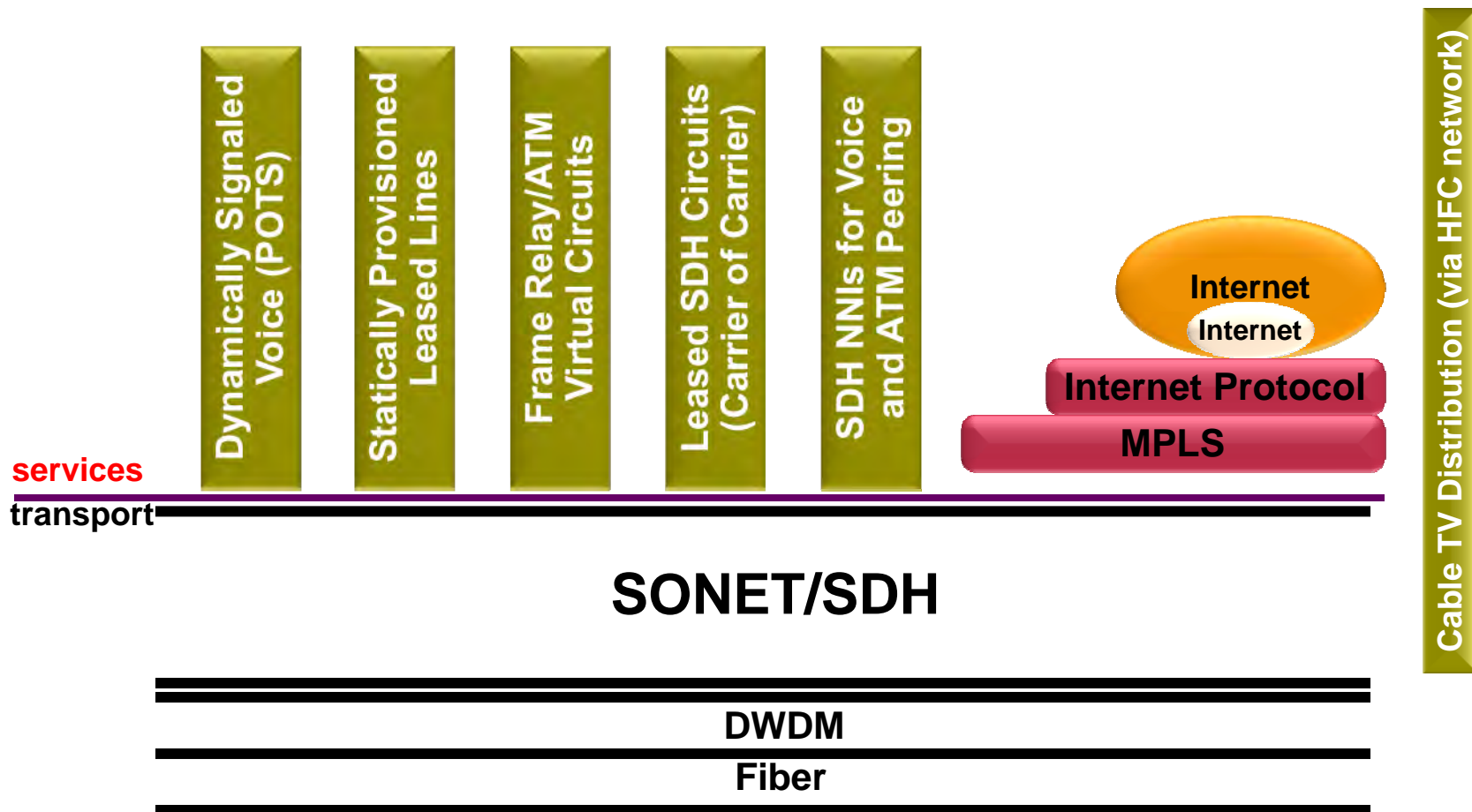
The bottom line is to improve both CapEx and OpEx

What Should the “Magic Layer” Be?

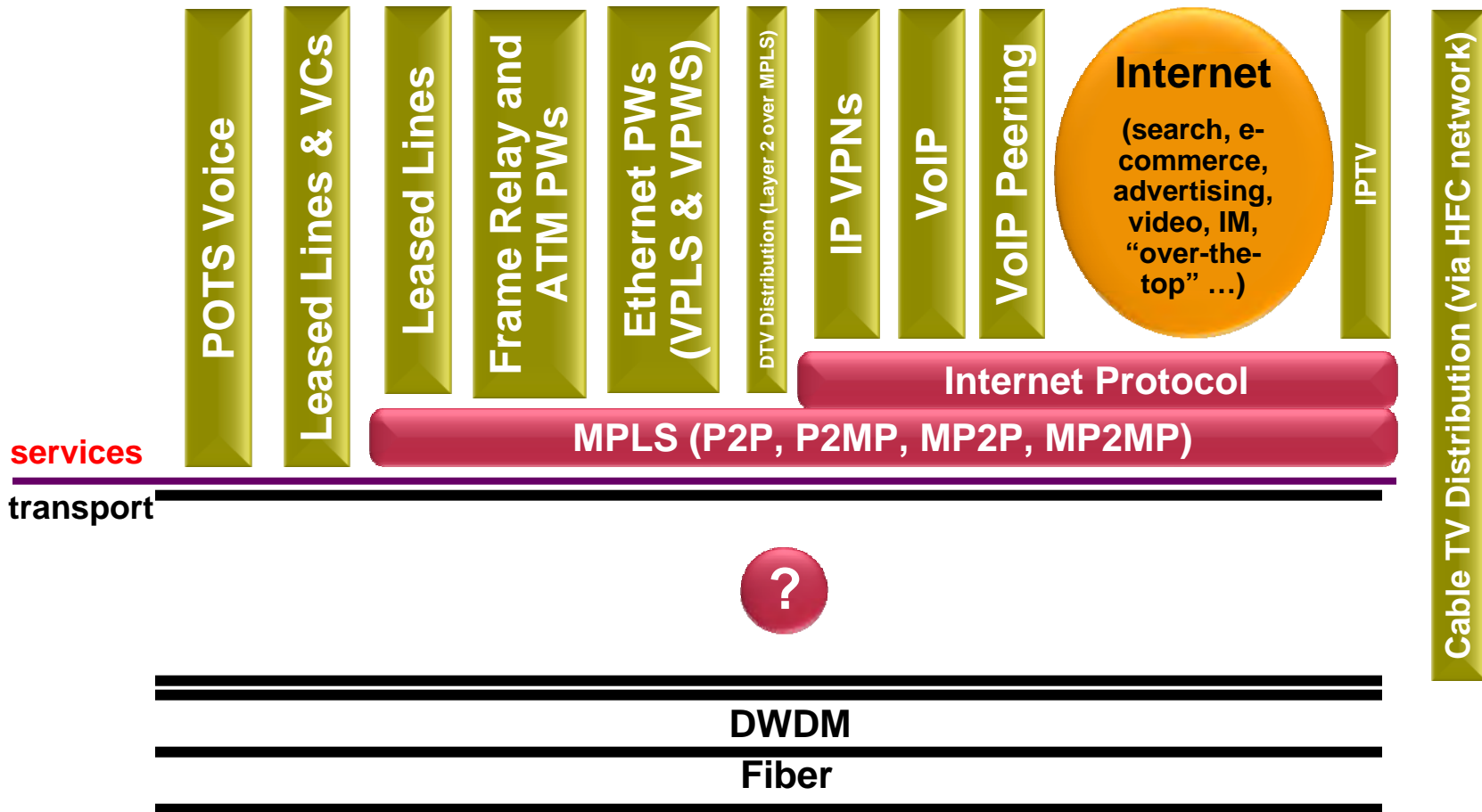
First Let's First See How We Got Here

- **However, before jumping to quick fixes, let's look at a brief history of the transition from TDM-centric networks to packet-centric networks**
 - Hopefully, in doing so, we will gain better perspective on why things are the way they are, and what really needs to change

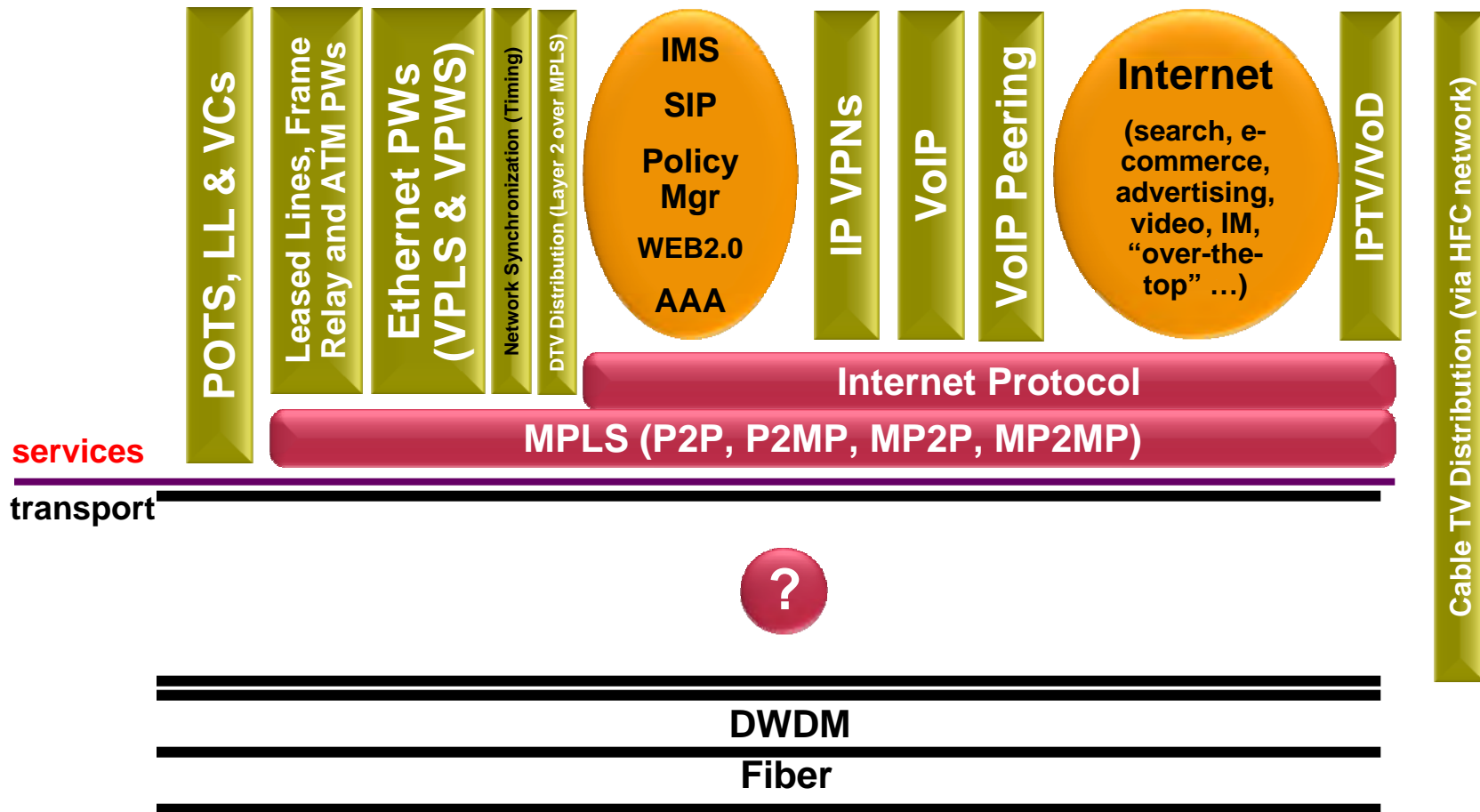
Picture from the Past (20/15/10/5 years ago)



Picture Today



Picture in a Couple of Years



What's wrong with this picture?

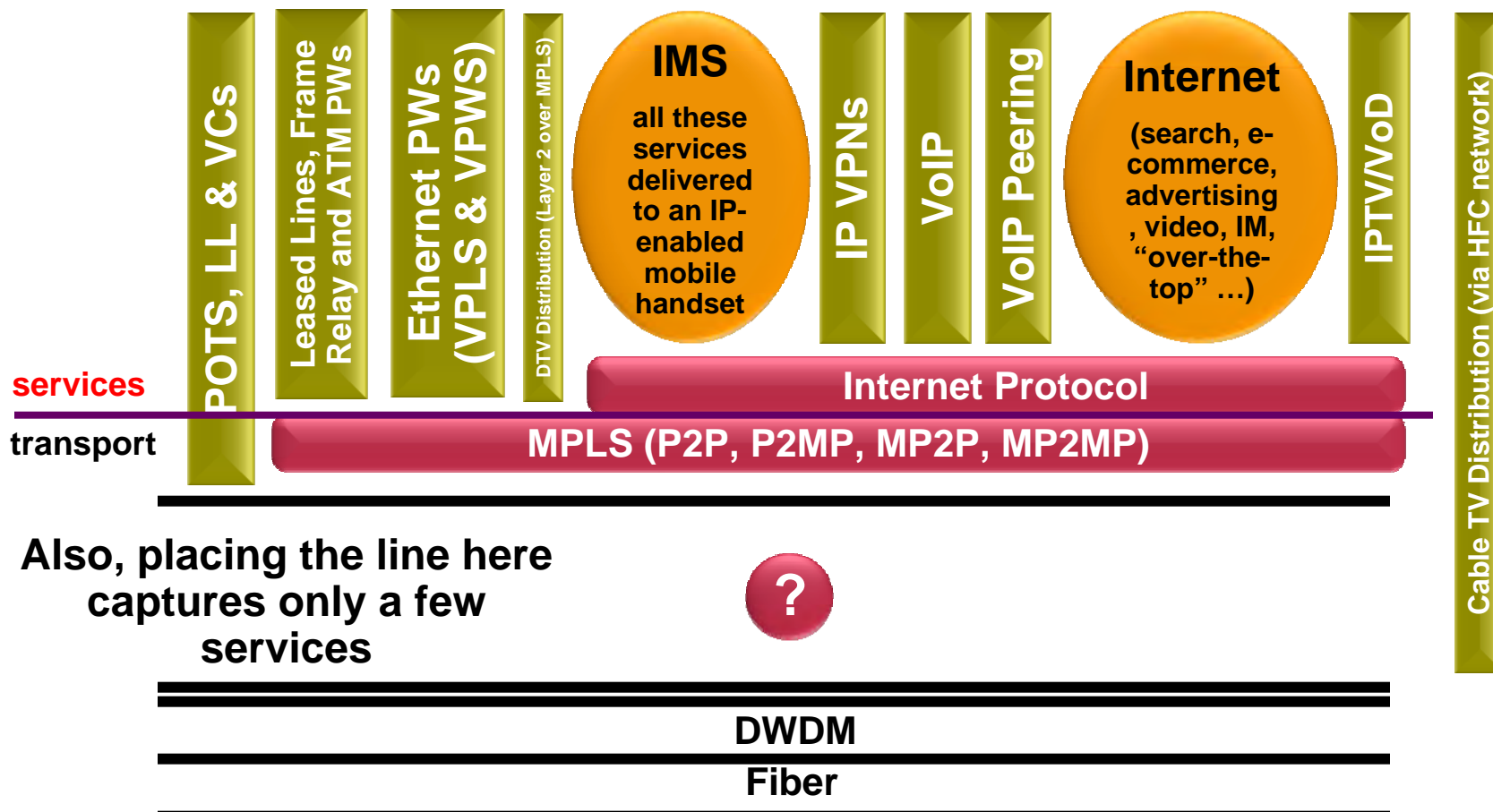
Is the Traditional Organization Still Valid?

- The “elephant in the room” is the *purple line* that separates the “IP/MPLS” part of the network from “transport”
- This has become entrenched in network architectures over the past 20 years, and manifests itself:
 - In organizational structures, both in service providers and equipment vendors
 - In philosophies of deployment and implementation
 - IP/MPLS: dynamic, fluid, distributed control plane, new connectivity paradigms (point-to-point, multipoint, multicast), new services
 - Transport: static, centralized, fixed notion of connectivity (point-to-point) and of services, stable
 - In regulations and laws set by governments
 - In unions and internal politics of various flavors
 - And in so many other hidden or unnoticed ways

The Purple Line

- **The purple line made sense 20 years ago, when several independent services rode over the transport network**
 - The purple line separated “infrastructure” from “services”
 - A particular service failure would typically affect *just that service*
 - The infrastructure going down would affect *all* services
 - Keeping infrastructure separate allowed for a very stable network, over which each service could be managed on its own
- **Today, there is essentially just one “service” over transport, namely IP/MPLS. The real services are further above**
 - Since IP/MPLS carries all the services, it must have the same stability and resilience as the “infrastructure” below the purple line
 - Thus it follows that IP/MPLS **must be part of the transport infrastructure**, i.e., the purple line must be redrawn ...
 - ... where?

The Right Picture?



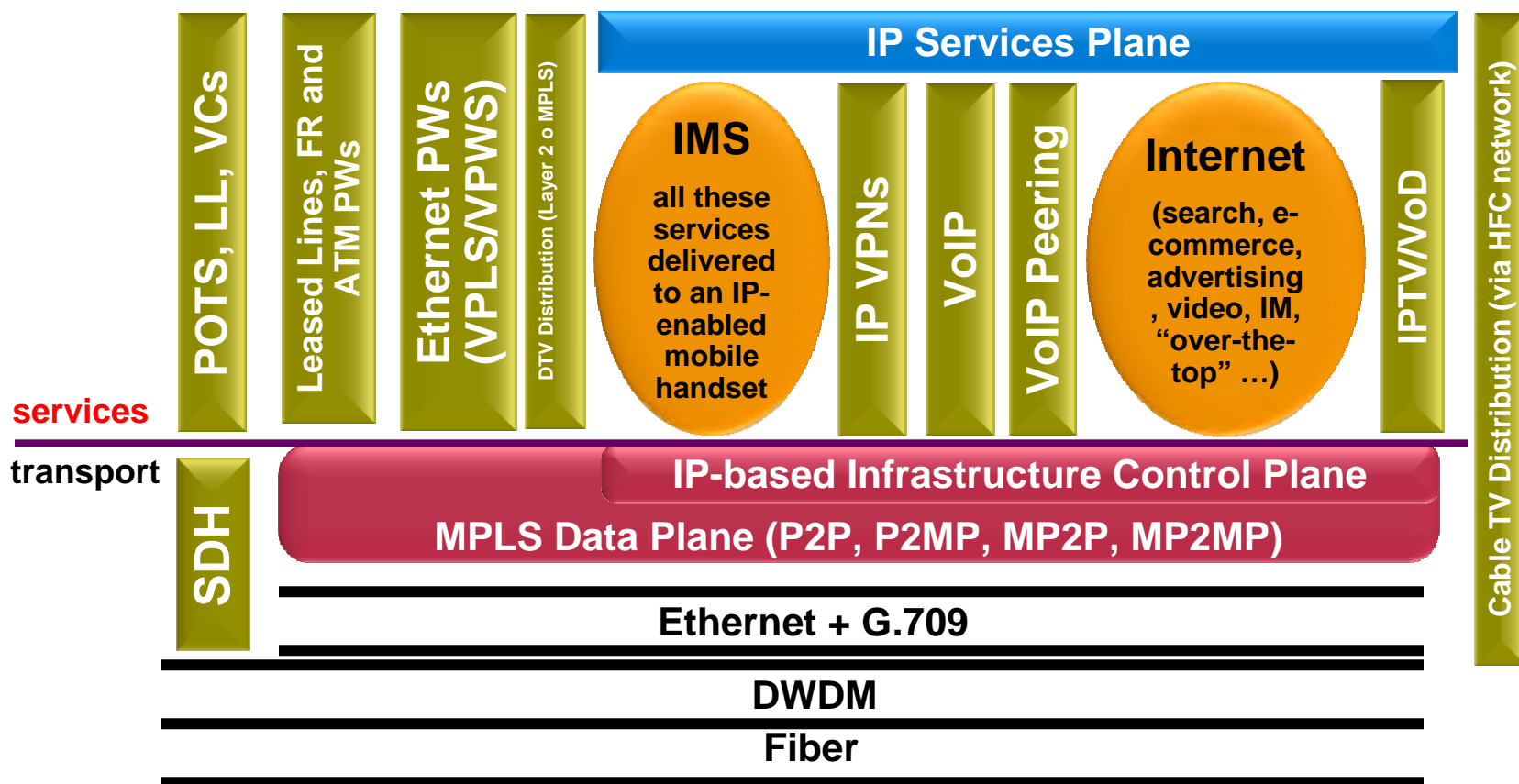
Also, placing the line here captures only a few services

This would negate the power of MPLS: the tight synergy of MPLS + IP

What is “IP/MPLS”, really?

- **This last picture brings into focus the architectural confusion in the term “IP/MPLS”**
- **There are really four separate components:**
 - *An IP-based infrastructure control plane (ISIS/OSPF, RSVP, LDP, ...)* that is common across IP and MPLS
 - *An IP services, policy and control plane (BGP, SIP, AAA, Radius, ...)* that underpins IP-based services
 - *An IP data plane* that delivers these services
 - *An MPLS data plane* that is the convergence platform for IP services, Layer 2/1 services, and backhaul “transport”, with improved traffic control and resilience

The Right Picture



This maintains the synergy between MPLS and IP and has the right partition between infrastructure/services

Filling in the Details

- **We can now fill in the “?”: a thin layer of Ethernet (for framing) and G.709 (for optical OAM and FEC)**
 - Also, the network is *still* a layered network – layering is *good*
- **This model of infrastructure/service separation applies equally to content providers, “full service” (Layer 3 and above) providers and to backhaul, wholesale and bandwidth (Layer 2/Layer 1) providers**
- **Convergence via MPLS is crucial to CapEx savings**
- **Finally, note that “legacy” SONET/SDH boxes may be needed to “cap and grow” legacy services**
 - Another approach is to emulate these services over MPLS; this decision will probably vary from Service Provider to Service Provider, as there are many complicated factors involved

Have No Illusions...

“If you’re not afraid, you don’t understand!”

This has been said in the context of networks many times, by many people, and it is as true today as ever before

- **We (as a total community) have to confront the purple line**
 - If not, one cannot build efficient, cost-effective networks
 - Without this, “Next Generation Networks” are just incremental changes, not real progress towards a packet-centric paradigm
 - All the talk of saving CapEx and OpEx will also be incremental, rather than fundamental changes towards an ultra-high-bandwidth future
- **At the same time, know that this will not be easy**
 - 20 years is a long time for habits and attitudes to accrete

The Way Forward

- **But it has been done and is being done today**
 - Several large carriers have already integrated their “transport” and “IP/MPLS” groups, both in network design and architecture and in operations
 - Others are doing this now, or have begun
- **This is the only way for networks to take a giant step forward, to become packet-centric rather than optimizing for TDM circuits, to become truly “Next Generation”**
- **That said, one must ask**
 - Is it feasible to make IP/MPLS part of the transport infrastructure?
 - What else does this make possible?
 - What are the consequences of such a move?
- **The next few slides will examine these questions, and show how moving the purple line interacts positively with the other themes I mentioned**

Consequences

- **Moving the purple line is not at all easy**
- **Doing so has consequences for many groups**
 - Vendors, service providers, regulators, unions, and others
- **How quickly and effectively these groups respond to this challenge will determine how fast we can move to the new paradigm of packet-centric networks**
 - New boxes have to be built to meet the new requirements
 - New architectures and new management paradigms are needed to best use these new boxes
 - New regulations may be needed to say which boxes can be deployed where and how, and to whom they can connect
 - The labor force may need to reorganize to address new opportunities
- **My expertise does not span all of these challenges**
 - So, I will confine my comments to what *vendors* should do

Recap

- **The purple line served a very useful purpose, but has remained stagnant over time, and today finds itself in the wrong place**
 - However, the idea of layering, and of separating “services” and “infrastructure” is sound, and should be preserved
- **Redrawing the purple line should be the first priority in designing a packet-centric “Next Generation Network” --**
 - a network that optimizes for cost and efficiency of the new communication paradigms (point-to-point, any-to-any, multicast, ...)
 - This will not be easy for anyone
- **In concert with the above, how packet and optical switches are built, deployed and managed has to be rethought**
 - The good news: we have validation from both the packet and the transport worlds that this is feasible, and will meet the requirements of a true NGN; we also have validation from many carriers who are moving in this direction



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