

Traffic Engineering or Network Engineering?

The transition to dynamic management of
multi-layer networks

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Agenda

- Multi-Layer Networks
- Planning Capacity and Placing Traffic
- Computation tools
- Integrated Multi-Layer Networks
- The Virtual Network Topology (VNT)
- Capacity-on-Demand
- Virtual Topology Manager (VNTM)

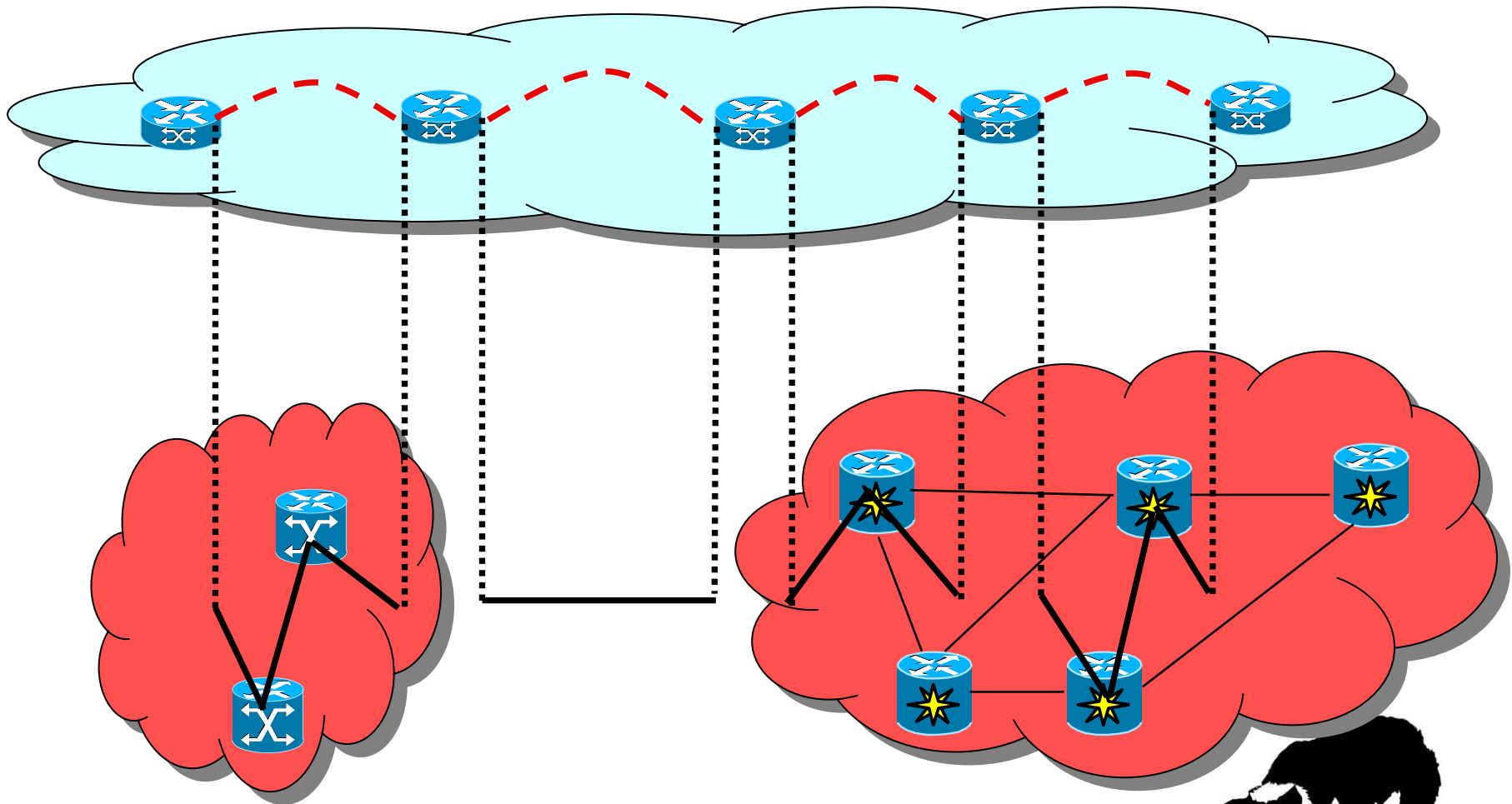


Multi-Layered Networks

- All data networks are multi-layered networks
- Data links may be physical links or virtual links
- Provisioning data connectivity in a network utilises data links from a lower layer
- Provisioning data links is out of scope for the higher layer network
 - Fibre planning is a long-term activity
 - Capacity planning is done with caution
 - Network layers are administered separately

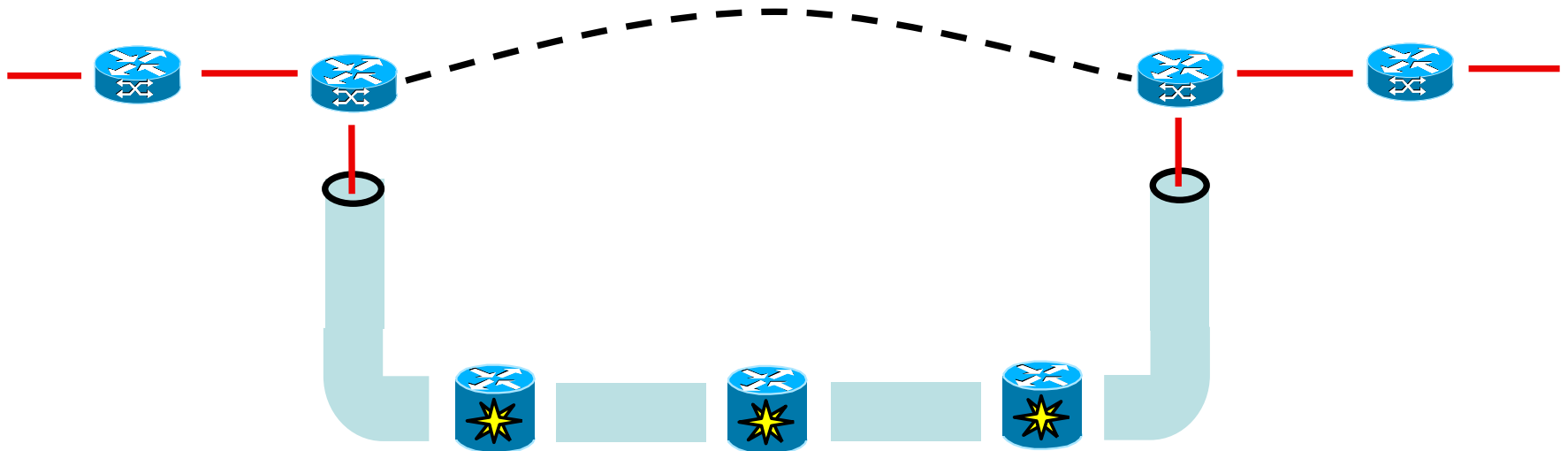


The Multi-Layered Network



How Does GMPLS Handle Layers?

- Hierarchical LSPs (tunnels)



- Lower layer may be a different switching type (TDM, WDM, ...)
- Lower layer may be a sub-type (OC48, OC12, etc.)
- Lower layer may be an administrative boundary



The Simplex Server Model

- The ratio of higher-layer LSP to lower-layer tunnel is 1:1
- Matching (or nearly matching) capacities
- Used at a technology boundary
 - Data is encapsulated to be carried across the lower layer
 - Link capacities are similar
- Used at an administrative boundary
 - May use LSP Stitching when technologies are identical



The Multiplex Server Model

- More than one higher-layer LSP is multiplexed into the tunnel
- Tunnel capacity is typically much larger than the LSP capacities
- What happens to the unused tunnel bandwidth if there is only one LSP?
 - “Wasted bandwidth”
- Doesn't work for stitching (that is 1:1)
 - Only applies when there is a technology boundary
 - Note that packet is a special case



Capacity Planning

- Where do the data links come from?
 - From the lower layers
- Physical links must be provisioned
 - Slow and expensive
- Logical links must be provisioned
 - Potentially quick, but uses expensive resources
- Capacity planning is typically an off-line activity
 - What capacity is needed in the upper layers?
 - What are the current and future traffic demands?
 - What additional services/protection do we want?
 - What is the impact on availability of lower layer resources?
 - Prediction of future capacity demand in the upper layer
 - There may be multiple higher-layer networks.



Traffic Engineering

- Where shall I place traffic in my network?
- Traditionally an off-line activity, now on-line
- Optimise the use of network resources
 - Avoid congestion
 - Increase network traffic load
 - Differentiate services (QoS, protection, etc.)
- Multi-layer considerations
 - Reduce capacity requests
 - Link-level protection
 - Shared Risk Link Groups (SRLGs)
 - Intelligent capacity request
 - Multi-layer Traffic Engineering



Computation Tools

- Path Computation Element (PCE)
- A network entity that computes paths
 - On-line or off-line
 - Part of the node, NMS, or separate
- Main intention is provide solutions for multi-domain traffic engineering
 - Topology information is limited by domain
 - Can't normally compute a path across domains
 - Might not find any path
 - Probably won't find optimal path
- Note that a multi-layer network is a multi-domain network



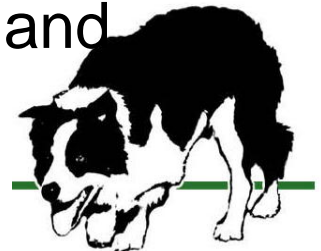
Integrated Multi-Layer Networks

- Better to say “Integrated Multi-Technology Networks”
- TE visibility is not limited to one layer
 - A single routing instance distributes information about multiple layers
 - Path computation can take account of resource availability in lower layers
- Tunnels across lower layers are triggered ‘on-demand’



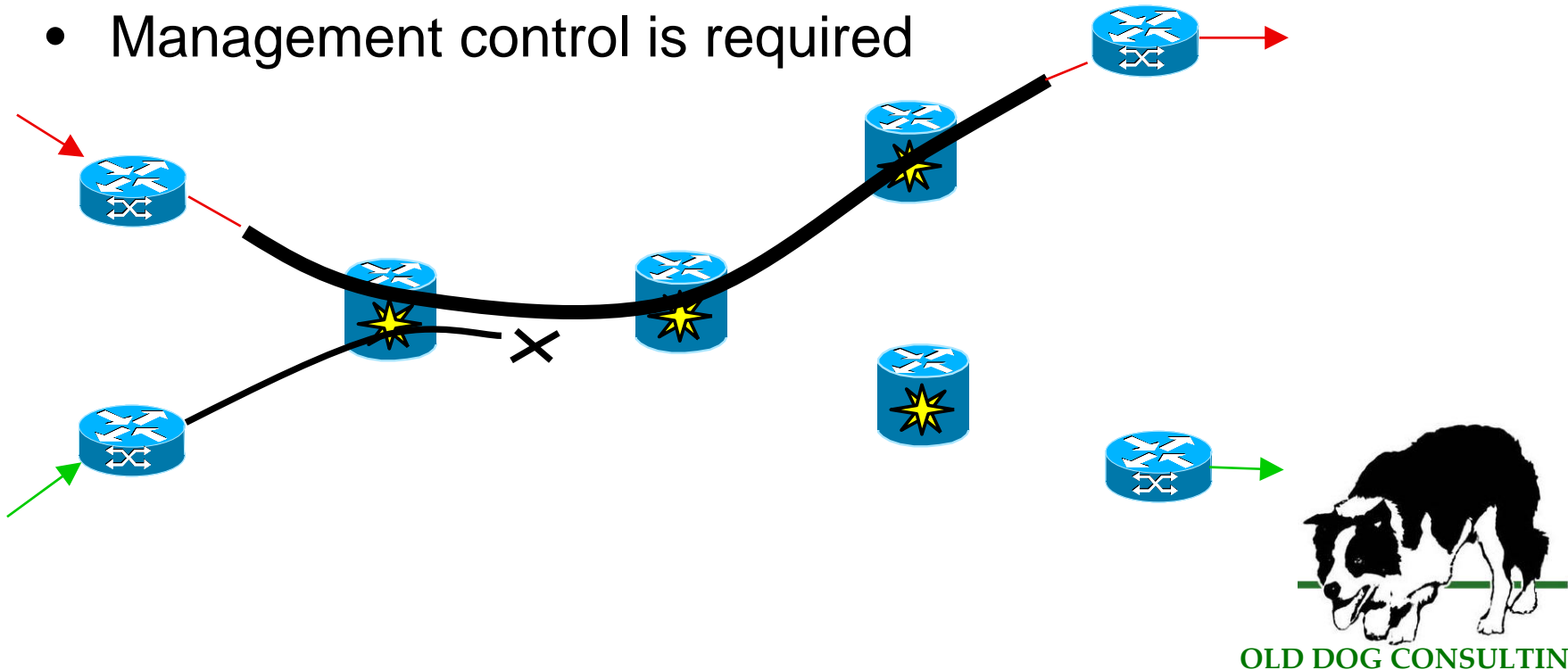
The Virtual Network Topology (VNT)

- The set of virtual links provided by a lower-layer network to a higher-layer network
 - The tunnels that provide connectivity
- The higher layer sees these as real data links
 - They form part of the TE Database
- Each virtual link may be:
 - Configured and pre-signaled (capacity planning)
 - Triggered on-demand and made available for general use (by integrated multi-layer network)
 - Configured in advance but signaled on-demand (flexible capacity planning)



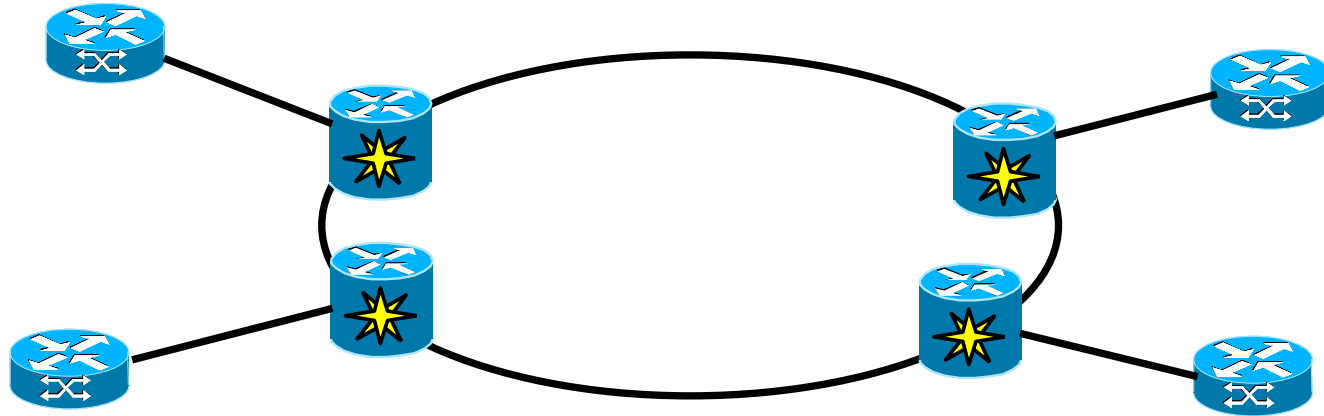
Is Capacity On-Demand Dangerous?

- Yes! Depending on the topology
- Unimportant, low-capacity demand may “steal” the lower-layer resources
- Important, high-capacity demand is blocked
- Proper capacity planning might have predicted this
- Management control is required



Is Capacity On-Demand Pointless?

- Yes! Depending on the topology.

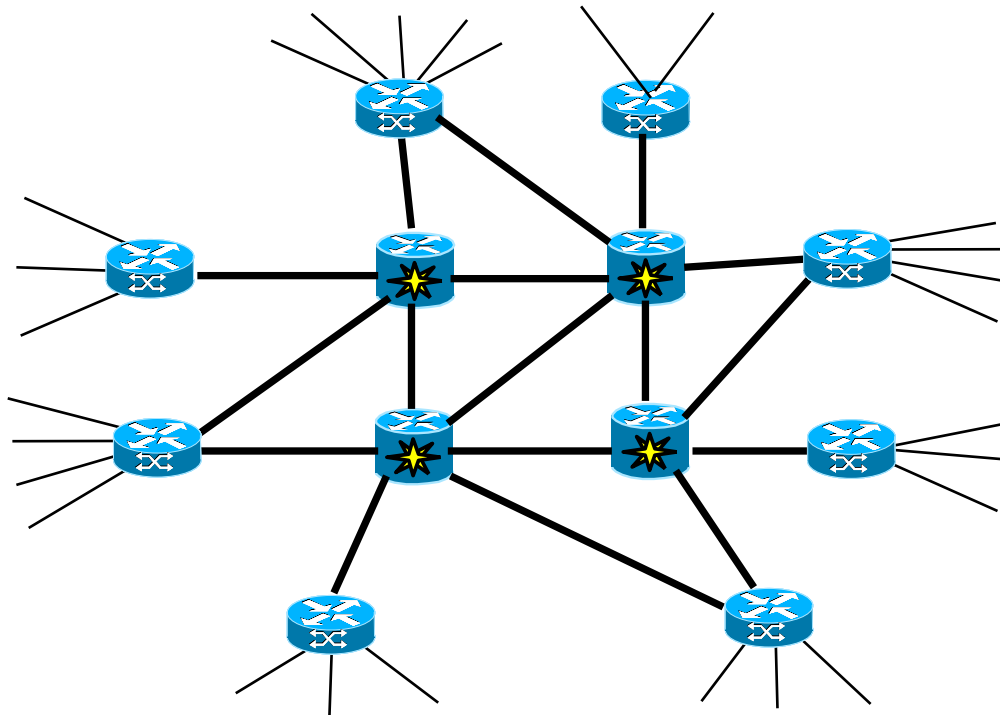


- If the physical connections exist and are dedicated, then just allocate the capacity
- We see this particularly with legacy topologies
- On-demand provisioning can take a few seconds
 - May be too slow for higher-layer network.



Can Capacity On-Demand Be Good?

- Yes! Depending on the topology
- Complex mesh in lower-layer core network
 - Cannot provide full mesh connectivity
- Higher-layer network demands vary over time
- GMPLS allows rapid provisioning in the lower-layer network



The Role of Policy

- Microflows must not be allowed to trigger high-capacity allocation in the lower layer
 - Unless that is what the operator wants
- Adding resources to the VNT is a policy
- There are implications for:
 - Billing
 - Service support
 - Multiple higher-layer networks
- Network engineering and planning still has a role in a dynamic multi-layer network



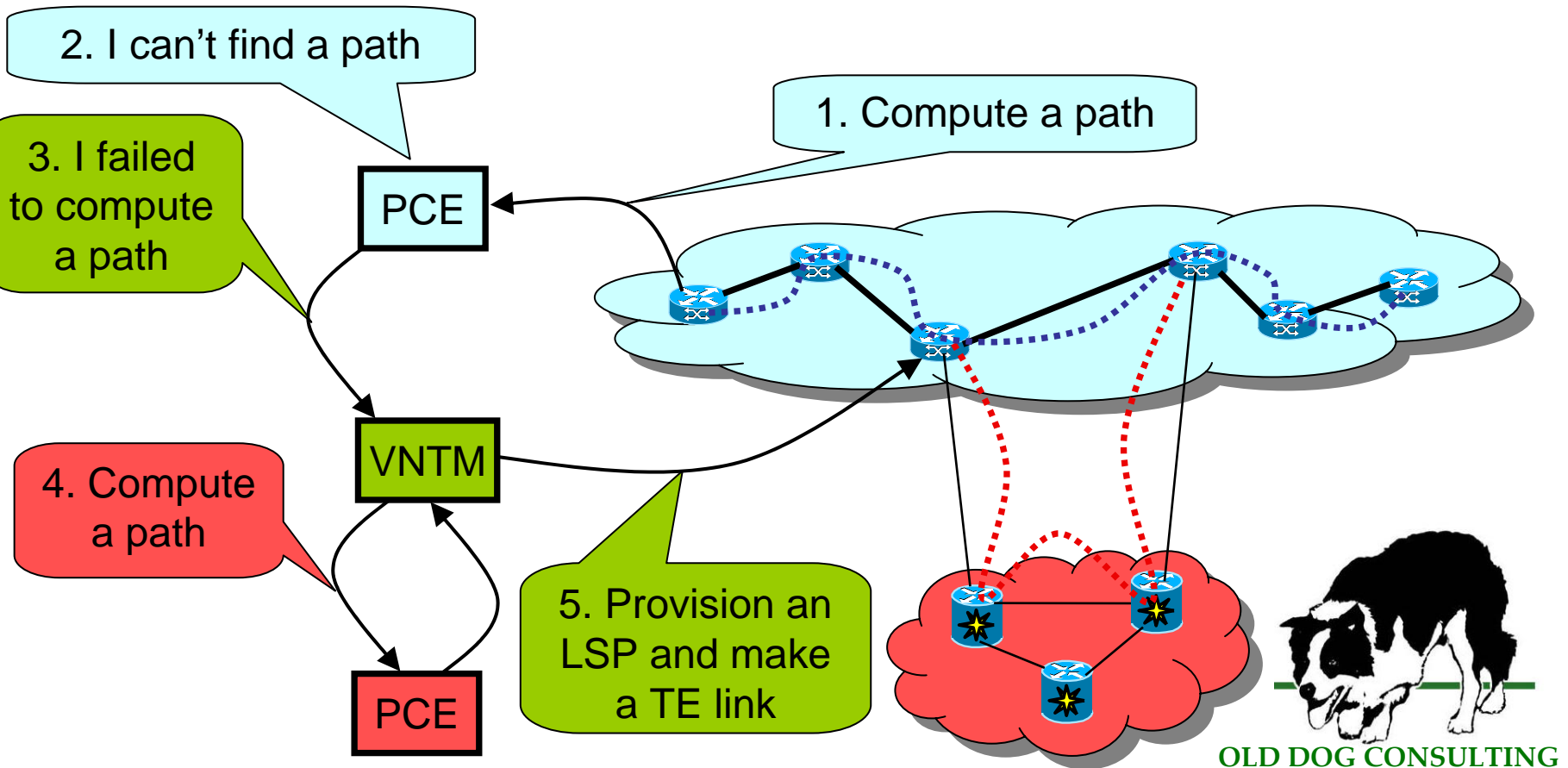
Virtual Network Topology Manager (VNTM)

- A new functional component
- Responsible for managing the VNT
 - Assesses demands
 - Is governed my policy
 - Takes commands from management
 - Establishes LSPs in lower layer
 - Causes the creation of TE links in higher layer
 - Re-grooms traffic to free up unused resources
- Interacts with PCEs in both layers



VNT Manager

- VNT Manager acts on triggers from operators and from higher layer
- Uses PCE to determine paths in lower layer
- Uses management systems to provision LSPs
- Causes new TE links to be advertised



References

- LSP hierarchy
 - RFC 4206
 - draft-ietf-ccamp-lsp-hierarchy-bis
- Multi-layer networking
 - draft-ietf-ccamp-gmpls-mln-reqs
- PCE
 - draft-ietf-pce-architecture
 - draft-ietf-pce-inter-layer-req
 - draft-ietf-pce-inter-layer-frwk
- VNT Manager
 - draft-oki-pce-vntm-def



Questions?

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