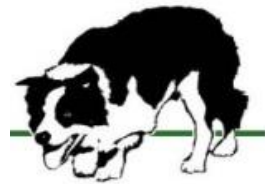


TE Technology Evolution in the IETF



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A Very Quick Overview and Introduction

- What is the IETF?
- What is Traffic Engineering?
- TE in Unreliable, Best-Effort Networks
- Introducing MPLS
- Working with Sub-IP Concepts
- Online versus Offline Planning
- Architectures
- Future Plans in the IETF

The Internet Engineering Task Force

- **The** standards organisation for the Internet (since 1986)
 - *“to make the Internet work better by producing high quality, relevant technical documents”*
 - All your favourite protocols
- Open participation
 - Anyone can participate
 - No fees, no boundaries
 - Working as engineers on common problems
- Open access to standards and work in progress (RFCs and Internet-Drafts)
 - Open website and mailing lists
 - No membership required
- Long history developing network protocols, architectures, and solutions



What is the Point of Traffic Engineering?

- Performance optimization of operational networks
- RFC 2702 says...
“The application of technology and scientific principles to the measurement, modelling, characterization, and control of Internet traffic, and the application of such knowledge and techniques to achieve specific performance objectives”

- Purpose:

- Allow a network operator to have better control of their network
- Provide more reliable traffic delivery
- Offer advanced services

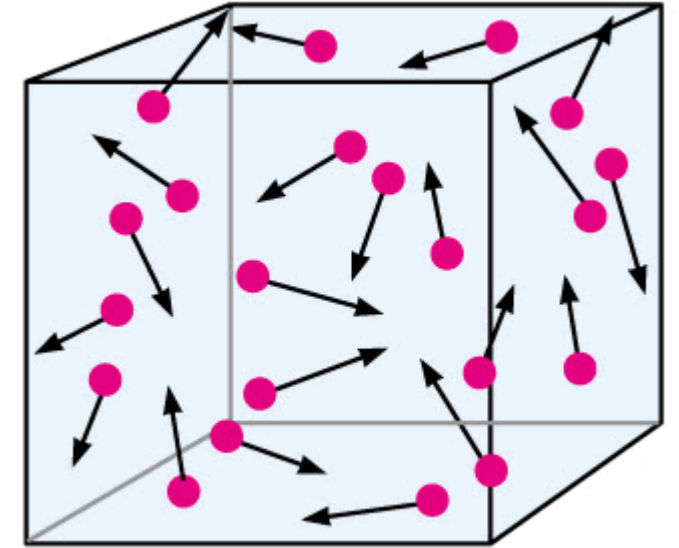


- Make better use of network resources
- Survive outages and planned maintenance
- Make the network predictable

- It turns out that bandwidth is not infinite!

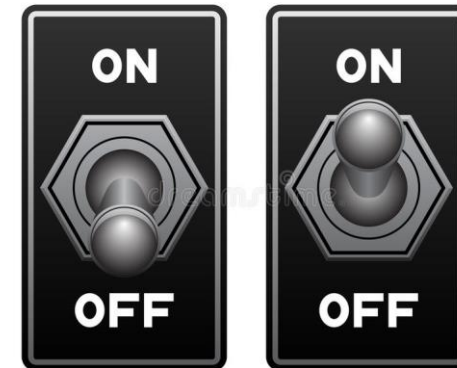
Controlling the Uncontrollable

- IP networking is intended to be “best-effort”
 - The routing paradigm heals around failures, but tends to converge traffic
- How to introduce predictability and traffic steering?
 - Many protocol mechanisms have been devised...
- IP Source Routing
 - Was always present in IPv4 through the Loose/Strict Source Route Option
- IGP Metric Tweaking
 - By *carefully* changing IGP metrics we can distribute traffic across the network
- Coloured Graphs
 - Build different graphs with different metrics overlaid on the same topology
- RSVP
 - Resource-reserving signaling protocol that follows the path of the traffic



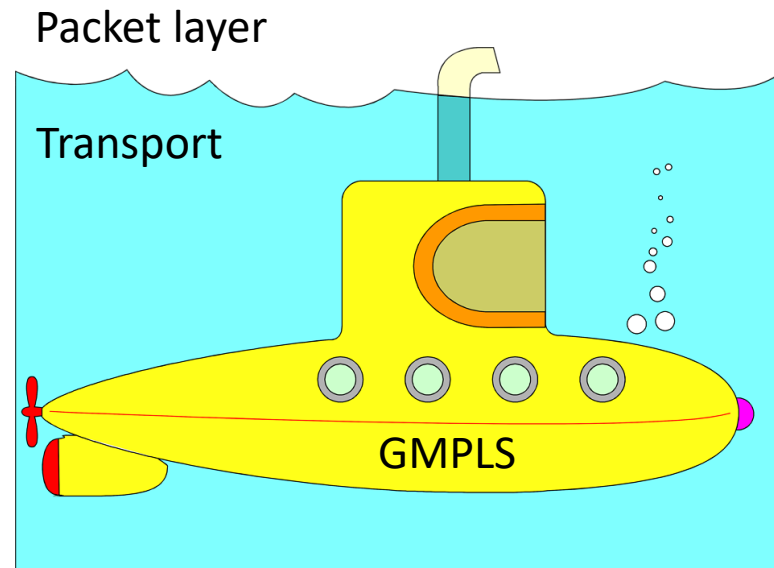
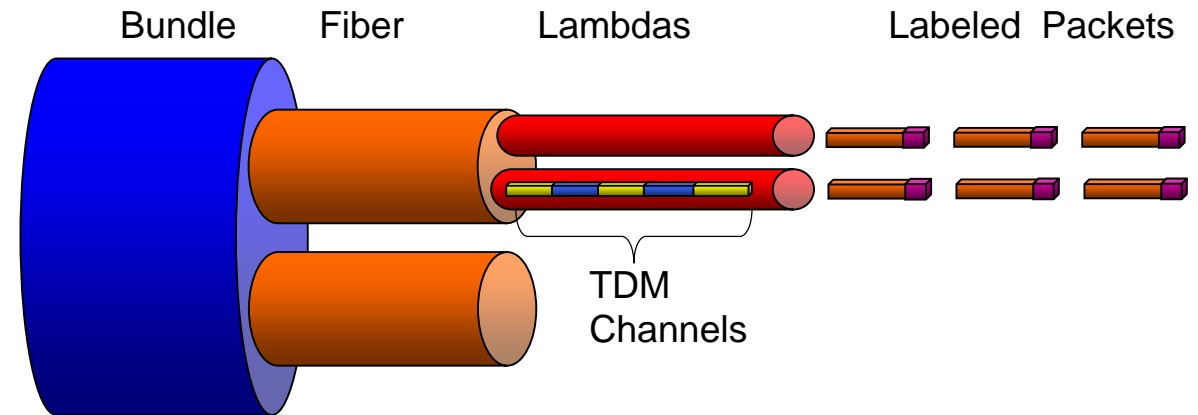
Multiprotocol Label Switching (MPLS)

- An encapsulation and forwarding paradigm (RFC 3031)
 - Learning lessons from ATM and Frame Relay
- The Label Switched Path (LSP) is connection-oriented
 - Make the concept of Traffic Engineering easier
 - LSPs can be placed in the network according to CSPF or central planning objectives
 - All the usual functions and requirements:
 - Load balancing
 - Resilience and recovery
 - Service/quality delivery
 - Cost saving / resource maximization
- Use of a signaling protocol (RSVP-TE)
 - Places LSPs in the network
 - Assigns network resources to LSPs



Below the Packet Layer

- Generalized MPLS (GMPLS)
 - A set of control plane protocols
 - Application of MPLS concepts to all circuit switching technologies
 - Data planes are defined by other SDOs



Network Planning is Holistic

- You can do a lot planning one service at a time
- But you can do a lot more planning a whole network
- You need to:
 - See the whole network
 - IGP extensions to track TE capabilities
 - BGP-LS to export topology map
 - YANG models to export topology and capabilities
 - Be able to request path/network computations
 - Path Computation Element (PCE)
 - Be able to signal or install forwarding instructions
 - RSVP-TE for MPLS or GMPLS
 - Segment Routing
 - Netconf/YANG to configure devices
- Machine learning and AI can be applied



Traffic Engineering Architectures and the IETF



- Topology aggregation / abstraction
 - RFC 7926
- Application Based Network Orchestration (ABNO)
 - RFC 7491
- YANG-based SDN Architecture for Service Delivery
 - RFC 8309
- PCE as a Central Controller
 - RFC 8283
- Abstraction and Control of TE Networks (ACTN)
 - RFC 8453
- Network Slicing and Enhanced VPNs (VPN+)
 - draft-ietf-teas-enhanced-vpn

“The future rewards those who press on”

- IETF currently working on protocol specifications
- PCE-CC
 - Application to inter-AS IP
 - Integration of central control and distributed control plane
- Enhanced VPNs
 - Framework still to be finalised
 - IGP and BGP extensions for Segment Routing proposed
- Abstraction and Control of TE Networks (ACTN)
 - Completion of YANG models for topology and TE constructs
 - Top-to-bottom integration of YANG models for service delivery
 - Application of architecture to network slicing, multi-tenant, virtualization

