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Converged Communication Networks

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Outline

- Convergence in core networks
- New broadband applications and requirements
- Rationale for MPLS traffic engineering
- New VS routing for MPLS path selection
- Technical merits of Virtual Space routing
- MPLS traffic engineering implementation
- Conclusions

Traditional Technologies in Core Networks

- ATM or Frame Relay network: Optimized for voice transport

  Advantages: connection oriented, reliable, supports QoS

  Disadvantages: limited scalability and flexibility, high overhead

- IP network: Optimized for data (packet) transport

  Advantages: excellent scalability and flexibility, efficient, common application platform, supports several data services

  Disadvantages: connectionless, best-effort, no performance guarantees

- Both networks are supported over TDM or SONET/SDH platform

- SONET/SDH network: Statically provisioned, reliable (SLA support)

MPLS for Convergence in Core Networks

- Very costly to keep separate voice, video, and data networks
- Bridging the gap between IP (data) and ATM (voice) networks
  → MPLS network to support voice, video, and data services
- Individual label-switched paths with QoS guarantees for aggregate flows
  – Explicit routed LSPs with specific resource reservation
- Evolutionary path to IP and ATM infrastructure → <u>Reduced CAPEX</u>
- Single operation and management plane → <u>Reduced OPEX</u>
- Additional services over existing networks → <u>Increased ROI</u>
  – Enable layer 2 and layer 3 virtual private networks (VPNs)

Emerging Broadband Applications

- Web-hosting and Data-warehousing services
- Internet gaming and streaming video services
- Video-on-demand and Bandwidth-on-demand services
- Bundled VoIP, Video telephony, and Wireless access services
- Video conferencing services (MPLS VPN Multicast) for global enterprises
- Banking, ERP, and CRM applications of global enterprises
- Bundled services for digital home network access, including

  broadband Internet, voice & video telephony, digital TV or HDTV

→ Different requirements for real-time performance, reliability, security, etc.

Broadband Applications

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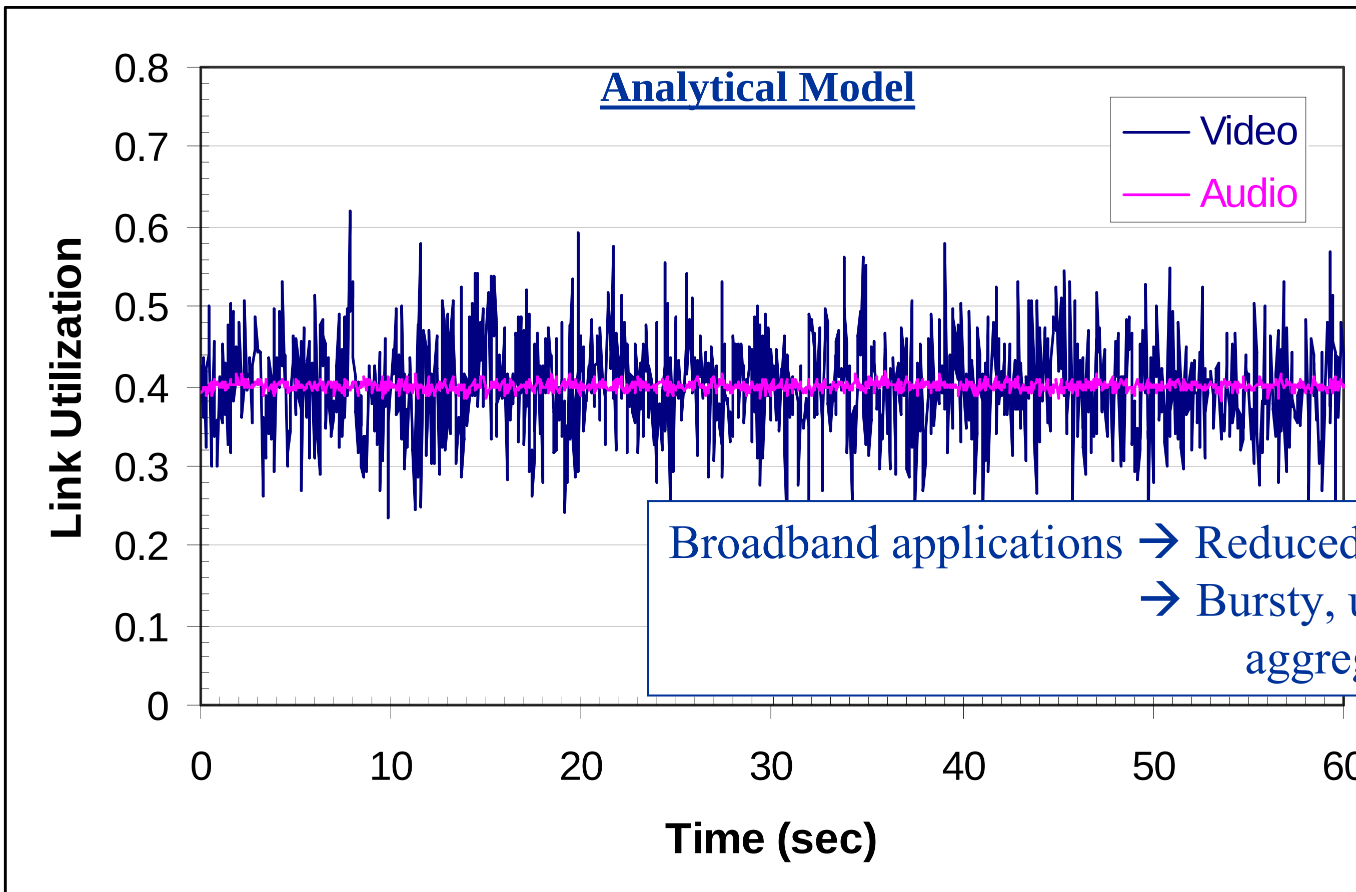
Statistical Multiplexing on OC-3 (155Mbps) Link

~ 6250 **audio** (G.729) channels with ~ 9.6 kbps rate

~ 33 MPEG **video** channels with ~ 1.82 Mbps rate



Broadband applications → Reduced smoothening
→ Bursty, unpredictable aggregate traffic

Rationale for MPLS Traffic Engineering

- Broadband applications → bursty, unpredictable aggregate traffic
  → high peak-to-average ratios in link loading
- Common approach – Static over-provisioning with load-balancing
  e.g. 2 links carrying <40% average traffic
  – Not an acceptable QoS solution under a link failure
- Achieve high network utilization with overlapping path protection
- Support QoS from the user perspective using application based aggregation (FEC) and traffic engineering
- Intelligent path selection based on specific QoS requirements, network resources, and performance parameters

Multi-parameter Optimization

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Traffic engineering objectives require multi-parameter optimization based on:

- Network performance parameters:

  Total network throughput (total connections x data rates)

  Number of hops in each path (leads to network loading)

  Link loading distribution (congestion and under-utilization of links)

  Blocking probability for arbitrary connection-requests

  Stability and scalability of implementation

- Flow or connection based QoS parameters:

  Available bandwidth

  Total path delay

  Packet drop rate

  Path protection

  Priority level (or CoS)

  Delay jitter

  Path attributes

  Reliability

New Approach: VS Routing

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- Minimize routing information – concise representation
  – elimination of redundant info.

  → better scalability, fast adaptability, and simple implementation

- Transform network topology information (VS embedding)

  into multi-dimensional network map (VS configuration)

  capable of geometric routing (directivity property)

- Combine directivity and dynamic link info. for path selection (VS routing)

- Use VS routing for multiple path selection & multi-parameter optimization

Virtual Space Routing

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- Differentiate between static and dynamic information

  Static → Network topology, Dynamic → Link status & loading

- Static (topology) information is embedded into VS configuration

  VS configuration enables simple geometric routing

  Directed distance to destination gives available path choices

- VS Embedding: Evolution of multi-dimensional VS configuration

  Energy minimization process in equivalent multi-body system

- Dynamic link/node costs: Reflects link/node status & loading

  Link or node failure represents extreme link or node cost

  Link / node costs are only distributed locally in VS space

Technical Merits

	Traditional scheme	VS scheme
• Routing information scaling:	$N^2 – N^3$	log(N)
• Information database:	Thousands of strings	<100 numbers
• Peak link loading:	–	~ 25% less
• Link state update time:	Slow	Fast
• Multiple QoS parameter support:	Partial	Full
• Resource requirements:	High	Low
• Failure recovery & convergence:	Slow	Fast

=> **VS routing scheme is highly scalable, dynamic, robust, and simple.**

MPLS Traffic Engineering Tool Implementation

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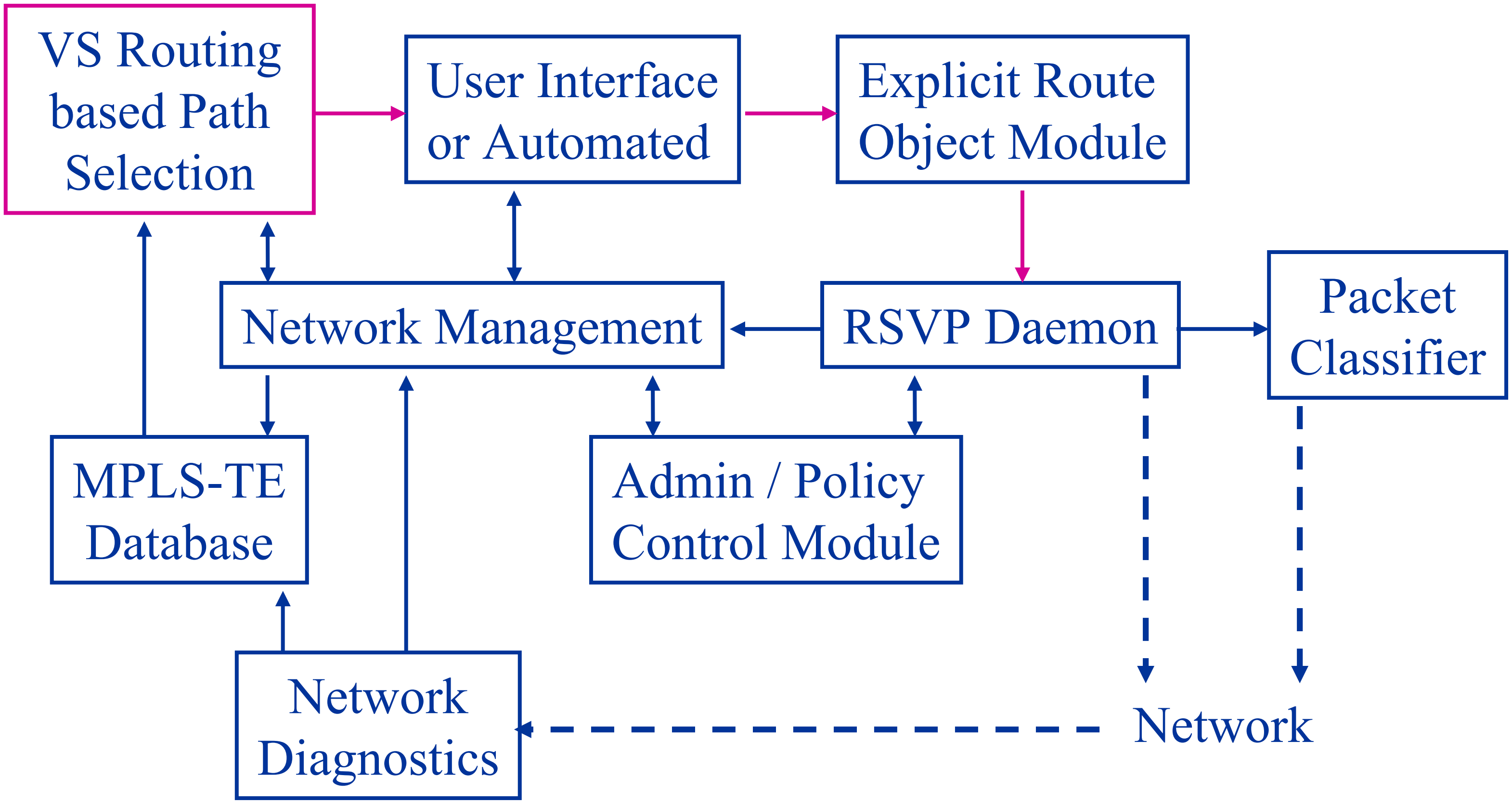

Using Virtual Space (VS) routing for MPLS-TE optimization

MPLS Traffic Engineering & Network Management

- QOS support for VVD convergence in the core
- Capability to handle hundreds of MPLS tunnels
- Path selection based on multiple QoS parameters:

  (i) hops (ii) delay (iii) bandwidth (iv) congestion (v) link status
- Efficient overlapping back-up paths for MPLS Fast Reroute
- Optimal point-to-multipoint LSP tree selection for MPLS multicast
- Identification of critical links and analysis of “what-if” scenarios
- Enhanced network resource utilization and performance
- Improved network management and planning

Conclusions

- Convergence of VVD services in the core is achieved using MPLS network
- MPLS traffic engineering enables QoS support and network optimization
- MPLS-TE tool is being developed based on new VS routing scheme
- Tool supports optimization of multiple QoS parameters, protection, and multicast

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Ref.: [1] High Performance Switching & Routing (HPSR) 2003, Torino, Italy

[2] International Conf. on Communications (ICC) 2004, Paris, France

[3] MPLS World Congress 2005, Paris, France