Provisioning of Differentiated IP Resilience and QoS - An Integrated Approach

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Outline

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- Serv. IP Services & Applications
- QoS QoS Architectures
- MPLS MPLS Resilience
- RD-QoS Resilience Differentiated QoS
- Conclusions & Outlook

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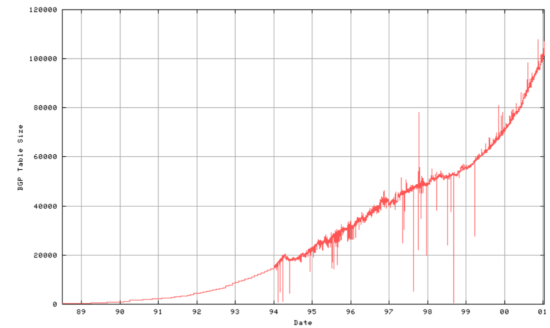
Motivation

New real-time and connection-oriented services over the Internet

Mission-critical E-Commerce

Explosive growth of the Internet „Everything over IP“



Increasing Demand for QoS and Resilience in IP-Based Networks

- High end-to-end availability is crucial for customers
- Increased QoS and resilience requirements imposed by new services
- Fast and predictable resilience mechanisms are necessary for IP

IP Services and Applications

IP-based networks offer a large variety of services and applications

- WWW
- Email, File Transfers
- E-Commerce, Online Brokerage, Virtual Private Networks
- Voice-over IP (VoIP), IP Telephony, IP Video Conferencing
- Real-time audio and video
- Mission critical Email, mission critical VoIP
- Database transactions
- Interactive games

with very different characteristics and requirements

- QoS: delay, delay jitter, bandwidth
- Resilience: network availability, recovery time

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Service Requirements

Resilience requirements of IP services are orthogonal to their "classical" quality-of-service requirements (bandwidth, delay, delay jitter)

		Application requires resilience	
		yes	**no**
Application requires traditional QoS	**yes**	mission-critical VoIP and multimedia services	standard VoIP and multimedia services
	no	database transactions, mission-critical control terminals, e-commerce applications	e-mail, FTP, standard WWW

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QoS Architectures

IntServ / RSVP	DiffServ
Services • Best Effort Service • Controlled Load Service • Guaranteed Service	**Services** • Expedited Forwarding • Assured Forwarding
Signaling Protocol • RSVP	**Signaling Protocols** • RSVP-TE • CD-LDP • Generalized Signaling
Characteristics Quantitative end-to-end per-flow reservation with soft-state	**Characteristics** Classification, marking and conditioning of packets at network edge

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Shortcomings of QoS Architectures

IntServ / RSVP

- Complex signaling protocol with high state overhead in nodes
  => scalability problems
  => flow aggregation concept needed for backbone
- Stability Issues due to Soft-State Behavior

DiffServ

- Designed for static Service level agreements
- QoS only assigned to Behavior Aggregates
  => suitable for ISPs, not for end-users
- Complex Traffic Management & Engineering

AND

No resilience attributes (availability, recovery time) supported

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MPLS Traffic Engineering

MPLS Basics

- Integrates Layer 3 Routing with Layer 2 Switching
- Introduces connection-oriented characteristics in IP by replacing traditional hop-by-hop IP routing with switching based on labels
- Packets are assigned to Forward Equivalence Classes (FEC) only once at the network ingress
- Packets follow a pre-defined Label Switched Path (LSP)
- Signaling protocols for path setup: CD-LDP & RSVP-TE

A main benefit of MPLS is the ability to support Traffic Engineering methods due to its connection-oriented character (i.e. the forwarding of packets along predefined paths)

→ **MPLS allows to assign different paths through the network for packet flows with same source and destination address, e.g. based on their QoS requirements**

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MPLS Recovery Introduction

- MPLS is currently a **key research issue** in the IETF
- **Several drafts** are published which present recovery mechanisms
- Good "**Framework for MPLS-based Recovery**" defined in [draft-ietf-mpls-recovery-frmwrk-01.txt]
- **Well known resilience concepts** from SDH and ATM Recovery are **mapped to MPLS** (described in next slide)

Benefits from MPLS Recovery

- Finer recovery granularity (compared to L1 recovery)
- Protection Selectivity based on Service Requirements possible
- Efficient and flexible resource usage (e.g., recovery path may have reduced performance requirements)
- Allows end-to-end protection of IP services
- Uses lower layer alarm signals (in contrary to IP Rerouting)

MPLS Recovery Options

Selected MPLS Reovery options:

Recovery models	**Protection Switching (1+1, 1:1)**	**Rerouting**			
Recovery cycles	**MPLS Recovery**	**MPLS Reversion**	**Dynamic Re-routing**		
Path Setup	**Pre-established**	**Pre-Qualified**	**Established-on-demand**		
Resource Allocation	**Pre-reserved**	**Reserved-on-demand**			
Recovery Scope	**Local Repair (Link/Node)**	**Global Repair**	**Alternate Egress Pair**	**Multi-Layer Repair**	**Conc. Prot. Domain**
Resource Use	**Dedicated-resource**	**Extra-traffic-allowed**			
Recovery Trigger	**Automatic inputs (internal signals)**	**External commands (OAM signaling)**			

Source: [draft-ietf-mpls-recovery-frmwrk-01.txt]

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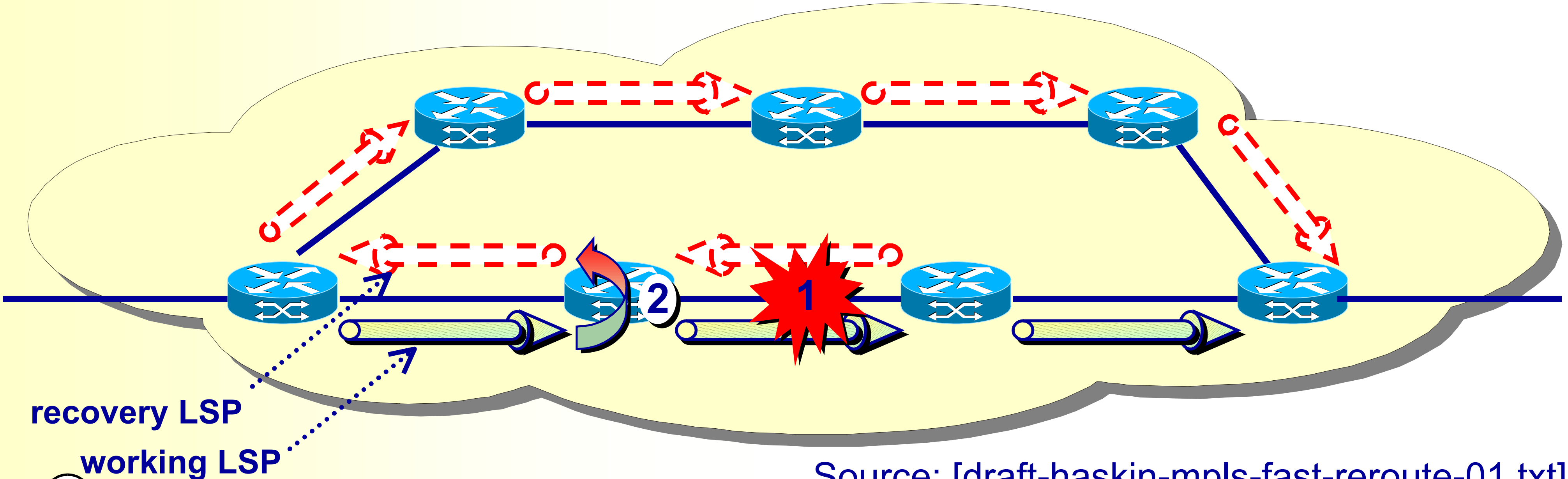
MPLS Fast Reroute

- **For each LSP an alternative recovery LSP is set up as indicated from the last-hop switch in reverse direction to the source of the working LSP and along a node-disjoint path to the destination switch**
- **When a failure is detected (1), the adjacent upstream node immediately switches the working LSP to the recovery LSP (2)**



Source: [draft-haskin-mpls-fast-reroute-01.txt]

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MPLS Interworking with DiffServ

DiffServ offers
QoS Classes

MPLS offers
Resilience Mechanisms

MPLS Support of Differentiated Services allows assignment of different resilience levels to different DiffServ classes

Open issue:

How can the level be identified at which a DiffServ class will be protected?
(1+1 / 1:1, dedicated / shared, protected / rerouted)

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Resilience-Differentiated QoS

PROPOSAL:

Extended quality-of-service definition: combine the standard QoS-metrics (bandwidth, delay, delay jitter) with resilience requirements of IP service classes

- **Resilience attribute included in QoS signaling between the application and the network.**
- **Depending on QoS architecture (IntServ, DiffServ) this is done on a per flow or on a per packet basis.**
- **Encoding of resilience attribute should be done either in DS-Field of DiffServ or in Rspec of RSVP.**
(see [draft-kirstaedter-extqosarch-00.txt])

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RD-QoS Resilience Classes

Proposed Resilience Classes with corresponding recovery options:

- **Resilience Class 1: High Resilience**
  Use of 1+1 or 1:1 protection switching
- **Resilience Class 2: Medium Resilience**
  Protection switching with On-Demand reservation of resources (recovery path is predefined)
- **Resilience Class 3: Low Resilience**
  No resources are reserved / allocated in advance. Traffic recovery requires rerouting and resource reservation.
- **Resilience Class 4: No Resilience**
  Corresponding to low-priority, pre-emptible traffic. Packets may be discarded in case of failures.

RD-QoS Basic Concept

IntServ

- Application signals resilience requirements to the network in addition to classical QoS requirements
- Network (additionally) reserves an alternative and disjoint route for the flow and switches it to this route in case of a link or network element failure

DiffServ

- Network Management or Resource Control establishes a set of pre-defined routes – together with the reservation of the corresponding bandwidth – according to the estimated or negotiated (by service level agreements) amount of traffic having resilience requirements.
- Packets with resilience requirements are marked when they enter the DiffServ network (e.g. by unused bits of DS-field or specific DS-Codepoints)
- In the case of a link or node failure the network only forwards packets with marked resilience requirements over alternative path

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RD-QoS Application with MPLS

Interworking of RD-QoS with MPLS allows a direct mapping of RD-QoS classes to MPLS LSPs with different protection levels according to the negotiated resilience requirements

Benefits:

- Integrated approach for the provisioning of end-to-end QoS and Resilience
- Direct mapping of Resilience Classes to FECs with appropriate recovery options possible
- Applications define their resilience requirements
  => protection flexibility
  => efficient resource usage
- QoS requirements of high resilience classes can be met in case of network failures

Conclusions & Outlook

- Network Resilience is a key requirement for future IP networks
- MPLS is an example where resilience is already taken into account for the development of a new Internet transport model
- MPLS and DiffServ seems a promising team for the provisioning of end-to-end QoS
- RD-QoS architecture extends QoS signaling with resilience requirements
- RD-QoS bridges the gap between DiffServ classes and MPLS protection

Current work:

- Implementation, Simulation and Evaluation of the RD-QoS architecture

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