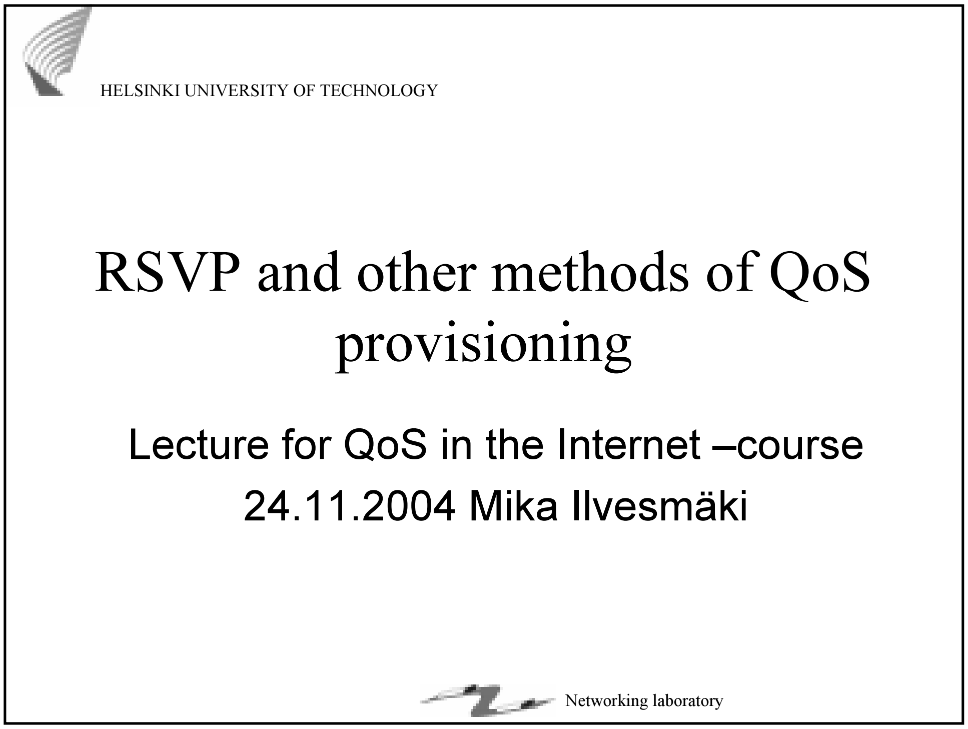

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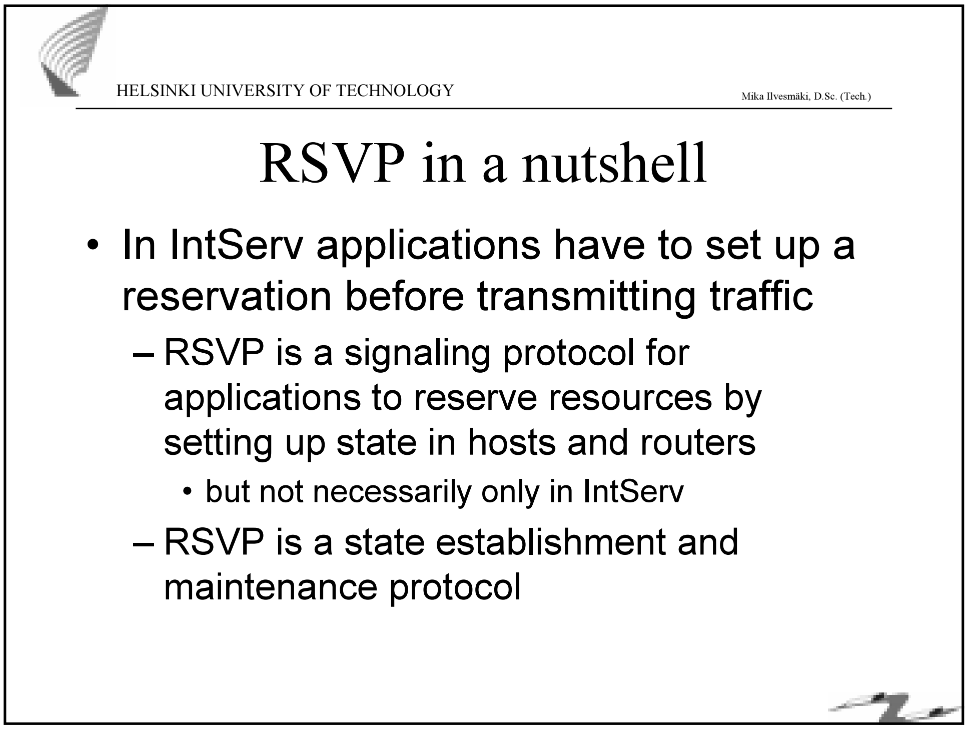
# RSVP and other methods of QoS provisioning

Lecture for QoS in the Internet –course

24.11.2004 Mika Ilvesmäki

Networking laboratory



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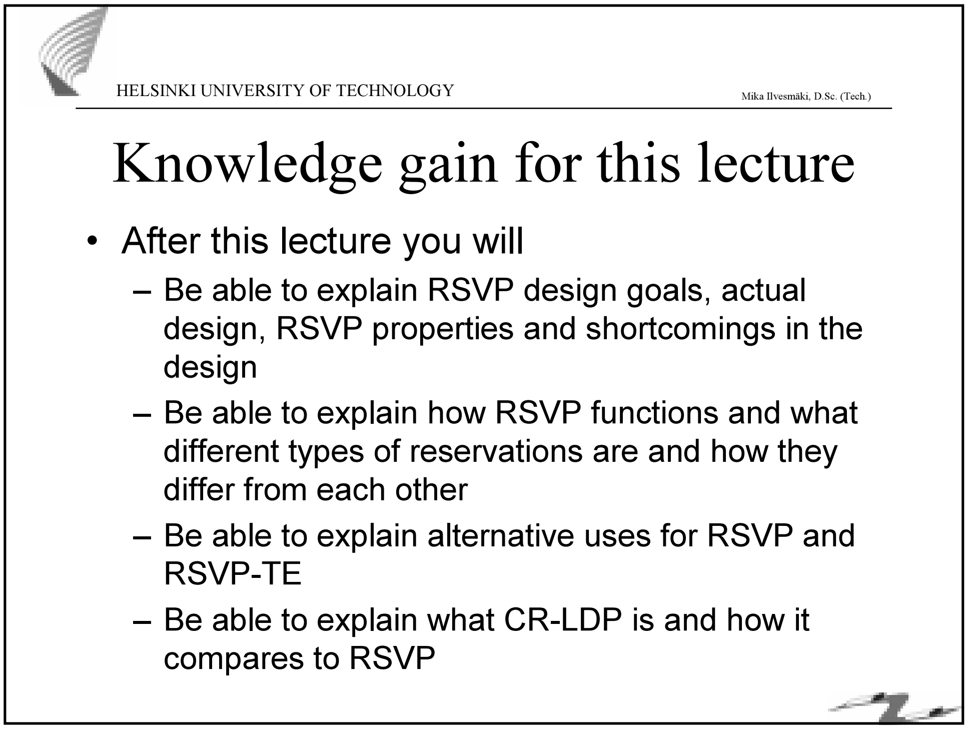
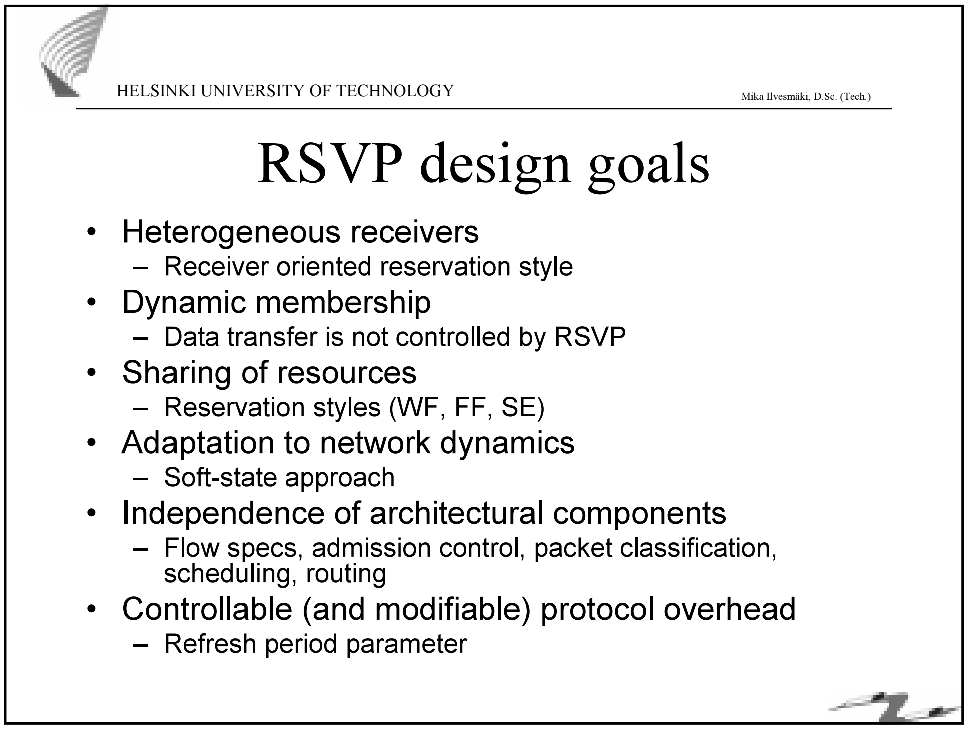
## RSVP in a nutshell

- In IntServ applications have to set up a reservation before transmitting traffic
  - RSVP is a signaling protocol for applications to reserve resources by setting up state in hosts and routers
    - but not necessarily only in IntServ
  - RSVP is a state establishment and maintenance protocol



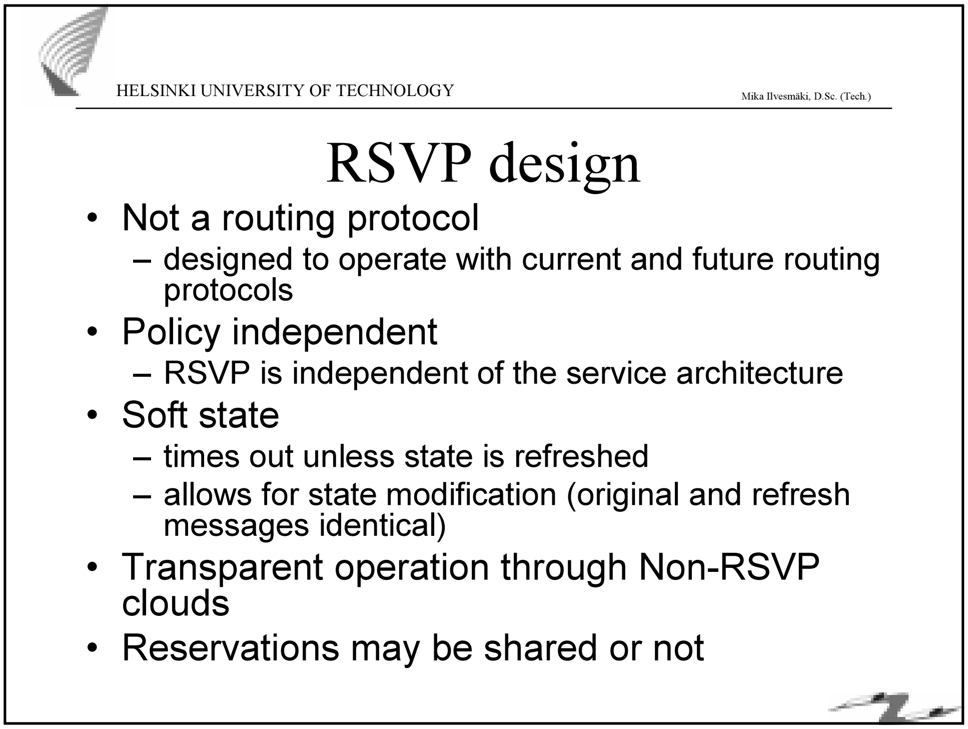
# Knowledge gain for this lecture

- After this lecture you will
  - Be able to explain RSVP design goals, actual design, RSVP properties and shortcomings in the design
  - Be able to explain how RSVP functions and what different types of reservations are and how they differ from each other
  - Be able to explain alternative uses for RSVP and RSVP-TE
  - Be able to explain what CR-LDP is and how it compares to RSVP



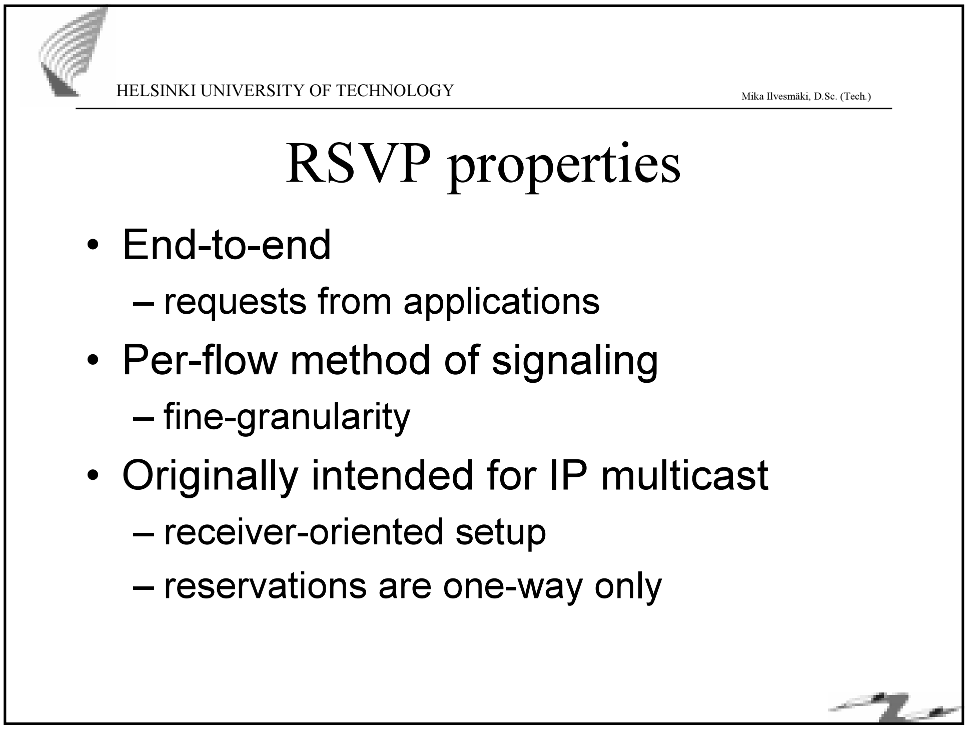
# RSVP design goals

- Heterogeneous receivers
  - Receiver oriented reservation style
- Dynamic membership
  - Data transfer is not controlled by RSVP
- Sharing of resources
  - Reservation styles (WF, FF, SE)
- Adaptation to network dynamics
  - Soft-state approach
- Independence of architectural components
  - Flow specs, admission control, packet classification, scheduling, routing
- Controllable (and modifiable) protocol overhead
  - Refresh period parameter



# RSVP design

- Not a routing protocol
  - designed to operate with current and future routing protocols
- Policy independent
  - RSVP is independent of the service architecture
- Soft state
  - times out unless state is refreshed
  - allows for state modification (original and refresh messages identical)
- Transparent operation through Non-RSVP clouds
- Reservations may be shared or not

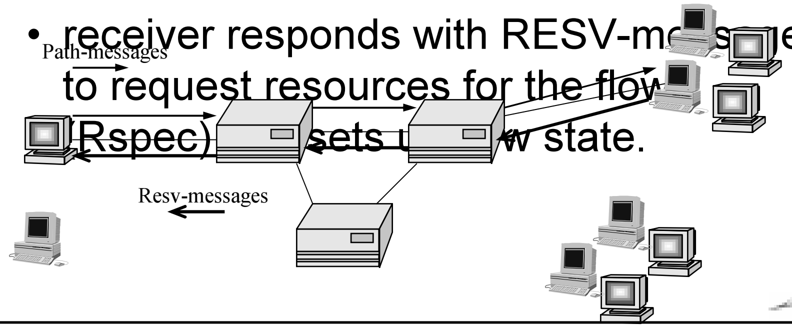


# RSVP properties

- End-to-end
  - requests from applications
- Per-flow method of signaling
  - fine-granularity
- Originally intended for IP multicast
  - receiver-oriented setup
  - reservations are one-way only

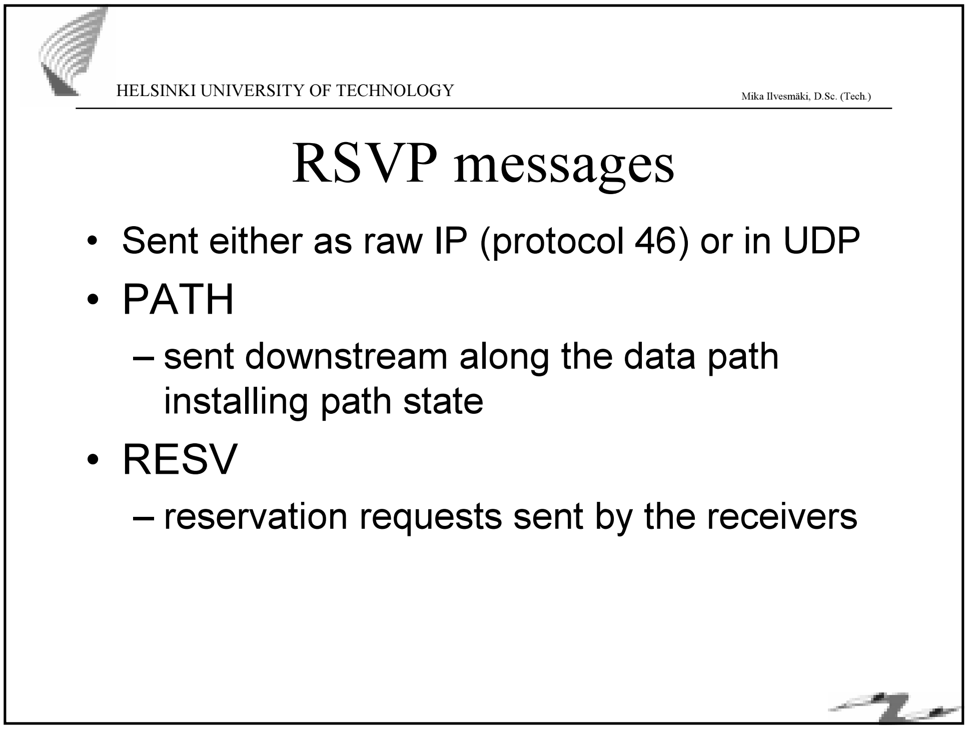
# Method of establishing flow state

- sender sends a PATH –message to the receiver specifying the traffic characteristics (Tspec) and setting up the path (path state)
- receiver responds with RESV-message to request resources for the flow (Rspec) and sets up flow state.



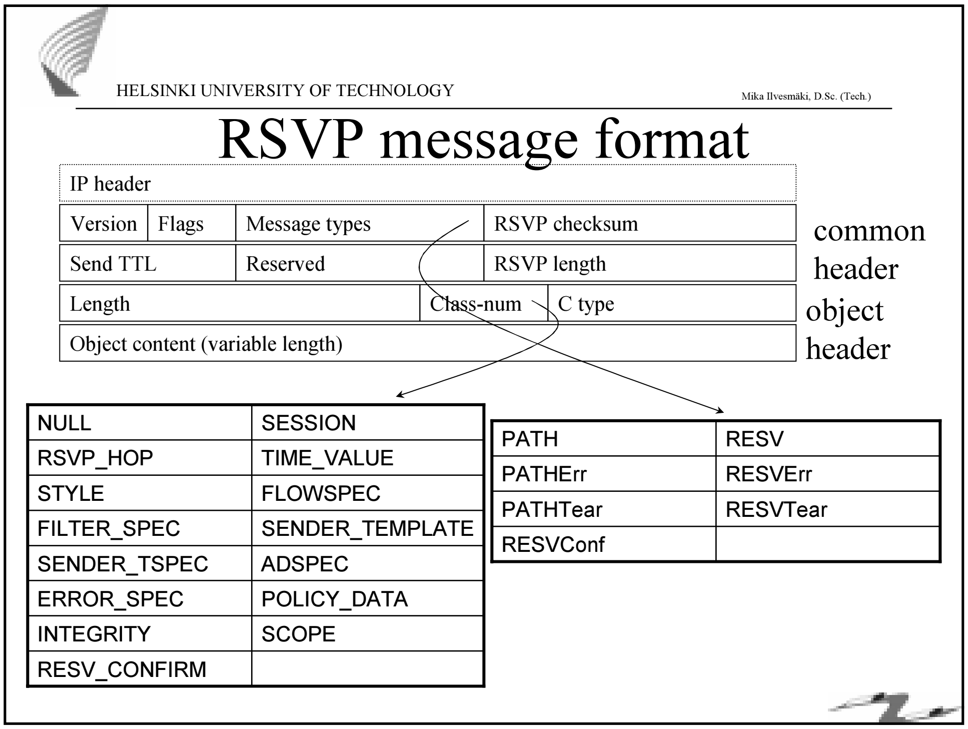
# Soft state

- RSVP sends (by default) PATH and RESV messages periodically
  - If states are not updated regularly they time out.
- PATH refreshes make it possible to adapt to path/(multicast distribution tree) property changes
- RESV refreshes may incorporate changes altered reservations -> adaptive QoS
  - Old reservations die out, no additional state maintenance



# RSVP messages

- Sent either as raw IP (protocol 46) or in UDP
- PATH
  - sent downstream along the data path installing path state
- RESV
  - reservation requests sent by the receivers



# RSVP message format

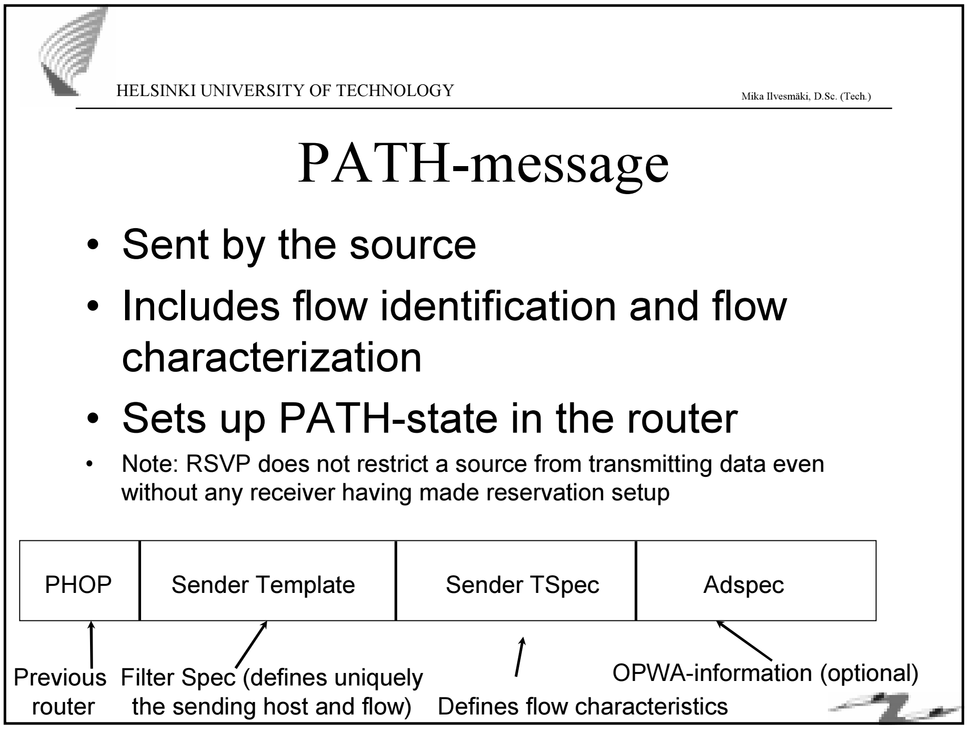
| | | | | |
|---|---|---|---|---|
| IP header | | | | |
| Version | Flags | Message types | | RSVP checksum |
| Send TTL | | Reserved | | RSVP length |
| Length | | | Class-num | C type |
| Object content (variable length) | | | | |

common header

object header

| | |
|---|---|
| NULL | SESSION |
| RSVP_HOP | TIME_VALUE |
| STYLE | FLOWSPEC |
| FILTER_SPEC | SENDER_TEMPLATE |
| SENDER_TSPEC | ADSPEC |
| ERROR_SPEC | POLICY_DATA |
| INTEGRITY | SCOPE |
| RESV_CONFIRM | |

| | |
|---|---|
| PATH | RESV |
| PATHErr | RESVErr |
| PATHTear | RESVTear |
| RESVConf | |



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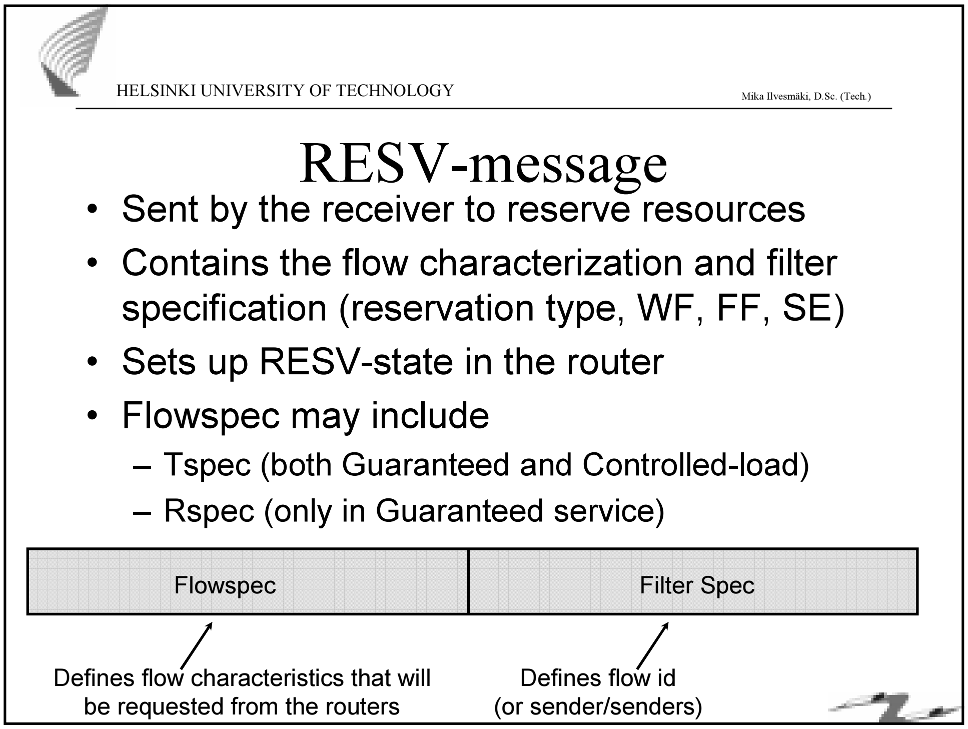
# PATH-message

- Sent by the source
- Includes flow identification and flow characterization
- Sets up PATH-state in the router
- Note: RSVP does not restrict a source from transmitting data even without any receiver having made reservation setup

| PHOP | Sender Template | Sender TSpec | Adspec |
|---|---|---|---|
| Previous router | Filter Spec (defines uniquely the sending host and flow) | Defines flow characteristics | OPWA-information (optional) |



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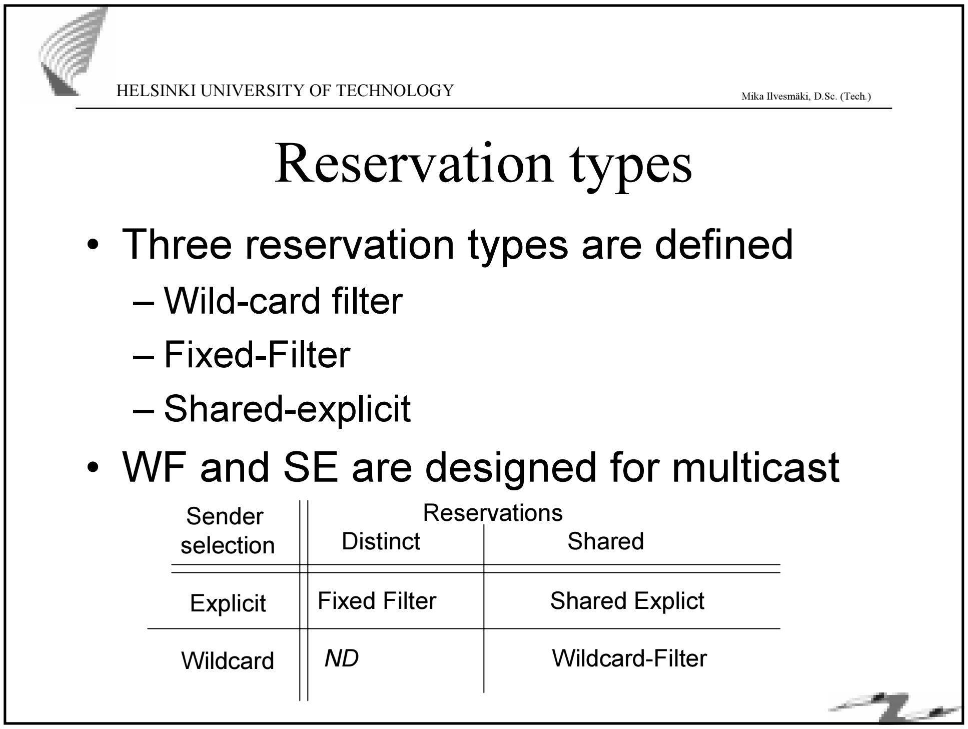
# RESV-message

- Sent by the receiver to reserve resources
- Contains the flow characterization and filter specification (reservation type, WF, FF, SE)
- Sets up RESV-state in the router
- Flowspec may include
  - Tspec (both Guaranteed and Controlled-load)
  - Rspec (only in Guaranteed service)

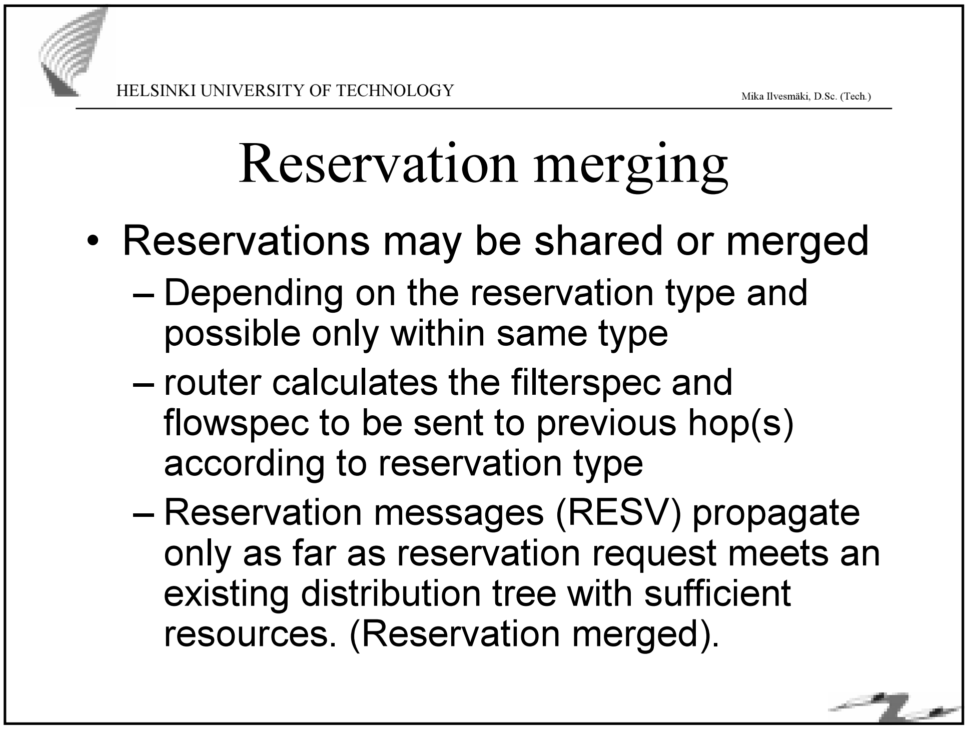
| Flowspec | Filter Spec |
|---|---|
| Defines flow characteristics that will be requested from the routers | Defines flow id (or sender/senders) |



# Reservation types

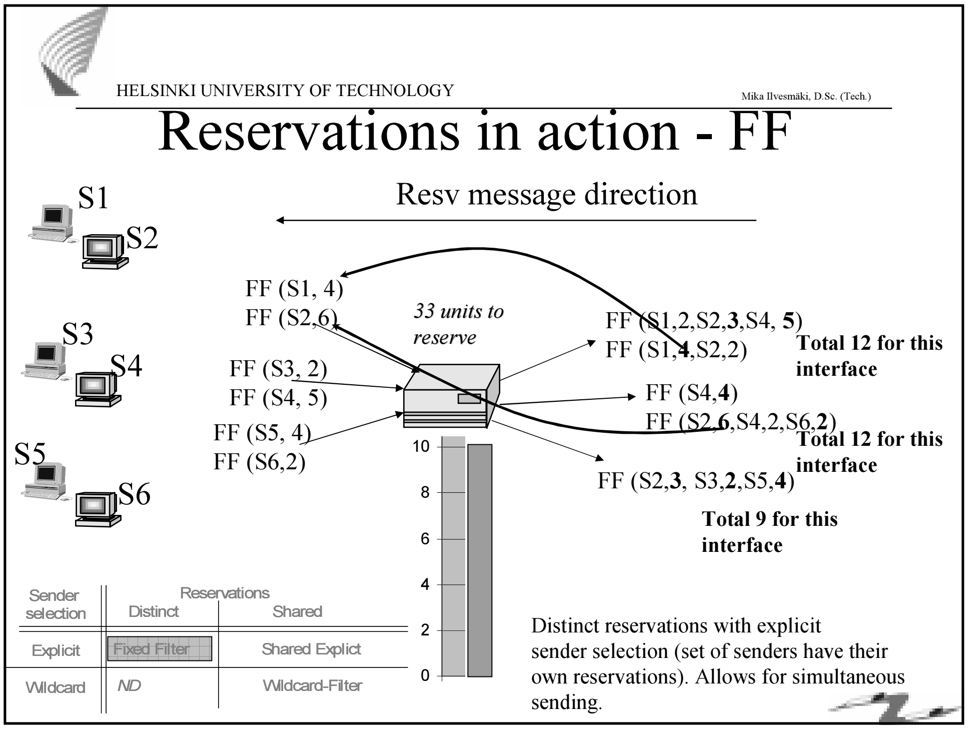
- Three reservation types are defined
  - Wild-card filter
  - Fixed-Filter
  - Shared-explicit
- WF and SE are designed for multicast

| Sender selection | Reservations | |
|---|---|---|
| | Distinct | Shared |
| Explicit | Fixed Filter | Shared Explict |
| Wildcard | *ND* | Wildcard-Filter |



# Reservation merging

- Reservations may be shared or merged
  - Depending on the reservation type and possible only within same type
  - router calculates the filterspec and flowspec to be sent to previous hop(s) according to reservation type
  - Reservation messages (RESV) propagate only as far as reservation request meets an existing distribution tree with sufficient resources. (Reservation merged).



# Reservations in action - FF

Resv message direction

S1

S2

S3

S4

S5

S6

FF (S1, 4)
FF (S2,6)

FF (S3, 2)
FF (S4, 5)

FF (S5, 4)
FF (S6,2)

*33 units to reserve*

FF (S1,2,S2,**3**,S4, **5**)
FF (S1,**4**,S2,2)

**Total 12 for this interface**

FF (S4,**4**)
FF (S2,**6**,S4,2,S6,**2**)

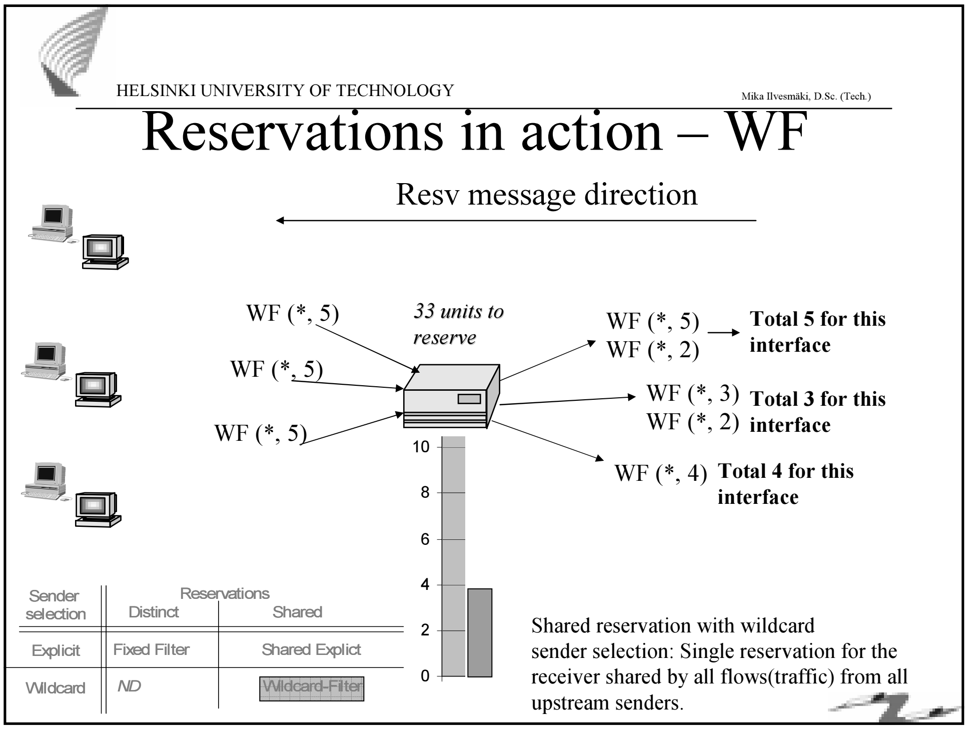
**Total 12 for this interface**

FF (S2,**3**, S3,**2**,S5,**4**)

**Total 9 for this interface**

| Sender selection | Reservations | |
|---|---|---|
| | Distinct | Shared |
| Explicit | Fixed Filter | Shared Explicit |
| Wildcard | *ND* | Wildcard-Filter |

Distinct reservations with explicit sender selection (set of senders have their own reservations). Allows for simultaneous sending.



# Reservations in action – WF

Resv message direction

WF (*, 5)

WF (*, 5)

WF (*, 5)

*33 units to reserve*

WF (*, 5)
WF (*, 2)

**Total 5 for this interface**

WF (*, 3)
WF (*, 2)

**Total 3 for this interface**

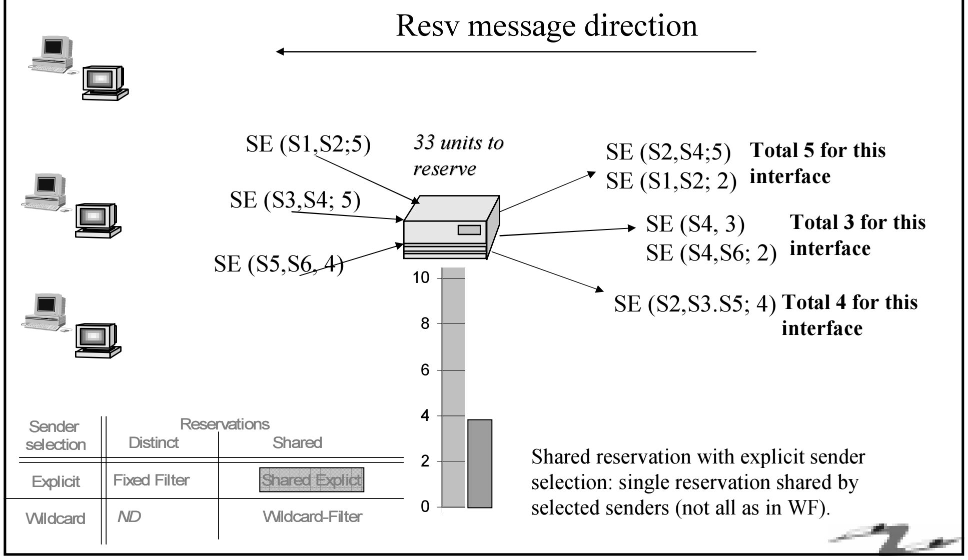
WF (*, 4)

**Total 4 for this interface**

| Sender selection | Reservations | |
|---|---|---|
| | Distinct | Shared |
| Explicit | Fixed Filter | Shared Explicit |
| Wildcard | *ND* | Wildcard-Filter |

Shared reservation with wildcard sender selection: Single reservation for the receiver shared by all flows(traffic) from all upstream senders.

# Reservations in action - SE



Resv message direction

SE (S1,S2;5)

SE (S3,S4; 5)

SE (S5,S6, 4)

*33 units to reserve*

SE (S2,S4;5)
SE (S1,S2; 2) **Total 5 for this interface**

SE (S4, 3)
SE (S4,S6; 2) **Total 3 for this interface**

SE (S2,S3.S5; 4) **Total 4 for this interface**

| Sender selection | Reservations | |
|---|---|---|
| | Distinct | Shared |
| Explicit | Fixed Filter | Shared Explict |
| Wildcard | *ND* | Wildcard-Filter |

Shared reservation with explicit sender selection: single reservation shared by selected senders (not all as in WF).

# Adspec

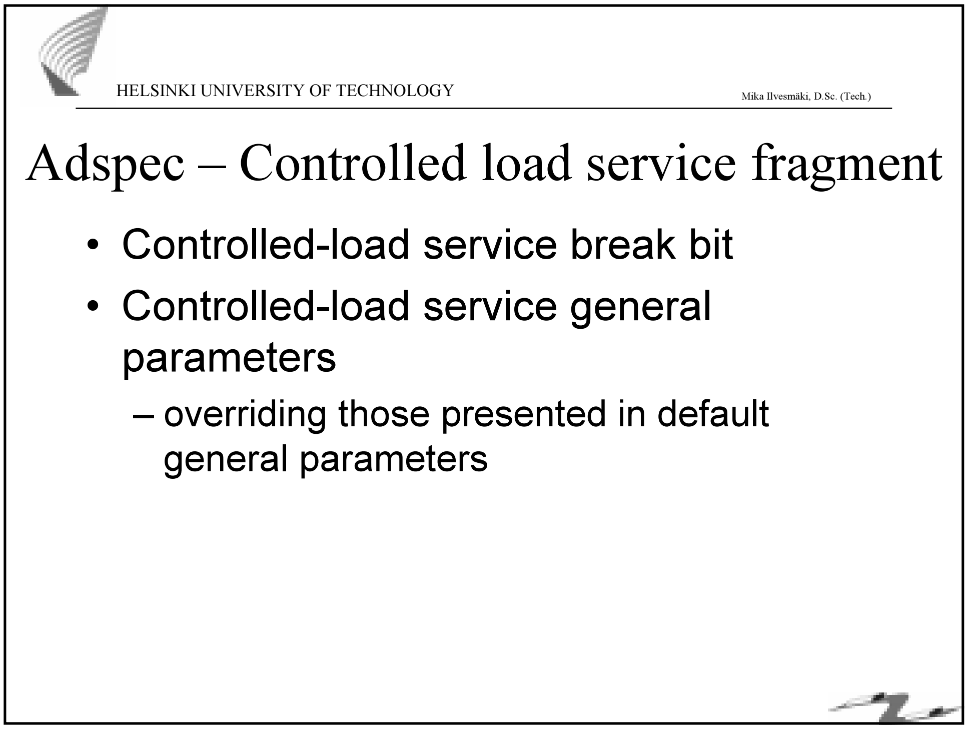
- optional object in the PATH-message
- Consists of
  - default general parameters
  - Guaranteed Service fragment
  - Controlled Load Service fragment
- advertise receivers the characteristics of the end-to-end **path**

# Adspec – Default general parameters

- Minimum Path Latency
- Path bandwidth
- Global break bit
  - cleared when Adspec is created by the sender
- IntServ Hop Count
- PathMTU

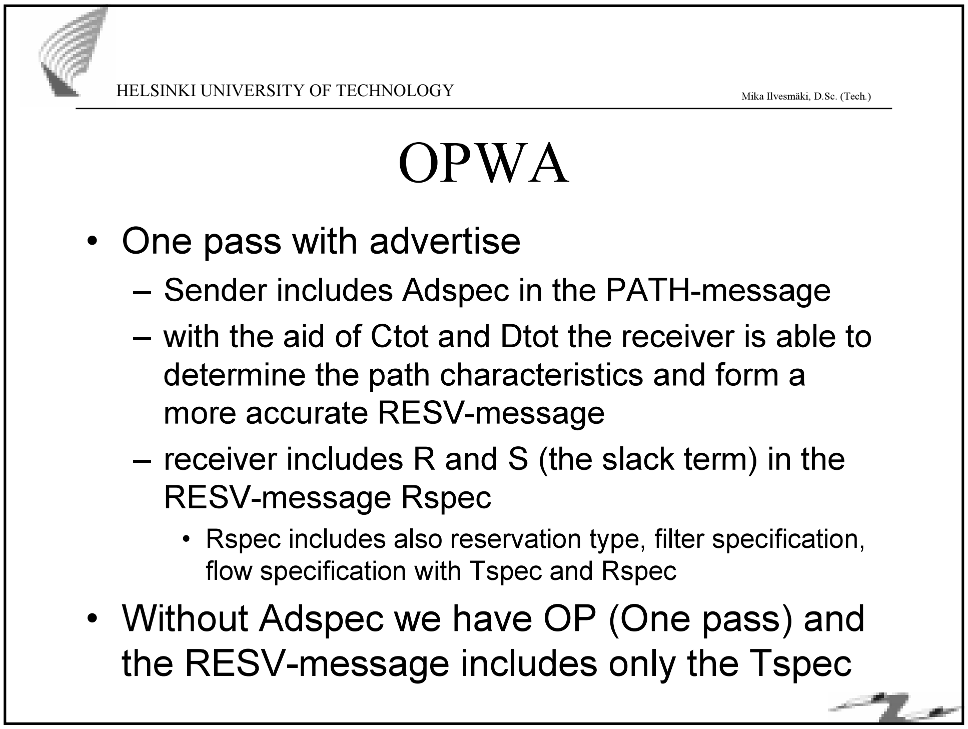
# Adspec – Guaranteed Service fragment

- Ctot, Dtot, Csum and Dsum
- Guaranteed Service break bit
- Guaranteed Service General Parameters
  - overrides the values in default general parameters



# Adspec – Controlled load service fragment

- Controlled-load service break bit
- Controlled-load service general parameters
  - overriding those presented in default general parameters

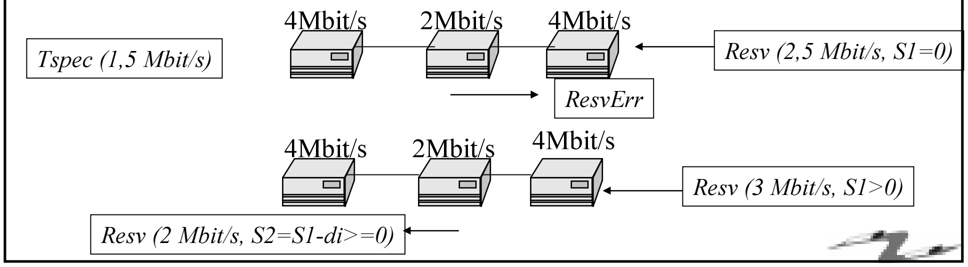


# OPWA

- One pass with advertise
  - Sender includes Adspec in the PATH-message
  - with the aid of Ctot and Dtot the receiver is able to determine the path characteristics and form a more accurate RESV-message
  - receiver includes R and S (the slack term) in the RESV-message Rspec
    - Rspec includes also reservation type, filter specification, flow specification with Tspec and Rspec
- Without Adspec we have OP (One pass) and the RESV-message includes only the Tspec

# Slack term

- Indicates the difference between the desired delay and the actual delay obtained with current R (bandwidth reservation)
- Allows the reservations some flexibility
  - balance between queue usage and service rate



4Mbit/s 2Mbit/s 4Mbit/s

Tspec (1,5 Mbit/s)

Resv (2,5 Mbit/s, S1=0)

ResvErr

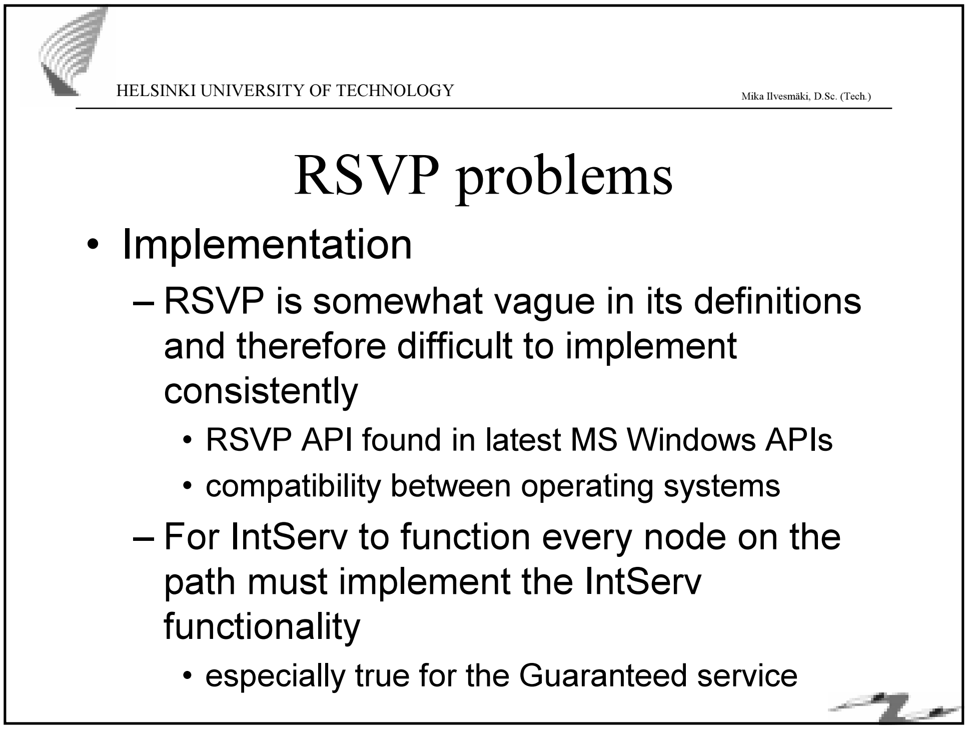
4Mbit/s 2Mbit/s 4Mbit/s

Resv (3 Mbit/s, S1>0)

Resv (2 Mbit/s, S2=S1-di>=0)

# Confused?

- PATH(Tspec) describes how the traffic will behave
  - PATH will also establish the route
- The receiver calculates (maybe based on Adspec) what kind of reservations have to be made and puts this reservation request into RESV(Rspec)
  - RESV will make the reservations on the route



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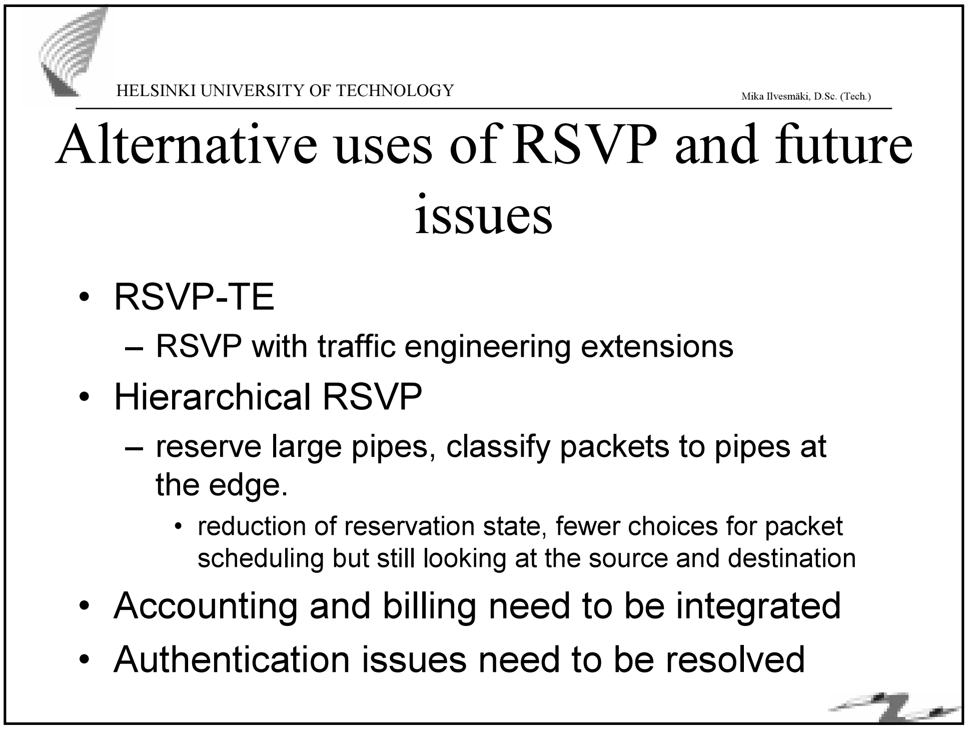
# RSVP problems

- Implementation
  - – RSVP is somewhat vague in its definitions and therefore difficult to implement consistently
    - RSVP API found in latest MS Windows APIs
    - compatibility between operating systems
  - – For IntServ to function every node on the path must implement the IntServ functionality
    - especially true for the Guaranteed service



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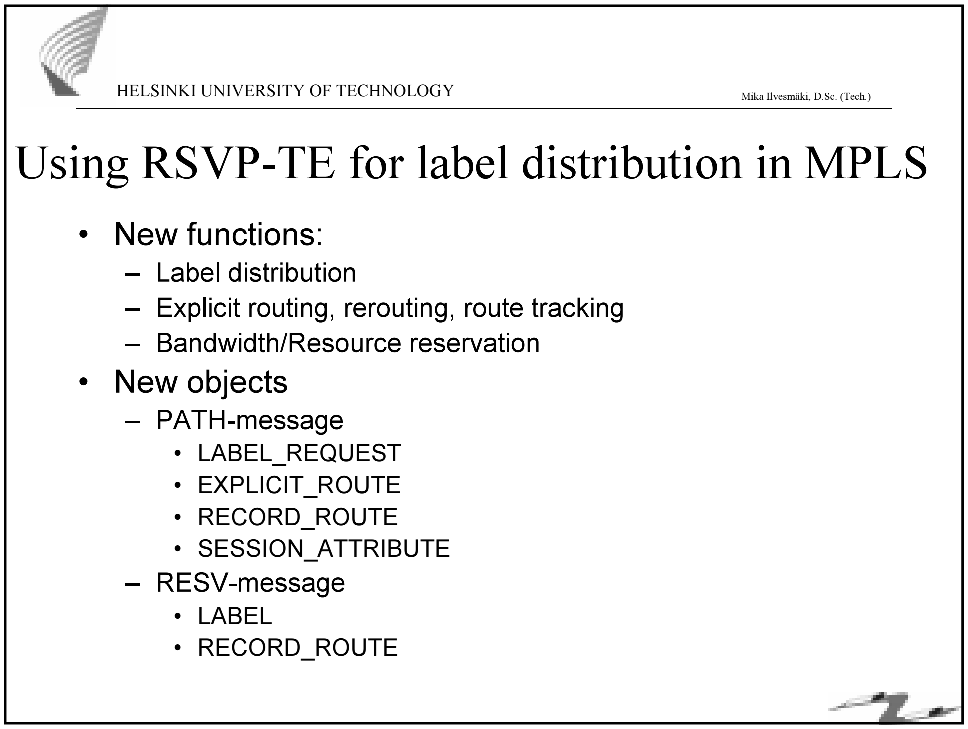
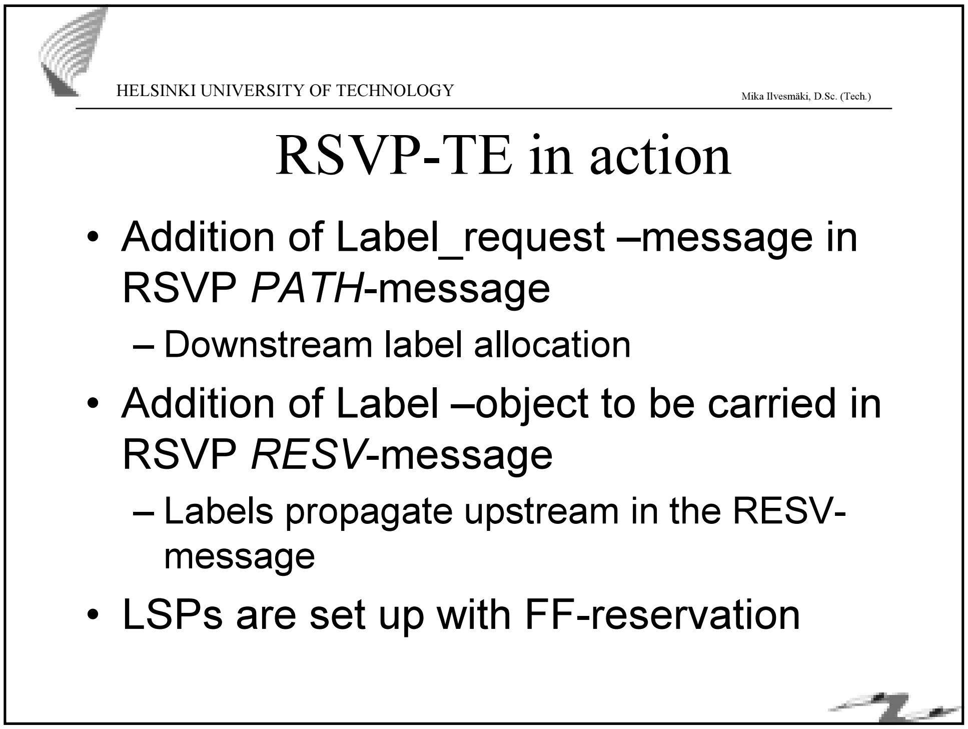
# Alternative uses of RSVP and future issues

- RSVP-TE
  - – RSVP with traffic engineering extensions
- Hierarchical RSVP
  - – reserve large pipes, classify packets to pipes at the edge.
    - reduction of reservation state, fewer choices for packet scheduling but still looking at the source and destination
- Accounting and billing need to be integrated
- Authentication issues need to be resolved



# Using RSVP-TE for label distribution in MPLS

- New functions:
  - Label distribution
  - Explicit routing, rerouting, route tracking
  - Bandwidth/Resource reservation
- New objects
  - PATH-message
    - LABEL_REQUEST
    - EXPLICIT_ROUTE
    - RECORD_ROUTE
    - SESSION_ATTRIBUTE
  - RESV-message
    - LABEL
    - RECORD_ROUTE



# RSVP-TE in action

- Addition of Label_request –message in RSVP *PATH*-message
  - Downstream label allocation
- Addition of Label –object to be carried in RSVP *RESV*-message
  - Labels propagate upstream in the RESV-message
- LSPs are set up with FF-reservation

# Domain wide QoS

- a.k.a Constraint based routing (CR) or QoS routing (QoSR)
- Calculate the route so that multiple constraints are met and that the route is optimal for every constraint
  - Constraints: delay, bandwidth, etc. and/or administrative
- Problems: route oscillation, path capacity
- Could be used together with a signalling protocol (RSVP or CR-LDP) that has knowledge on the constraint values

# CR-LDP

- LDP (label distribution protocol) is defined for distribution of labels in MPLS-networks.
  - Constraint-based Routing LDP (CR-LDP) uses information not available for routing protocols when setting up the paths.
    - Explicitly routed LSPs
- CR-LDP is simple, scalable (TLV), open and non-proprietary signalling protocol

# CR-LDP and QoS

- Strict and loose explicit routing
  - Route pinning
- Specification of traffic parameters (peak rate, delay variation…)
- Use of resource classes (instead of traffic parameters)
- LSP pre-emption
  - Set-up priority better than holding priority may preempt an existing LSP

# Comparing RSVP_TE and CR-LDP

- Both can be used to establish LSPs
- CR-LDP works over TCP, RSVP works over IP (or UDP)
- Direction of resource reservations is different

| Property | CR-LDP | RSVP_TE |
|---|---|---|
| *Transport mechanism* | Transport on TCP (reliable) | Raw IP packets (unreliable) |
| *State management* | Hard state | Soft state; needs per-flow refresh management |
| *Msgs required for LSP set-up and maintenance* | Request, mapping | Path, Resv, Resv_Conf |
| *Base architecture* | Based on LDP for MPLS | Based on RSVP, may require major changes |
| *Signalling of QoS and traffic parameters* | Can signal DiffServ and ATM traffic classes | Extendable, currently based on IntServ |
| *Types of LSPs* | Strict, loose, and loose pinned | Strict and loose, no pinning |
| *Models of label distribution and LSP set-up* | All modes | Only downstream on demand |
| *Failure notification* | Reliable procedure | Unreliable procedure |
| *Loop detection/prevention* | Employs path vector TLV to prevent Label Request –loops. Hop Count TLV used to find looping LSPs | May be done using Record_Route -object |