The Spatial Reuse Protocol (SRP)

Overview

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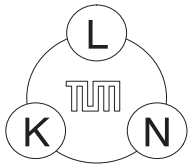
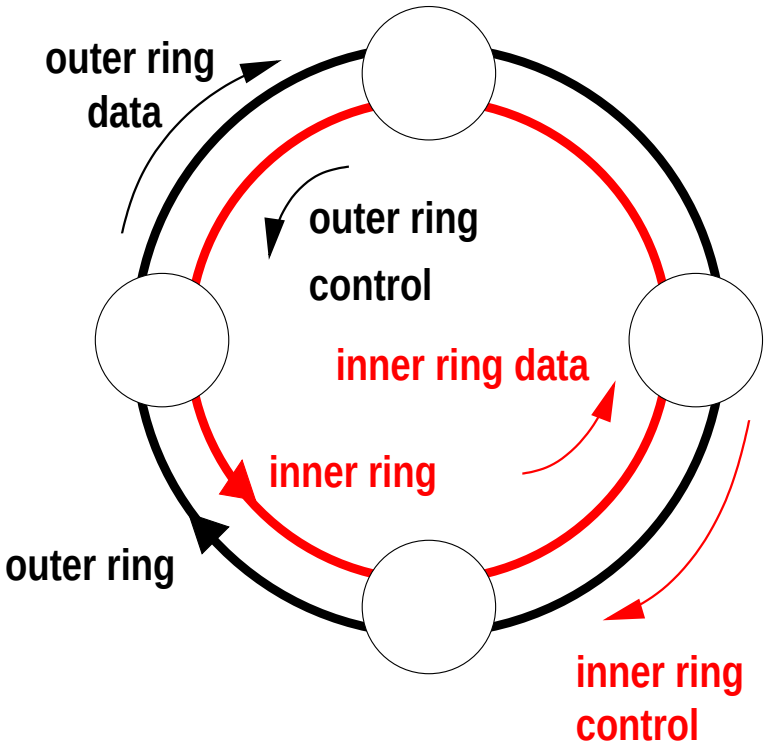


Introduction

SRP Characteristics

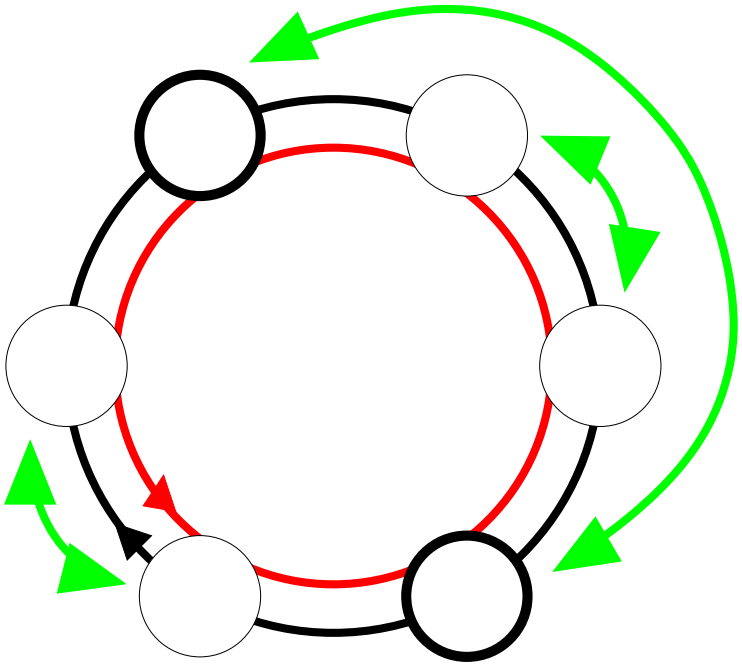
Ring-based solution to interconnect routers:



- Dual counter-rotating rings
- Point-to-point links possible (two-node ring)
- Traffic is bidirectional and can be prioritized
- Multicasting possible
- Control information carried in opposite direction from data
- Protection switching
- Spatial Reuse Protocol (SRP) as media independent MAC layer with objective packet over optical networks

SRP: RFC 2892 (Informational) by Cisco with pending patents

Bandwidth Efficiency



Efficient use of bandwidth by spatial reuse

- Sources transmit concurrently
- Destination stripping of unicast traffic
- Bandwidth consumed only on traversed segment

Local reuse of bandwidth

- Fair share of bandwidth for all connections
- Additional access for less than fully utilized segments of the ring (left path)

Statistical multiplexing gain

- Ring instead of star topology
- Ring protection on packet level (unlike SDH)

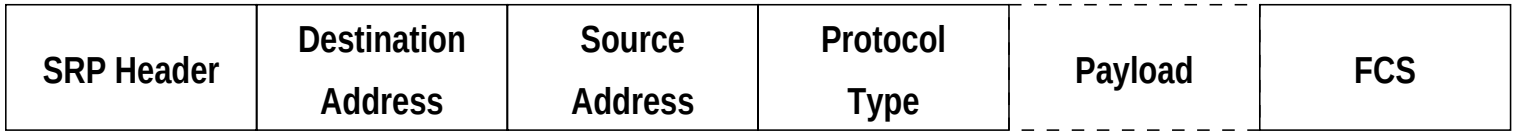
Minimal protocol overhead

- May hold in comparison to ATM

SRP Packets

Packet Format

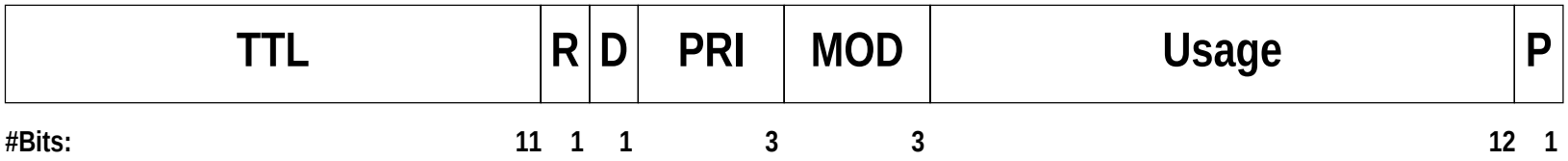
SRP payload encapsulation:



- Fixed-sized header for SRP control
- Destination/Source Address: 48 bit address assigned by the IEEE
- Protocol Type: defined values for IPv4 packets, Address Resolution Protocol (ARP) packets and SRP control packets; new version supports ATM cells as well
- Payload supported with upper bound on maximum transfer unit (MTU) of 9194 octets
- Frame Check Sequence (FCS): 32-bit Cyclic Redundancy Check (CRC) over destination address, source address, protocol type and payload
- Erroneous packets are discarded

Header Format

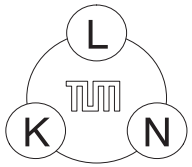
Generic SRP header without addresses and protocol type field:



- Time To Live (TTL): hop-count, if expired $\Rightarrow$ packet will be stripped
- Ring Identifier (R): differentiation between inner and outer ring
- Destination Strip (D): indicator for destination to strip the packet
- Priority Field (PRI): eight priority levels
- Mode (MOD): differentiation between data packets, idle packets and several control messages
- Usable Bandwidth Field (Usage): indicator for the currently usable bandwidth this node sees
- Parity Bit (P): parity bit over above fields

Control Packets

- SRP control packet format similar to payload packets but with additional header before payload
- Priority should be highest
- Control packets are transmitted only to adjacent nodes
- Control message sinks:
  - Host (similar to payload interface)
  - Local buffer at node (usually protection messages; implementor configures handling)
- Currently defined messages:
  - Protection switching messages
  - Topology discovery (TD) packet
- Control packets have own TTL (control layer hop-count)
- Control payload with variable length



Link Aspects

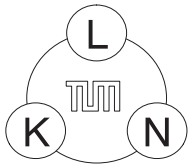
Keepalive Indications and Clock Synchronization

Keepalive packets:

- Control packets generated periodically when no data packets going upstream
- Propagation of messages contained in header (usage, etc.) when link is idle
- Together with data packets indication that a valid data link exists

SRP Clock Synchronization:

- Receive clock derived from incoming receive stream
- Transmit clock derived from a local oscillator
- Differences in clock frequency accommodated by inserting small amount of idle bandwidth at each node's output



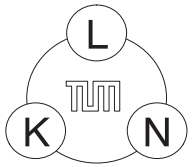
Media for SRP

SRP packets can be sent over any point-to-point layer 1 link:

- SONET/SDH using octet stuffing
  - Incase of full SONET/SDH protection: hold off timer for SRP protection switching to avoid multilayer protection interactions
  - Synchronization: external or transmit clock locked to receive clock
- SONET/SDH *framing* using octet stuffing for employment of SRP directly over an optical channel
- ATM (delineation by AAL5?)
- Point-to-point Ethernet (delineation by Ethernet header and length field?)

SRP over SONET/SDH is the first media type perceived for SRP applications.

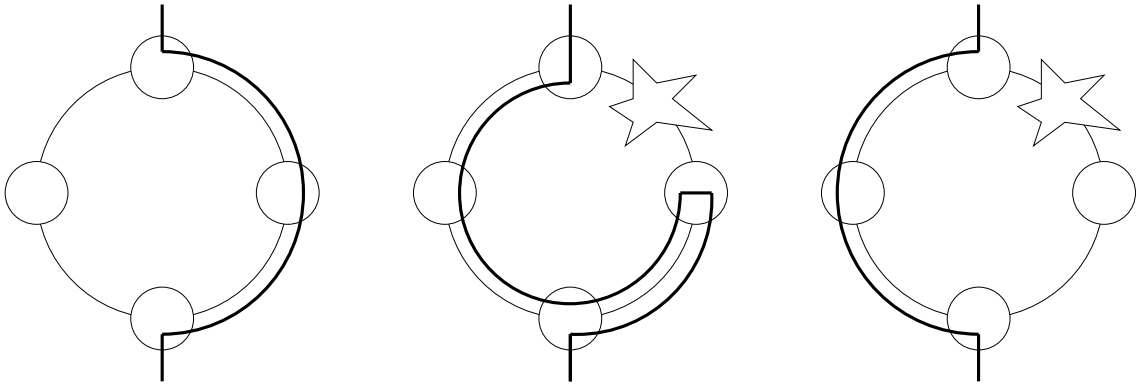
SRP together with information of layer 1 $\Rightarrow$ support of SONET MIB (RFC 1595)



Protection

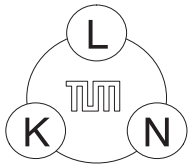
Intelligent Protection Switching (IPS)

- Bidirectional protection switching
- First step: loopback of traffic by the nodes adjacent to the failure (ring wrap)
- Second step: a new ring topology is discovered and reconfiguration may take place
- Ring wrap controlled similar to SDH/SONET bidirectional line-switched rings
- Objective: wrapping as fast as SONET/SDH or faster



IPS: Protection Switching Requests

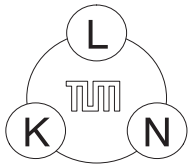
- Request types for protection switching in the order of priority:
  1. Forced Switch (FS): by operator
  2. Signal Fail (SF): detection through media signal or SRP keepalive failure
  3. Signal Degrade (SD): detection through e.g., excessive bit error rate
  4. Manual Switch (MS): by operator
  5. Wait to Restore (WTR): automatic switch back after leaving SF or SD state plus a WTR period
- Higher priority requests rule out lower priority requests potentially present in the ring (exception: multiple SF and FS switches)
- Protection request of a node transmitted over both the short and the long path to peer node



Topology Discovery

Topology Discovery (TD)

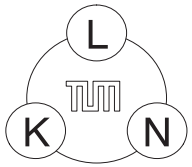
- Each node performs TD by sending out TD packets on one or both rings
- New TD packet contains egressing ring ID and MAC binding
- Each node receiving a TD packet appends its MAC address binding and sends it to the next hop on the ring
- Wrap state on the ring:
  - Wrapped node indicates a wrap when appending its MAC
  - MAC address bindings are not added on the wrapped section
- The node that generated the TD packet takes the packet from the ring if first MAC binding matches and ingress and egress ring ID are equal
- Topology map is changed only after receiving two TD packets which indicate the same new topology



Topology Map

Topology Map:

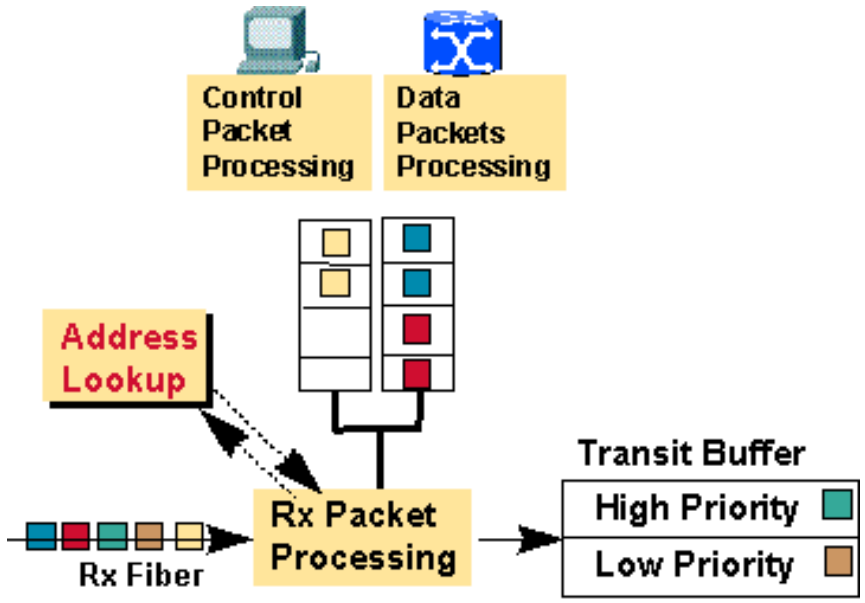
- Topology map contains reachable nodes only
- Provides information:
  - Number of nodes in the ring
  - Hop distances to nodes to determine the shortest path to a node
- Topology discovery actions:
  - Periodical action (e.g., self-configuration after adding a node to the ring)
  - Initiated action (e.g., manually adding a node to the ring or detecting a ring wrap)



SRP Nodes

Receiver Architecture

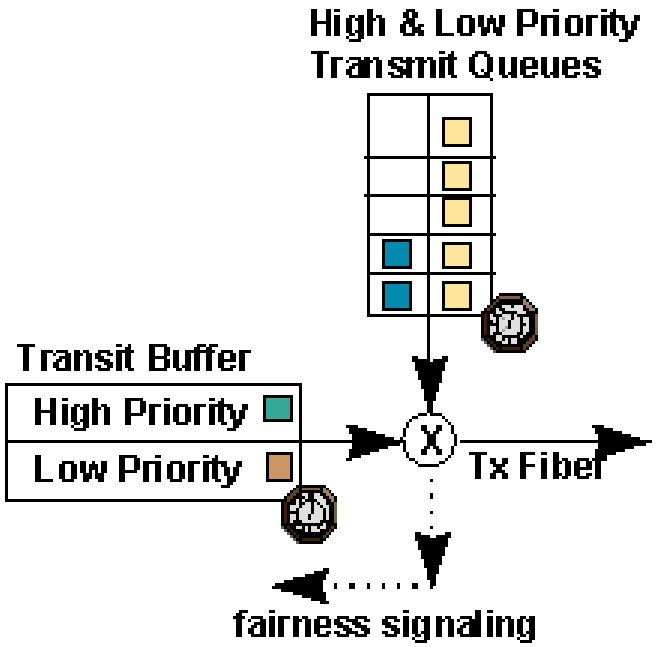
Receiver packet handling:



(Picture source: Cisco)

- Destination address (DA) match ⇒ packets are copied to the control and data receive-buffers
- DA match and also unicast packet and destination strip bit set ⇒ packet will be stripped
- No DA match or multicast packet without source address (SA) match ⇒ packet placed into the transit buffers depending on priority
- Pass through to transit obviating layer 3 possible (no DA match)

Transmitter Architecture



(Picture source: Cisco)

Transmitted packets:

- Forwarded packets from transit buffer with correct CRC and unexpired TTL
- Transmitted packets originating at node

Processing of high priority packets:

- *Forwarded* data always sent first
- *Originating* data sent as long as low priority transit buffer not full

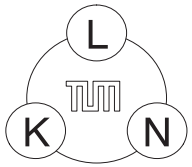
Processing of low priority packets:

- Low priority transit buffer emptied if over threshold value
- Control of the rate of low priority forwarded and originating data through the fairness algorithm employing the usage counters

Fairness Algorithm (SRP-fa)

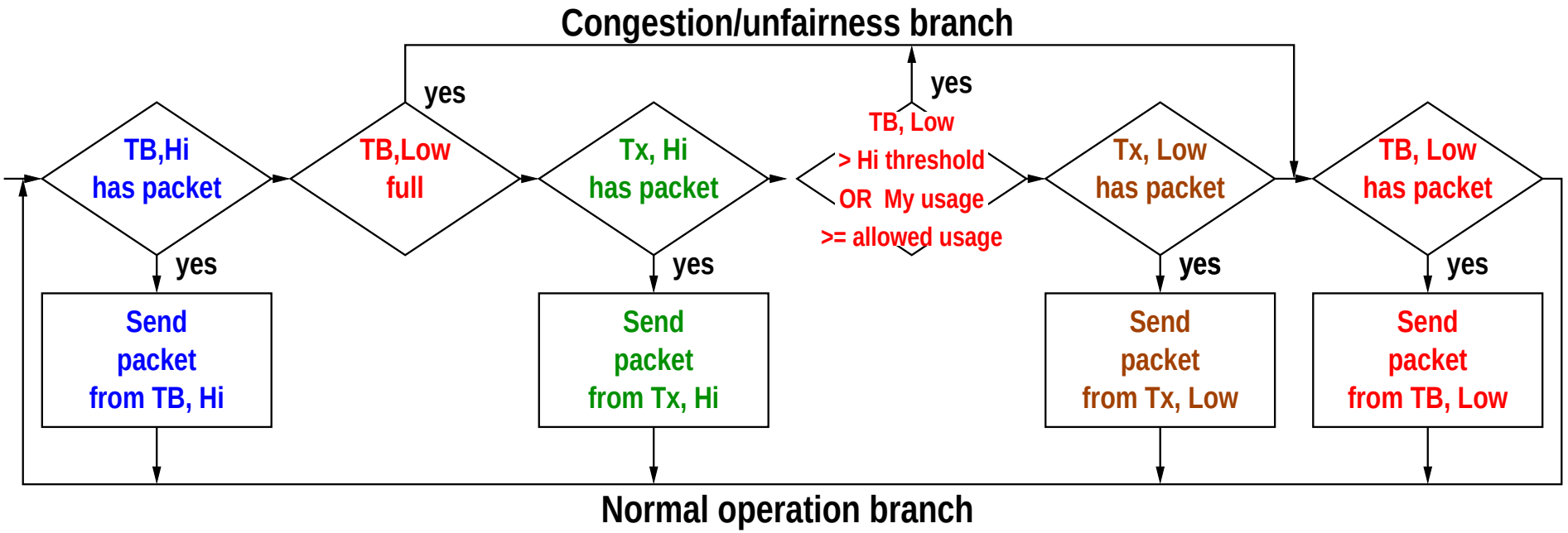
- Congestion detection if limit of depth of the low priority transit buffer is exceeded
- Congestion at a node $\Rightarrow$ advertisement of node's transmit usage counter to upstream nodes via the opposite ring
- Upstream nodes adjust their transmit rates so as not to exceed the advertised values.
- Nodes also propagate the advertised value received to their immediate upstream neighbor.
- Nodes receiving advertised values who are also congested propagate the minimum of their transmit usage and the advertised usage.

Due to limitations in the SRP-fa:
Practical limit to the number of nodes of a ring is currently 32.



Transmission Flowchart

Transmission decisions at each node:



Outlook IEEE 802.17

IEEE 802.17

Specification by IEEE 802.17 Study Group “Resilient Packet Ring (RPR)”

RPR scope:

- Ring operations (forwarding, topology, fairness, protection)

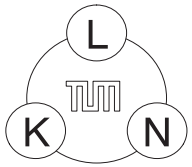
Out of RPR scope:

Vendor specific: Service intelligence (adaptation, QoS, protocols)

PHY specific: Optical transmission choice (Ethernet, SONET, ...)

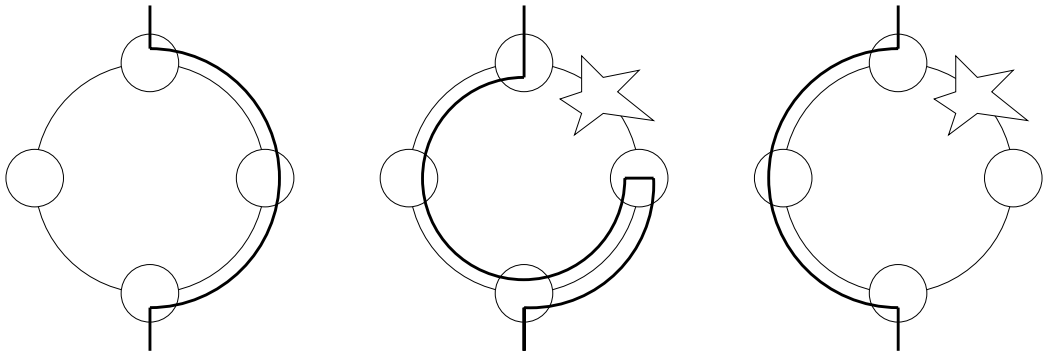
$\Rightarrow$ SRP one RPR solution

IETF: Working group for IP over RPR requirements and framework

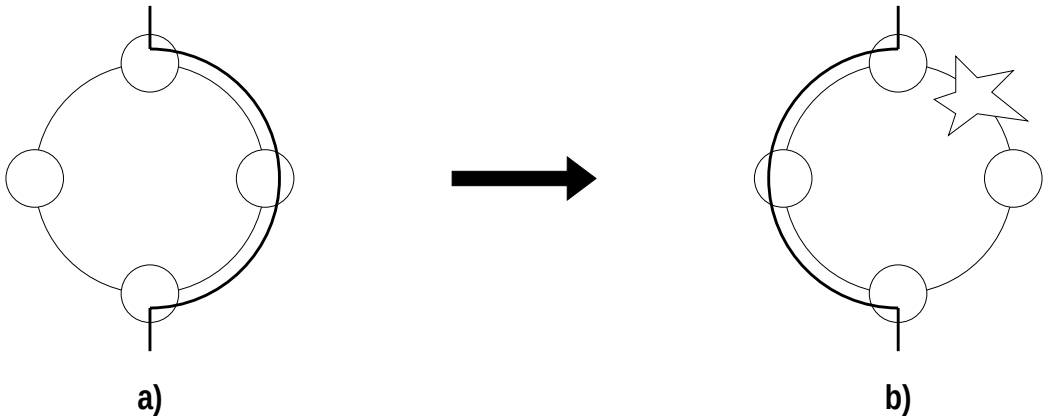


Wrapping vs. Steering

Wrapping (SRP):

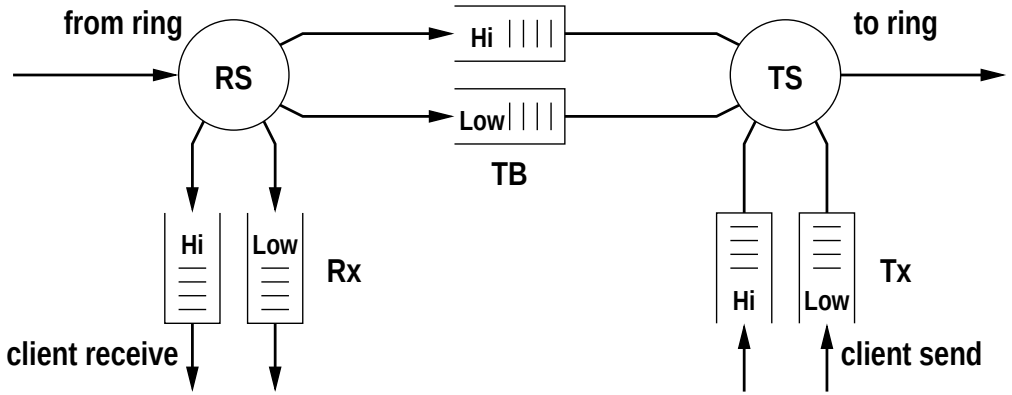


Steering:

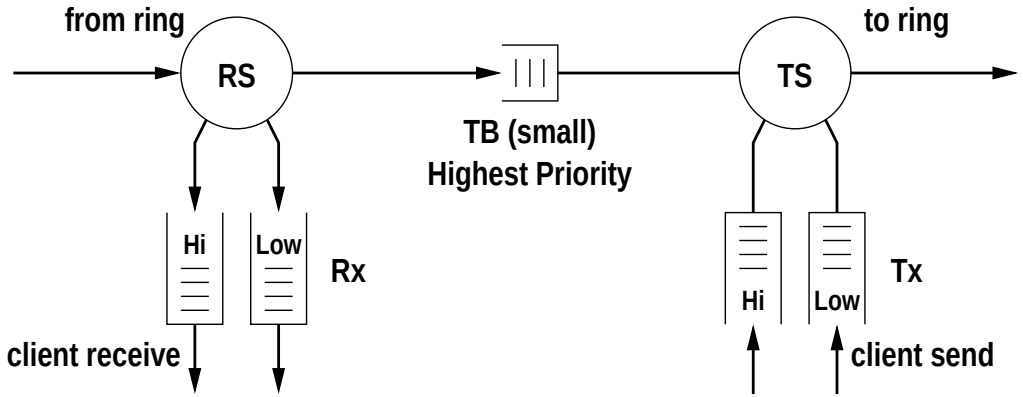


Store and Forward vs. Cut-through

Store and forward (SRP):



Cut-through:



Further Information

1. Tsiang, D.; Suwala, G.: “The Cisco SRP MAC Layer Protocol,” RFC 2892, 2000. `http://www.ietf.org/rfc/rfc2892.txt`.
2. Jäger, M.; Foisel, H.-M.; Westphal, H.-M.; Chawki, J.; Ovsthus, K.; Bischoff, J.-C.: “Evaluation of Network Architectures for the Integration of IP over Optical Networks,” 2nd Int. Workshop on Design of Reliable Communication Networks (DRCN 2000), 2000.
3. Schupke, D.A.: “Packet Transfer Delay of the SRP Ring,” IEEE Conference on Local Computer Networks (LCN), Tampa, Florida, November 15-16, 2001 (to appear).
4. Hammond, J.L.; O’Reilly, P.J.P.: “Performance Analysis of Local Computer Networks,” Addison-Wesley, Reading, MA, USA, 1988.
5. Schupke, D.A.: “Reliability Models of SRP Rings,” Americas Conference on Information Systems (AMCIS), Long Beach, CA, USA, August 10 - 13, 2000. `http://www.lkn.ei.tum.de/~ds/`
6. IEEE 802.17 Resilient Packet Ring Working Group Website. `http://www.ieee802.org/rprsg/`
7. IETF IP over Resilient Packet Rings (iporpr) Website. `http://www.ietf.org/html.charters/iporpr-charter.html`