G.8032
Ethernet Ring Protection Overview

March, 2008

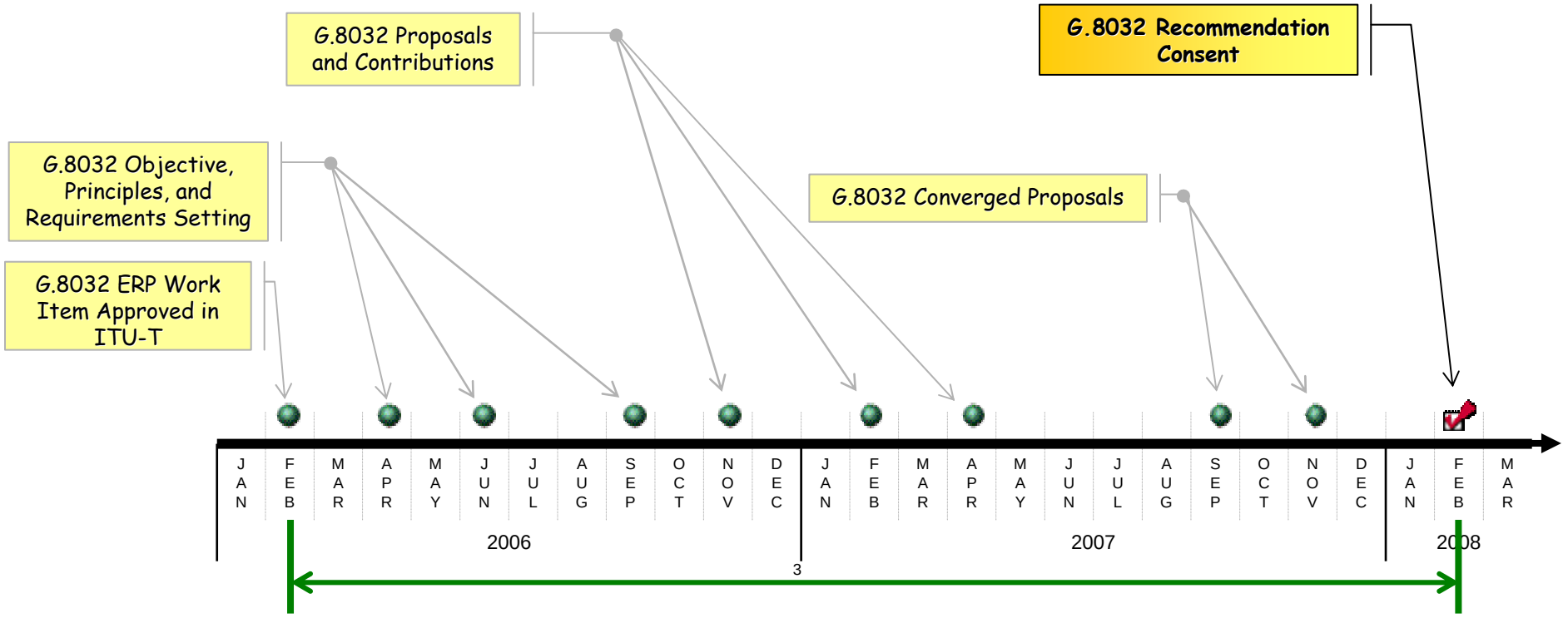
ITU-T Q9 – SG 15

Agenda

- G.8032 Recommendation Introduction
- G.8032 Objectives and Principles
- G.8032 Concepts
- G.8032 Protection Switching
- G.8032 R-APS Messages
- G.8032 Items Under Study

ITU-T SG15/Q9 G.8032 Recommendation

- G.8032 Recommendation consented February 2008
  - This Recommendation defines the APS protocol and protection switching mechanisms for ETH layer ring topologies. Included are details pertaining to bridged ring protection characteristics, architectures and the ring APS protocol.



G.8032 Objectives and Principles

- Use of standard 802 MAC and OAM frames around the ring. Uses standard 802.1Q (and amended Q bridges), but with xSTP disabled.
- Ring nodes supports standard FDB MAC learning, forwarding, flush behaviour and port blocking/unblocking mechanisms.
- Prevents loops within the ring by blocking one of the links (either a pre-determined link or a failed link).
- Monitoring of the ETH layer for discovery and identification of Signal Failure (SF) conditions.
- Protection and recovery switching within 50 ms for typical rings.
- Total communication for the protection mechanism should consume a very small percentage of total available bandwidth.

G.8032 Terms and Concepts

Ring Protection Link (RPL) – Link designated by mechanism that is blocked during Idle state to prevent loop on Bridged ring

RPL Owner – Node connected to RPL that blocks traffic on RPL during Idle state and unblocks during Protected state

Link Monitoring – Links of ring are monitored using standard ETH CC OAM messages (CFM)

Signal Fail (SF) – Signal Fail is declared when ETH trail signal fail condition is detected

No Request (NR) – No Request is declared when there are no outstanding conditions (e.g., SF, etc.) on the node

Ring APS (R-APS) Messages – Protocol messages defined in Y.1731 and G.8032

Automatic Protection Switching (APS) Channel - Ring-wide VLAN used exclusively for transmission of OAM messages including R-APS messages

G.8032 Timers

G.8032 specifies the use of different timers to avoid race conditions and unnecessary switching operations

- WTR (Wait to Restore) Timer – Used by the RPL Owner to verify that the ring has stabilized before blocking the RPL after SF Recovery
- Hold-off Timers – Used by underlying ETH layer to filter out intermittent link faults
  - Faults will only be reported to the ring protection mechanism if this timer expires

Controlling the Protection Mechanism

Protection switching triggered by

- Detection/clearing of Signal Failure (SF) by ETH CC OAM
- Remote requests over R-APS channel (Y.1731)
- Expiration of G.8032 timers

R-APS requests control the communication and states of the ring nodes

- Two basic R-APS messages specified - R-APS(SF) and R-APS(NR)
- RPL Owner may modify the R-APS(NR) indicating the RPL is blocked: R-APS(NR,RB)

Ring nodes may be in one of two states

- Idle – normal operation, no link/node faults detected in ring
- Protecting – Protection switching in effect after identifying a signal fault

Ring Idle State

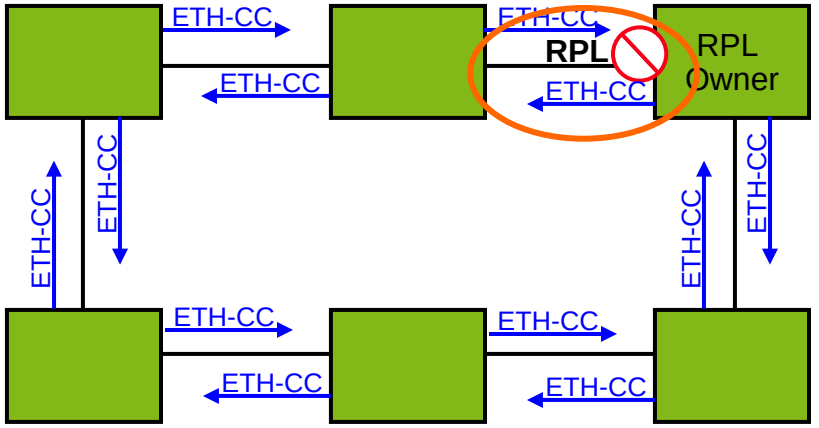
A. Physical topology has all nodes connected in a ring

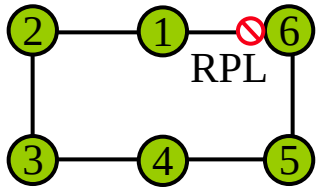
B. ERP guarantees lack of loop by blocking the RPL (link between 6 & 1 in figure)

C. Logical topology has all nodes connected without a loop.

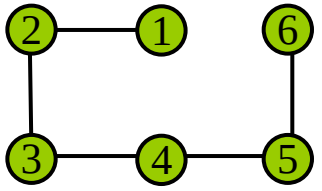
D. Each link is monitored by its two adjacent nodes using ETH CC OAM messages

E. Signal Failure as defined in Y.1731, is trigger to ring protection
   - Loss of Continuity
   - Server layer failure (e.g. Phy Link Down)





Physical topology



Logical topology

Protection Switching — Link Failure

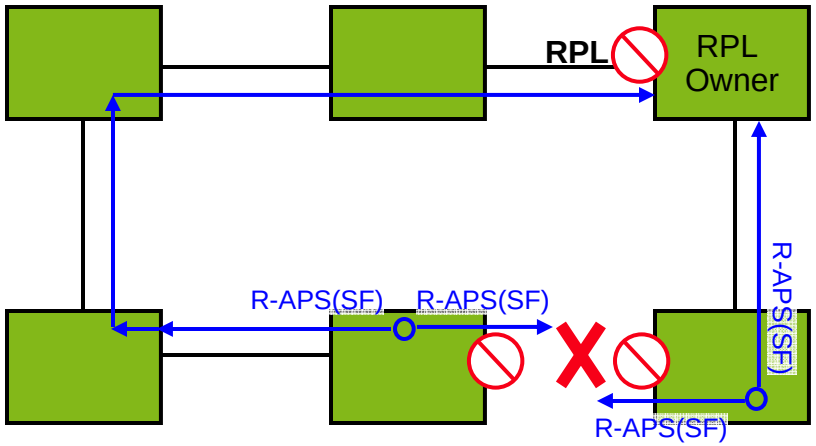
A. Link/node failure is detected by the nodes adjacent to the failure.

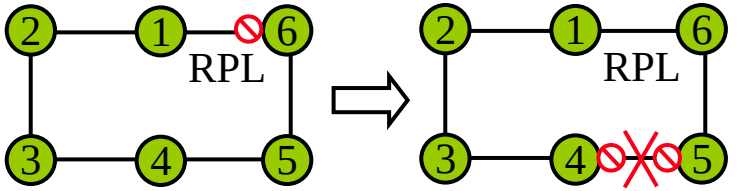
B. The nodes adjacent to the failure, block the failed link and report this failure to the ring using R-APS (SF) message

C. R-APS (SF) message triggers
   - RPL Owner unblocks the RPL
   - All nodes perform FDB flushing

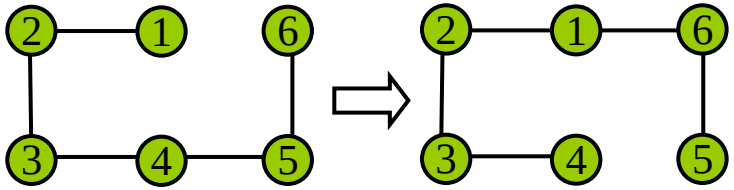
D. Ring is in protection state

E. All nodes remain connected in the logical topology.





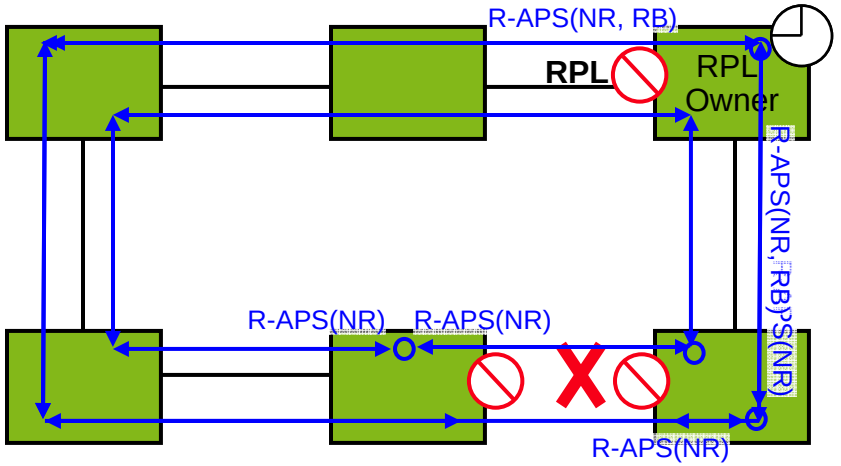
Physical topology

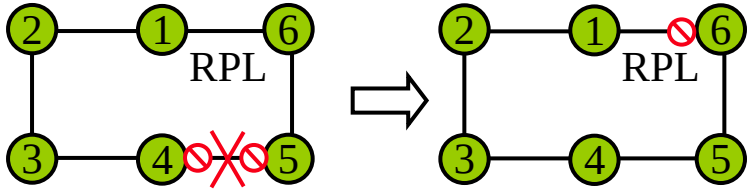


Logical topology

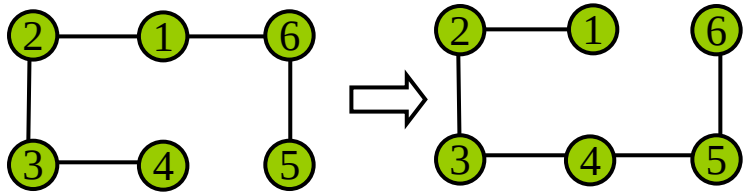
Protection Switching — Failure Recovery

A. When the failed link recovers, the traffic is kept blocked on the nodes adjacent to the recovered link
B. The nodes adjacent to the recovered link transmit R-APS(NR) message indicating they have no local request present
C. When the RPL Owner receives R-APS(NR) message it Starts WTR timer
D. Once WTR timer expires, RPL Owner blocks RPL and transmits R-APS (NR, RB) message
E. Nodes receiving the message – perform a FDB Flush and unblock their previously blocked ports
F. Ring is now returned to Idle state





Physical topology



Logical topology

Signaling Channel Information

ERP uses R-APS messages to manage and coordinate the protection switching

R-APS defined in Y.1731 - OAM common fields are defined in Y.1731.

- Version – ‘00000’ – for this version of Recommendation
- OpCode – defined to be 40 in Y.1731
- Flags – ‘00000000’ – should be ignored by ERP

	1								2								3								4							
	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1	8	7	6	5	4	3	2	1
1	**MEL**			**Version (0)**					**OpCode (R-APS = 40)**								**Flags (0)**								**TLV Offset (32)**							
5	R-APS Specific Information (32 octets)																															
..	...																															
37	*[optional TLV starts here; otherwise End TLV]*																															
last																									End TLV (0)							

Defined by Y.1731

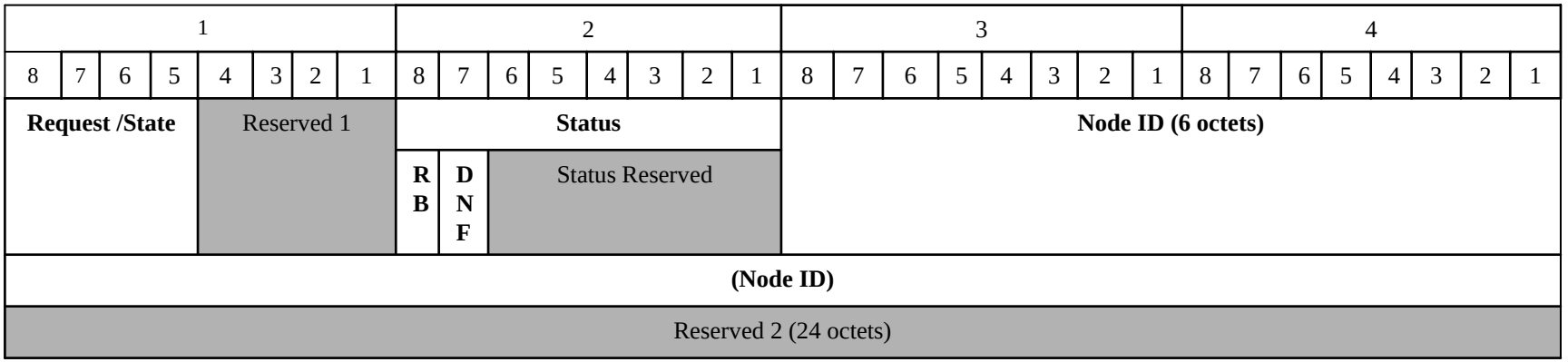
Defined by G.8032

Non-specified content

R-APS Specific Information

Specific information (32octets) defined by G.8032

- **Request/Status**(4bits) **–** ‘1011’ = SF | ’0000’ = NR | Other = Future
- **Status – RB** (1bit) **–** Set when RPL is blocked (used by RPL Owner in NR)
- **Status – DNF** (1bit) **–** Set when FDB Flush is not necessary (Future)
- **NodeID** (6octets) **–** MAC address of message source node (Informational)
- **Reserved1**(4bits)**, Status Reserved**(6bits)**, Reserved2**(24octets) **-** Future development



Items Under Study

G.8032 is currently an initial recommendation that will continue to be enhanced. The following topics are under study for future versions of the recommendation:

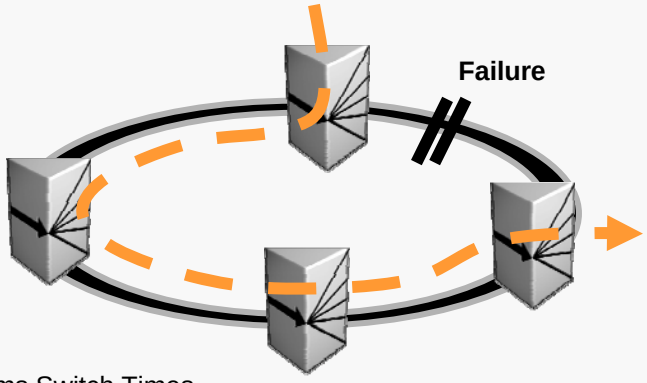
a) Interconnected rings scenarios: shared node, shared links
b) RPL blocked at both ends – configuration of the ring where both nodes connected to the RPL control the protection mechanism
c) Support for Manual Switch – administrative decision to close down a link and force a “recovery” situation are necessary for network maintenance
d) Support for Signal Degrade scenarios – SD situations need special consideration for any protection mechanism
e) Non-revertive mode– Allows the network to remain in “recovery” configuration either until a new signal failure or administrative switching
f) RPL Displacement – Displacement of the role of the RPL to another ring link flexibly in the normal (idle) condition
g) In-depth analysis of different optimizations (e.g., FDB flushing)
h) Etc.

Thank You

Backup

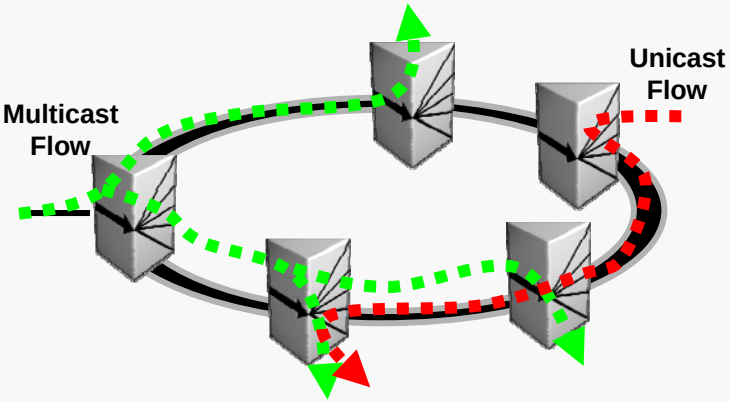
G.8032 Basic Functions

Robustness: Source Steering Protection

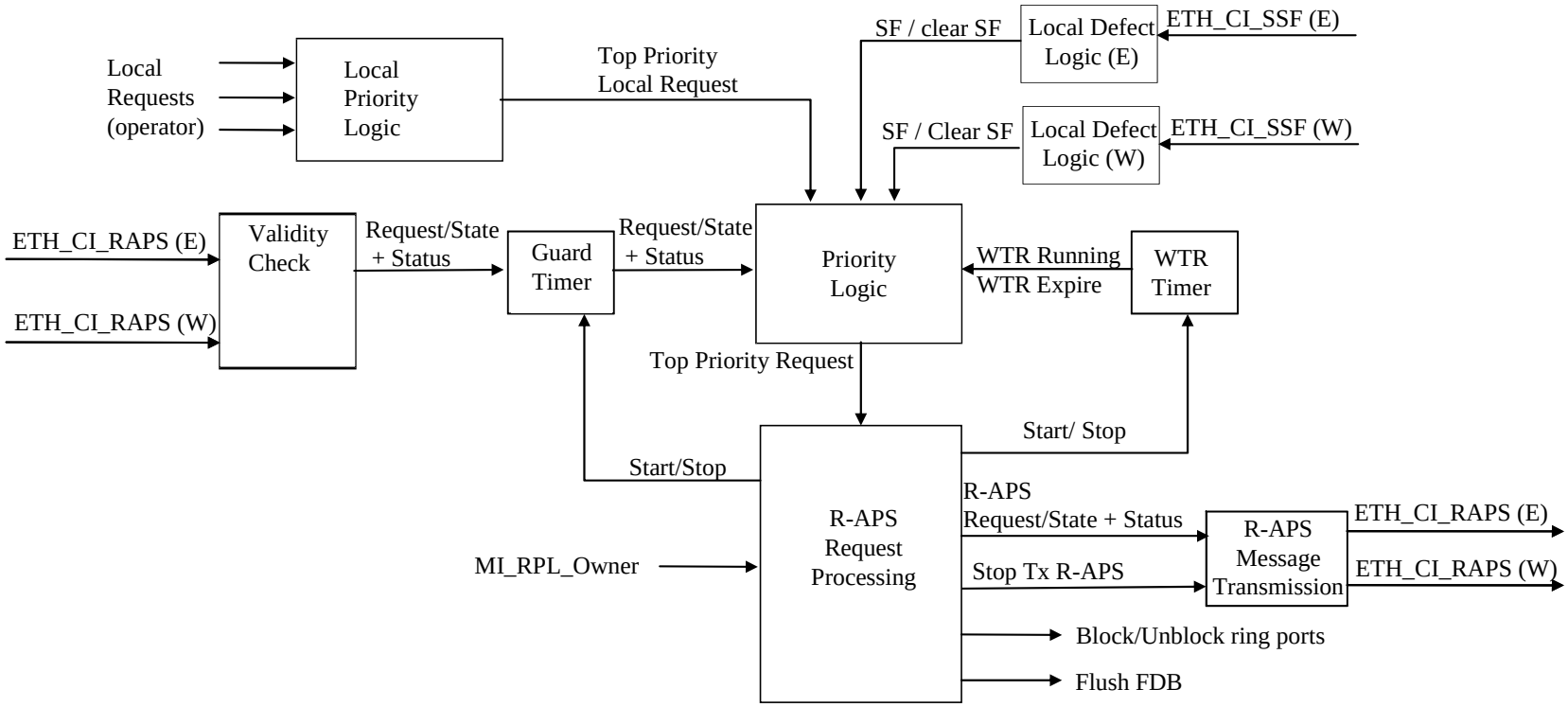


50ms Switch Times

Connectivity: Unicast, MC and BC Data Transfers



ERP Functionality Decomposition



Inputs – Local node requests, ETH signals, R-APS messages, *WTR Timer*.

Filters – *Local Priority Logic, Validity Check, Guard Timer, Priority Logic* – guarantee that highest priority message arrives for processing.

ERP Processing – *R-APS Request Processing* – processes filtered message according to State Machine with knowledge of current state and RPL-Owner indication

Outputs – Node functions (FDB Flushing, Block/Unblock port), sending (or stopping) R-APS messages

State Machine

- Three node states –
  - Initialization – when first defining the ring
  - A (Idle) – the 'normal' state of the ring nodes with RPL blocked and all nodes/ports working
  - B (Protecting) – when protection switching is in effect, RPL unblocked, other (usually fault) link is blocked.
- Different input messages assigned priority as appears in the State Machine description.
- Priority mechanism to allow proper reaction to faults
- State Machine describes the actions to be taken by the node dependent on current state and input message.
  - Only message with highest priority will pass through the filtering.
  - Different actions include – transmission of R-APS message, blocking/unblocking a port, flushing the FDB, switching current state of node, and starting/stopping timers.

Inputs			**Outputs**	
Node State	High Priority request	Row #	Actions	Next node state
*	Initialization	0	Stop guard timer Stop WTR timer If RPL Owner: Block RPL port Unblock non-RPL port Tx R-APS (NR, RB) Else: Block both ports Stop Tx R-APS	B
A (Idle)	Local SF	1	Block failed port; Unblock non Failed port; Tx R-APS(SF); Flush FDB;	B
	Local Clear SF	2	No action	A
	R-APS(SF)	3	Unblock non Failed port; Stop Tx R-APS If not "DNF" Flush FDB;	B
	WTR Expires	4	No action	A
	WTR Running	5	No action	A
	R-APS(NR, RB)	6	Unblock non-RPL port	A
	R-APS(NR)	7	No action	A

State Machine

- FDB flushing will clear all of the *learned* filtering rules within the node.
  - Current Recommendation includes basic optimization – only flushing once on fault discovery and once on recovery.
  - DNF status flag is for future definition

Inputs			**Outputs**	
Node State	High Priority request	Row #	Actions	Next node state
B (Protecting)	Local SF	8	Block failed port; Unblock non Failed port; Stop WTR; Tx R-APS(SF);	B
	Local Clear SF	9	Start guard timer, Tx R-APS(NR),	B
	R-APS(SF)	10	Stop WTR, Unblock non Failed port, Stop Tx R-APS	B
	WTR Expires	11	Block RPL port, Unblock non-RPL port Tx R-APS (NR,RB) Flush FDB,	A
	WTR Running	12	No action	B
	R-APS(NR, RB)	13	If not RPL Owner: Unblock both ports, Stop Tx R-APS, If not “DNF” Flush FDB	A
	R-APS(NR)	14	If RPL Owner: Start WTR	B

Switching Triggers

Detection/Clearing of SF (Signal Fail):

- SF: Loss of CCM, SF signal passed up from underlying (sub)layer
- Switching is performed when hold-off timer expires after detection of SF.

Operator's request:

- Lockout, Forced switch, Manual switch, Clear (for future specification)

Remote request:

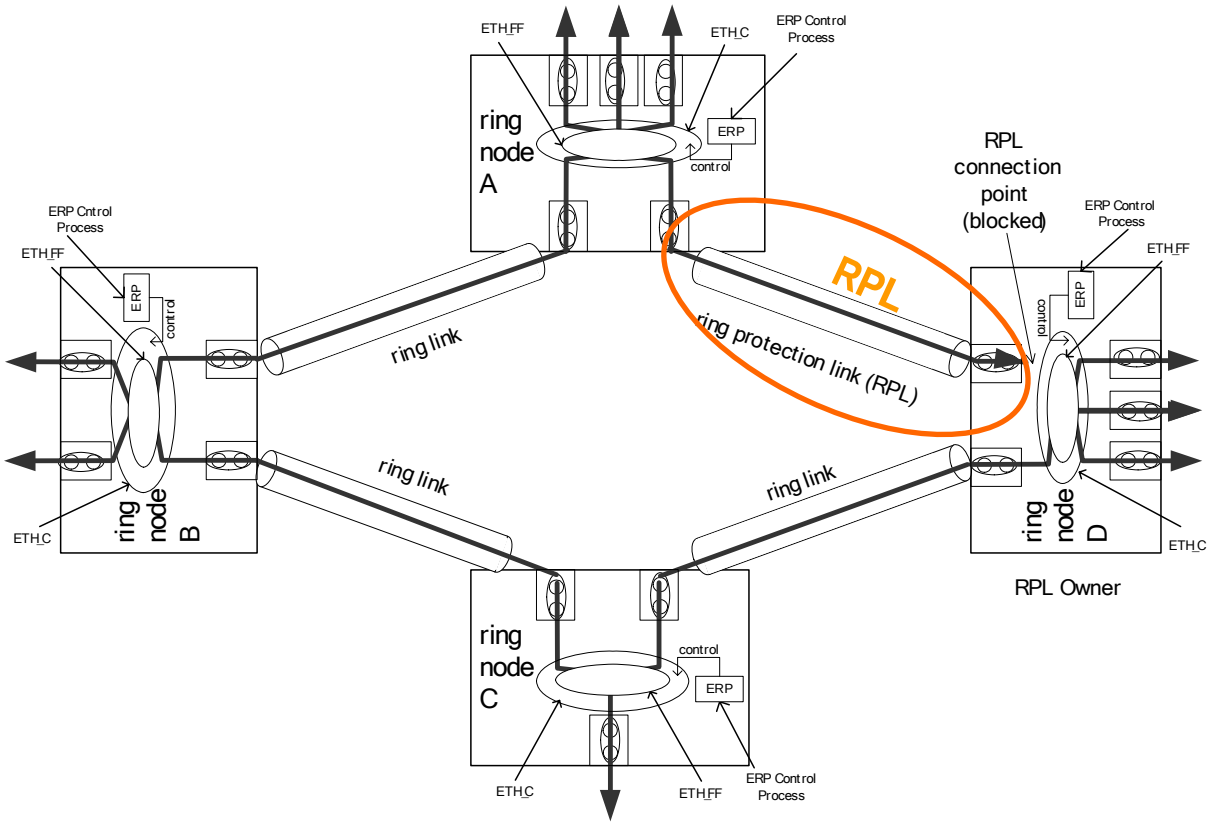
- Switching request indicated in received R-APS information from the other node.

→Protection switching algorithm is based on priorities assigned to all triggers

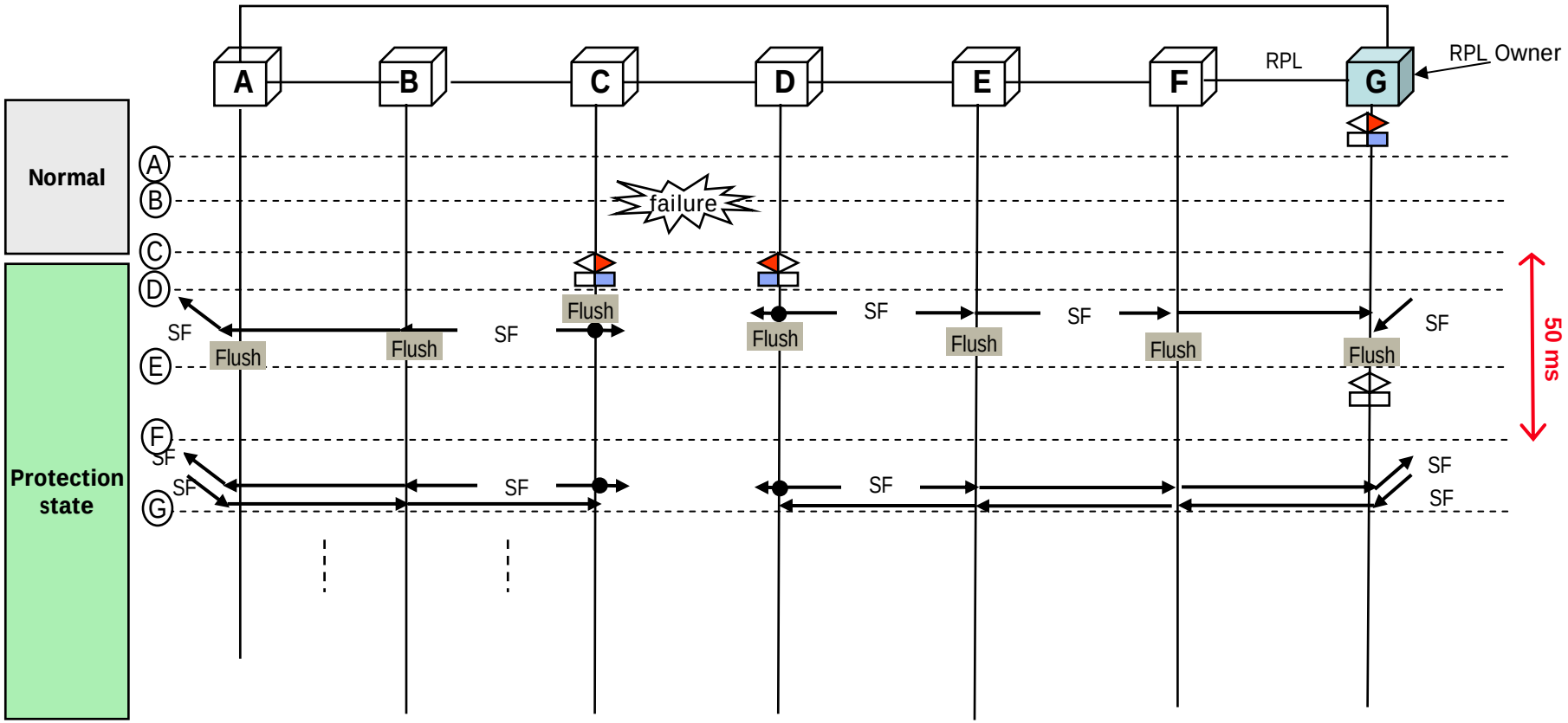
Ethernet Rings and the RPL

- Ethernet nodes connected in a ring topology.
  - Each node connected to two neighbors via links (E & W ports)
  - Deterministic network topology

- Avoid loops within ring by blocking a designated link (RPL)
  - Node responsible to control the blocking state of RPL is RPL owner
  - RPL is unblocked during protection state and may revert to blocked during recovery



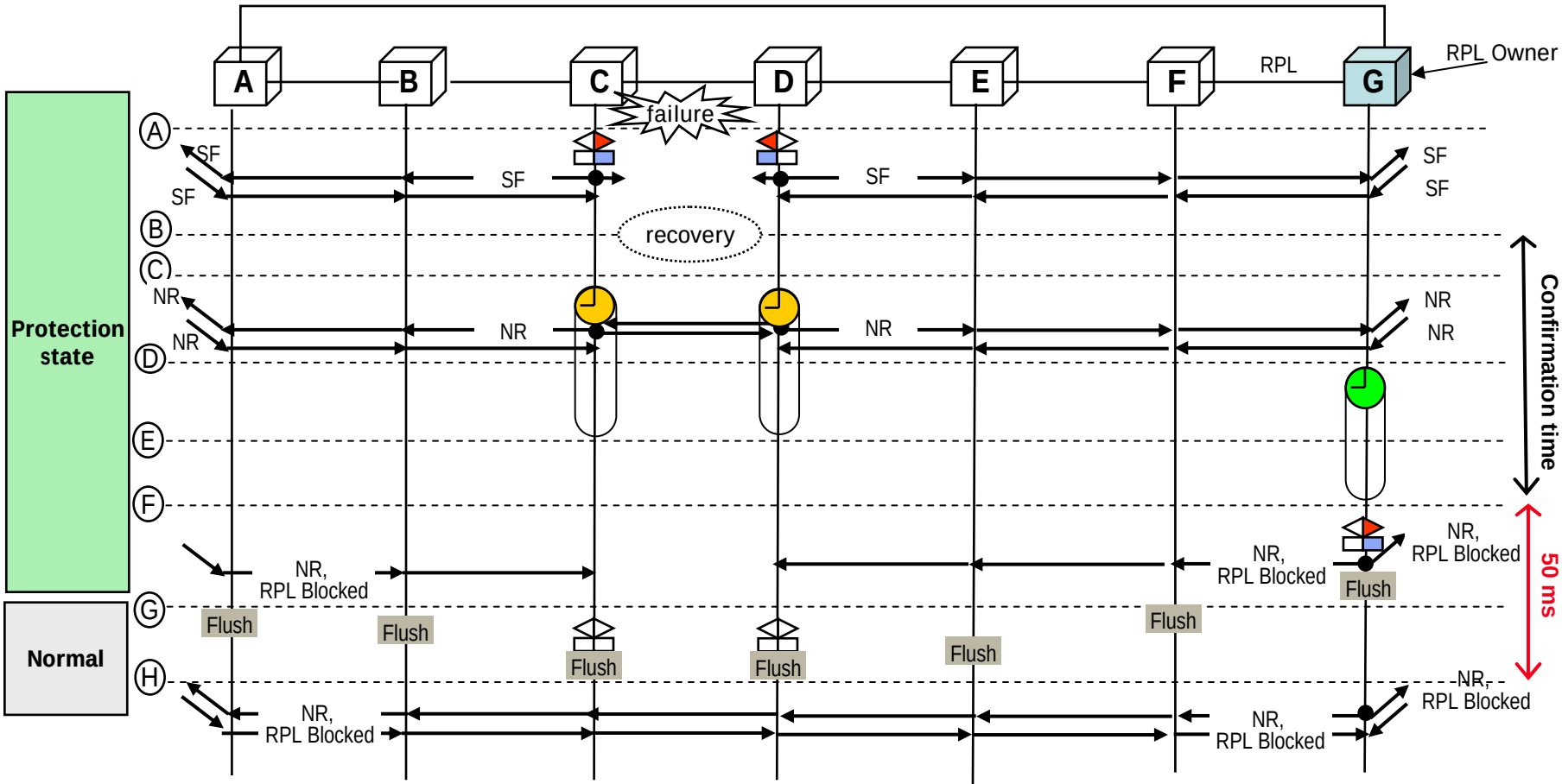
Scenario A - Normal to Protection



A. Normal State
B. Failure Occurs
C. Nodes C and D detect local Signal Failure condition and after respecting hold-off time and Block failed port [row 1]
D. Node C and D periodically send SF message, on both ring ports, while SF condition persists. Each node performs a FDB Flush when receiving the SF message
E. RPL Owner receives SF message and unblocks its end of RPL link [row 3]
F. Stable State – SF messages on the ring
G. Further SF messages trigger no further action [row10]

● Message source ▶ R-APS ch block
▭ Client ch block

Scenario B recovery



A. Stable SF condition Nodes C and D continue to send SF message every 5 secs.
B. Recovery of Link failure
C. Nodes C and D detect clearing of SF condition , start guard timer and initiate periodical transmission of NR message on both ring ports. (Guard timer prevents reception of R-APS messages) [row 9]
D. When the RPL Owner receives NR message, it starts the WTR timer [row 14]
E. When node C and D expire the guard timer, they may accept the new R-APS messages that they receive. [in guard timer]
F. At expiration of WTR timer, RPL owner blocks its end of the RPL, sends, *NR RB* message [row 11]
G. Each node that receives the NR,RB message it flushes its FDB. When Nodes C and D receive *NR RB* message , they remove block on their blocked ports. [row 13]
H. Stable normal condition all nodes in Idle state