A Critical Note On Ring Flushing

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Abstract

Rapid Spanning Tree Protocol enable switches to flood incoming frame with broadcast or unknown unicast destination address even in switched Ethernet networks having redundant links. It also allows switches to secretly learn location of connected devices in such networks. However some of those learnt location may become stale if a topology change is detected by RSTP and need to be flushed by switches in the network. It is found that standard address flushing technique of RSTP flushes too many addresses from large number of switches after a topology change. As a result there is a sudden massive increase in flooding traffic which may cause network-wide congestion, frame delay and frame loss. Recently a new address flushing technique named as Ring Flushing was proposed for RSTP that flushes addresses from small number of selective ports of very selective switches and so dramatically reduces the amount of flooding traffic after a topology change. However, numbers of flaws are identified in the current implementation of this newly proposed technique. This paper will not critically discuss the flaws in the current implementation of Ring Flushing but will also propose there simple yet effective solutions.

Keywords: Ring Flushing, Frame flooding, Network Scalability, RSTP compatibility.

1. INTRODUCTION

The current standard spanning tree protocol – Rapid Spanning Tree Protocol – is an indispensable management protocol for switched Ethernet networks. It constructs, in a distributive manner, an overlying logical tree spanning over all the switches in the underlying physical topology. The protocol is very essential for switch for flooding unknown broadcast or unicast frame and for learning addresses by inspecting incoming frame because of two reasons. First, RSTP prevents flooded broadcast or unknown unicast frame from persisting forever in the network. Second, RSTP make it feasible for a switch to learn location of devices in the network by inspecting incoming frames by ensuring that there always exist one and only one path from a switch to a particular device at any particular instant of time. Learnt locations of network connected devices are temporarily cached into a table called forwarding table.

Rapid Spanning Tree Protocol [1] is specifically designed to converge switched Ethernet network after topology change. It is basically the extension of its ancestor protocol Spanning Tree Protocol [2] (STP), first proposed by Perlmen in [3]. The enhancements and extensions incorporated in RSTP were first proposed by Mick Seaman in [4],[5],[6] and [7]. RSTP, due to their modifications, can converge within 1-3s [8] sharply in contrast to its ancestor STP which may take as much as 50s [9].

To compute the spanning tree, RSTP assigns a unique Identifier to each switch in the network. Each port of a switch also has an identifier unique within the scope of switch. All switches in the network elects a Root Switch and then try to compute and maintain the shortest path to that Root Switch thus creating logical spanning tree for the physical network. Switches blocks all ports, i.e. does not allow ports to transmit or receive data frames, expect the port necessary for itself to get access to the Root Switch through the shortest path (the root port) or ports required to provide the shortest path to neighboring switches (designated ports). Both the root port and designated ports of a switch will eventually moved into forwarding state, a state in which a port is allowed to transmit and receive data frames. A port of a switch **A** is called Backup port if it is connected to a link (network segment) that designated port also belongs to the switch **A**. A port of a switch is considered as an Alternate port if it can provide an alternative path to the Root Switch in case of failure of the root port of the switch. Both Backup and Alternate ports will eventually moved into blocking state.

RSTP [1] uses Bridge Protocol Data Unit (BPDU) for communication, a message to convey information to neighboring switches. It modifies STP in four different ways. First, an RSTP switch can immediately puts its alternate port in forwarding state after failure of its root port [1][4]. Second, an RSTP switch uses a handshaking mechanism called sync to quickly moves a designated port, connected to a point-to-point link, in a forwarding state [1][5]. Third, an RSTP switch can accept even an inferior BPDU on its non-designated port if it is transmitted by a designated bridge through its designated port [1][6]. Four, a Non-Root RSTP switch may generate BPDUs in contrast to STP in which Non-Root switch are only allowed to relay BPDUs originally transmitted by the Root Switch [1].

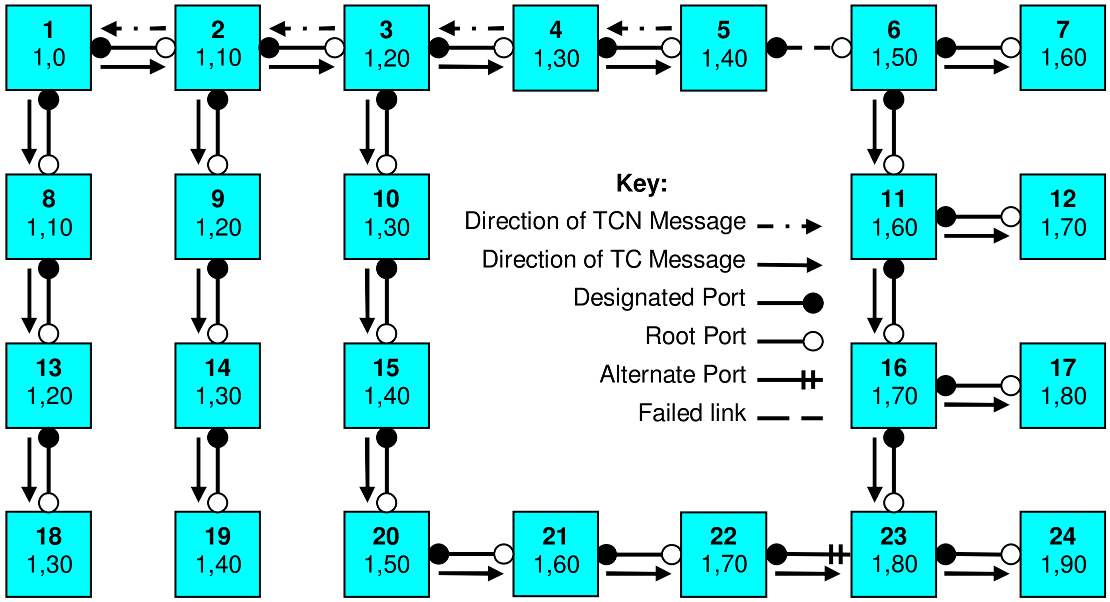
A change in physical topology of an RSTP controlled Ethernet network always urge RSTP to recomputed its spanning tree. This may result in change of position of some network connected devices with respect to some switches and thus making their cached learnt locations stale on those switches. Hence, stale cached learnt locations must be flushed from suffering switches to ensure accessibility to those devices. Unfortunately, the current standard address flushing technique used by RSTP to flush stale cached location unnecessarily flushes too many valid cached locations. Also, the scope of address flushing for this technique is network-wide. Due to this large amount of flushing of large number of switches produces sudden massive flooding traffic, due to unknown unicast frame, resulting in network congestion, frame delay and frame loss. Recently, a new address flushing technique named as Ring Flushing was proposed by Horvath et al. in [10]. This new technique does not only reduce the amount of flushed addresses but also reduces the scope of flushing to very few switches and so have a dramatic direct impact on the amount of flooding traffic. Unfortunately, current implementation of Ring Flushing has number of flaws. This paper will identify the flaws in the current implementation of Ring Flushing and will propose their simple yet effective solutions.

The rest of paper is organized as follows. Section 2 will give an overview of classical address flushing techniques used by STP and RSTP. Section 3 will describes the newly proposed Ring Flushing technique. Section 4 will identifies the flaws, along with their proposed solutions, in current implementation of Ring Flushing. Then section 5 will concludes the paper.

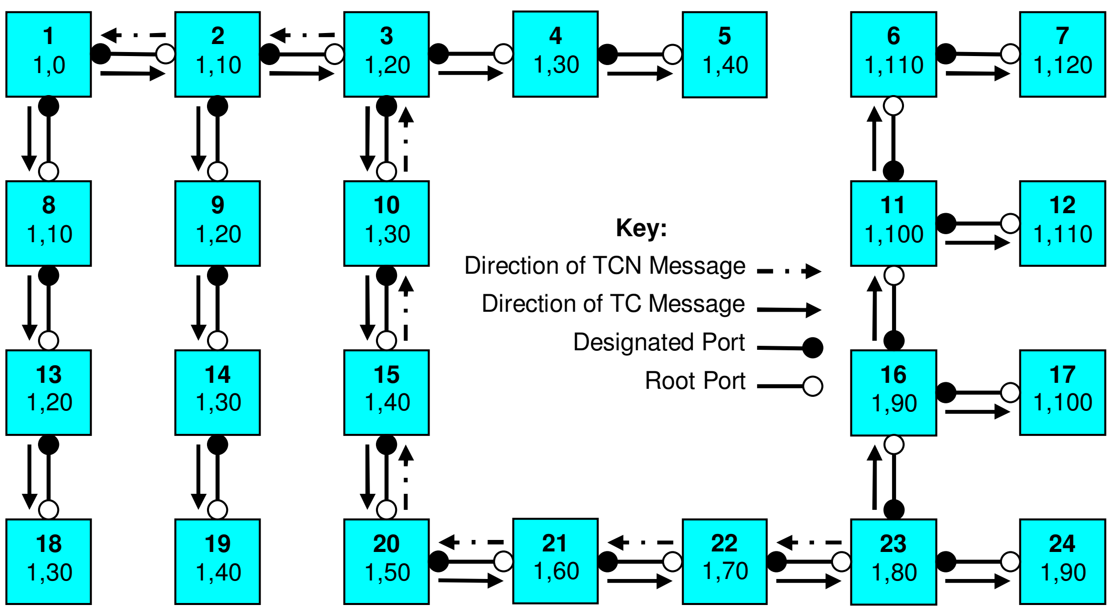
2. CLASSICAL ADDRESS FLUSHING TECHNIQUES

Both STP and RSTP force their probably suffering switches to flush probably stale (invalid) cached learnt locations of network connected devices from their filtering tables after a topology change. But they use slightly different techniques for this purpose. This section will give an overview of address flushing techniques used by STP and RSTP.

In STP both moving of a port into blocking state and moving of a port into forwarding state are marked as topology change. When a Non-Root switch detects a topology change, it transmits a Topology Change Notification BPDU on the link to which its Root Port is attached. This transmission is repeated until the switch receives an acknowledgment from the designated switch for that link. The designated switch passes the notification to, or towards, the Root using the same procedure. If the Root receives such a notification, or detects a topology change itself, it will set a Topology Change flag in all Configuration Messages transmitted for some time. This time is such that all switches will receive one or more of the Configuration Messages. While this flag is set, switches use a short value to age out cached learnt locations in the forwarding table. When the flag is reset again, switches revert to original Ageing Time.



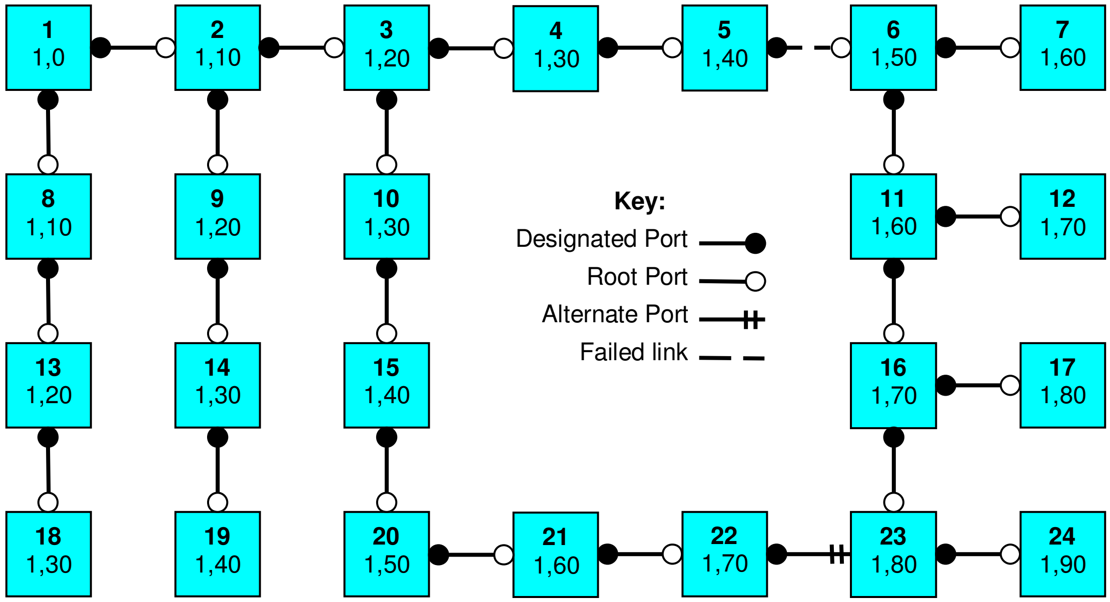
(a). Flow of TC and TCN messages when a designated port of switch **5** and the root port of switch **6** is moving into blocking state due to failure of link between switch **5** and switch **6**.



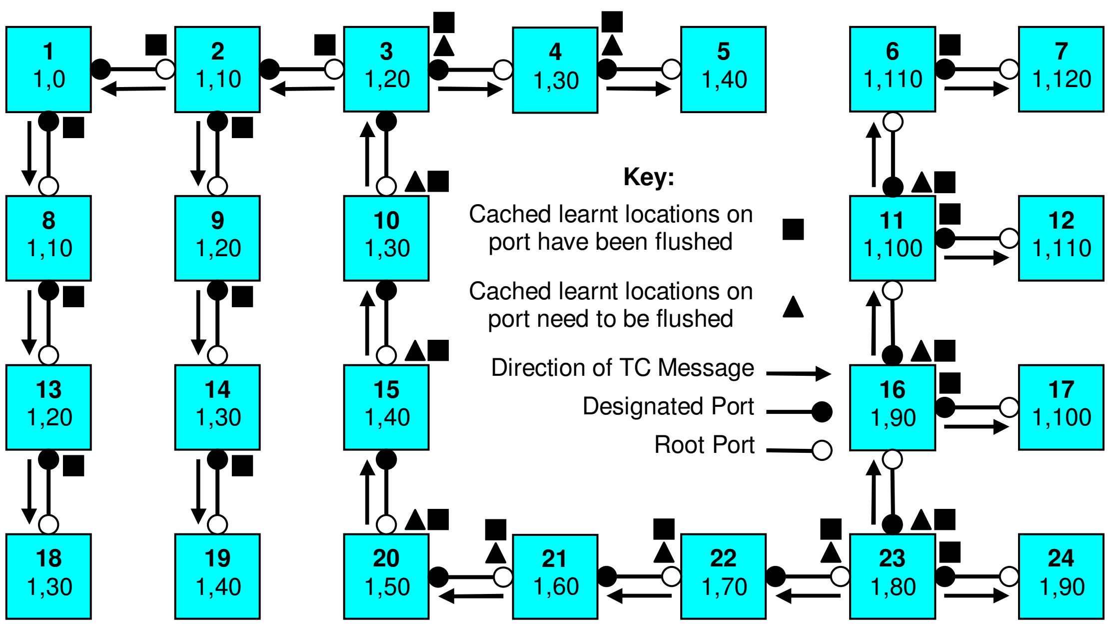
(b). Flow of TC and TCN messages when the new root port of switch **23** is moving into forwarding state to reconverge the network.

FIGURE 1: Flow of TC and TCN messages in STP.

Figure 1 is showing the flow of TCN message and TC message, Configuration BPDU such that its TC flag is set, in STP. In all figures, switches are represented by small boxes. The top number in the box is the Switch Identifier, the lower set of numbers represents the Root Switch Identifier as perceived by the switch and the cost to this Root Switch. It is assumed that all links have cost of 10.



(a). Topology at failure of link between switch **5** and switch **6**



(b). Flow of TC messages when alternate port of switch **23** become the new forwarding root port.

FIGURE 2: Flow of TC messages in RSTP

In RSTP, a topology change is recognized if a port that is previously not part of spanning tree (i.e. Disable, Alternate or Backup port) now becomes part of spanning tree (i.e. Designated or Root port in forwarding state). As such a port may relocate some network connected devices with respect to some switches in the network. So, when a switch detects a topology change it flushes the cached learnt locations in the forwarding table and transmits TC message, RST BPDU such that its TC flag is set, from all active ports (designated or root ports). A switch that receives an TC message on its active port flushes the cached learnt locations associated with all other active port and then propagates TC message through them. Figure 2 is illustrating the flow of TC message in RSTP after a topology change.

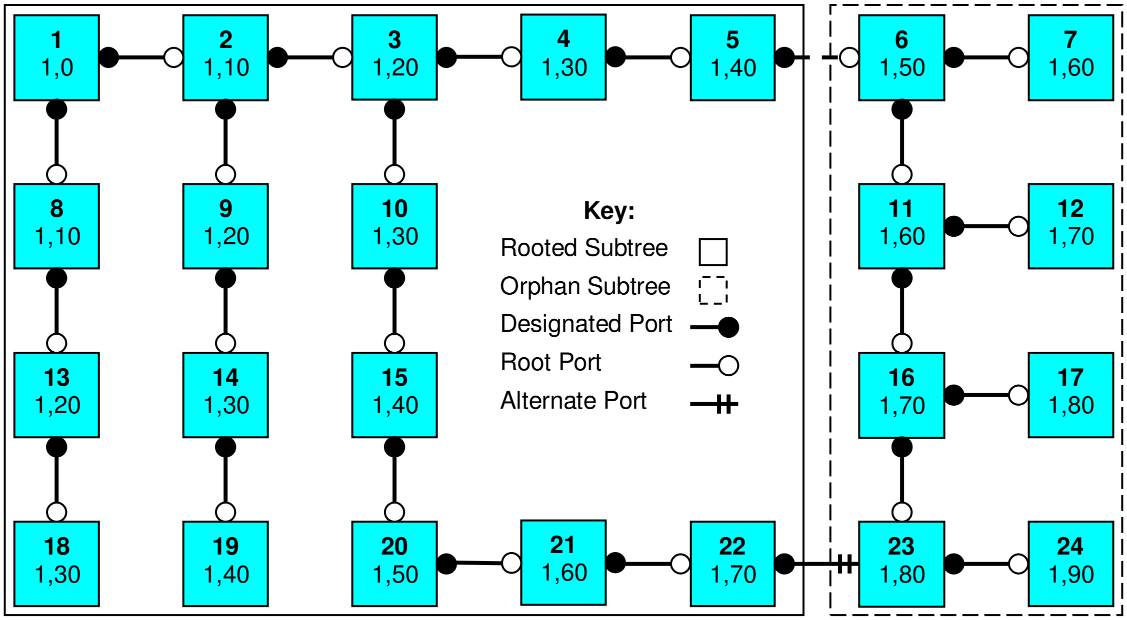
STP uses a centralized approach for address flushing i.e. a switch that detects a topology change first informs its Root Switch and then the Root Switch instructs all the switches in the network to shorten their aging time. In contrast, RSTP uses a decentralized approach i.e. a switch that detects a topology change not only informs its Root Switch but also immediately transmit RST BPDU with TC flag on all its other active ports on behalf of the Root Switch. It helps RSTP to quickly propagate the topology change information to all switches in the network. Moreover, unlike STP, RSTP immediately flushes the probably stale cached learnt locations instead of quickly aging them out.

3. RING FLUSHING

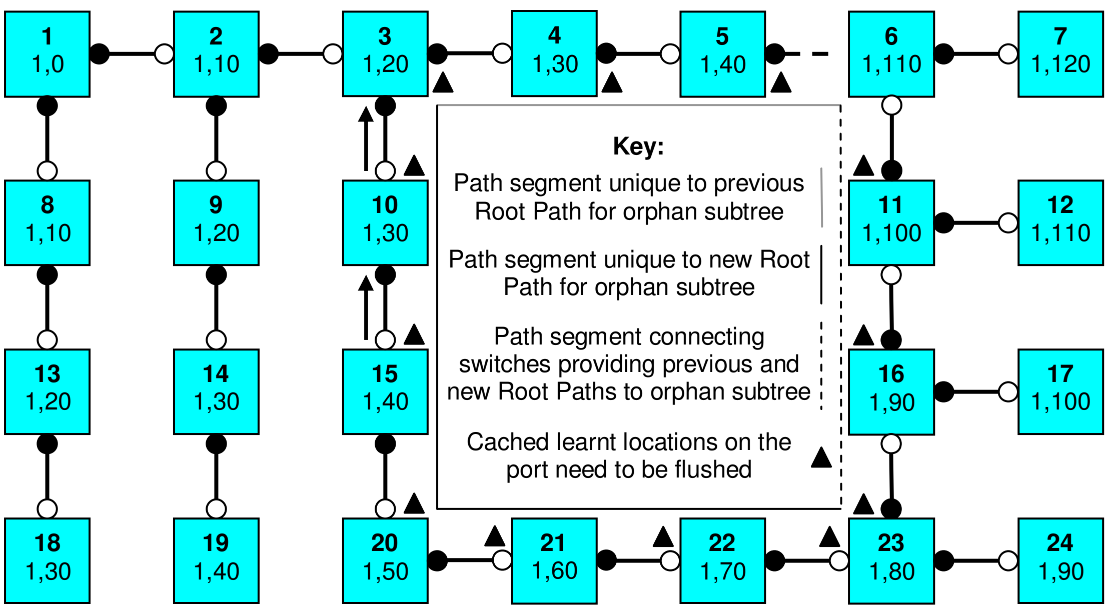
Ring Flushing is an address flushing technique that recently proposed by Horvath et al. The technique is specifically designed to reduce the amount of flooding traffic after a topology change generated due to excessive flushing of cached learnt locations in forwarding table. It is achieved not only by reducing the number of potential switches that may have stale (invalid) cached learnt locations in their forwarding tables but also by reducing the number of potentially stale cached learnt locations on those switches. This section will give an overview of ring flushing technique.

Theoretical Background

When the root port (or designated port associated with the root port) of a switch fails (or stops acting as the root port), it segregates the network into two distinct subtrees namely a *rooted subtree*, a subtree that still have the Root Switch, and an *orphan subtree*, a subtree that no longer have the previous Root Switch. The segregated subtrees can be merged again by turning an alternate port into forwarding designated port or the forwarding root port. If this happens, three path segments are very important with respect to changes locations of network connected devices. First, the path segment unique to previous Root Path for orphan subtree. Second, the path segment unique to new Root Path for orphan subtree. Third, the path segment, in the orphan subtree, between the switches providing the previous Root Path and the new Root Paths to orphan subtree respectively. All cached learnt locations associated with the designated ports along the path segment unique to previous Root Path for orphan subtree are compromised, and so they need to be flushed or removed, because they no longer providing accessibility to network connected devices in orphan subtree. Similarly, all the cached learnt locations associated with the root ports along the path segment unique to new Root Path for orphan subtree are also compromised, and so they also need to be flushed or removed, because they no longer providing accessibility to network connected devices in orphan subtree. Moreover, all cached learnt locations associated with now designated ports (previous the root ports) along the path segment, in the orphan subtree, the switches providing the previous Root Path and the new Root Paths to orphan subtree respectively are also compromised, and so they must be flushed or removed, as they no longer providing accessibility to network connected devices in rooted subtree. The above three mentioned path segments called sector 1, sector 2 and sector 3 respectively in [10]. No other port except the above mention ports requires flushing or removal of their cached learnt locations because all remaining learnt locations are still fresh (valid). If all three above mentioned path segments are present, they form a ring or cycle in the physical topology of the network and address flushing is required only in that ring or cycle. That is why this address flushing technique is named as “Ring Flushing” by Horvath et al. in [10].



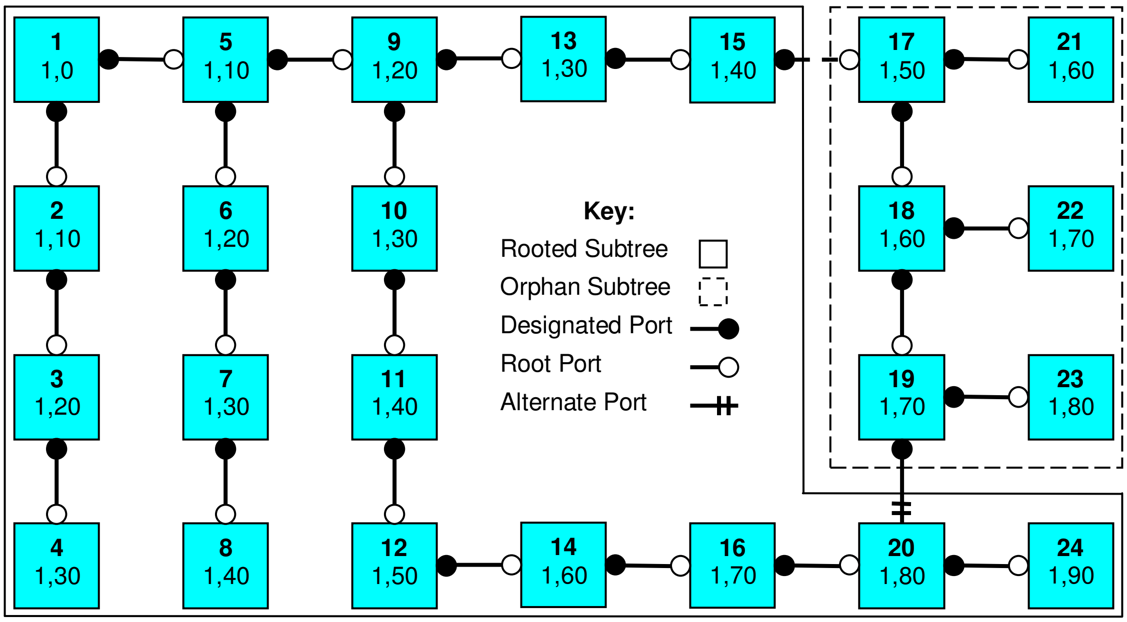
(a). Topology at failure of link between switch **5** and switch **6**.



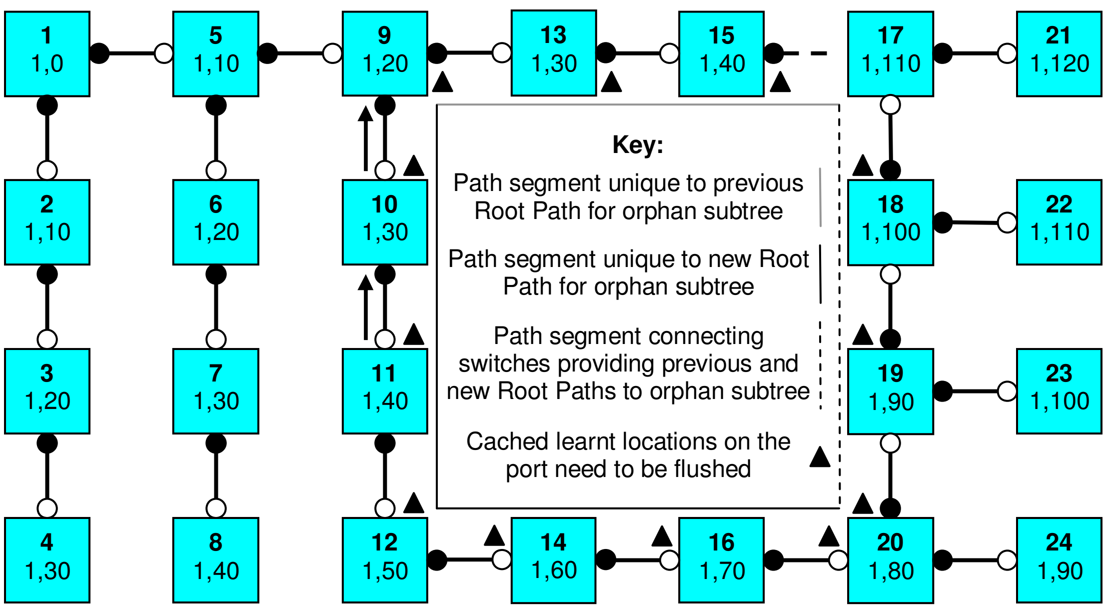
(b). Topology when alternate port of switch **23** become new forwarding root port to reconverge the network.

FIGURE 3: Three path segments in Ring Flushing along with ports that need address flushing.

No address flushing except on the corresponding Designated port of Backup port is required, If Backup port is used to merged the two segregated subtrees by making it a forwarding designated port. This is because none of the three mentioned path segments are presents. Moreover, a Backup port transitioning to forwarding root port act as if it were previously a Designated port A newly enabled port of a switch that is becoming either the forwarding designated port or the forwarding root port also pretend as if it were previously an alternate port. Figure 3 and 4 are illustrating the ports on the three mentioned path segments that need flushing or removal of cached learnt locations when an alternate port of a switch becomes new forwarding root port or becomes a forwarding designated port respectively.



(a). Topology at failure of link between switch **15** and switch **17**.



(b). Topology when alternate port of switch **20** become forwarding designated port to reconverge the network.

FIGURE 4: Three path segments in Ring Flushing along with ports that need address flushing.

It is not necessary that all three mentioned path segments are present simultaneously in the segregated network having rooted and orphan subtrees. For example the path segment, in the orphan subtree, between the switches providing the previous and new Root Paths to orphan subtree respectively may absent if both the failed root port and the alternate port that is becoming either the forwarding designated port or the forwarding root port are present on the same switch. Similarly, path segment unique to previous Root Path of orphan subtree may absent if the two trees merging together are not part of a single network in the recent past.

Horvath Implementation of Ring Flushing

Inventers of Ring Flushing, Horvath et al., proposed an implementation for Ring Flushing in [10] using three messages of two different types. The two types of messages are an DTC message and an RTC message. A switch receiving an DTC message flushes the cached learnt locations associated with the designated port receiving the message. Whereas a switch receiving an RTC message flushes the cached learnt locations associated with its root port. Two DTC messages are generated respectively on path segment unique to previous Root Path for orphan subtree and path segment between the switches providing previous and new Root Paths to orphan subtree respectively. These two DTC messages are responsible for flushing of cached learnt locations on designated ports along the two paths. An RTC message is generated on path segment unique to new Root Path for orphan subtree and it is responsible for flushing cached learnt locations on the root ports along the path segment. Figure 4 is illustrating the flow of two required DTC messages and a required RTC message in Horvath implementation for Ring Flushing.

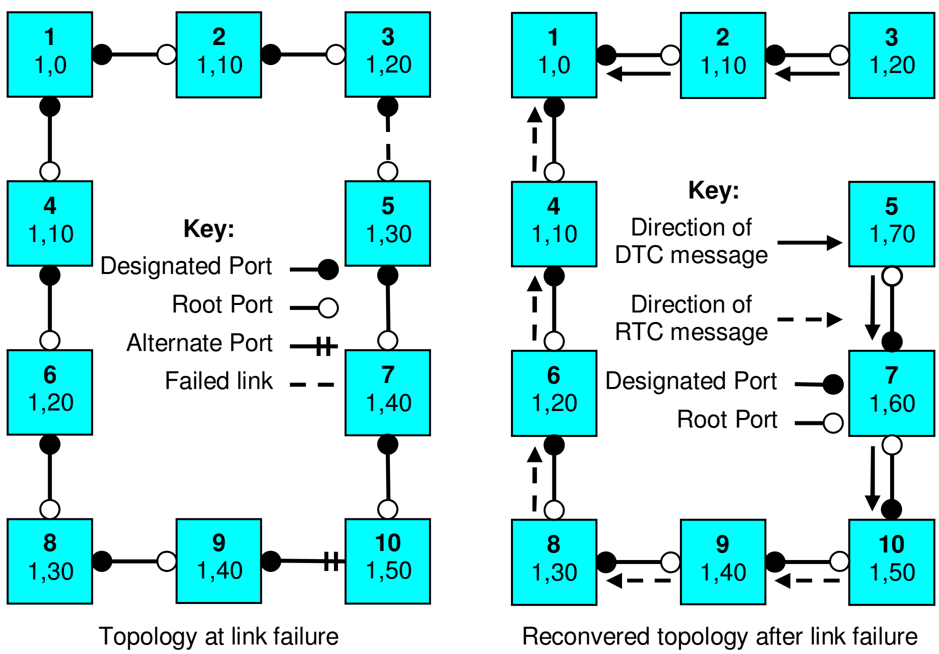


FIGURE 5: Flow of two DTC messages and an RTC message that are required in Horvath implementation for Ring Flushing

To generate and propagate the above mentioned three messages for Ring Flushing, following set of rules are prescribed in [10].

1. A port moving into blocking (discarding) state must generate an DTC message on its (new) root port.
2. A designated port receiving an DTC message must first flushes the cached learnt locations associated with it and then propagates the received DTC message on the (new) root port.
3. A port moving into forwarding state must generate an RTC message on its (new) root port.
4. A designated port receiving an RTC message must first flushes the cached learnt locations associated with the root port and then propagates the received DTC message on the (new) root port.

Above prescribed rules may be implemented by making subtle changes in the RSTP port state machine. As DTC and RTC messages generated only on the root port of switch, so they will eventually terminate at the Root switch.

Limitation of Ring Flushing

Ring Flushing is heavily dependent on generation of DTC message on path segment unique to previous Root Path for orphan subtree because this message is necessary for flushing or removal of cached learnt locations on designated ports along that path segment. The required DTC message may be generated by the root port previously connecting the orphan subtree to rooted subtree. But if the segregation of spanning tree, into orphan and rooted subtrees, is due to failure of the link connecting the two subtrees, then the DTC message will never reach to the path segment unique to previous Root Path for orphan subtree. A solution to this problem is that the designated port associated with the root port previously providing the Root Path to the orphan subtree will generate the DTC message on behalf of that root port. But a designated port can timely sense the physical failure of link connected to the root port if and only if the link is true point-to-point link. Hence, Ring Flushing technique cannot be used in a network having at least one multipoint link. Ring Flushing considers a link as point-to-point link if and only if two switch ports are connected to the link and there is no other network connected device on the link.

4. IDENTIFIED FLAWS IN HORVATH IMPLEMENTATION

Ring Flushing technique can be useful in reducing the amount of flooding traffic after a topology change as it reduces both the number of effective switch and number of cached learnt locations that need to be flushed from those switch. But, it is unfortunately find that current implementation of Ring Flushing presented in [10] and restated in section 3.2 have number of flaws. This section will point out those flaws and give their simple yet effective solutions.

Flaw 1: No Generation Of Required DTC Message In Rooted Subtree

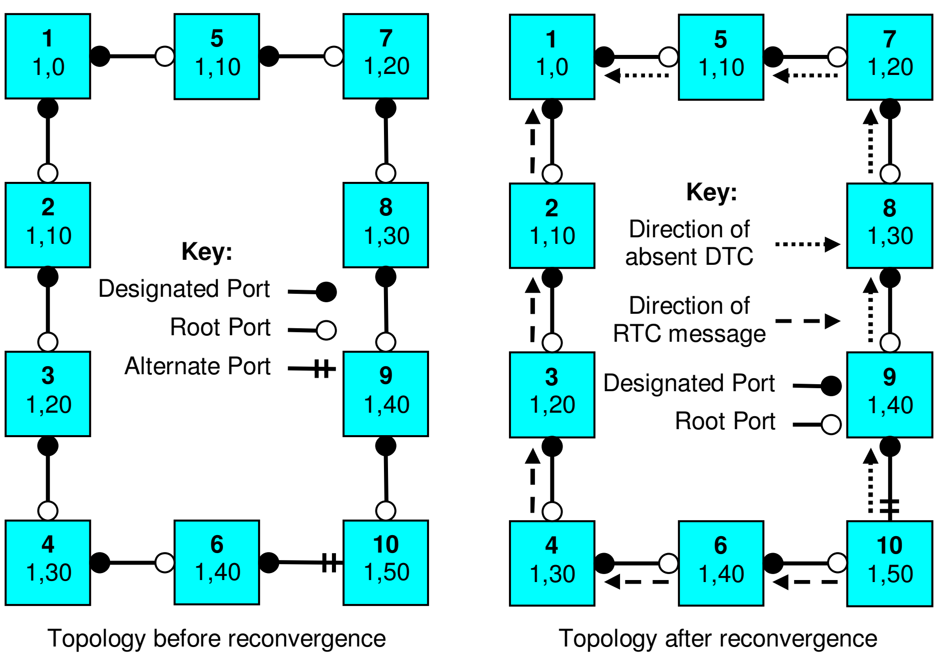


FIGURE 6: Flow of absent DTC message that is not generated by switch **10** when it receives a superior BPDU on its alternate port.

An DTC message is required to be generated on previous Root Path in Ring Flushing to flush stale cached locations associated with designated ports that are along that path segment. However, Horvath implementation of Ring Flushing is unable to generate the required DTC message if the switch silently transitions from current root port to a new root port. The reason is that in current implementation of Ring Flushing the switch transitioning to the new root port generates the DTC message only on its new root port whereas designated port associated with previous root port of the switch unable to generate the required DTC message as that designated port is not experiencing any change in its port state. A switch may silently transitions from current root port to a new root port if it receives a superior BPDU (better information) on one of its port as depicted in figure 6.

Flaw 2: No Generation Of Required DTC Message In Orphan Subtree
An DTC message is required to be generated by the switch previously providing the Root Path to orphan subtree. This message is necessary to flush stale cached locations associated with now designated ports (previous root ports) that are along the path segment, in orphan subtree, between the switches providing previous and new Root Paths to orphan subtree respectively. However, in the Horvath implementation of Ring Flushing, the responsible switch (the switch previously providing the Root Path to orphan subtree) is unable to generate the required DTC message. The reason is that in RSTP a Non-Root switch declares itself the Root Switch as soon as its root port fails and it has no alternate port (Clause 17.6 IEEE 802.1D 2004). This newly declared Root Switch of orphan subtree can later restore connectivity with the rooted subtree by transitioning one of its forwarding designated port to the root port. However, no DTC message is not generated by the switch, as illustrated in figure 7, because, in RSTP, the port does not necessarily change its state when it transitions into the root port (Clause 17.29.2 IEEE 802.1D 2004).

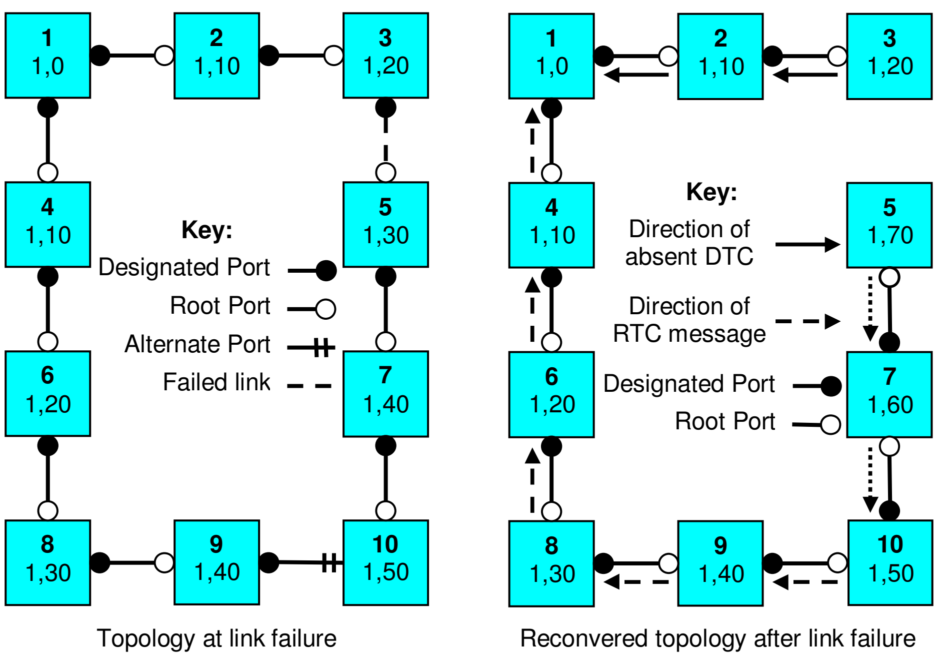


FIGURE 7: Flow of absent DTC message when link between switch **3** and switch **5** fails.

Flaw 3: Generation Of Unnecessary DTC And RTC Messages
In Horvath implementation of Ring Flushing, unnecessary DTC and RTC messages are generated by all the switches on the path segment between the switches, in orphan subtree, providing previous and new Root Paths to orphan subtree respectively. The reason is three folded. First, Horvath implementation of Ring Flushing urges a switch to generate DTC message (RTC message) on its (new) root port whenever it moves into blocking state (forwarding state).

Second, an RSTP switch has tendency to temporarily block its port to prevent loops when the port is transitioning its role from Root Port to Designated Port (Clause 17.29.3 IEEE 802.1D 2004). Third, all the switches on the path segment between the switches, in orphan subtree, providing previous and new Root Paths to orphan subtree respectively are transitioning their respective previous root ports into designated ports. As a result these designated ports are temporarily reverting back to blocking state forcing their respective switches to generate unnecessary DTC messages (see Figure 8). Later these designated ports are promoted again to forwarding state and thus subsequently forcing their respective switches to generate unnecessary RTC messages (see Figure 8).

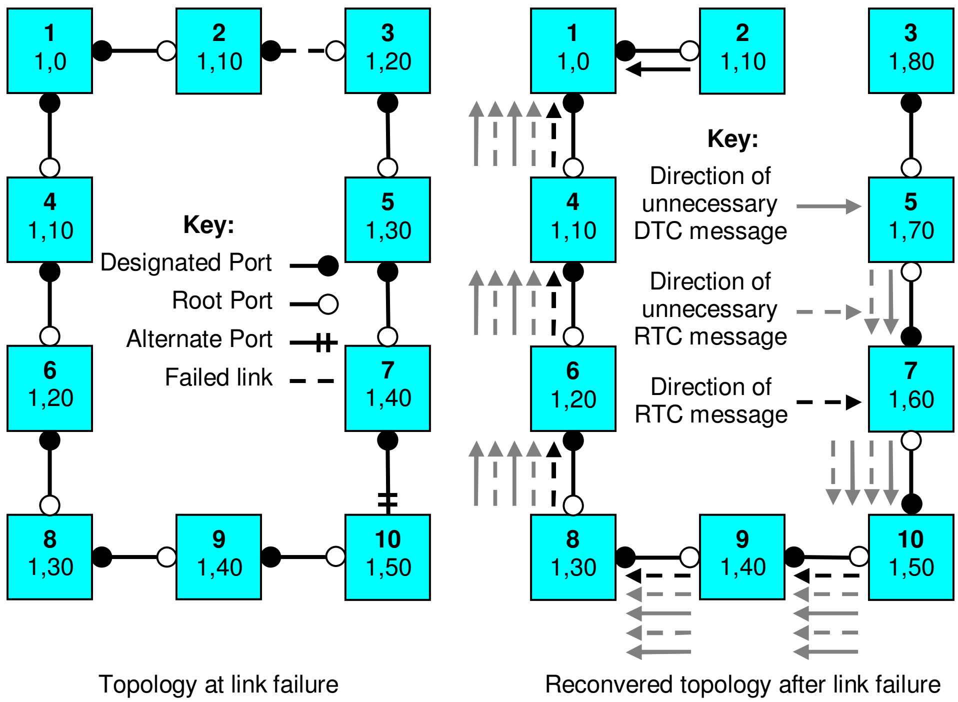


FIGURE 8: Flow of unnecessary DTC and RTC messages when link between switch **2** and switch **3** fails.

5. PROPOSED SLOUTION: ROLE BASED RULES FOR RING FLUSHING

Rules for Horvath implementation of Ring Flushing are port state based i.e. DTC and RTC messages are generated only on sensing a change in port state. The above mentioned three flaws can be removed by using new port role based rules for Ring Flushing instead of current port state based rules. Here are port role based rules for Ring Flushing.

1. A port flushes its associated cached learnt locations and generates an DTC message on the current root port when its role transitions from forwarding Designated Port to Disabled Port or Alternate Port.
2. A port flushes its associated cached learnt locations and generates an DTC message on itself if its role is transitioning from forwarding Root Port to Disabled Port or Alternate Port.
3. A port generates an RTC message on the current root port when its role transitions from Disable or Alternate to Designated or Root and the current state of port is forwarding.
4. A port flushes its associated cached learnt locations if its role is transitioning from Root Port to Designated Port.
5. A designated port that is receiving an DTC message flushes its associated cached learnt locations and propagates the received DTC message on the current root port.
6. A designated port that is receiving an RTC message flushes its associated cached learnt locations and propagates the received RTC message on the current root port.

Rule 2 ensures that the forwarding root port must inform its designated port when it becomes Alternate or Disabled to eliminate flaw 1. Rule 4 ensures that now designated ports (previous root ports) flushes their cached learnt locations without any need of DTC message and thus eliminate flaw 2. This rule also prevents generation of unnecessary DTC messages and thus partially eliminates the flaw 3. Rule 3 ensures that only the switch providing the new Root Path to orphan subtree will generates RTC message and thus prevent unnecessary generation of RTC messages and so subsequently partially eliminating flaw 3. Therefore, the new port role based rules for Ring Flushing are well protected against all three identified flaws unlike the port state based rules presented in [10].
It is not necessary for a port to generate an DTC message if it transitions its role from Designated to Disabled or Alternate but its neighboring port on the attached point-to-point link have Alternate or Backup role. This type of port will be called Passive Designated Port in this text. On the other hand, a port must generate an DTC message if it transitions its role from Designated to Disabled or Alternate and its neighboring port on the attached point-to-point link have Root role. This sort of port will be called Active Designated Port in this text. Hence, rule 1 from above six role based rules for Ring Flushing can modified as.

1. A port flushes its associated cached learnt locations and generates an DTC message on the current root port when its role transitions from forwarding Active Designated Port to Disabled Port or Alternate Port.

6. BACKWARD COMPATIBILITY WITH LEGACY SWITCHES

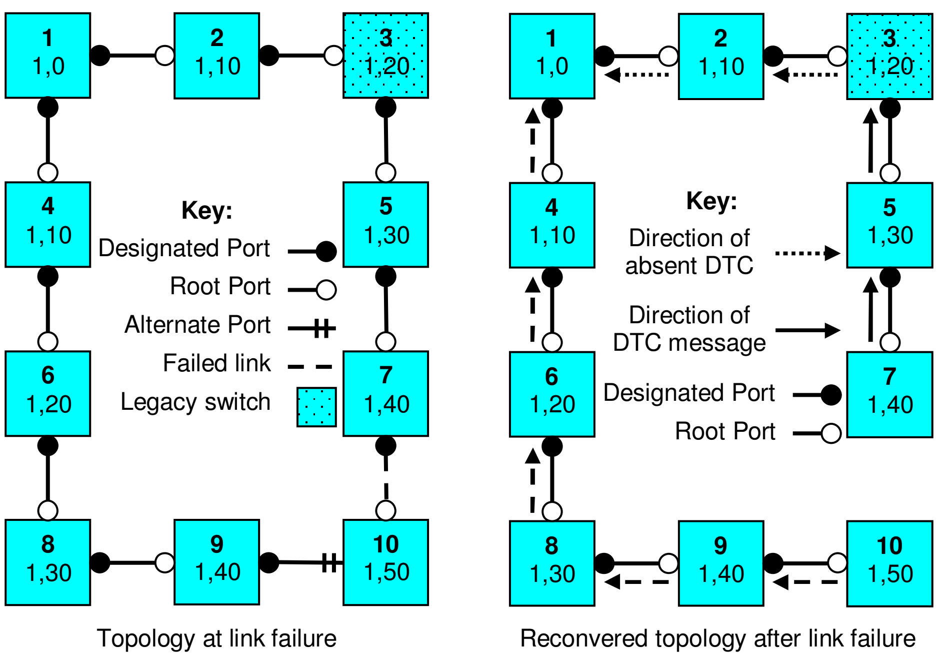


FIGURE 9: Flow of absent DTC message due to its interception by a legacy RSTP switch.

Horvath et al., inventers of Ring Flushing technique, proposed encoding of RTC message and DTC message into TC flag and unused TCAck flag of RST BPDU respectively. Moreover, they claimed that this encoding of DTC and RTC messages within RSTP BPDU ensures backward compatibility with legacy RSTP switches as no new BPDU was introduced. However, it is unfortunately not true. It is because of two reasons. First, a legacy RSTP switch receiving an DTC message on its designated port is unable to flush cached learnt locations associated with that port because set DTC flag in RST BPDU will be perceived as TCAck flag by receiving legacy RSTP switch. Second, the received DTC message encoded in RST BPDU will not be propagated further on the root port by receiving RSTP switch as TCAck flag is always clear in RST BPDU (Clause 17.21.20). As a result not only the legacy RSTP switch but also all its upstream switches, whether they legacy RSTP switches or Ring Flushing capable RSTP switches, till the Root Switch are unable to flush their designated ports along the previous Root Path for orphan subtree (See Figure 9). Hence, a more comprehensive mechanism is required to ensure backward compatibility. This section will present a mechanism that will not only provide backward compatibility with STP and RSTP switches but it will also allow multipoint links in the network.

The proposed mechanism divides each port on Backward Compatible Ring Flushing RSTP switch into two type namely Ring Flushing port and legacy port. The root port, an alternate port, a backup port and an edge designated port are all always considered as Ring Flushing port (RF port). Only non-edge designated port may or may not be an RF port. All non-edge designated ports are by default considered as legacy active designated port. A legacy active designated port connected to a point-to-point link becomes an RF active designated port when all the ports on its neighboring switch are RF ports and revert back to legacy active designated ports as soon as there is a legacy port on the neighboring switch. This information can be communicated through a newly introduced RF BPDU. The new BPDU will contain two flags specifically a “Total Ring Flushing switch” Flag and an DTC flag as depicted in Figure 10. Legacy active designated ports in “Backward Compatible Ring Flushing RSTP switch” will behave like designated ports in an RSTP switch i.e. flushes their associated cached learnt locations when an TC message is received on one of the designated ports or the root port of switch, or one of the designated ports or the root port of switch fails. While RF ports will behave like “Ring Flushing RSTP switch” i.e. flushes their associated cached learnt locations according to rules for ring flushing defined in section 5.

Total Ring Flushing Switch Flag
DTC Flag

FIGURE 10: Structure of Ring Flushing BPDU

The above mentioned backward compatibility mechanism will work because it ensures a legacy active designated port connected to a point-to-point link becomes an RF designated port if only if it can receive all the DTC messages transmitted by their downstream switches i.e. there is no legacy RSTP switch in its downstream. Moreover, there is no need of transmitting a separate RTC message because a legacy TC message, RST BPDU with TC flag, has capability to flush cached learnt locations associated with the respective root ports of switches along the new Root Path for orphan subtree. Hence, rules for “Backward Compatible Ring Flushing RSTP switch” can be summarized as:

1. The root port, an alternate port, a backup port, a disabled port and an edge designated port is always an RF port.
2. A port transitioning into Designated role is always assumed as a legacy active designated port.
3. A designated port becomes an RF active designated port when it receives an RF BPDU such that its “Total Ring Flushing Switch” flag is set.
4. A designated port becomes legacy active designated port as soon as it receives an RF BPDU such that its “Total Ring Flushing Switch” flag is clear.
5. A switch sets the “Total Ring Flushing Switch” flag of RF BPDU and transmits it on the current root port as soon as its all ports become RF ports.
6. A switch having only RF ports clears the “Total Ring Flushing Switch” flag of RF BPDU and transmits it on the current root port as soon as one of its RF ports becomes legacy port.
7. A port flushes its associated cached learnt locations and generates an DTC message on the current root port of the switch when its role transitions from forwarding RF active Designated Port to Disabled Port or Alternate Port or it become disputed designated port, a disputed designated port is a designated port in forwarding state such that its neighboring port on point-to-point is also a designated port with forwarding state.
8. A port flushes its associated cached learnt locations and generates an DTC message on itself if its role is transitioning from forwarding Root Port to Disabled Port or Alternate Port.

9. A port generates an TC message on the current root port and its all legacy active designated ports when its role transitions from Disable or Alternate to Designated or Root and the current state of port is forwarding.
10. A port flushes its associated cached learnt locations if its role is transitioning from Root Port to Designated Port.
11. A designated port that is receiving an DTC message flushes its associated cached learnt locations and propagates the received DTC message on the current root port of the switch.
12. A designated port that is receiving an TC message flushes cached learnt locations associated with the current root port and all other legacy active designated ports of the switch and propagates the received TC message on the current root port and all other legacy active designated ports of the switch.
13. The root port that is receiving an TC message flushes cached learnt locations associated with all legacy active designated ports of the switch and propagates the received TC message on all legacy active designated ports of the switch.

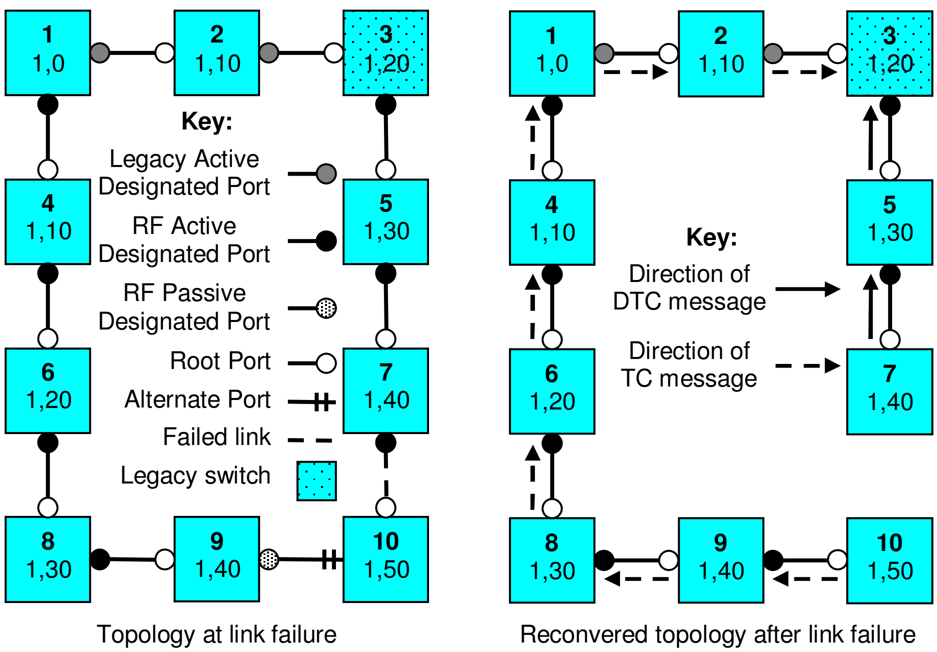


FIGURE 11: Flow of TC and DTC messages in backward compatible implementation for Ring Flushing.

Figure 11 is illustrating the flow of TC and DTC messages in backward compatible implementation of Ring Flushing. To implement the above mentioned rules, subtle change are required in Port Information state machine, Port Transmit state machine, Port Role Transitions state machine and Topology Change state machine of RSTP. A new state machine is needed to keep track that when all ports of the switch become RF port and when a port of the switch becomes legacy port. It is very important to note that the above mentioned rules will reduce to what used by RSTP switches when all the switches in the network are legacy switch and reduce to that defined in section 5 when all switches in the are “Backward Compatible Ring Flushing RSTP switches”. Moreover, there is no requirement of any extra measure for backward compatibility with legacy STP switches. Hence the proposed solution is completely backward compatible to legacy STP and RSTP switches.

7. RELATED WORKS

Although Address flushing techniques are essentially required to flush potentially stale cached learnt locations after a topology changes in a spanning tree protocol controlled switched Ethernet networks but there is very little literature available on this topic. To, the best of my knowledge, the first address flushing technique was one incorporated with STP. It is a centralized technique in which the Root Switch is responsible to instruct all switches in the network to reduce their aging time after a topology change. Later a much improved technique was proposed by Vipin Jain and Mick Seaman in [7] and it is now the standard address flushing technique for RSTP. This technique generates TC message only when a port of a switch changes its state to forwarding. Moreover, this technique instantly flushes the potentially stale cached locations instead of quick aging to improve network availability. However, the scope of effected switches after a topology change in this technique is network wide. Hence, this technique is not very much scalable. In contrast, Ring Flushing [10], an address flushing technique proposed by Horvath et al., reduces the scope effected switch to a ring in physical topology and thus not only reduces the amount flooding traffic but also enhance the network scalability. Ethernet Ring Protection (ERP) [11] is a spanning tree protocol specifically designed to improve reliability of switched Ethernet networks. Two techniques are recently proposed to specifically reduce flooding traffic in ERP. They are FDB Flip [12], proposed by Rhee et al., and selective FDB advertisement [13], proposed by Lee et al.

8. CONSLUSION

This paper critically discusses a new address flushing technique, Ring Flushing, proposed by Horvath et al. for RSTP switches. This paper mentions that although the Ring Flushing itself is a very good technique but there are three very serious flaws in the implementation of Ring Flushing proposed by Horvath et al. Due to those flaws some of the stale cached learnt locations remain persist on the switches while some fresh and valid cached learnt locations are unnecessarily flushed from the switches in the network. The paper the proposed a set of rule to successfully eliminated those mentioned flaws. In the end, it is discussed that the solution provided by the inventers of this technique for backward compatibility with RSTP switch is also not working. A new more comprehensive solution is then proposed to achieve complete backward compatibility not only with legacy RSTP switches but also with legacy STP switches. Moreover, due to the newly proposed compatibility mechanism it is now possible to use legacy multipoint link even in the network having Ring Flushing switches.

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