

1394.1

Autoconfiguration

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1 Terms

Active Redundant Link:

A link in a network which passes packets between two parts of the network, but there is another physical link between the same two parts of the network that is in the Companion Portal Disabled State.

Alpha Portal:

The portal on a bus which performs certain bus-related management duties.

Alpha Portal Arbitration Request Packet:

A packet sent by portals to other portals on its bus to contend to be the Alpha Portal.

Alpha Portal Arbitration Response Packet:

A packet sent by bridge nodes in response to receiving an Alpha Portal Arbitration Request Packet.

Bridge:

A device with two physical Serial Bus connections. Each physical connection is on a different Serial Bus. The bridge is the means by which nodes on one Serial Bus may send packets to nodes on a different Serial Bus.

Bus:

A single Serial Bus.

Bus Assignment Request Packet

A packet sent by an Alpha Portal to the Prime Portal when it wishes to have a bus number assigned to it.

Bus Assignment Response Packet:

A packet sent by the Prime Portal to an Alpha Portal in response to a Bus Assignment Request Packet indicating the bus number being assigned to the Alpha Portal.

Bus De-Assignment Request Packet:

A packet sent by the Prime Portal indicating that the target Alpha Portal has had its bus number revoked.

Bus De-Assignment Response Packet:

A packet sent by an Alpha Portal that has received a Bus De-Assignment Request Packet to the Prime Portal acknowledging that its bus number has been revoked.

Bus Direction:

Field in each entry of the Bus Number Assignment Table that indicates which Companion Portal on this bridge node last received a Bus Information Response Packet from the target bus.

Bus Information Request Packet:

A packet broadcast by the Prime Portal requesting information about a particular bus from its Alpha Portal.

Bus Information Response Packet:

A packet broadcast by an Alpha Portal that contains information about its bus.

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Bus Number Assignment Table:

A table maintained by every portal that contains its knowledge of other buses, including other buses' relative position to the portal.

BUS_INFORMATION_REQUEST_PERIOD:

The nominal time between Bus Information Request Packets.

Companion Portal Disabled State:

A state used to describe a portal that does not send packets to its Companion Portal.

Companion Portals:

The two portals of a bridge.

GUID:

An identifier that is guaranteed to be unique to every node on a network. The GUID persists across bus resets.

Inactive Redundant Link:

A link in a network which does not pass packets, but there is another link between the same two parts of the network that does pass packets between the two parts of the network.

INERTIA_COUNTER:

A counter maintained by each Alpha Portal that is a measure of how long the Alpha Portal has been active on the network and the number of nodes on the network.

Loop Detection Packet:

A packet sent periodically by portals in the Companion Portal Disabled State to determine if there is still a closed loop in the network.

Network:

Two or more Buses connected by Bridges.

Network Management Packets:

Packets that are used to manage a network of Serial Buses.

Non-redundant Link:

A link in a network which is the only physical link between two parts of the network.

Portal:

A bridge node that is connected to a Serial Bus.

PRIME_PORTAL_ARBITRATION_IDLE:

Amount of time an Alpha Portal waits without receiving a Prime Portal Arbitration Response Packet before exiting the Prime Portal Arbitration State.

PRIME_PORTAL_CONTENDER Register:

A register maintained by Alpha Portals during Prime Portal selection that indicates the highest priority contender for Prime Portal seen by the portal so far.

PRIME_PORTAL_INERTIA_COUNTER:

The most recently received value of the Prime Portal's INERTIA_COUNTER.

Prime Portal:

The Alpha Portal on a network which performs certain network-related management duties.

Prime Portal Arbitration Request Packet:

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A packet sent by an Alpha Portal to the other portals on its bus indicating a new highest priority contender for Prime Portal has been seen.

Prime Portal Arbitration Response Packet:

A packet sent by a non-Alpha Portal to its Alpha Portal with the contents of a Prime Portal Arbitration Request Indication.

Prime Portal Arbitration State:

A state used to describe Alpha Portals while Prime Portal arbitration is in progress.

Survivor Network:

When two networks are joined, the network that retains its bus numbers.

Victim Network:

When two networks are joined, the network that has its bus numbers re-assigned to accommodate the other network.

Victim Network Acknowledge Packet:

Packet broadcast by Prime Portal to acknowledge it is no longer a Prime Portal.

Victim Network Notification Packet:

Packet sent to all portals of a Victim Network to notify them their bus number is invalid.

VICTIM_NETWORK_NOTIFICATION:

Period of time after a Victim Network Notification Packet is sent without receipt of a Victim Network Acknowledge Packet before another Victim Network Notification Packet is sent.

Virtual ID Map:

A table containing, for a particular bus, the correlation between the physical node ID and virtual node ID of every device on the bus.

Virtual ID Map Packet:

A packet containing the Virtual ID Map of the local bus.

2 Autoconfiguration

2.1 Overview

Below is a summary of the proposed method of autoconfiguration:

1. On the network, there is 1 portal that performs certain network level management functions, called a Prime Portal.
2. Each bus selects 1 portal to interact with the Prime Portal on behalf of the bus, called an Alpha Portal.
3. The Prime Portal periodically checks with each bus on the network to ensure it is still present and operating properly.
4. All portals listen to the communication between Prime Portal and Alpha Portals to construct a local map of what buses are on the network, and the relative locations of those buses to the portal.
5. When 2 networks are joined, the network with the most 'Inertia' maintains its bus numbers, while the network with less 'Inertia' must reassign bus numbers.
6. There is only 1 path a packet may follow from any given source node to any given destination node.
7. When a redundant connection is made within a network, a portal in the redundant path automatically detects it and the portal disables itself.
8. Portals that automatically disable themselves to prevent redundant paths in a network periodically check to see if the redundant path still exists. If it no longer exists, the portals automatically enable themselves.

2.2 Network-Level Actions

The Prime Portal shall perform network-level actions that are administered centrally.

2.2.1 Packet Forwarding By Portals

There are several types of packets that shall be used to manage networks composed of Serial Buses. These Network Management Packet types are listed in the following table:

| Packet Type | Delivery Mechanism |
|--|--------------------|
| Alpha Portal Arbitration Request Packet | Local Directed |
| Alpha Portal Arbitration Response Packet | Local Directed |
| Bus Information Request Packet | Global Broadcast |
| Bus Information Response Packet | Global Broadcast |
| Bus De-Assignment Request Packet | Global Broadcast |
| Bus De-Assignment Response Packet | Global Broadcast |
| Bus Assignment Request Packet | Global Broadcast |
| Bus Assignment Response Packet | Global Broadcast |
| Loop Detection Packet | Global Broadcast |
| Prime Portal Arbitration Request Packet | Attached Directed |
| Prime Portal Arbitration Response Packet | Attached Directed |
| Victim Network Acknowledge Packet | Global Broadcast |
| Victim Network Notification Packet | Global Broadcast |
| Virtual ID Map Packet | Local Broadcast |

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Local directed packets are destined for a portal on the local bus, and they are targeted at a specific portal.

Local broadcast packets are destined for all portals on the local bus.

Attached directed packets are destined for an Alpha Portal on a bus that is attached to a portal on the current bus. The packet is addressed to a local portal, which forwards the packet to its companion portal. The companion portal sends the packet to its Alpha Portal.

Global broadcast packets are used in three circumstances: 1. When all portals need to know the contents of the packet, 2. When the address or location of the target portal is not known, and 3. When the target portal does not have a valid bus number yet.

All global broadcast Network Management Packets shall contain a 10 bit Hop Count field. This field is initially set to 0 by the portal that generates the packet, and is incremented by each bridge node that forwards the packet to its Companion Portal.

When a portal sees a packet on its bus, it shall determine whether or not to forward the packet to its Companion Portal for transmission on the adjacent bus. A portal in the Companion Portal Disabled State shall never forward packets, regardless of packet type. A portal not in the Companion Portal Disabled State shall optionally forward packets based on the following prioritized list of considerations.

Local directed Network Management Packets shall be acted upon by the local portal without being forwarded.

Local broadcast Network Management Packets shall be acted upon by all local portals without being forwarded.

Target portals shall forward attached directed Network Management Packets.

Global broadcast Network Management Packets with a hop count of 1023 shall be dropped without further action, regardless of the packet type.

Portals not in the Companion Portal Disabled State shall forward the following global broadcast Network Management Packet types:

- Bus Information Request Packets
- Bus Information Response Packets
- Bus Assignment Response Packets
- Bus De-Assignment Request Packets
- Loop Detection Packets

Portals not in the Companion Portal Disabled State shall forward the following global broadcast Network Management Packet types unless they are in the process of performing Victim Network Notification for their old network:

- Victim Network Acknowledge Packets
- Victim Network Notification Packets

Portals not in the Companion Portal Disabled State shall forward the following global broadcast Network Management Packet types according to the Bus Direction field of the Prime Portal entry in its Bus Number Assignment Table:

- Bus Assignment Request Packets
- Bus De-Assignment Response Packets

Portals not in the Companion Portal Disabled State shall forward non-Network Management Packets according to the Bus Direction field of the appropriate entry of its Bus Number Assignment Table.

All other packets shall be dropped without further action.

2.2.1.1 Alpha Portal Arbitration Request Packet Contents

1. GUID of the initiating node (n bits).
2. GUID of the last known Prime Portal (n bits).
3. The last known value of the Prime Portal's INERTIA_COUNTER (32 bits).

2.2.1.2 Alpha Portal Arbitration Response Packet Contents

1. GUID of the initiating node (n bits).
2. GUID of the last known Prime Portal (n bits).
3. The last known value of the Prime Portal's INERTIA_COUNTER (32 bits).

2.2.1.3 Bus Assignment Request Packet Contents

1. GUID of the requesting Alpha Portal (n bits)
2. Preferred bus number (10 bits)
3. Hop count (10 bits)

2.2.1.4 Bus Assignment Response Packet Contents

1. GUID of the target Alpha Portal (n bits)
2. Bus number assignment (10 bits)
3. Hop count (10 bits)

2.2.1.5 Bus De-Assignment Request Packet Contents

1. GUID of the offending Alpha Portal (n bits)
2. Hop count (10 bits)

2.2.1.6 Bus De-Assignment Response Packet Contents

1. GUID of the Alpha Portal (n bits)
2. Hop count (10 bits)

2.2.1.7 Bus Information Request Packet Contents

1. GUID of the Prime Portal (n bits)
2. Contents of the Prime Portal's INERTIA_COUNTER (32 bits)
3. Hop count (10 bits)
4. From which bus number the Prime Portal is requesting information (10 bits)

2.2.1.8 Bus Information Response Packet Contents:

1. GUID of the Alpha Portal (n bits)
2. Hop count (10 bits)
3. Number of nodes on the target bus (6 bits)

2.2.1.9 Loop Detection Packet Contents

1. GUID of the initiating node (n bits)
2. Hop count (10 bits)

2.2.1.10 Prime Portal Arbitration Request Packet Contents

1. GUID of highest priority contender (n bits)
2. INERTIA_COUNTER of highest priority contender (32 bits)
3. Whether or not the highest priority contender is currently a Prime Portal (1 bit)

2.2.1.11 Prime Portal Arbitration Response Packet Contents

1. GUID of highest priority contender (n bits)
2. INERTIA_COUNTER of highest priority contender (32 bits)
3. Whether or not the highest priority contender is currently a Prime Portal (1 bit)

2.2.1.12 Victim Network Acknowledge Packet Contents

1. Hop count (10 bits)

2.2.1.13 Victim Network Notification Packet Contents

1. Hop count (10 bits)

2.2.1.14 Virtual ID Map Packet Contents

1. Virtual ID of each portal (6 bits / entry)
2. Lowest numbered physical ID identified by this packet (6 bits)
3. GUID of Prime Portal (n bits)

2.2.2 Bus Enumeration and the INERTIA_COUNTER

The Prime Portal shall periodically broadcast a Bus Information Request Packet. The Bus Information Request Packet is a request for the Alpha Portal of the specified bus to respond, if it exists. The Prime Portal shall send a Bus Information Request Packet to all legal bus numbers with equal frequency.

All portals shall listen for Bus Information Request Packets. When received, a portal shall update the value of its locally maintained PRIME_PORTAL_INERTIA_COUNTER, store the GUID of the Prime Portal, and forward the packet to its Companion Portal. Companion Portals shall re-broadcast the packet. In this way all portals shall have a current value of the Prime Portal's INERTIA_COUNTER and Prime Portal GUID, which are needed should another network be joined to it and Survivor / Victim Networks need to be chosen. When the Alpha Portal of the target bus receives a Bus Information Request Packet, it shall, in addition to the actions taken by all portals, broadcast a Bus Information Response Packet back to the Prime Portal. If there is no bus with the target bus number, no Bus Information Response Packet shall be generated.

Whenever a Bus Information Response Packet is forwarded to an adjacent bus, the portal shall update its Bus Number Assignment Table.

After the Prime Portal broadcasts a Bus Information Request Packet for its own bus ID, the Prime Portal shall wait for $\frac{1}{2}$ BUS_INFORMATION_REQUEST_PERIOD, then broadcast a Bus Information Response Packet.

2.2.2.1 Prime Portal Actions

When the Prime Portal receives a Bus Information Response Packet, it shall:

1. Check if the bus number of the response packet matches the bus number of its outstanding request packet.
2. Check if it has already received a Bus Information Response Packet for this bus.
3. If it has already received a Bus Information Response Packet, check if the GUID of the current Bus Information Response Packet matches the GUID of the first Bus Information Response Packet.

There are several possible outcomes.

Case 1: If the bus number is not correct, the Prime Portal shall discard the Bus Information Response Packet without further action.

Case 2: If the bus number is correct and it is the first Bus Information Response Packet received, the Prime Portal shall:

1. Increment its INERTIA_COUNTER by the number of nodes on the target bus.
2. Set to 0 in the Bus Number Assignment Table the number of Bus Information Request Packets that have been sent to that bus number without receiving a Bus Information Response Packet.
3. Update the Bus Direction field in its Bus Number Assignment Table.
4. Store the GUID of the responding Alpha Portal.

Case 3: If the bus number is correct, it is not the first Bus Information Response Packet received, and the GUID of the current packet matches the GUID of the first Bus Information Response Packet received, the Prime Portal shall discard the Bus Information Response Packet without further action.

Case 4: If the bus number is correct, it is not the first Bus Information Response Packet received, and the GUID of the current packet does not match the GUID of the first Bus Information Response Packet received, the Prime Portal shall send a Bus De-Assignment Request Packet to the target bus. The Prime Portal shall wait for a Bus De-Assignment Response Packet. If the response packet is not received, the Prime Portal shall retransmit the Bus De-Assignment Request Packet.

2.2.2.2 Other Portal Actions

When an Alpha Portal other than the Prime Portal receives a Bus Information Response Packet, it shall:

1. Check if the bus number of the response packet matches the bus number of the outstanding request packet.
2. Check if it has already received a Bus Information Response Packet for this bus.
3. If it has already received a Bus Information Response Packet, check if the GUID of the current Bus Information Response Packet matches the GUID of the first Bus Information Response Packet.

There are several possible outcomes.

Case 1: If the bus number is not correct, the Alpha Portal shall discard the Bus Information Response Packet without further action.

Case 2: If the bus number is correct and it is the first Bus Information Response Packet received, the Alpha Portal shall:

1. Increment its INERTIA_COUNTER by the number of nodes on the target bus.
2. Set to 0 in the Bus Number Assignment Table the number of Bus Information Request Packets that have been sent to that bus number without receiving a Bus Information Response Packet.
3. Update the Bus Direction field in its Bus Number Assignment Table.
4. Store the GUID of the responding Alpha Portal.

Case 3: If the bus number is correct, it is not the first Bus Information Response Packet received, and the GUID of the current packet matches the GUID of the first Bus Information Response Packet received, the Alpha Portal shall discard the Bus Information Response Packet without further action.

Case 4: If the bus number is correct, it is not the first Bus Information Response Packet received, and the GUID of the current packet does not match the GUID of the first Bus Information Response Packet received, the Alpha Portal shall discard the Bus Information Response Packet without further action.

2.2.3 Bus Number Assignment

All portals shall maintain a Bus Number Assignment Table based on Bus Information Request Packets and Bus Information Response Packets. The Prime Portal shall use the Bus Number Assignment Table to determine what bus numbers are available when an Alpha Portal requests a bus number assignment. Bus numbers shall be considered unassigned when more than 6 Bus Information Request Packets have been sent to a particular bus number without a valid Bus Information Response Packet being received. Portals other than the Prime Portal maintain a Bus Number Assignment Table in case one of them becomes the Prime Portal. This allows bus numbers that were established under the old Prime Portal to be maintained. All portals use the Bus Number Assignment Table to determine, when a packet destined for another bus has been placed on their bus, if they should forward the packet to their Companion Portal.

When an Alpha Portal wishes to have a bus number, it sends a Bus Assignment Request Packet to the Prime Portal. The request packet shall contain the Alpha Portal's preferred bus number.

When the Prime Portal receives a Bus Assignment Request Packet it shall check to see if there is already an outstanding request from the Alpha Portal in its queue of outstanding requests. If there is, the request is dropped without further action. If there is not already an outstanding request from the Alpha Portal in the queue, the Prime Portal shall check to see if the preferred bus number is available.

If the preferred bus number is available, the Prime Portal shall broadcast to the requesting node a Bus Assignment Response Packet indicating it has been assigned its preferred bus number, and initialize the Bus Number Assignment Table entry for that bus.

If the preferred bus number is not available, but another bus number is available, the Prime Portal shall broadcast to the requesting node a Bus Assignment Response Packet indicating it has been assigned a bus number other than its preferred bus number.

If the preferred bus number is not available, and no other bus number is available, the Prime Portal shall add the request to a queue of outstanding bus number requests.

Whenever a bus number becomes available, the Prime Portal shall check to see if there are entries in the outstanding bus number request queue. If there are, the Prime Portal shall assign the newly available bus number to the oldest outstanding request, initialize the Bus Number Assignment Table entry for that bus, and broadcast to the requesting Alpha Portal a Bus Assignment Response Packet indicating it has been assigned a bus number other than its preferred bus number.

Bus Number Assignment Table Entry Fields:

1. Number of Bus Information Request Packets without a Bus Information Response Packet (3 bits).
2. Which Companion Portal, A or B, last received a Bus Information Response Packet from this bus (1 bit).

2.2.4 Initiating Prime Portal Selection

It is possible through error for more than one portal on a network to be a Prime Portal, or for the Prime Portal to be removed from the network or to otherwise become inoperable. Both of these situations shall be detected by listening for Bus Information Request Packets. If the Prime Portal detects another Prime Portal on the network (i.e., if it receives a Bus Information Request Packet that it did not originate), it shall initiate Prime Portal Selection. When an Alpha portal observes a period of 4096 * BUS_INFORMATION_REQUEST_PERIOD without any Bus Information Request Packets being received, it shall initiate Prime Portal Selection.

2.2.5 Prime Portal Selection

Once an Alpha Portal has decided to initiate Prime Portal selection, it enters Prime Portal Arbitration State and initializes its PRIME_PORTAL_CONTENDER register. This register initially consists of:

1. Its own GUID (n bits)
2. Whether or not the Alpha Portal is currently the Prime Portal (1 bit)
3. Its own INERTIA_COUNTER (32 bits)

The Alpha Portal shall then send a Prime Portal Arbitration Request Packet individually to each portal on its bus. The Prime Portal Arbitration Request Packet shall include the contents of its PRIME_PORTAL_CONTENDER register. When a non-Alpha Portal receives a Prime Portal Arbitration Request Packet it shall forward the packet to its own Alpha Portal.

Eventually, all of the non-Alpha Portals on the bus will receive Prime Portal Arbitration Response Packets back from their Companion Portals. Prime Portal Arbitration Response Packets shall be passed on to the originating Alpha Portal.

If a particular portal does not return a Prime Portal Arbitration Response Packet in a timely manner, the Alpha Portal shall send another Prime Portal Arbitration Request Packet.

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There are several possibilities when an Alpha Portal receives a Prime Portal Arbitration Request Packet:

Case 1: The Alpha Portal is currently performing Prime Portal selection, the contents of the Prime Portal Arbitration Request Packet do not match its own PRIME_PORTAL_CONTENDER register, and the contents of the Prime Portal Arbitration Request Packet indicate a higher priority contender.

Case 2: The Alpha Portal is currently performing Prime Portal selection, the contents of the Prime Portal Arbitration Request Packet do not match its own PRIME_PORTAL_CONTENDER register, and the contents of the Prime Portal Arbitration Request Packet indicate a lower priority contender.

Case 3: The Alpha Portal is currently performing Prime Portal selection and the contents of the Prime Portal Arbitration Request Packet do match its own PRIME_PORTAL_CONTENDER register.

Case 4: The Alpha Portal is not currently performing Prime Portal selection.

When Case 1 occurs, the Alpha Portal shall:

1. Update its own PRIME_PORTAL_CONTENDER register with the contents of the Prime Portal Arbitration Request Packet.
2. Send a Prime Portal Arbitration Response Packet to the portal from which the Prime Portal Arbitration Request Packet came.
3. Send a Prime Portal Arbitration Request Packet individually to each portal on its bus.

When Case 2 occurs, the Alpha Portal shall:

1. Send a Prime Portal Arbitration Response Packet to the portal that sent the lower priority Prime Portal Arbitration Request Packet.

When Case 3 occurs, the Alpha Portal shall:

1. Send a Prime Portal Arbitration Response Packet to the portal that sent the Prime Portal Arbitration Request Packet.

When Case 4 occurs, the Alpha Portal shall:

1. Enter Prime Portal Arbitration State.
2. Initialize its PRIME_PORTAL_CONTENDER register.
3. Perform the actions of either Case 1 or Case 2 or Case 3, as appropriate.

There are several possibilities when an Alpha Portal receives a Prime Portal Arbitration Response Packet:

Case 1: The Alpha Portal is currently performing Prime Portal selection, the contents of the Prime Portal Arbitration Response Packet do not match its own PRIME_PORTAL_CONTENDER register, and the contents of the Prime Portal Arbitration Response Packet indicate a higher priority contender.

Case 2: The Alpha Portal is currently performing Prime Portal selection, the contents of the Prime Portal Arbitration Response Packet do not match its own PRIME_PORTAL_CONTENDER register, and the contents of the Prime Portal Arbitration Response Packet indicate a lower priority contender. This case should not happen, but is included for completeness.

Case 3: The Alpha Portal is currently performing Prime Portal selection and the contents of the Prime Portal Arbitration Response Packet do match its own PRIME_PORTAL_CONTENDER register.

Case 4: The Alpha Portal is not currently performing Prime Portal selection. This case should not happen, but is included for completeness.

When Case 1 occurs, the Alpha Portal shall:

1. Update its own PRIME_PORTAL_CONTENDER register with the contents of the Prime Portal Arbitration Response Packet.
2. Send a Prime Portal Arbitration Request Packet individually to each portal on its bus.

When Case 2 occurs, the Alpha Portal shall:

1. Send a Prime Portal Arbitration Request Packet to the portal that sent the lower priority Prime Portal Arbitration Response Packet.

When Case 3 occurs, the Alpha Portal shall:

1. Take no action.

When Case 4 occurs, the Alpha Portal shall:

1. Take no action.

When an Alpha Portal is in Prime Portal Arbitration State, all non-Alpha Portals on the bus have returned Prime Portal Arbitration Response Packets indicating the current value of the PRIME_PORTAL_CONTENDER register, and no Prime Portal Arbitration Request Packets have been received for a period of PRIME_PORTAL_ARBITRATION_IDLE, the Alpha Portal shall exit Prime Portal Arbitration State. If the Alpha Portal is the Prime Portal, it may then start performing the Prime Portal duties.

2.2.6 Prime Portal Priority

When comparing two potential Alpha Portals for Prime Portal, the following criteria shall be used:

1. A portal that was already Prime Portal shall win over a portal that was not Prime Portal.
2. If (1) is a tie, the portal with the larger INERTIA_COUNTER wins.
3. If (1) and (2) are a tie, the portal with the smaller GUID wins.

2.2.7 Connecting Two Networks

Networks can be joined in two ways:

1. A bridge that has only 1 portal connected to an active bus can have the other portal attached to a bus.
2. Two buses can be joined without an intervening bridge.

2.2.7.1 Connecting Two Networks Through A Bridge

When a portal is connected to a bus, it shall inquire from its Companion Portal as to whether or not it is connected to an active bus, and if so the GUID of the Prime Portal of the bus. There are several cases:

Case 1: The Companion Portal is not connected to a bus.

Case 2: The Companion Portal is connected to a bus, and its Prime Portal is the same as the Prime Portal of the new bus.

Case 3: The Companion Portal is connected to a bus, and its Prime Portal is different from the Prime Portal of the new bus.

When Case 1 occurs, no further action is taken.

When Case 2 occurs, the connection is redundant and the bridge shall enter the Companion Portal Disabled State. This bridge is said to be an Inactive Redundant Link.

When Case 3 occurs, two networks have been joined into a single network. At this point both portals of the bridge node have the information necessary to choose a Victim Network and a Survivor Network. The determination is made by:

1. A network with a Prime Portal wins over a network without a Prime Portal.
2. If (1) is a tie, and neither network has a Prime Portal, the bus whose Alpha Portal GUID is smaller wins.
3. If (1) => (2) are a tie, and both networks have a Prime Portal, the network with a larger value of Prime Portal INERTIA_COUNTER wins.
4. If (1) => (3) are a tie, and both networks have a Prime Portal, the network with a smaller value of GUID for the Prime Portal wins.

Once Survivor and Victim Networks have been chosen, the new portal on the Victim Network broadcasts a Victim Network Notification Packet. All portals that receive it forward this packet if they are not in Companion Portal Disabled State, so that all portals on the Victim Network are aware their bus number is no longer valid and must request a new bus number. The new portal on the Victim Network shall wait for a period of VICTIM_NETWORK_NOTIFICATION for a Victim Network Acknowledge Packet from the Victim Network's Prime Portal acknowledging it is no longer a Prime Portal. If an acknowledgement is not received by this time, the new portal on the victim network shall rebroadcast the Victim Network Notification Packet.

While waiting for a Victim Network Acknowledge Packet, no packets shall cross the new bridge connection, they shall be dropped. Once the Victim Network Acknowledge Packet is received, or after the maximum number of Victim Network Notification Packets have been sent, packets shall be allowed to cross the new bridge connection as normal.

2.2.7.2 Connecting Two Networks Without A Bridge

After Alpha Portal selection, all portals on the combined bus know their new Prime Portal GUID and old Prime Portal GUID. If these do not match, they are on the Victim Network. All of the portals from the Victim Network on the combined bus shall take the actions that the new portal on the Victim Network takes when two networks are connected through a bridge.

If the Alpha Portals determines that all new portals previously had the same Prime Portal as its own, a new connection has been made to the existing network, and there is now a closed loop in the network. The Alpha Portal shall instruct all portals on the new, combined bus to take the actions stated under Disabling A Closed Loop In A Network.

2.2.7.3 Disabling A Closed Loop In A Network

Under normal operating conditions, there is only one path between any two buses through which packets may pass. However, when buses are combined, or under other atypical (error) conditions, there may be two or more paths. When buses are combined, the Alpha Portal on the combined bus immediately knows as part of the Alpha Portal selection if there is closed loop in the network. If the condition occurred in another manner, this condition must be detected.

2.2.7.3.1 Closed Loop Due To Combined Buses

When the Alpha Portal knows after a bus reset that a loop has been created in the network, it shall instruct each portal on the network to send a Loop Detection Packet. Portals shall wait LOOP_DETECT_TIME to see if they receive their own Loop Detection Packet. Any portal that receives its own Loop Detection Packet within this time shall enter Companion Portal Disabled State. Until LOOP_DETECT_TIME has elapsed, only Loop Detection Packets shall be allowed to cross portals on the bus. After LOOP_DETECT_TIME, normal rules for forwarding packets shall again be observed.

2.2.7.3.2 Closed Loop Due To Error Condition

This is a maintenance function.

Bridges not in the Companion Portal Disabled State shall send a Loop Detection Packet from one portal every $1024 * \text{BUS_INFORMATION_REQUEST_PERIOD}$. If the packet is later received on its Companion Portal, the bridge shall enter the Companion Portal Disabled State.

Note that unlike other global broadcast Network Management Packets, the initiating node only sends Loop Detection Packets from one portal.

2.2.8 Severing A Link In A Network

When a connection is severed, there are several possibilities:

1. The link was an Inactive Redundant Link.
2. The link was an Active Redundant Link.
3. The link was a Non-redundant Link, and the single network has been broken into two separate networks.

If the link was an Inactive Redundant Link, the bridge shall exit the Companion Portal Disabled State and no further action shall be taken.

If the link was an Active Redundant Link, some parts of the network are no longer able to communicate with other parts of the network, even though they are still physically connected. Bridges that are in the Companion Portal Disabled State shall send a Loop Detection Packet from one portal once every $1024 * \text{BUS_INFORMATION_REQUEST_PERIOD}$. If a bridge sends three such packets without receiving its own Loop Detection Packet back on its companion portal, it shall assume the closed loop has been broken elsewhere and exit the Companion Portal Disabled State.

If the link was a Non-redundant Link, the network that retains the Prime Portal shall continue to operate normally. Eventually, the Prime Portal will make available the bus numbers that were assigned to the now independent network. Alpha Portals on the network that does not retain the Prime Portal shall eventually detect that their Prime Portal is missing (no Bus Information Request Packets are received). They shall then arbitrate for Prime Portal.

2.3 Bus-Level Actions

Whenever a bus reset occurs, all devices on the bus participate in the configuration process. Part of this process is assigning, to each node, a physical ID that is used to address the node. Due to the manner in which physical IDs are assigned, there is no guarantee that a particular node will retain its prior physical ID after a bus reset. Indeed, it is highly likely that its physical ID will change. Thus, communication channels established prior to the bus reset, if based on physical ID, must be re-established.

On a large network consisting of multiple buses connected by bridges, there will be frequent resets on the various buses as devices are added and removed. To prevent widespread disruption of communication channels whenever a bus on the network is reset, it is desirable to assign a virtual node ID to each node by which it will be known to devices on other buses. This virtual node ID would persist across bus resets, so that communication channels which cross bridges would not have to be re-established.

Below is an outline of the procedure used to assign virtual node IDs after a bus reset. The subsections that follow add detail to the outline.

1. After the reset, one portal is chosen as the Alpha Portal.
2. The Alpha Portal assigns a virtual node ID to every node on the bus.
3. The Alpha Portal constructs a Virtual ID Map.
4. The Alpha Portal sends the Virtual ID Map to each portal on the bus individually.

2.3.1 Alpha Portal Selection

After a bus reset, every portal listens to the Self_ID packets of other portals and notes their physical ID and location. From this, the portal constructs a bus topology map. After Self_ID is complete, each portal sends, individually to every other portal, an Alpha Portal Arbitration Request Packet.

When a portal receives an Alpha Portal Arbitration Request Packet, it shall send back an Alpha Portal Arbitration Response Packet. Each portal continues to send Alpha Portal Arbitration Request Packets until:

1. It receives an Alpha Portal Arbitration Response Packet indicating it has lost the arbitration, or
2. It has won the arbitration

When a portal receives an Alpha Portal Arbitration Response Packet, it determines whether it has lost arbitration to this portal by the following priority:

1. A portal that had a Prime Portal before the bus reset wins over a portal that did not have a Prime Portal before the bus reset.
2. If (1) is a tie, and neither had a Prime Portal, the portal with the smaller GUID wins.
3. If (1) => (2) are a tie, and both had a Prime Portal, and the Prime Portals are different, the portal with the higher PRIME_PORTAL_INERTIA_COUNTER wins.
4. If (1) => (3) are a tie, the portal with the smaller GUID wins.

2.3.2 Virtual Node ID Assignment

The Alpha Portal shall be able to determine whether or not a node is new to the bus based on the current topology of the bus and the previous topology of the bus. If the node was already on the bus before the reset, the node shall retain its previous virtual node ID. If the node was not on the bus prior to the reset, the Alpha Portal shall assign a new virtual node ID to it.

The Alpha Portal shall always assign to itself a virtual node ID of 0x0.

If after a bus reset a portal that has just joined the bus becomes the Alpha Portal, all virtual node IDs shall be re-assigned. When two buses are joined into a single bus, all of the nodes previously on the Victim Network shall have new virtual node IDs re-assigned.

Implementation Notes:

1. The Alpha Portal must maintain its old bus topology map (from before the bus reset) until the new topology map and Virtual ID Map are complete.

2.3.3 Virtual ID Map Construction

As the Alpha Portal is assigning virtual node IDs, it shall construct a map of physical node ID / virtual node ID correlation. The Virtual ID Map has two purposes. First, when forwarding a packet from a node on this bus to a node on another bus, the portal shall look up the physical node ID contained in the packet as the source address in the Virtual ID Map and substitute the virtual node ID for the physical node ID. Second, when a portal receives a packet from another bus that is meant for this bus, it shall look up the virtual node ID provided in the packet as the destination address in the Virtual ID Map, and substitute the physical node ID for the virtual node ID.

2.3.4 Informing All Portals of Virtual ID Map

All portals need to have a copy of the Virtual ID Map for two reasons. First, they need to perform the mapping of virtual node ID / physical node ID for packets sourced from or destined for the bus. Second, if the Alpha Portal is removed from the bus, one of them will need to become the Alpha Portal. To prevent the established communication channels from being disrupted, they need to be able to retain the current virtual node ID assignments. This can be done if they have a copy of the Virtual ID Map.

The Alpha Portal shall write the map to each portal on the bus individually.

3 Open Issues

Bus Enumeration and the INERTIA_COUNTER:

1. How frequently should Bus Information Request Packets be sent?
2. How many times should a Bus De-Assignment Request Packet be sent to a target bus/Alpha Portal without receiving a Bus De-Assignment Response Packet before giving up?

Bus Number Assignment:

1. How long should an Alpha Portal wait after sending a Bus Assignment Request Packet without receiving a Bus Assignment Response Packet before sending a new Bus Assignment Request Packet?

Prime Portal Arbitration:

1. How long should an Alpha Portal wait for a response to its Prime Portal Arbitration Request Packet to a particular portal before sending a Prime Portal Arbitration Read Packet?
2. How long should PRIME_PORTAL_ARBITRATION_IDLE be?

Connecting Two Networks:

1. How long should a portal wait after sending a Victim Network Notification Packet without receiving a Victim Network Acknowledge Packet before resending the notification packet?
2. How many times should Victim Network Notification Packets be sent without receiving a Victim Network Acknowledge Packet before giving up?

Virtual Node ID Assignment:

1. Should the Alpha Portal attempt to not re-assign previously assigned virtual node IDs for a time?

Informing All Portals of Virtual ID Map:

1. How should portals respond to packets sourced from or destined for the bus before the Virtual ID Map is valid?

General: