

Red Hat Cluster Suite Networking

Revision History

0.1	17th January 2008	Christine Caulfield	Initial version
0.2	18th January 2008	Christine Caulfield	Mention RHEL4 cluster IDs
0.3	22nd February 2008	Christine Caulfield	Add a bit about bandwidth use
0.4	17nd March 2008	Christine Caulfield	Mention wireshark decoders
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0.7	9th June 2008	Christine Caulfield	Mention version of wireshark for DLM

This document describes how cluster suite in RHEL4 and RHEL5 uses networking. It does not describe in detail the internal protocols of the components, it is intended as an aid to understanding what sort of packets are in use and why, and as a troubleshooting document.

It is assumed that the reader has a working knowledge of the basic cman toolset (principally cman_tool, ccscd and the use of cluster.conf)

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1. Overview of protocols

In both RHEL4 and RHEL5 versions of cluster suite, CMAN uses UDP packets and the DLM uses TCP packets. The DLM does *not* use CMAN as a communications medium. There are many varied reasons for this, but principally in RHEL4 it is because the cman protocol is not suited to high traffic loads, and in RHEL5 it is because cman is in userspace and the DLM is in the kernel.

1.1 RHEL4 CMAN

cman in RHEL4 uses broadcast UDP packets by default. It determines the broadcast address of the interface given by the IP address at configuration time (see later on name resolution). This is determined by cman_tool and the resultant sockets passed into the kernel. cman actually uses two sockets, a broadcast socket and a unicast socket. One is bound to the broadcast address and receives all traffic bound for the whole cluster, the other is the unicast socket and deals with node to node traffic as

well as being the sending socket for all traffic (this makes sure that ACK messages come back to the correct node). Both sockets are bound to the same port number, 6809 by default.

cman can use multicast if it is configured in cluster.conf. This might be useful if the nodes are separated by a router, but be careful that the router is configured correctly and can pass packets in a timely manner. RHEL4 is not as time-critical with multicast routing as RHEL5 but a badly configured router could easily cause node failures, particularly during transitions or GFS mounts when the message traffic is highest. The TTL on multicast packets is set to 10. There is no way of changing this currently, without resorting to iptables tricks.

The protocol is very simple, source and target nodeids are embedded in the messages which are broadcast/multicast and each message has a sequence number. Messages can be ACK or no-ACK. Only one ACK message can be in-flight at one time from a particular node, all other ACK messages from the node will be queued behind one that is waiting. No-ACK messages can be sent at any time. HELLO messages are sent as no-ACK messages every (default) 5 seconds. All messages (even node to node ones) are broadcast/multicast apart from ACKs.

All packets contain the 16 bit cluster number in them. This allows multiple clusters to share the same network and port number. A node will simply discard any messages that have a different cluster number in the cman header. The opposite is also true, of course. If two clusters have the same cluster number (the name hash isn't very clever) then they will probably try to join together to make one larger cluster – and if the node IDs clash that can cause join rejections. The `cman_tool status` command will show you the cluster name and the generated cluster ID. If you are getting clashes then you can override the name hash by putting your own cluster id into cluster.conf:

```
<cman cluster_id="16577"/>
```

1.2 RHEL5 CMAN

cman in RHEL5 is layered on OpenAIS. This always uses multicast UDP packets – there is no broadcast option. The default TTL is set to 1, the only way to change this is via some iptables fudgery, but you very well might need to if the packets need to traverse a router.

If no multicast address is configured in cluster.conf then one is generated using the cluster ID as the bottom 16 bits and 239.192 (IPv4) or FF15:: (IPv6) as the top 16 bits .

The openais 'totem' protocol is far more complicated than that used by cman in RHEL4 so I won't attempt to summarise it here. There are academic papers that describe it in excruciating detail if that's what you need. Very simply, a rotating token visits all the nodes in a 'ring', this system ensures that messages arrive at nodes in a predictable order and provides useful features such that when a message arrives back at its originating node, that node knows that all other nodes have seen it.

Openais uses three UDP sockets for communications. A multicast receive socket which is bound to the multicast address. A multicast send socket which is bound to the local IP address but at the port number specified minus one, and a token socket which is bound to the local IP address. The default port number is 5405, so a normal system will have two sockets bound to port 5405 and one to 5404.

1.3 CMAN common bits

cman traffic is crucial to the liveness of the cluster. To ensure that it is not queued behind other bulk networking traffic it sets the socket priority to TC_INTERACTIVE (6). There are various traffic scheduling algorithms available in Linux to change the way the priorities are processed, but most will prioritize TC_INTERACTIVE above other (eg http or even DLM) traffic.

If you choose your own multicast address, make sure you do it carefully. A lot of people seem to choose things like 224.0.0.x which is “All hosts on the network” and might not be routed correctly, or even at all, by some hardware. A better solution is to use the 239.192.x.x address series that cman uses. Whichever you do choose, we strongly recommend that you double-check the configuration of any routers that the packets must pass through. Some can take a long time to learn addresses, stalling or breaking cluster formation.

I have, a couple of times, seen the statement 'cman works using a crossover cable, but behaves oddly on my routed network' ... check your router if this happens. And/or adjust the TTL. I am indebted to David Robinson for the following magic:

```
# iptables -t mangle -A OUTPUT -d 239.224.72.11 -j TTL --ttl-set 128
```

If you use this, remember to change the multicast address 239.224.72.11 above to match the one in use by your cluster; and you might like to set the TTL down a little too, if you know or can work out what it should be for your network.

1.4 DLM

As mentioned, the DLM does not use cman as a transport protocol, it makes its own connections using TCP/IP. It gets the local IP address and the remote node IP addresses from cman (which gets them indirectly from cluster.conf). By default the DLM uses port 21064 for communication.

DLM expects the transport to be reliable and ordered, and, ideally, fast. Under heavy GFS load the DLM can generate a lot of lock traffic. Most DLM messages are very small, but they are coalesced internally as far as possible to maximise network bandwidth use. During recovery (eg when a node joins or leaves the cluster, or a GFS filesystem is mounted) much larger packets can be generated.

All network traffic in the dlm is processed by the dlm_send and dlm_rcv kernel threads (work queues in RHEL5). If you see dlm_rcv high in the process CPU list then it is likely that a lot of work is coming in from remote nodes. All remote locking operations happen in this process. dlm_send is responsible simply for sending the packets and coalescing messages together so should not use much cpu time.

There is an option for DLM to use SCTP for communications rather than TCP. This is not currently supported but it works in the same way as TCP communications except that multiple interfaces are supported by SCTP, this is the only way to implement multi-homing.

The dlm starts up its communications when the first lockspace is created and shuts it down when the last lockspace is removed, so don't just 'modprobe dlm' and expect to see sockets bound to port 21064.

When using TCP, the DLM might have two connections to another node. This is expected behaviour

and happens because two nodes might try to establish communications with each other at the same time. It is not possible to close one of these connections without losing data on it. The overhead of having two connections is minimal. If there are two connections between nodes then each node will send on the connection it initiated, rather than the incoming connection from the other node.

2. Name resolution and cluster.conf

cman tries hard to match the local host name(s) to those mentioned in cluster.conf. Here's how it does it:

1. It looks up \$HOSTNAME in cluster.conf
2. If this fails it strips the domain name from \$HOSTNAME and looks up that in cluster.conf
3. If this fails it looks in cluster.conf for a fully-qualified name whose short version matches the short version of \$HOSTNAME
4. If all this fails then it will search the interfaces list for an (ipv4 only) address that matches a name in cluster.conf

cman will then bind to the address that it has matched.

It should be noted that RHEL4 (until very recently) had a bug in stage 3 of this process which meant that it bound to the short name found, rather than the full name in cluster.conf. In fact this is what prompted this document. An example will, I hope clarify this step:

Suppose the host has the \$HOSTNAME `myhost.mycompany.com` but also has interfaces accessible by names `myhost.internal.mycompany.com` and `myhost.remote.mycompany.com`. It is possible to use `myhost.internal.mycompany.com` as the node's name in cluster.conf and cman will find it.

In general I recommend that fully-qualified names are used for hostname and in cluster.conf as it avoids a lot of ambiguity. If there is any complexity in the configuration it might also help to add the nodename to the cman_tool join command line eg:

```
# cman_tool join -n myhost.internal.mycompany.com
```

If you are ever in any doubt about what IP address cman is using for communications, the command “`cman_tool status`” will enlighten you. It is worth mentioning here that cman does NOT lookup the address of remote cluster nodes using cluster.conf. It expects them to be visible using the broadcast or multicast address it was given to use. If the remote nodes are not available or only partially visible via that route then all hell will break loose and the cluster will likely fall apart. In particular, connecting two interfaces to the same piece of physical network can cause problems unless you explicitly set up the correct routes. If in doubt consult a real networking expert.

I mentioned that the DLM gets all of its IP addresses from the local cman. It's important to realise that cman only ever resolves its *own* address – using the rules above. The other nodes' addresses are obtained from communication with the remote nodes themselves - using the broadcast or multicast messaging, and the DLM picks them up from cman. It does *not* resolve the names, ever.

3. Other Bits

I'll just briefly mention other parts of Cluster Suite in an attempt to clear up any confusions that have occasionally arisen.

1. GFS does not use any networking itself. It relies on the DLM to do its locking
2. ccsd uses networking to distribute the cluster.conf files. The following two bullet points are taken from the cluster wiki:
 - 50006/TCP - Cluster Configuration System front-end port. This is used to obtain configuration information from ccsd. Connections not from a reserved port (e.g. <1024) are dropped. This port is only bound on loopback interfaces; remote access is disabled.
 - 50008/TCP (ipv4) & 50009/TCP (ipv6) - Cluster Configuration System update ports. This port is used to handle updates and/or changes to the cluster configuration file (cluster.conf). Connections from outside the known-live cluster are dropped.

4. Routing

Neither cman nor DLM do any special routing, they do normal networking send and receive calls. If you have any special routing requirements the normal system routing utilities will work.

5. Diagnostic Tools

If you are experiencing networking problems with cluster suite, the first thing to check is that you are using the correct IP address. `cman_tool` status will tell you this. Check it against cluster.conf and the list above to see if it is behaving as you expect. If you can't even get cman up and running because of suspected networking configuration problems then try starting the cluster with '`cman_tool join d`' which will give you more information about how cman is trying to resolve the host name. Note this is a lot more help on RHEL5 than RHEL4, sorry. However, it is possible to use `strace` on `cman_tool` in RHEL4 to get information about name resolution. In RHEL4 all the ccs functions and name resolution happens in `cman_tool` and the sockets are passed into the kernel. In RHEL5 that detail happens in `cman`, after `aisexec` is started.

Another handy utility is `netstat`, its `-u` and `-t` switches will show you which ports and addresses are bound to UDP and TCP sockets respectively. If running as root, adding `-p` will also show you the process ID and name.

For serious network diagnostic tasks, `tcpdump` or `wireshark` are what you need. The output from these can be very cryptic but also immensely useful in diagnosing problems, you don't need to understand all the output to find them helpful.

```
# tcpdump port 6809
```

will show all the traffic for a RHEL4 cman cluster. You can tell which packets are being sent (and to where) from the local host and which nodes' packets are being received too. If do this on two nodes that are apparently not communicating you might just find out why! If packets are not being received then it's always worth checking your iptables rules. You should see 'HELLO' packets being sent from each node every five seconds.

On a RHEL5 cluster

```
# tcpdump port 5405
```

will show the token packets being passed around.

If you are experiencing really odd problems *and are asked by a support or development engineer* to send in a tcpdump for diagnostic purposes it's important to add the -s0 switch to capture the whole packet, eg

```
# tcpdump -wmyfile.dmp -xs0 port 6809
```

will save traffic information to a file called myfile.dmp.

tcpdump can also be used to check DLM communications, however it's very important to make sure that cman is communicating correctly first. As the DLM sends packets only as needed, there will be nothing to see on a quiescent system, and a busy GFS system can soon overwhelm you with data. In general, if cman is communicating correctly then DLM will too. If that is not the case then it's probably a case of those pesky iptables rules again.

The ip command is helpful for determining which interfaces are bound to which multicast addresses, if you suspect something is wrong here.

```
# ip maddr ls
# ip link ls
```

The tc command shows and changes the network queueing discipline:

```
# tc qdisc show
qdisc pfifo_fast 0: dev eth0 root bands 3 priomap  1 2 2 2 1 2 0 0 1
1 1 1 1 1 1 1
```

Here you can see that priority 6 traffic is mapped internally to '0' (remembering to count the list from 0) which schedules it ahead of other packets. If you load another networking queueing discipline then make sure that it does something equivalent.

If you're serious about tracing DLM packets, then version 1.0.0 of Wireshark has a dissector for the RHEL5 DLM packet format included and I believe that an OpenAIS one is being worked on. Even if you don't have a recent enough version of Wireshark to include these decoders, it's handier than tcpdump in many ways because it can separate out the protocol headers from the data. That can save a lot of effort and/or printouts with scribbled pencil marks on them!

6. Bandwidth Use

6.1 RHEL4 CMAN

A quiescent cman in RHEL4 uses very little bandwidth. Just the (default) 5 second heartbeat messages from each node. Even during a transition the usage is minimal and unlikely to impact

significantly on a network. Large numbers of nodes (say over 20) will cause a flurry of traffic during a transition but nothing most networks shouldn't be able to cope with.

6.2 RHEL5 CMAN

Even when quiescent, a RHEL5 cluster will generate a measurable network load. This is the totem token being passed around the cluster members. In addition to this load, there are more daemons using the openais messaging system for communications. In particular plocks use openais messages and can add considerably to the networking traffic. In a future version of RHEL5, the totem multi-ring system should become supported and allow the traffic in large clusters to be split over several physical networks to help alleviate this.

Although it is possible to run several RHEL5 clusters on the same network, it is recommended that RHEL5 clusters at the same site are run on separated networks.

6.3 DLM

The DLM uses whatever it can get depending on what it needs. That is, if you have a very busy collection of GFS filesystems with lots of inter-node locking then you will see a lot of large DLM packets. With fast nodes and a lot of traffic, it is possible to flood a network with DLM traffic. It's impossible to put an exact figure on this because it depends on the GFS load, other programs doing locking, and where the master & directory nodes for a lock is.

The addition or removal of a node from a DLM lockspace can cause a great deal of lock traffic if lots of locks are active as locks are recovered and the lock directory is rebuilt

7. Connection Security

None of the cluster suite components implement much in the way of security on their connections. Red Hat recommends that all cluster traffic is routed over an internal, ideally isolated, LAN or VLAN. This not only ensures the security of cluster communications but should also allow for enough bandwidth for a busy cluster to operate at full efficiency.

The DLM will refuse to accept new connections from nodes that are not known to CMAN, and will only accept a maximum of two connections from any node that is known to CMAN. This is for reasons detailed in section 1.4.

CMAN in RHEL5 uses Openais and always enables packet encryption. If no security key is specified then cman will use the cluster name as the key. This does not provide good security but is probably enough to dissuade casual snooping or spoofing. If you are serious about preventing snooping of Openais traffic then you should create a keyfile, securely distribute that around the cluster and add its name to cluster.conf with a line similar to the following:

```
<cman keyfile="/etc/cluster/cman_keyfile"/>
```