LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

AdvLigo CDS

Networking Architecture

R. Bork

Distribution of this document:

LIGO Scientific Collaboration

This is an internal working note

of the LIGO Laboratory.

California Institute of Technology

LIGO Project – MS 18-34

1200 E. California Blvd.

Pasadena, CA 91125

Phone (626) 395-2129

Fax (626) 304-9834

E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology

LIGO Project – NW22-295

185 Albany St

Cambridge, MA 02139

Phone (617) 253-4824

Fax (617) 253-7014

E-mail: info@ligo.mit.edu

LIGO Hanford Observatory	**LIGO Livingston Observatory**
P.O. Box 1970	**P.O. Box 940**
Mail Stop S9-02	**Livingston, LA 70754**
Richland WA 99352	Phone 225-686-3100
Phone 509-372-8106	Fax 225-686-7189
Fax 509-372-8137	

http://www.ligo.caltech.edu/

Contents

1   Introduction

The purpose of this document is to describe the design for the aLIGO Control and Data Systems (CDS) computer networking architecture.

2   Scope

CDS must provide an internal data networking system to support data exchange between CDS provided computers, as outlined in the CDS Networking Requirements Document.

The scope this design primarily limited to support of new CDS computer systems to be installed as part of aLIGO. Therefore, not in the scope of this design are:

1) Design details for connection of LIGO CDS legacy systems. This design does provide entry points, but connection details and additional equipment required is considered part of LIGO operations.
2) This is for internal CDS networking only ie no gateway computers, routers, etc are provided for connection to site general computers. Again, this is to be addressed as part of LIGO operations in accordance with LIGO cyber security policies.

3   References

Earlier versions of this document contain sketches of the planned CDS network designs. Since that time, generic network drawings have been produced and are referenced later in this document.

1) aLIGO DAQ Configuration and Networks (LIGO-D1400003)
2) aLIGO Front-end Reflected Memory (RFM) Networks (LIGO-D1400030)
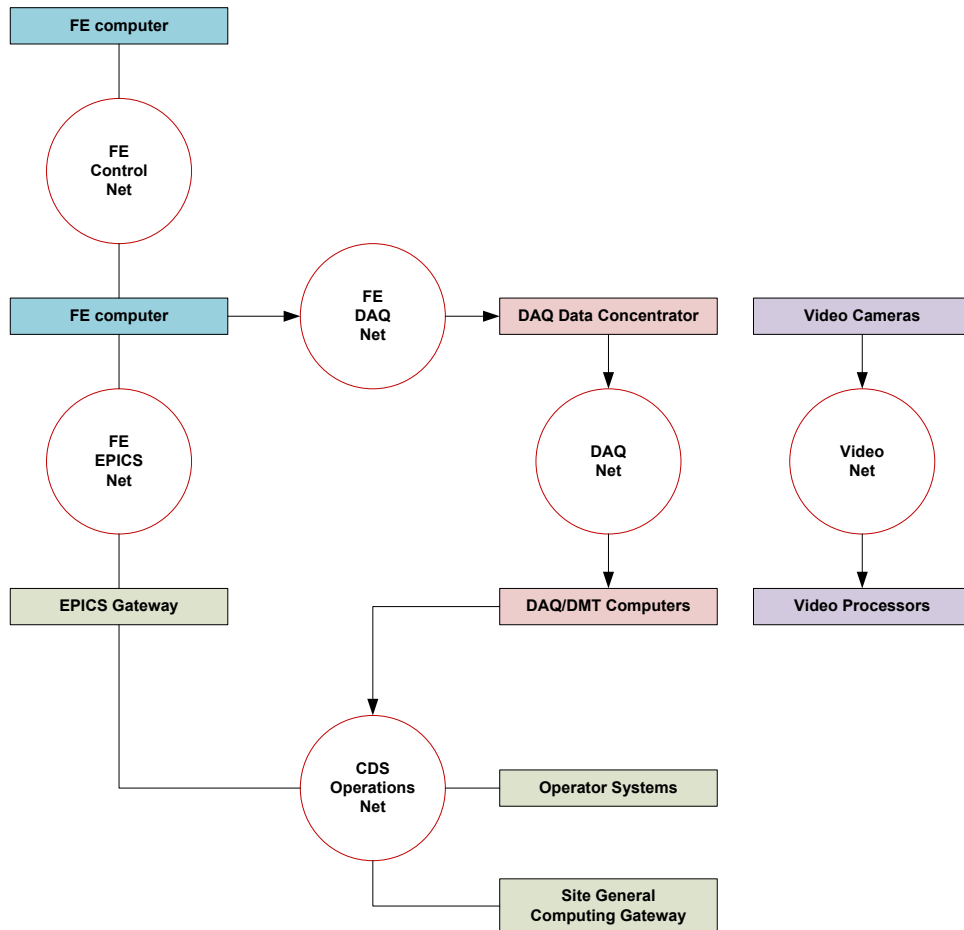
4   Overview

To support these required capabilities, the CDS networking system design provides a number of independent networks, as depicted in Figure 1 below. These networks are divided by functionality, and described in the following subsections of this document. These networks are:

1) FE control network. This network interconnects the various computers running real-time control and monitoring tasks. It allows their real-time applications to exchange data, with deterministic latencies, in order to provide distributed control capabilities.
2) DAQ Networks. Two Ethernet networks will be provided to for the purposes of moving DAQ and GDS data.
   a. Network which connects the real-time control computers and the DAQ data concentrator.
   b. Network which connects the DAQ data concentrator to the remaining DAQ computers.
3) FE computer Ethernet. This network is used to move EPICS data to/from the EPICS gateway computers.

4) CDS Operations Ethernet. This network includes all of the operator stations and other general CDS support computers.
5) GigE Camera Network. This is an independent network for connection of the aLIGO video cameras.

The following sections further describe these various networks. The final section of this document provides a composite diagram, along with part lists.

Figure 1: Network Architecture Overview

5   FE Control Network

The aLIGO CDS design calls for a distributed system of computers running coordinated, synchronous real-time control applications. The number of computers is ~15-20, located as much as 4km from each other. These computers must exchange a limited amount of data (~100-200 signals per IFO), in real-time. These signals must be exchanged at rates of up to 16384 times per second.

To provide this capability, CDS will employ two types of network structures.

1) PCIe Reflected Memory (RFM) networks, for computers in close proximity to each other (6 meters).
2) Long haul RFM networks to cover the 4km between corner and end station computers.

Network layouts and connections can be found in LIGO-D1400030.

5.1 Local Computer Real-time Communications

In the aLIGO corner station, all real-time control computers will be co-located in the Mass Storage Room (MSR), adjacent to the control room. At the end stations, computers are co-located in a room adjacent to the VEA. In each of these three areas, computers are interconnected via a PCIe network. In this scheme, local memory on each computer is mapped as PCIe space which is accessible by the other computers on the network as PCIe devices. This system provides for low latencies (<1usec) and high data rates (10Gbit/sec), with point to point connections. Several manufacturers provide this equipment, which consists of:

1) A PCIe switch. This unit interconnects the various computers via CX4 cables. The specifications and description of a representative unit can be found at PCIe switch.
2) A PCIe interface card within each computer. A description of a representative board of this type can be found at PCIe network card,

5.2 Corner Station to End Station Communications

Real-time communication between corner station and end station computers is also required. While it would be desirable to use the same PCIe network, the 4km distance is not presently supported by PCIe (limit of 300m over fiber). Therefore, this network is to be the latest version of the Reflected Memory (RFM) networking equipment used in initial LIGO. To minimize latency, a separate RFM network is run to each end station. This network consists of:

1) One (or two) PCIe RFM interface card(s) in each computer shown. This card contains 64Mbytes of memory. The three corner station computers contain two of these cards, one for each end station network. Descriptions and specifications for these interface cards can be found at RFM Network Node.
2) A nine port RFM bypass switch for each end station network. This allows for each corner station computer to be manually or automatically removed from the loop. These switches are equipped with a long range, single mode transceiver for the links to the end station computers. Details and specifications can be found at RFM Network Hubs.

6   FE EPICS Network

The CDS uses EPICS Channel Access (CA) to communicate control settings and monitoring information. To avoid overtaxing real-time computers with UDP broadcasts and many socket connections from EPICS clients, such as control room operator displays, the CDS design provides a separate network connecting real-time control computers to an EPICS gateway computer.

The network infrastructure consists of five Gigabit Ethernet switches, interconnected via single mode fiber optics. One switch (24 port) is provided at each end and mid station (mid station LHO only) and one at the corner station MSR (48 port). The end station units use VPN to provide 12 ports for FE EPICS network connections and 12 ports for CDS operations network connections. The latter is required for remote operator stations.

These switches are readily available, commercial units. While exact vendor and model are TBD, representative specification sheets can be found at 24 port switch and 48 port switch.
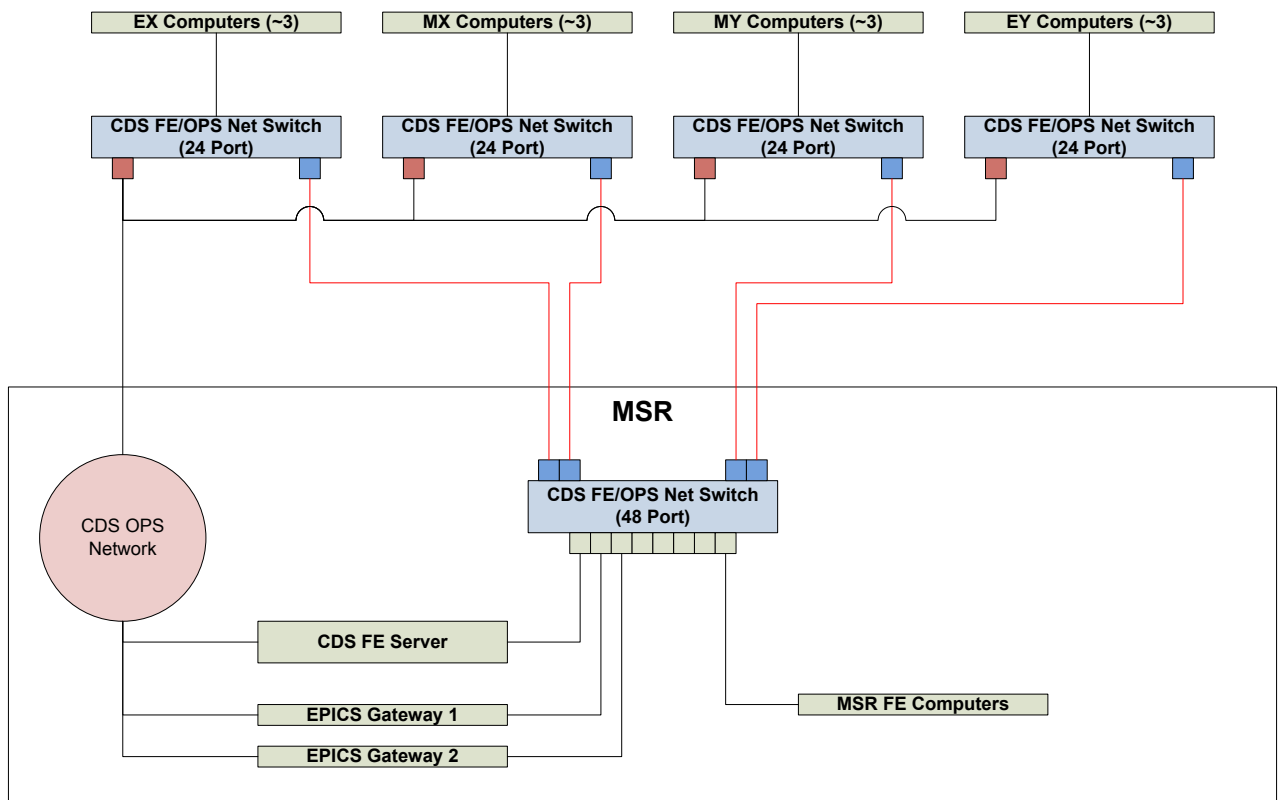

Figure 2: FE EPICS Network

7   DAQ Network

For ELIGO, and a few aLIGO prototype systems, a combination of Myrinet and Infiniband was used to provide the network communications for the DAQ system. However, this final design replaces both with Ethernet. Among the reasons for this change are:

1) Reduce number of network types that need to be supported during operations.
2) Standard network with foreseen long-term support.
3) Non-proprietary

An overview of the aLIGO DAQ networks is shown in LIGO-D1400003. The DAQ Ethernet network design consists of two parts:

1) A Gigabit Ethernet infrastructure to communicate DAQ data from the CDS FE control computers to the DAQ data concentrators.
2) A 10 Gigabit Ethernet to broadcast DAQ data from the DAQ data concentrators to the remaining DAQ computers.

As with the FE EPICS network, a Gigabit Ethernet network switch will be provided at each end and mid station (mid stations LHO only) and in the MSR. The MSR unit, however, will have the addition of two 10Gigabit up links for connection to the DAQ data concentrators. Specifications of a representative commercial switch which provides the 10GigE uplink capability can be found at GigE Switch with 10GigE Uplink.

For broadcasting data from the data concentrators, a 10Gigabit Ethernet switch is provided. While exact vendor and model are TBD, a representative data sheet can be found at 10Gig Switch.

8   CDS Operations Network

The purpose of the CDS operations network is to:

1) Provide interconnection of aLIGO operator stations, with connections to DAQ and EPICS Gateway computers.
2) Provide connection of LIGO auxiliary and legacy 'slow' control and monitoring systems. This would include the LIGO vacuum controls, weather station and dust monitors, etc.

The network design includes two 48 port switches, stacked to provide a total of 96 Gigabit Ethernet ports, as shown in the following figure. Along with the operator stations and auxiliary system computers, EPICS Gateway, DAQ Network Data Server (NDS) and CDS servers will be connected to this network. In this manner, operator stations will have access to EPICS and DAQ system data, as well as CDS file systems.
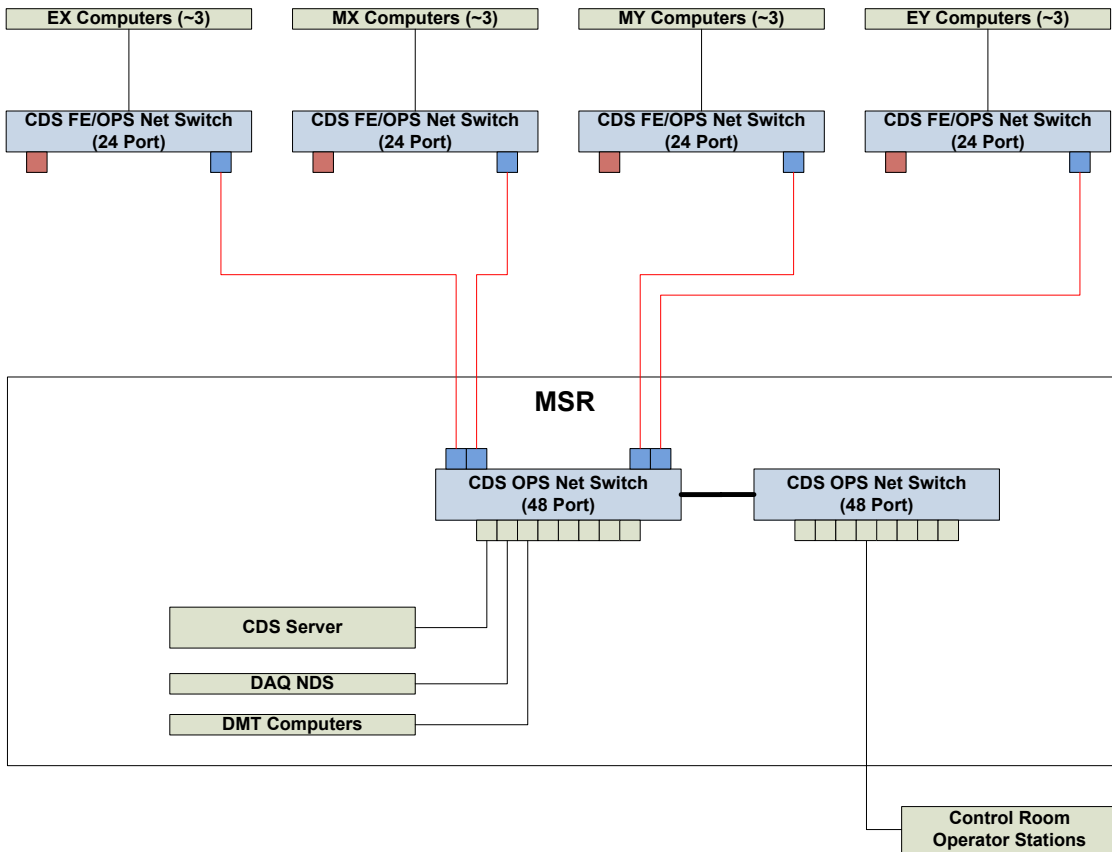

Figure 3: CDS Operations Network

9   Video Network

aLIGO will deploy approximately 30 GigE video cameras, per interferometer. Video information from these cameras must be made available to a TBD number of computers providing video analysis software. To support this, a separate Ethernet backbone is provided, as depicted in the following figure.

The same Gigabit Ethernet switches would be provided, as described in previous CDS network backbones. Similar to the DAQ network connection to the DAQ data concentrators, the final connection to the video processing computers will be via 10Gbit Ethernet links from a 24 Port switch. Information on a representative commercial switch can be found at 24 port switch w/10G uplink. To avoid exceptionally long runs from LVEA based cameras, in addition to the MSR switch, an 24 port switch will be provided in a TBD location.
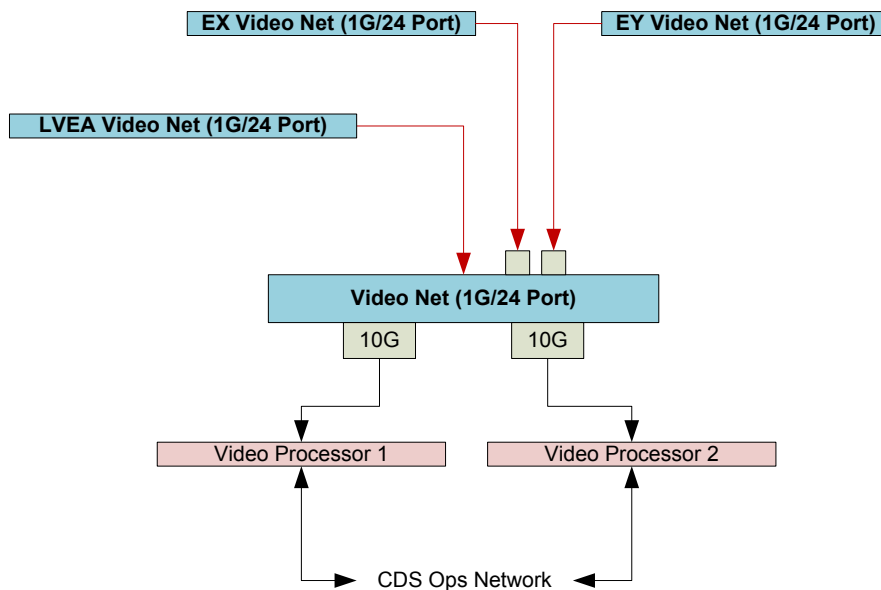
Figure 4: Video Network

10 Equipment Summary

10.1 Ethernet

The following figure depicts the composite Ethernet design for a single interferometer (exception of CDS ops net, which is per site). This figure shows primary, but not all, CDS computer connections. Note that mid station (MX/MY) equipment is only to be provided at the LHO site. The mid station DAQ network switches will only be provided if it remains a requirement to acquire PEM sensor data at those locations.
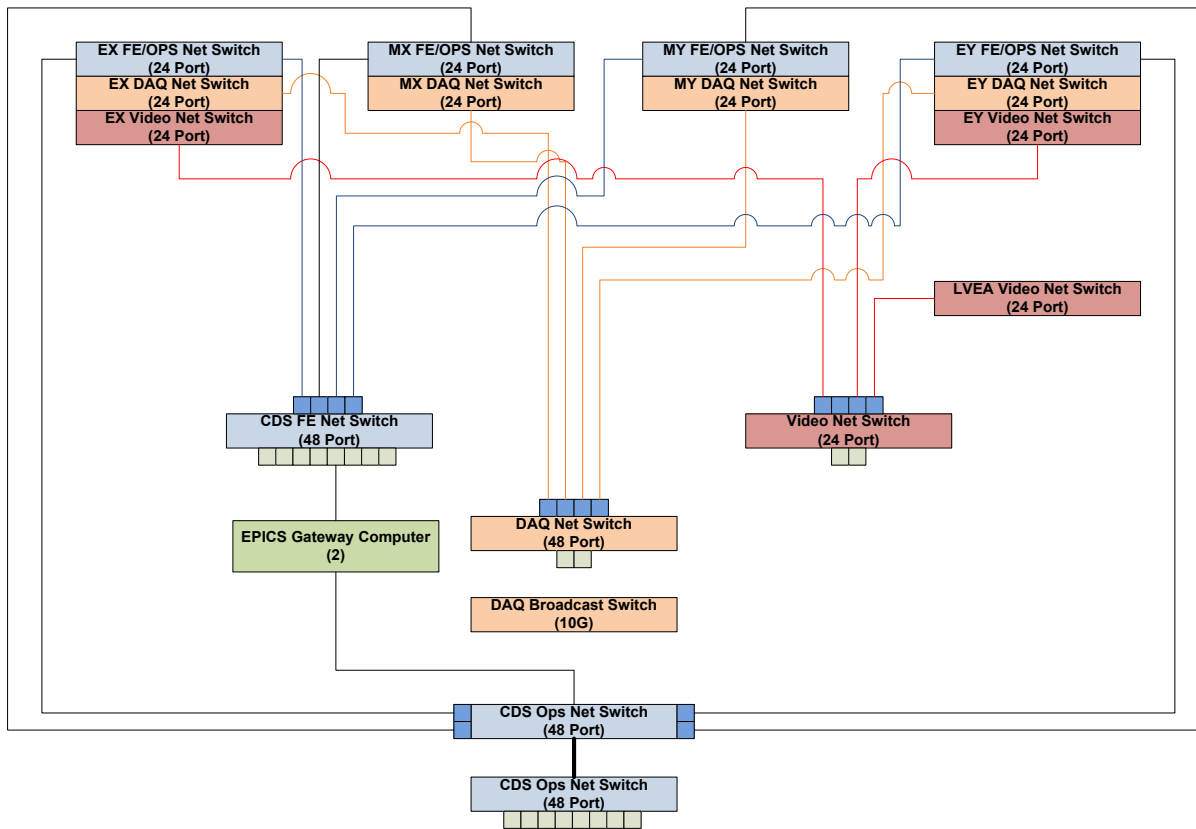

Figure 5: CDS Network Backbone Composite

11

The following table summarizes the equipment required to implement the CDS networking design.

Ethernet Equipment List				
Type	**Qty Installed**		**Qty (Spare)**	**Total**
	Per IFO	**Per Site**	**Per Site**	**Both Sites**
GigE Switch (24 Port)	7	4 (LHO mids)	1	27
GigE Switch (48 Port)	1	2	1	11
GigE Switch (24 Port) with 10GigE Uplinks (Video System)	1		1	5
GigE Switch (48 Port) with 10GE uplinks (DAQ System)	1		1	5
10GigE Switch (DAQ System)	1		1	5
Computer EPICS Gateway between FE EPICS net and CDS Ops Net	2		1	8

10.2 FE Control (real-time) Network

The following table lists the equipment to be provided for the FE Control Network.

FE Control Network Equipment List			
Description	**QTY** **Installed** **Per IFO**	**QTY** **Spare** **Per Site**	**TOTAL**
RFM Bypass Switch	4	1	14
PCIe Network Switch	3	1	12