LBT AO System
Network Layout

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ABSTRACT

This report contains a brief discussion of the network layout as required by the LBT AO System.

Contents

1 Introduction

Due to some limitations in the BCU implementation of the TCP/IP stack, and to the required throughput on the network connections, there are a few constraints on the network layout which may be used for the LBT-AO System.

In the following pages we discuss these constraints and suggest a possible network configuration which ensures proper functioning of the AO System.

2 Issues driving network design choices

The network layout described in the following pages is the result of design choices based essentially on two main issues.

2.1 BCUs Limitations

The Basic Control Unit (BCU) is the main building block for all the electronics used within the AO System. Notably BCUs are used as frame grabbers for the WFS CCDs, as Slope Computer, as controllers of the Adaptive Mirror actuators, and so on [1, 2].

They are provided with an Ethernet controller for all the housekeeping tasks, including diagnostics, and their internal firmware implements a subset of the UDP/IP functionalities.

The BCU ethernet based protocol is non standard in many aspects. Here is a brief list of the capabilities:

1. The BCU can reply to ICMP echo requests (*ping*), but this function, due to internal implementation details, is particularly heavy for the BCU. I.e.: ping must be used sparingly.
2. The BCU can reply to ARP broadcast requests (but see the following discussion).
3. The BCU can receive UDP packets not longer than ethernet MTU (i.e.: the payload cannot be longer that 1440 bytes). I.e.: the UDP implementation is not standard.

4. The BCU can send an unsolicited stream of UDP unicast packets containing diagnostic data. Anyway, because the client part of the ARP protocol is not implemented in the BCU networking stack, in order to allow the BCU to assemble the UDP packets the MAC address of the recipient must be set up previously as part of the startup configuration.

Tests in many environment conditions have shown that the BCUs are very sensitive to input traffic rate. An unusually large rate of input packets can fill up the input data buffers of the Ethernet interface and block the communication. After that, only a complete reset of the board can bring the Ethernet communication back to work.

The Supervisor code related to BCU communication has been designed to take into account this limitation and in the normal use the packet rate limit is never reached, but any other input traffic, such as broadcast packets (e.g.: ARP requests) or ICMP requests from other nodes is likely to fill up the input data buffers of the Ethernet port and block the communication.

In order to insulate the BCU's from unwanted traffic, together with dedicated ethernet controllers on the AO workstations, either VLANs or level 3 switching can be used, The latter approach has been adopted at LBTO.

Level 3 switching, although effective in normal conditions, does not prevent network nodes other than the controlling server to cause harmful traffic towards the BCU, such as ping requests or port scanning. For this reason a real level 2 VLAN configuration would be preferred. If this is not viable, the network setup must be carefully checked to verify that no harmful traffic is reaching the BCUs.

2.2 Network Performances

Network performances required by the diagnostic system, as detailed in a following section, are not far from the practical limits of the Ethernet technology, both for throughput and for communication delays. The use of dedicated ethernet controllers would provide the further benefit to optimize communication performances.

3 AO Network Architecture

The network layout for the AO Subsystem is shown in figure 1.

Notes to figure 1:

- The figure shows both the right and the left side of the telescope. The two sides are identical except for the assignment of IP numbers and device names. The figure shows the actual numbering used for the two FLAO systems deployed at LBTO.
- The dedicated fibers running between the WFS and the AdSec are indicated in the figure just for the sake of completeness. They transmit loop data from WFS to the corresponding AdSec with a dedicated protocol and are not involved in any ways in the present discussion.

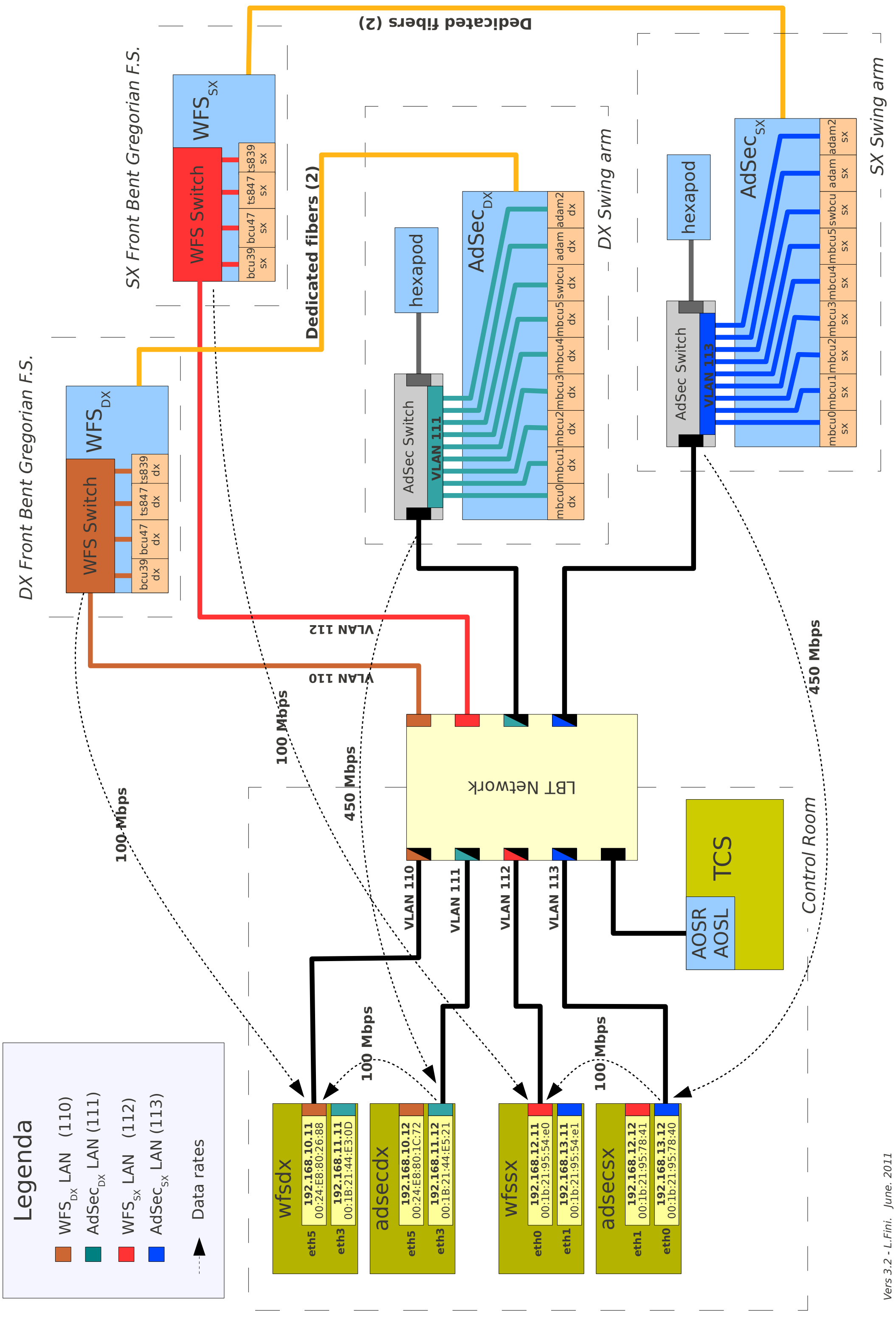

Figure 1: LBT-AO Network Layout

- The LBTO LAN in the figure is shown as a single central switch. This doesn't necessarily represent the actual topology and it is not part of the specifications in this document. It is only supposed that network traffic is properly managed between any Ethernet ports within the LBTO network.

From the point of view of network layout, each side of the AO System can be subdivided into four subsystems:

1. The **WFS Server**, the computer running the WFS subsection of the AO Supervisor. It must communicate with the AdSec Server and with the Wavefront Sensor assembly. It must also communicate with the workstations used as operator consoles.
2. The **AdSec Server**, the computer ruining the AdSec subsection of the AO Supervisor. It must communicate with the WFS Server and with the AdSec assembly. It will also be the host of the AO Arbitrator, i.e.: the Supervisor component managing communication with the AOS[1]. This requires, thus, a communication path with the TCS cluster. The same path is used also to communicate with the operator consoles.
3. The **Wavefront sensor** (WFS) which includes a few network nodes, all contained in the AGW crate at the focal station. The communication path is through an internal Ethernet switch (WFS switch).
4. The **Adaptive Secondary Mirror** (AdSec), which includes a small number of network nodes all located in the electronics boxes on the secondary swing arm. Here also network communication is based on an internal Ethernet switch (AdSec switch).

   The AdSec assembly, as shown in figure 1 includes the hexapod because the related controlled is hosted in the AdSec electronics box and thus the Ethernet line for the operation of the hexapod is from the AdSec switch.

All the following discussion will refer to the diagram of the network layout shown in figure 1. The throughput required by AO subsystem on various LANs is also indicated in the same figure[2].

4 Network Architecture Detailed Discussion

In figure 1 one may identify four "sensible" VLANs (two for each side): those which are dedicated to the communication with the AO hardware and are shown in color. A fifth VLAN is indicted in black and supports the communication between the two AO dedicated servers of each side and the communication with the TCS computers and operator consoles, the external access, etc.

More in detail:

1. WFS_{DX} **and** WFS_{SX} **LANs**[3] are dedicated to each Wavefront Sensor assembly.

[1]The AOS is the TCS subsystem dedicated to the communication between the TCS and the AO Supervisor.
[2]All values are expressed in Megabit per second (Mbps).
[3]Right side is LAN 192.168.10.0 on VLAN 110 and left side is LAN 192.168.12.0 on VLAN 112.

2. $AdSec_{DX}$ **and** $AdSec_{SX}$ **LANs**[4] are dedicated to each Adaptive Secondary assembly.

Note: there is no need of routing between the dedicated VLANs as defined here to support the communication paths used by the AO System. I.e.: All communications in WFS LAN are between the WFS Server and WFS devices, all communications in AdSec LAN are limited to AdSec Server and AdSec devices, and so on.

Routing is, instead necessary to allow the AO servers (ADSECDX, WFSDX, ADSECSX, WFSSX) to communicate with the rest of the LBTO network.

4.1 WFS LANs

WFS_{DX} and WFS_{SX} LANs are dedicated to the Wavefront Sensor subsystems. They include the Ethernet controller of the WFS Server and, through the WFS switch, the networked devices within the WFS (which include two BCUs and some commercial devices). A corresponding Ethernet controller on each AdSec Server is also configured on this same LAN, but is not used normally and may be left unconnected.

The indicated throughput (100 Mbps) is essentially due to diagnostic data from the WFS which uses the UDP protocol. The rest of the traffic (commands to the WFS using the TCP protocol) is negligible.

4.2 AdSec LANs

$AdSec_{DX}$ and $AdSec_{SX}$ LANs are dedicated to the Adaptive Secondary subsystems. They include the Ethernet controller of the AdSec Server and, through the AdSec switch, the networked devices into the AdSec assembly. Here 8 BCUs plus some other commercial devices are used. A corresponding Ethernet controller on each WFS Server is also configured on this LAN, but is not used normally and may be left unconnected.

The indicated throughput (450 Mbps) is essentially due to diagnostic data from the AdSec which uses UDP protocol. The rest of the traffic (commands to the AdSec using the TCP protocol) is negligible. Also negligible is the traffic due to the hexapod.

Note: In order to increase the available throughput for the diagnostic data, which would allow to avoid data decimation at the higher loop frequency, we are planning to explore the possibility to use *jumbo frames* in the AO network. In this case the capability of network devices involved in communication to support jumbo frames would be a must.

4.3 Diagnostic traffic between the two AO Servers

The WFS and AdSec servers must exchange a fairly large amount of diagnostic data during the AO operation. An UDP based data stream from the AdSec Server to the WFS Server supports this function.

The indicated throughput (100 Mbps) is exclusively due to this diagnostic data stream produced by `FastDiagnostic`.

[4]Right side is LAN 192.168.11.0 on VLAN 111 and left side is LAN 192.168.13.0 on VLAN 113.

5 Ethernet Switches

The required network architecture has some impact on the communication equipment used.

Each side of the AO system includes two ethernet switches, labeled in the drawing, respectively, as "WFS switch" and "AdSec switch".

5.1 The WFS Switch

The WFS switch is embedded in the AGW electronics box, but it only requires basic capabilities[5].

The current selection (D-Link DGS 1005D) does not provide management capabilities.

5.2 The AdSec Switch

The Adaptive Secondary assembly Ethernet switch is placed in the electronics rack hosted at the base of the swing arm. Because the same switch is used for hexapod communication, it must be configured to support two VLAN: the one associated with the AdSec LAN (111/113) and the one defined for the hexapod.

It has no special requirements regarding performances[6] but must cope with environmental specs.

The selected device is Cisco Catalyst 3750 [5]. Section 9 provides details about the configuration.

6 The AO Servers

The AO Servers are the computers hosting the AO Supervisor. They are indicated in figure 1 as WFS_{DX}/WFS_{SX} and $AdSec_{DX}/AdSec_{SX}$.

They are both equipped with at least two Ethernet controllers, one used for communication and the other as spare.

Note: Both AO servers are configured for communication with both AO subsystems (i.e.: the WFS and the AdSec). Only one of the two Ethernet controllers is used in normal operations on each server. The other is available to allow degraded operation in case of failure of one of the two servers[7]

[5]The only selection criteria are the physical dimensions and the environmental specs (see [3, 4])

[6]Due to bandwidth limitations in the implementation of the TCP/IP stack of BCUs, any Gigabit Ethernet switch should provide the required performances.

[7]The AO Supervisor software structure allows to operate both WFS and AdSec from a single server, albeit with degraded performances.

7 Communication bandwidth

The bandwidth needed for the AO System is essentially due to communication with the BCUs and is limited by BCUs throughput. Values, as shown in figure 1, are around 450 Mbps (Megabit per second) for the adaptive secondary[8] and 100 Mbps for the Wavefront Sensor.

As of this writing there are discussions ongoing about the possibility to obtain better performances for BCU data communication by using “jumbo frames”. If this solution could be pursued the bandwidth requirements for both subsystems would increase of about 80%.

8 IP numbers assignment

The range of numbers assigned to the AO system at the telescope includes eight class C LANs [6]:

```
192.168.10.x   192.168.11.x   192.168.12.x   192.168.13.x
192.168.14.x   192.168.15.x   192.168.16.x   192.168.17.x
```

In the current plan we will use **192.168.10.x** and **192.168.11.x** for the right side and **192.168.12.x** and **192.168.13.x** for the left side of the telescope.

As per LBTO specifications, the lower numbers of each class C LAN (192.168.x.1 through 192.168.x.10) are left free for system use.

The two servers supporting the Supervisor software have been named **wfsdx** and **adsecdx**, for the right side and **wfssx** and **adsecsx** for the left side.

In tables 1 and 2 all IP numbers assigned for AO system operation are listed.

9 Ethernet Switch Configuration

For the WFS switch no configuration is needed (actually id doesn’t support management!).

The AdSec switch must be configured to map its ports used for AdSec devices in the AdSec VLAN (111 for the right side, 113 for the left side) and to map the port used for the hexapod on the related VLAN

The same switch can then be further configured in order to allow to be managed as all the other switches in LBTO network (E.g.: it could have assigned an IP number of its own).

After some tests done in may 2011, the final setup of the network switch has been reached by using the ACL capability provided by Cisco Switches [7]. The insulation from external network traffic required by both the WFS and the AdSec devices is obtained by defining two access control lists named `AO-in` and `AO-out` which define the subset of IP numbers in the VLAN which can communicate with other VLANS.

[8] The bandwidth required by the hexapod is negligible.

Table 1: IP numbers assignment for right side

†: IP address of the MsgD-RTDB			
WFS Right		**AdSec Right**	
wfsdx -eth5	192.168.10.11	adsecdx -eth5	192.168.10.12
-eth3	192.168.11.11	-eth3	† 192.168.11.12
ts847dx	192.168.10.130	mbcu0dx	192.168.11.130
ts839dx	192.168.10.131	mbcu1dx	192.168.11.131
bcu47dx	192.168.10.132	mbcu2dx	192.168.11.132
bcu39dx	192.168.10.133	mbcu3dx	192.168.11.133
		mbcu4dx	192.168.11.134
		mbcu5dx	192.168.11.135
		swbcudx	192.168.11.140
		adamdx	192.168.11.150
		adam2dx	192.168.11.152

Table 2: IP numbers assignment for left side

†: IP address of the MsgD-RTDB			
WFS Left		**AdSec Left**	
wfssx -eth0	192.168.12.11	adsecsx -eth1	192.168.12.12
-eth1	192.168.13.11	-eth0	† 192.168.13.12
ts847sx	192.168.12.131	mbcu0sx	192.168.13.130
ts839sx	192.168.12.132	mbcu1sx	192.168.13.131
bcu47sx	192.168.12.133	mbcu2sx	192.168.13.132
bcu39sx	192.168.12.134	mbcu3sx	192.168.13.133
		mbcu4sx	192.168.13.134
		mbcu5sx	192.168.13.135
		swbcusx	192.168.13.140
		adamsx	192.168.13.150
		adam2sx	192.168.13.152

The current setting allows communication from/to the other VLANS for the IP numbers in the range `x.x.x.1` through `x.x.x.31`. All the remaining IP numbers can communicate with IP numbers of the same VLAN.

This implies that all the devices which must be protected from external traffic must have IP addresses in the range **x.x.x.32** through **x.x.x.254**.

10 Temporary settings during commissioning

10.1 Network configuration

During the commissioning of the AO system, the preliminary tests after reassembling at LBTO will be performed in the "Clean Room" and will require that the Supervisor software is up and running.

At that time the two switches quoted above (see section 5) will be located in the clean room, while the AO servers will be already in place in the Control Room.

Thus, at least temporarily, it is necessary that the LBTO network allows communication between the AO servers and the AO System devices as specified in the previous sections, in this configuration too.

10.2 ssh and X11 connectivity

During commissioning we foresee the need of random `ssh` connections to the IP LANs assigned to AO from PCs with X11 emulators both when in Clean Room and after installation at the telescope.

10.3 Access to AO private LANs (WFS LAN and AdSec LAN)

Sometimes it might be necessary to access the "private" AO VLANs (see sections 4.1 and 4.2) for debugging purposes. Such access should be supported by the LBT network configuration.

References

[1] Microgate S.r.l, "Adaptive Secondary Control System. Design Report", LBT CAN N. 640a006.

[2] Microgate S.r.l, "Adaptive Secondary Basic Computational Unit. Design Report", LBT CAN N. 640a009.

[3] Joar Brynnel,"LBT672 On-axis Wavefront sensor #1. Lab Acceptance Test Report", LBT CAN N. 687s001, July 2008.

[4] Joar Brynnel,"LBT672 On-axis Wavefront sensor #2. Lab Acceptance Test Report", LBT CAN N. 687s002, February 2009.

[5] Simone Esposito, Andrea Tozzi, Armando Riccardi, Roberto Biasi, Daniele Gallieni "FLAO Interface Control Document", LBT CAN 485f005e, March 2009.

[6] N. Cushing, "LBT Networks". Excel file named: `IP_Addressing-4-2.xlsx`, December 2009.

[7] Cisco Systems, "Catalyst 3750 Switch Software Configuration Guide", November 2004.

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