LBT-ADOPT
TECHNICAL REPORT

Doc.No : 485f004i
Version : 2.0
Date : 12 Nov. 2016

FLAO System
Network Layout

Luca Fini

CAN: 485f004i

INAF - Osservatorio di Arcetri
http://adopt.arcetri.astro.it/

ABSTRACT

Due to some limitations in the BCU implementation of the UDP/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 FLAO System. In the following pages we discuss these constraints and suggest a possible network configuration which ensures proper functioning of the FLAO System.

Contents

1 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: BCU limitations and required network performances.

1.1 BCU Limitations

The Basic Control Unit (BCU) is the main building block for all the electronics used within the FLAO 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 protocol stack.

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 very 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 the Ethernet MTU. I.e.: the UDP implementation is not standard in that the UDP message payload cannot be longer than 1440 bytes.
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 exceedingly 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 FLAO 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 can possibly 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 FLAO servers, 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.

1.2 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.

2 FLAO Network Architecture

The network layout for the FLAO 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 four new servers supporting the last FLAO version (often referred to as UAO), named `ao-wfsdx`, `ao-adsecdx`, `ao-wfssx` and `ao-adsecsx`.

  When the older servers (`wfsdx`, `adsecdx`, `wfssx`, `adsecsx`) are operational[1], they take exactly the same role as the new ones.
- 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.
- The LBTO Network in the figure is shown as a single central switch. This doesn't necessarily represent the actual layout 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.

[1]They are still used for some operational modes, e.g.: for LBTI operations.

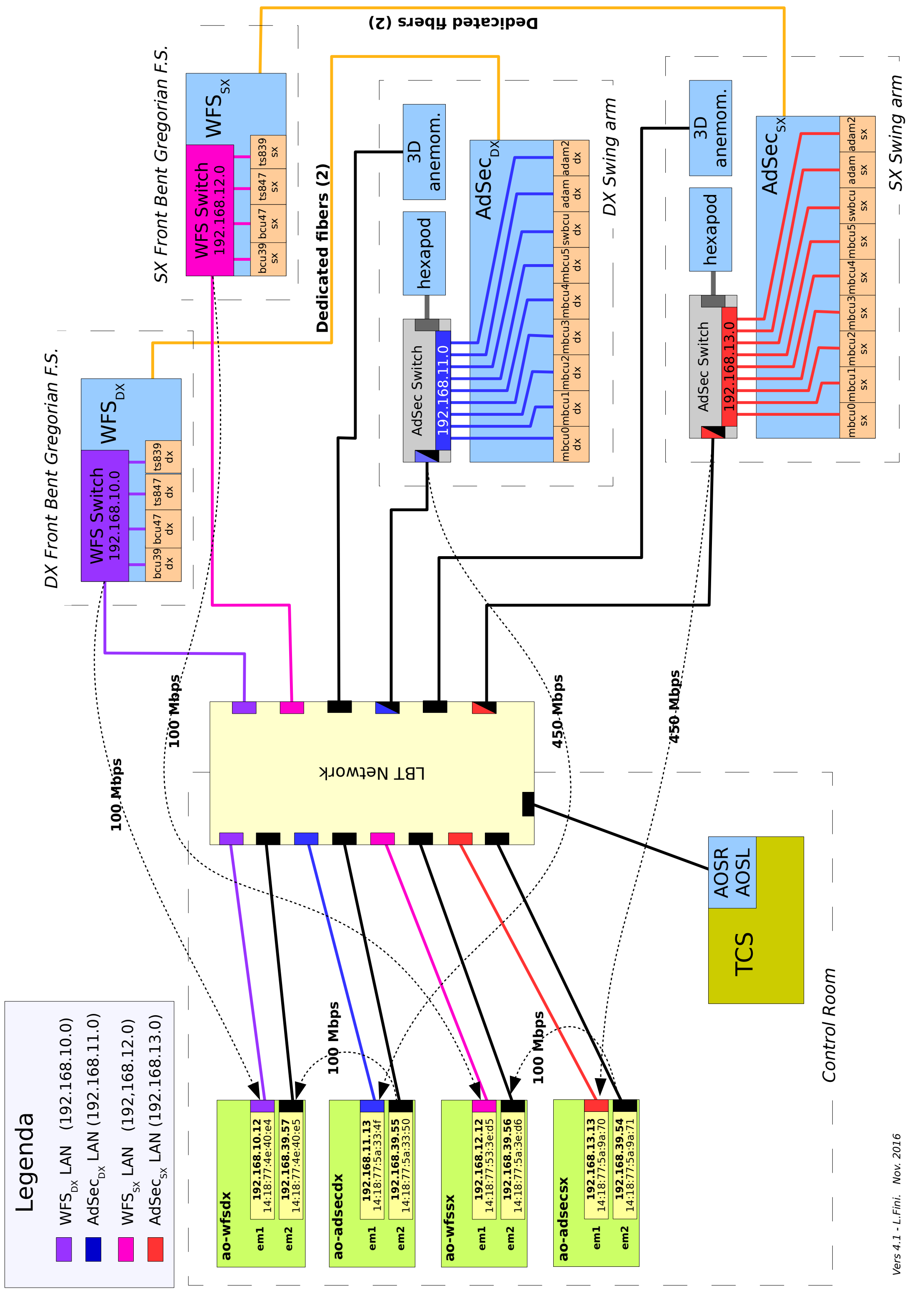

Figure 1: FLAO Network Layout

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

1. The **WFS Server**, the computer running the WFS subsection of the FLAO 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 FLAO Supervisor. It must communicate with the WFS Server and with the AdSec assembly. It will also be the host of the FLAO Arbitrator, i.e.: the Supervisor component managing communication with the AOS[2]. 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 includes an internal Ethernet switch (WFS switch) hosted in the AGW unit.
4. The **Adaptive Secondary Mirror** (AdSec), which includes a small number of network nodes all located either in the swing arm rack or in the electronics boxes in the adaptive secondary itself. The communication path includes an internal Ethernet switch (AdSec switch) hosted in the swing arm rack.

   The AdSec assembly, as shown in figure 1, includes the secondary hexapod because the related controller is hosted in the swing arm rack and thus the Ethernet line for the operation of the hexapod is from the AdSec switch.

   The AdSec assembly also includes an anemometer (usually referred to as “3D anemometer”). Although it is configured with network numbers outside the set assigned to the FLAO subsystem, it is included in the drawing (and in tables 1 and 2) because it is an integral part of the FLAO subsystem.

All the following discussion will refer to the diagram of the network layout shown in figure 1. The throughput required by FLAO subsystem on various LANs is also indicated in the same figure[3].

3 Network Architecture Detailed Discussion

As shown in figure 1 each FLAO server is provided with two Ethernet adapters, one is dedicated to the “private” traffic (shown in color in the drawing) and one for the generic communication paths (shown in black).

The private traffic is limited to communication between the server and the related hardware devices. The generic traffic is related to any other communication needs: data exchange between the AdSec server and the corresponding WFS server, ssh connections, network disk access, GUI operations and the like.

[2]The AOS is the TCS subsystem dedicated to the communication between the TCS and the FLAO Supervisor.
[3]All values are expressed in Megabit per second (Mbps).

3.1 WFS Private 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).

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.

3.2 AdSec Private LANs

$AdSec_{DX}$ and $AdSec_{SX}$ LANs are dedicated to the Adaptive Secondary subsystems. They include the private Ethernet controller of the AdSec Server, the AdSec switch and the networked devices into the AdSec assembly. Here 8 BCUs plus some other commercial devices are used.

The indicated throughput (450 Mbps) is essentially due to diagnostic data from the AdSec BCUs which uses the (subset) UDP protocol described in section 1.1. The rest of the traffic (commands to other AdSec internal devices using the TCP protocol) is negligible. Also negligible is the traffic due to the hexapod commands and to the anemometer data[4].

Note: In order to increase the available throughput for the diagnostic data, which would allow to avoid data decimation at the higher loop frequency, one could to explore the possibility to use *jumbo frames* in the AdSec private networks.

3.3 Diagnostic traffic between the two FLAO Servers

The WFS and AdSec servers must exchange a fairly large amount of diagnostic data during the FLAO 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 the `FastDiagnostic` FLAO process.

As indicated in the figure the network setup on the AdSec servers must ensure that the diagnostic data stream from the AdSec server and the corresponding WFS server uses the generic Ethernet interfaces.

4 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".

[4]Hexapod and anemometer are not part of the AdSec private LAN, but their traffic contribute to the network load anyway.

4.1 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.

4.2 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 private LAN 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 **??** provides details about the configuration.

5 IP Numbers Assignment

The range of numbers used by the FLAO system at the telescope includes four class C LANs [6]:

`192.168.10.x   192.168.11.x   192.168.12.x   192.168.13.x`

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

In tables 1 and 2 all IP numbers assigned for FLAO system operation are listed. Both tables also include IP numbers for the older FLAO servers.

6 Network Configuration in FLAO Servers and Clients

Resuming the above discussion of network related issues for the FLAO system, the following guidelines must be taken into account.

6.1 Routing configuration in FLAO Servers

The routing setup in FLAO servers must allow to "protect" the private Ethernet adapter from unwanted traffic.

Table 3 shows the relevant items from the `route` command for the FLAO servers.

Briefly, the default route must be on the generic Ethernet adapter, so that the private Ethernet adapter is used only for the IP traffic to the hardware devices.

[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.

Table 1: IP numbers assignment for right side

†: IP address of the AdSec MsgD			
WFS Right		**AdSec Right**	
wfsdx generic	192.168.39.53	adsecdx generic	† 192.168.39.52
ao-wfsdx generic	192.168.39.56	ao-adsecdx generic	† 192.168.39.55
wfsdx private	192.168.10.11	adsecdx private	192.168.11.12
ao-wfsdx private	192.168.10.12	ao-adsecdx private	192.168.11.13
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
		3Danemdx	192.168.18.163

6.2 FLAO System Clients

Clients connecting to the FLAO servers, such as the AOS, the ARGOS arbitrator, the FLAO engineering GUIs, etc., must be configured to use the “generic” interface. This is particularly important when the LAN infrastructure is operated via level 3 switches (as it is the case of LBTO LAN) because “private” IP numbers could be used inadvertently without causing communication problems, except for possible malfunctioning of BCUs as explained in Section 1.1.

Table 2: IP numbers assignment for left side

†: IP address of the MsgD			
WFS Left		**AdSec Left**	
wfssx generic	192.168.39.51	adsecsx generic	† 192.168.39.50
ao-wfssx generic	192.168.39.57	ao-adsecsx generic	† 192.168.39.54
wfssx private	192.168.12.11	adsecsx private	192.168.13.12
ao-wfssx private	192.168.12.12	ao-adsecsx private	192.168.13.13
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
		3Danemsx	192.168.18.164

Table 3: IP routing configuration for FLAO servers

Server	Destination	Gateway	Mask	IFace
ao-wfsdx	192.168.10.0	*	255.255.255.0	em1
	default	192.168.39.1	0.0.0.0	em2
ao-adsecdx	192.168.11.0	*	255.255.255.0	em1
	default	192.168.39.1	0.0.0.0	em2
ao-wfssx	192.168.12.0	*	255.255.255.0	em1
	default	192.168.39.1	0.0.0.0	em2
ao-wfssx	192.168.13.0	*	255.255.255.0	em1
	default	192.168.39.1	0.0.0.0	em2

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.

Doc_info_start
Title: FLAO System - Network Layout
Document Type: Specification
Source: Osservatorio di Arcetri
Issued by: Luca Fini
Date_of_Issue: 12 Nov. 2016
Revised by: L. Fini
Date_of_Revision:
Checked by:
Date_of_Check:
Accepted by:
Date_of_Acceptance:
Released by:
Date_of_Release:
File Type: PDF
Local Name:
Category: 400
Sub-Category: 480
Assembly: 485 Adaptive Optics System
Sub-Assembly:
Part Name:
CAN Designation: 485f004
Revision: i
Doc_info_end