



**MIL-STD-1553B "NETWORKING" TECHNIQUES FOR LOCAL  
AREA NETWORKS BASED ON M.A.R.A. AIRBORNE COMPUTER**

by

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**TENTH EUROPEAN ROTORCRAFT FORUM**  
AUGUST 28 — 31, 1984 — THE HAUGE, THE NETHERLANDS

## **A B S T R A C T**

MIL-STD-1553B, Time Sharing Multiplexed bus, is a military standard representing one of the basic instruments used for today's avionic systems integration.

Following this standard the management of the Remote Terminal Units connected to the 1553B avionic bus is typically devolved to the Bus Controller Unit which receives/sends informations from/to the various Remote Terminals, on a predefined sequence (polling mode).

Selenia 1553B utilization strategy, extends these concepts and allows the asynchronous data messages exchange through the bus and the allocation of a set of "FUNCTIONS" and "LOGICAL DEVICES" on a hardware configuration of "NODES" and "PHYSICAL DEVICES" connected by the 1553B bus.

The peculiar characteristics of the Selenia Networking Techniques assure the application software transparency to the network and the communication efficiency between functions belonging to different nodes of the same network. These performances have been conceived according to M.A.R.A. (SELENIA SL/AYK-203 airborne computer) networking requirements and implemented as natural extensions of the standard basic software already in use.

# 1. SL/AYK-203 ARCHITECTURE

## 1.1 Introduction

SL/AYK-203 is the avionic version of the Selenia M.A.R.A. computers family. M.A.R.A. is the acronym of "Modular Architecture for Real Time Applications". In fact we are not concerned with a computer or a system, but rather with a modular architecture, i.e. personalizable units which may be connected by means of a set of uniform principles in an extremely diversified way, with a high degree of flexibility.

In the M.A.R.A. design two aspects of the degree of modularity of a system have been considered as fundamental.

- the availability of a concentrated processing power modularly upgradable;
- the capability of physically distributing the subsystems of a system.

M.A.R.A. solution to these requirements defines uniform elementary units, capable of being combined in many ways, but without changing the basic philosophy.

## 1.2 Loose and tight coupling

In the SL/AYK-203 architecture are present both fundamental types of computer interconnections: loose and tight coupling.

These types of coupling can be met in hardware as well as in software.

From the H/W point of view, an SL/AYK-203 node may be a monoprocessor or a multiprocessor, i.e. with a common bus and a set of memories and I/O devices in common, so as to interface tightly with the other processors of the node configuration (fig. 1).

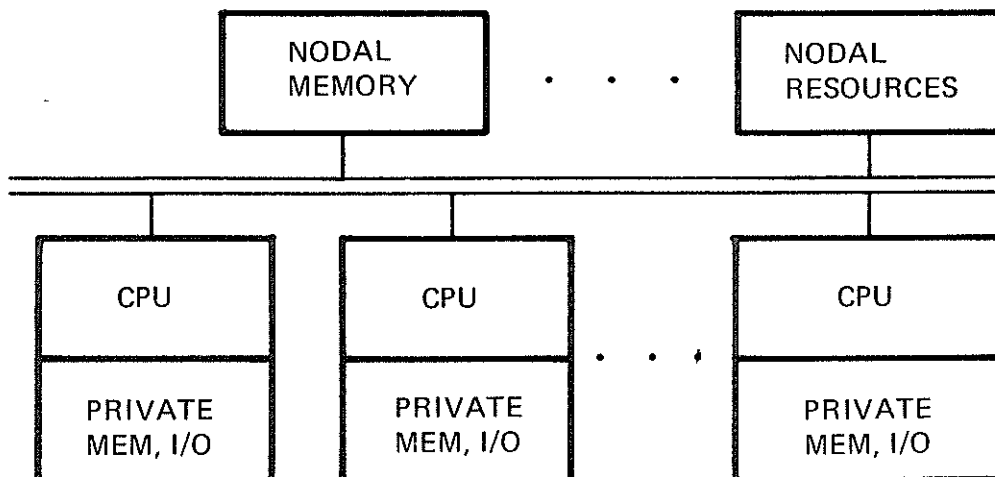
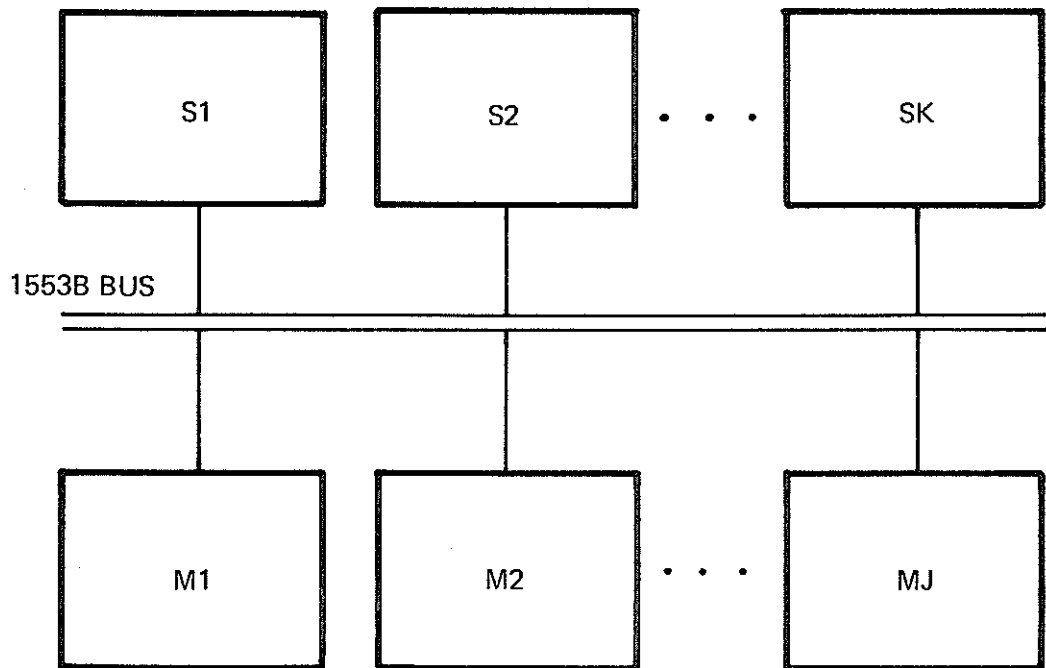


fig. 1 — SL/AYK-203 hardware architecture

However several SL/AYK-203 nodes may be connected through a 1553B bus to realize a local area network; in this way they interact in a loosely coupled mode (fig. 2).



$S_i$  = Single processor node ( $i = 1, K$ )  
 $M_i$  = Multiprocessor node ( $i = 1, J$ )

**fig. 2 — local network configuration**

Similarly, from the S/W point of view, the same type of collaboration exists between tasks. So the "Tight" connection allows the parallel tasks to have a direct visibility of the common resources and gives the application programmer the possibility of managing those resources. This type of collaboration is allowed in a mono or multiprocessor node.

If the collaborating tasks are splitted in several nodes of a network, a type of collaboration defined to as "loose" is realized. It requires that the parallel tasks do not have objects in common, but they collaborate exclusively by means of messages exchange or by means of explicit resources managers, which hide to the users the inter-computer communications.

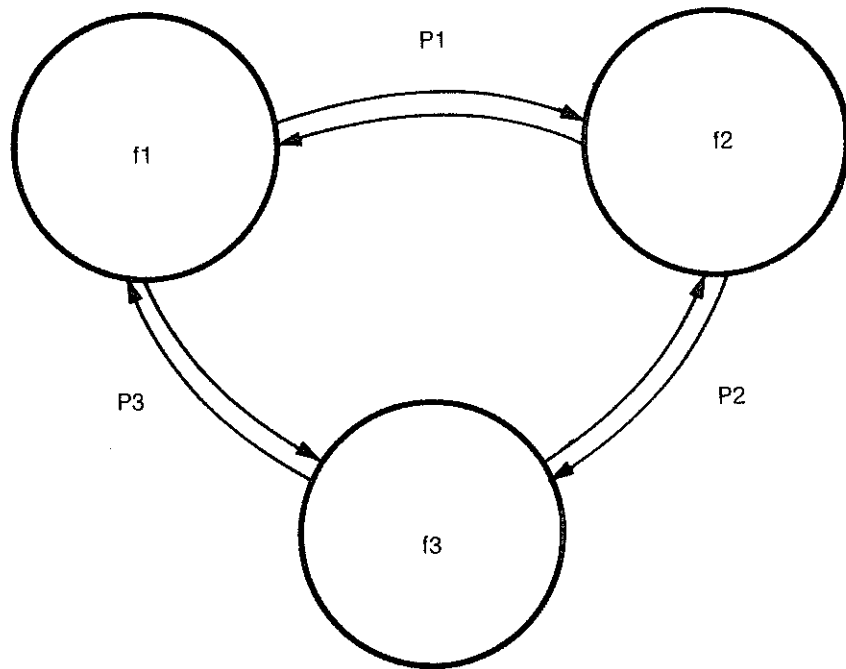
## 2. NETWORKING

### 2.1 Physical and virtual nodes

The whole SL/AYK-203 application S/W is organized as a number of FUNCTIONS. Each function is a set of programs, tasks, data structures, considered by the designer as operatively homogenous and tightly interconnected (virtualization of a node). A function (virtual node) cannot be distributed between more than one physical node, but a physical node may support several functions.

The functions communicate one another by means of SL/AYK-203 executive services which allow the exchange of messages via a "path network".

A path is a simple virtualization of a classic point-to-point full duplex communication line (fig. 3). The most important advantage of this standardized interface between functions (paths) is the possibility of performing interfunction communications independently of the physical functional allocation.



**fig. 3. — paths between functions**

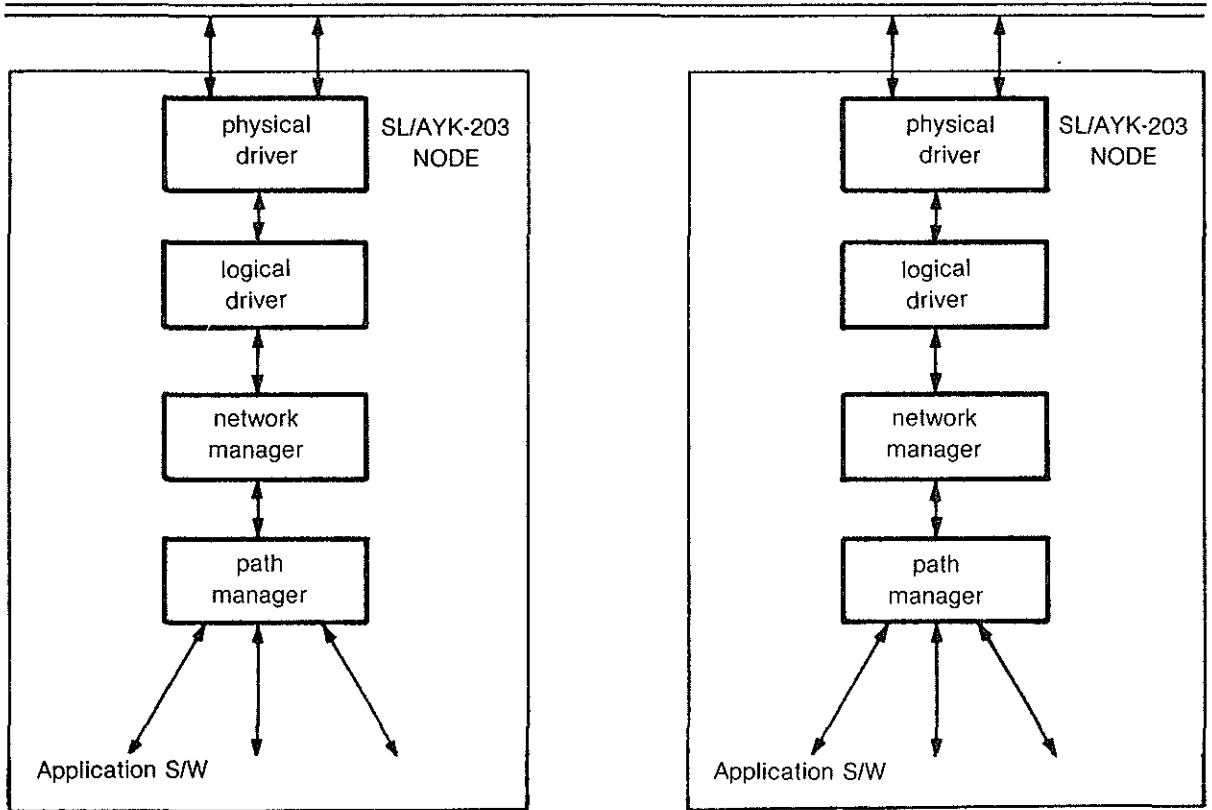
In other words an absolute separation between the physical structure of the system and functional one has been realized with the great advantage of locating several virtual nodes on the same physical node or of distributing them on a network configuration, in a way completely transparent to the application programmer.

The operating system service which manages the interfunction communications is called "path manager".

Each SL/AYK-203 physical node of the network contains the following operating system services

- path manager
- network manager
- logical driver
- physical driver

which are related according to the following architectural scheme (fig. 4).

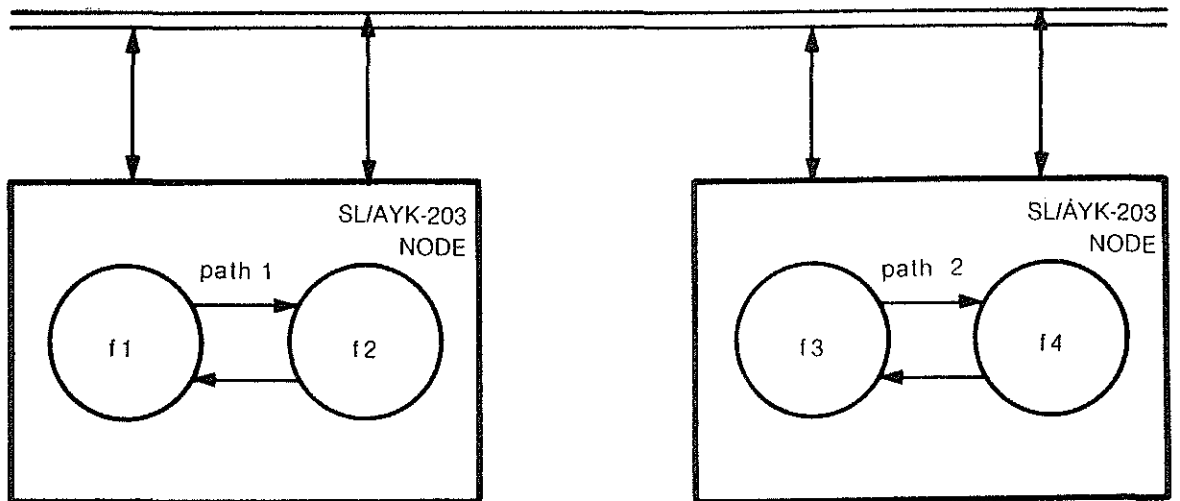


**Fig. 4 — networking software organization**

When an application function must exchange messages with another function of the network, it simply asks the "path manager" for a virtual full duplex communication line: "path". It doesn't matter what is the physical allocation of the application functions.

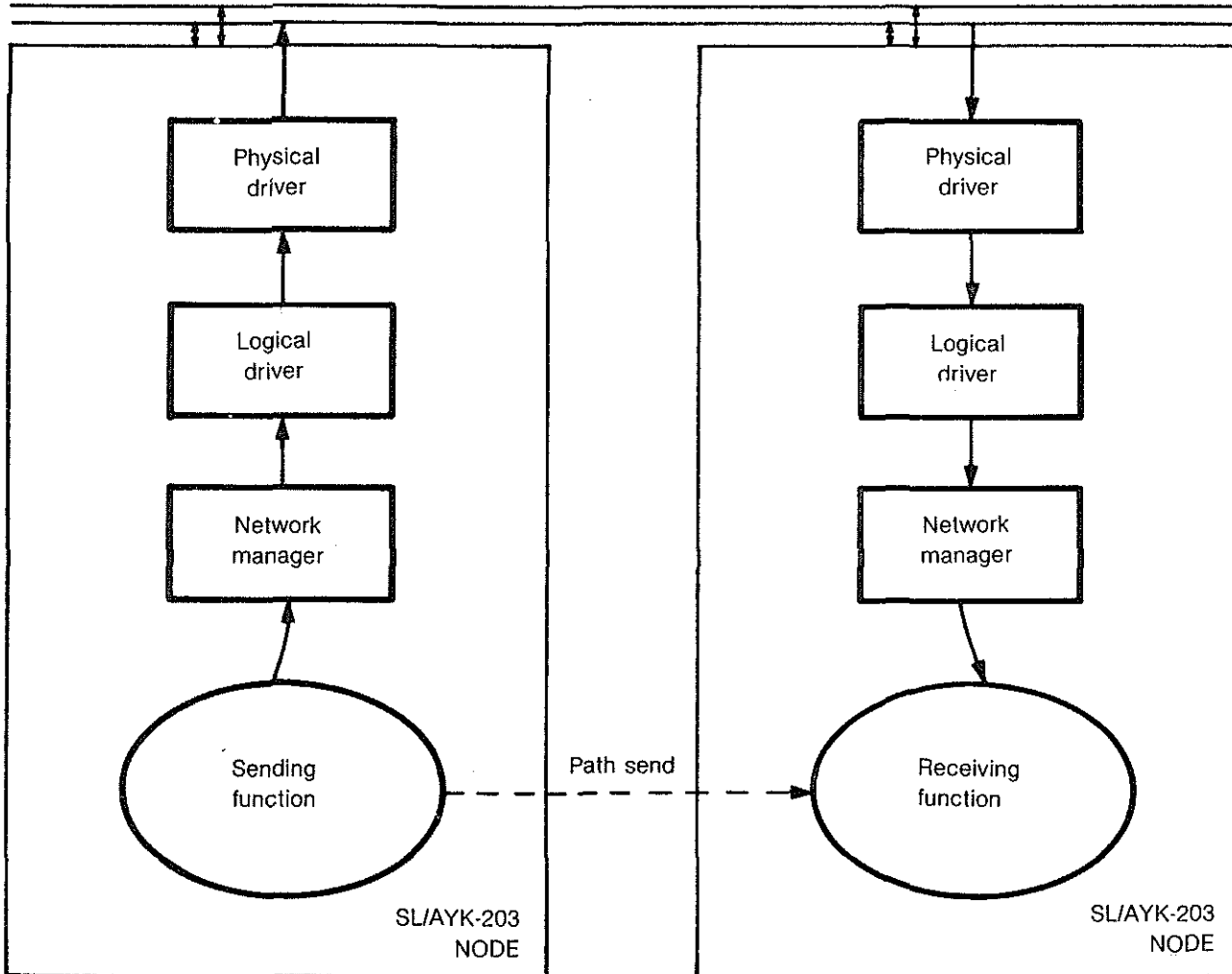
If the two path-connected functions belong to the same logical node there is no intervention of the network manager and the two functions are directly connected (fig. 5).

1553B



**fig. 5 — Intra-node communications**

The other way round, if the two functions to be connected are allocated on two different physical nodes of the network, all the above mentioned software packages are interested in the data exchange.



**fig. 6 — Internode communication**

Fig. 6 shows the routing of a message sent by a function of a physical node which is received by a function located on another physical node connected to the 1553B bus.

In this case the "path" is a virtual communication line through the 1553B bus.

## 2.9 Network management service

This operating system service is repeated on all the network nodes. The network manager handles all the communications between virtual nodes not belonging to the same physical node.

Two virtual nodes that have to exchange messages (between one another) ask the Path Manager for the creation of a "path" at the moment of the software system initialization.

A virtual node asks for the communication with another virtual node through a path logical name, without knowing the physical allocation of the partner function. The network manager only knows the physical allocation of the functions into the nodes of the network; in this case it is the service that, in case of internode communication, transforms a logical addressing in a physical routing through the 1553B avionic bus.

### 2.3 Network logical driver

The Network logical driver makes the exchanges of messages not dependent from the data-link physical characteristics.

It handles the high level logical protocol by formatting the messages according to the physical driver characteristics, by queuing multiple requests of buffers transmission, and by receiving messages from other network physical nodes.

Logical driver performs as well a message error handling by providing a set of techniques for message repetition, in case of recoverable errors, or of error signaling to the node supervisor in case of fatal error detection.

### 2.4 1553B physical driver

The 1553B physical driver is a S/W package which manages the 1553B H/W interface module. The driver is designed to work in a multiprogrammed environment both in the presence or in the absence of the above mentioned networking mechanisms.

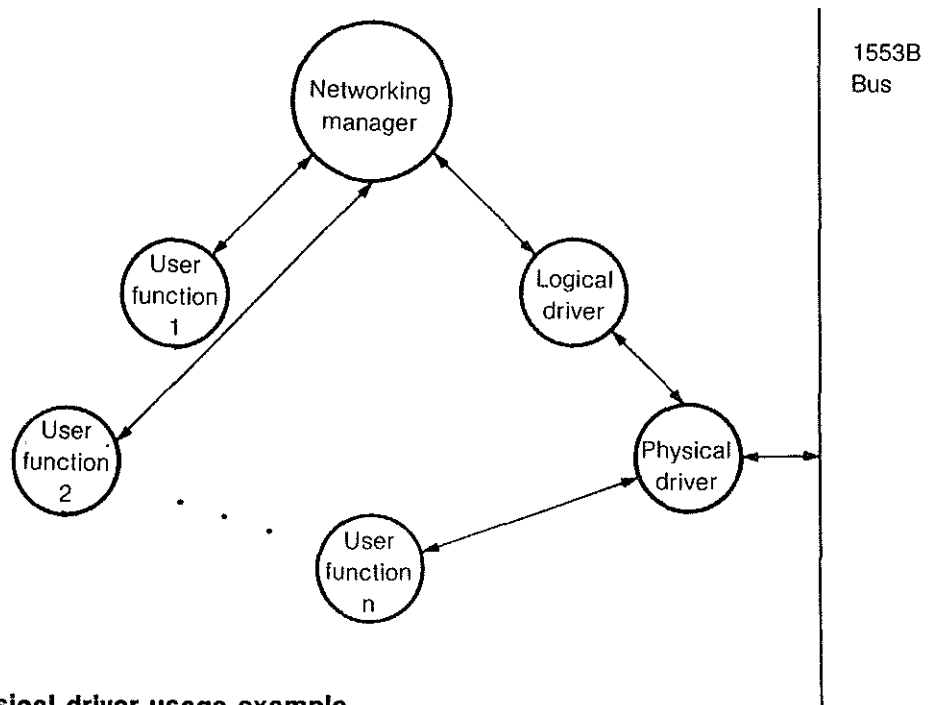


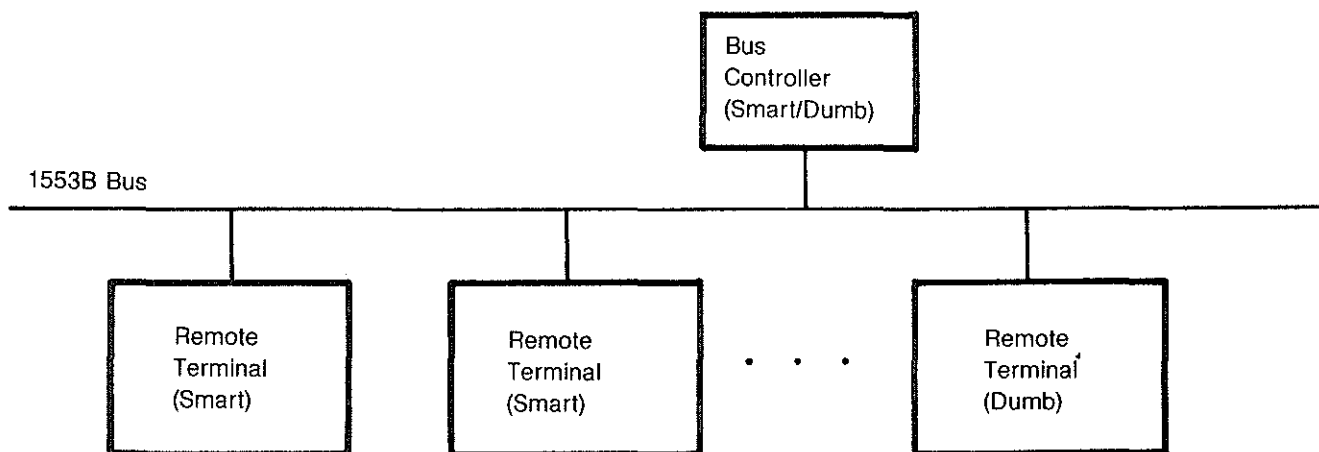
fig. 7 — physical driver usage example



The driver has been designed to be used by "n" users at the same time (in a multiprogrammed environment).

A typical example is showed on fig. 7 where the physical driver is called both by the logical driver for the networking techniques and directly by the application users who want use the 1553B without passing through the networking mechanisms.

Fig. 8 shows a typical example of an avionic system where, on the same bus, both "smart" and "dumb" units are present at the same time. The Remote Terminals supporting networking mechanisms are called "smart" nodes, while all the other are called "dumb" nodes.



**fig. 8 — avionic system typical example**

In this case the application functions which communicate with dumb nodes, must directly access the physical driver module, without using the networking services.

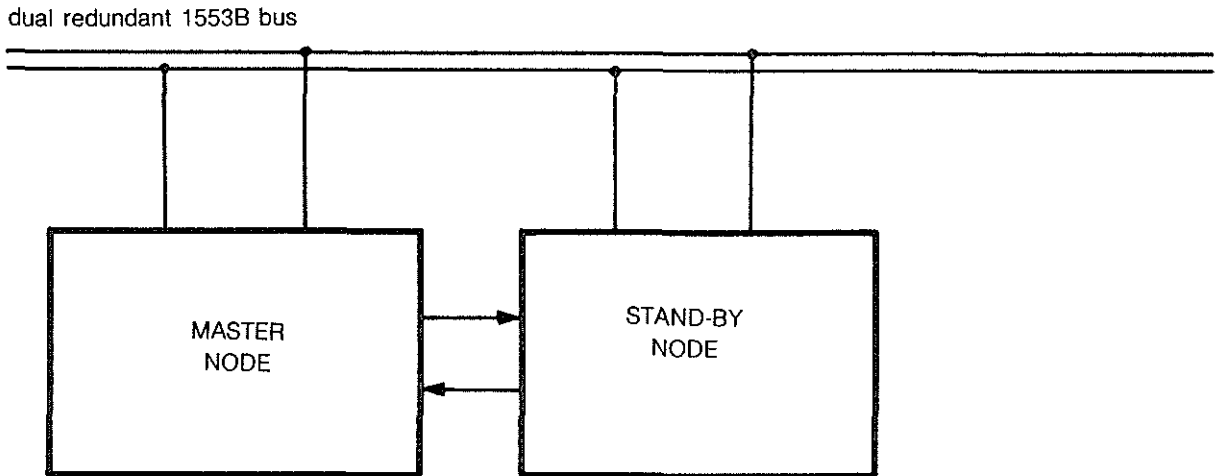
### **3. FUNCTION DISTRIBUTION**

#### *3.1 Matched pair*

With the scheme of fig. 8. it is possible to distribute the functions of a software system among various Remote Terminal nodes (smart RT) and the Bus Controller (smart BC) based on SL/AYK-203 computers, to increase the system processing power and, at the same time, the system reliability.

In fact if all the functions of a system are located in one computer (mono or multiprocessor) this computer is the bottleneck of the system reliability and a computer fault gets the fault of the entire system.

Naturally in this case a dual-computer configuration for the system is possible: a master node and a hot stand-by node in a matched pair configuration.

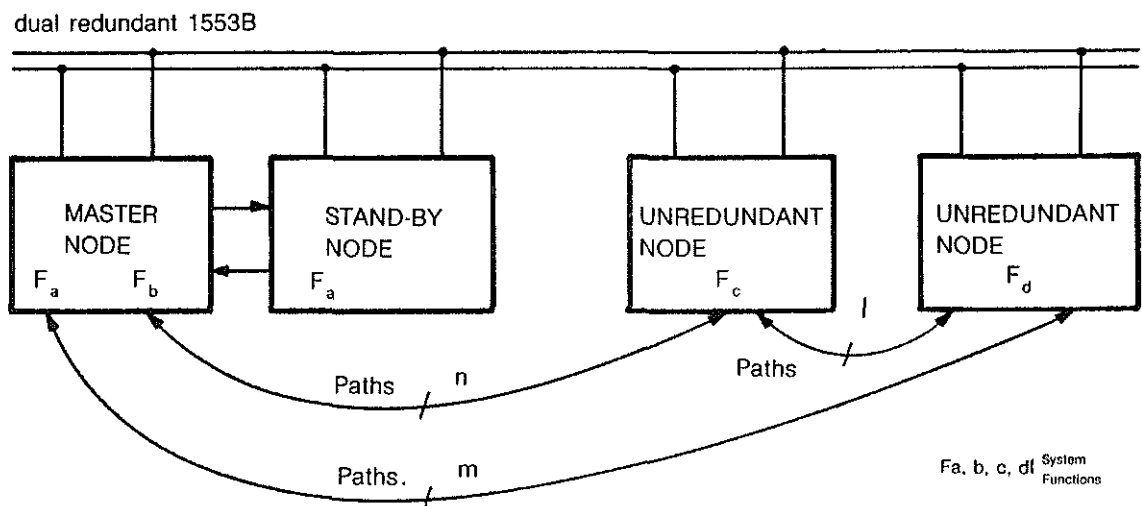


**fig. 9 — a matched pair configuration**

However in this case a fault of only one function causes the total system reconfiguration by means of a master/stand-by role switching.

### 3.2 Local area network (LAN)

The alternative to this solution is to spread the "m" functions of a system over a certain number of physical nodes with a stand-by node for a number "n" of critical functions only: n/m redundancy (fig. 10).



**fig. 10 n/m redundant configuration**

The above explained "path" concept, as virtual communication line, allows both solution. In fact the first case (matched-pair configuration) requires no networking intervention, while the second one (n/m redundant configuration) is a typical local area network example. In this case the redirection of the physical routing of the paths, when a master processor fault occurs, is care of the above mentioned "Networking service", with no application software intervention and no change in the logical path names.

Owing to the standardization of the interfunction communications by means of "path" mechanisms it's possible to define in an independent way the system H/W configuration and the application software functional architecture. This approach allows the software designer to ignore the detailed H/W needs during the project functional architecture definition. In this way, the software designer can transfer his attention to the abstract model of the problem solution in order to obtain the best quality in the software design.

#### 4. 1553B UTILIZATION STRATEGY

##### 4.1 Improvement for LANS

In the typical usage of the 1553B avionic bus the Bus Controller (BC), on a predefined and fixed sequence, orders each Remote Terminal (RT) to transmit a data block (subaddress) on the bus or to receive it from the bus (fig. 11).

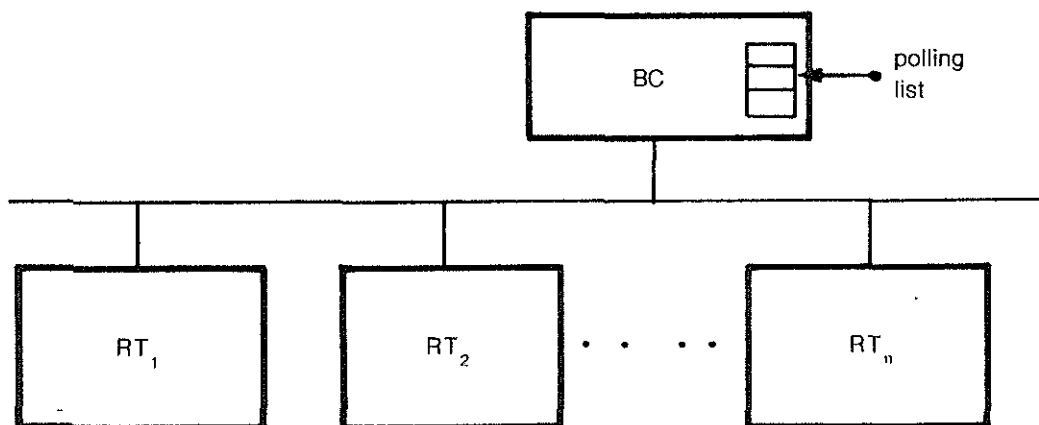


fig. 11 — 1553B network system

So the Remote Terminals must respect the communication sequences and timings established during the system configuration phase.

The Selenia implementation of the Bus Controller and Remote Terminal interfaces extends, also respecting the standard MIL-1553B, this commonly used philosophy to allow the following features:

- Each RT may exchange data block of variable size with every other RT (or BC), according to its real needs and not in the periodical way usually embedded in the BC unit;
- two types of information may be exchanged on the bus:
  - slow information which can be queued (transmitted or received through "path").
  - fast information which don't require a queuing.
- the transmission request may be started both from the Remote Terminals and the Bus Controller.
- the paths opened between the nodes of the network are unknown to the Bus Controller.

#### *4.2 Typical timing*

Fig. 12 shows the time necessary for the end-to-end transmission of a 32-word (16 bit) using path between two nodes with absence of bus traffic.

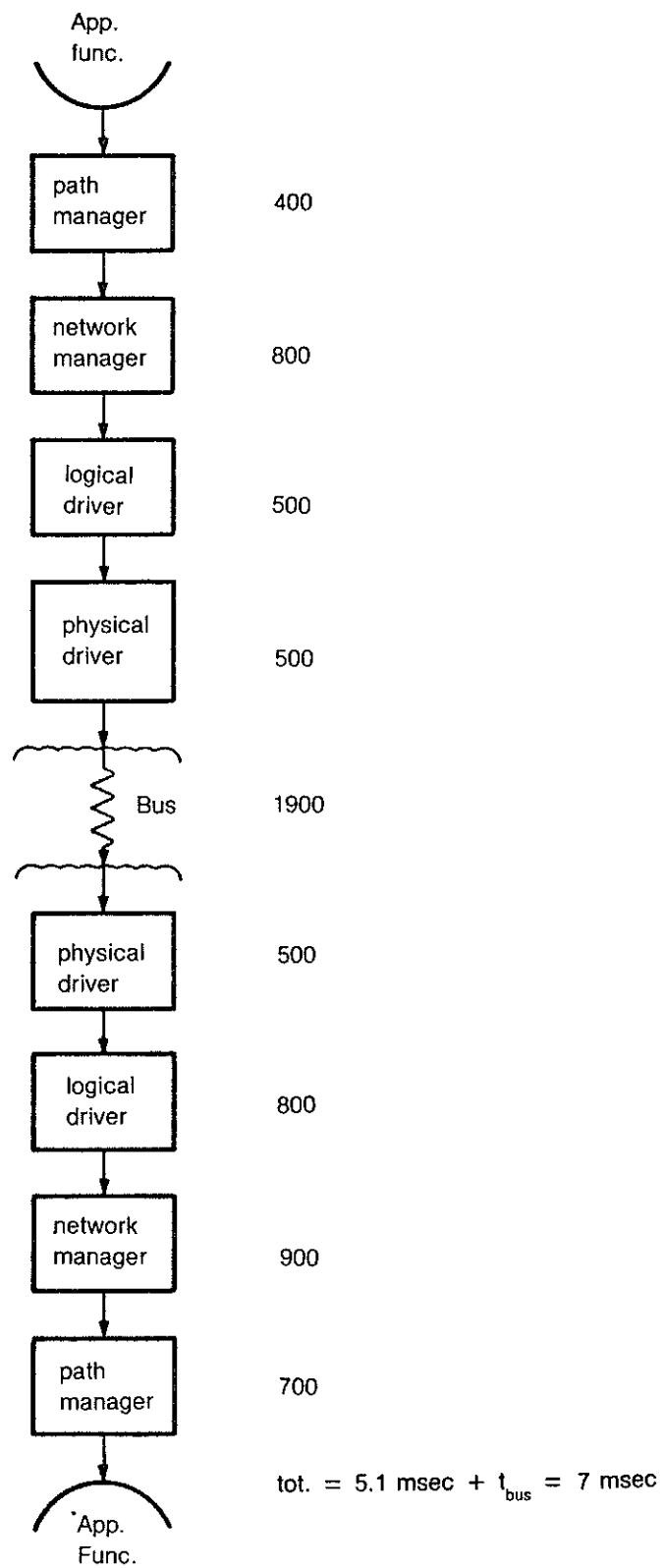


fig. 12 — data block transmission time

## CONCLUSION

The standard 1553B operating mode compells intelligent units (computer nodes) eventually connected to the bus as Remote Terminals to respect the communication sequence and timing embedded in the Bus Controller and established during the system configuration phase.

SELENIA implementation of the Bus Controller and Remote Terminal interfaces extends this generally used philosophy. It allows any software application function (resident on a generic intelligent Remote Terminal) to perform logical "connections for data communication" with any other software function of the network system, independently of the functions physical allocation. Using this technique an avionic software system can be implemented without knowing the physical hardware configuration. This results in a significant increasing of the system configurability.

In addition this philosophy permits also the use of the non-intelligent Remote Terminals in the conventional mode.

By means of SELENIA approach, the asynchronous software request of data exchange between nodes may be generated in real time by the application programs embedded in the computer based Remote Terminals. Such operating mode permits the implementation of distributed computing systems using several Remote Terminals as computing nodes connected to the 1553B Bus. These nodes can operate each other using general "networking" access techniques (Local Area Network).

The above mentioned networking technique permits new system solutions, promising a more efficient and flexible utilization of the devices connected to a 1553B avionic bus.