Interconnecting Field-buses through ATM

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Abstract: Networks in the area of factory automation, named field-buses, have been developed to fulfill real-time requirements. However, they can only cover areas such as factory halls or buildings. This paper describes a model for a internetworking unit connecting field-buses via ATM networks, in order to break these limits. A remote bridge is used to span longer distances between field-bus components in a separated field-bus. The second version of a bridge acts like a multiport bridge connecting several independent field-buses. The emphasis is laid on the investigation to the quality of service requirements the transport channel provided by the ATM network has to meet. By means of the wide spread field-bus PROFIBUS, standardized by the German standardization office, the implications for real-time applications and the system behavior are considered.

1 INTRODUCTION

Communication networks are used for very different purposes. The popularity of the Internet, for example, is constantly growing and real-time communication support is increasingly required in the Internet. However, it has not been designed for real-time applications. The emerging ATM technology - as networking infrastructure - and new protocols at the network layer and above may enable an Internet that is capable of supporting real-time applications.

In contrast to the Internet, networks in the area of factory automation have been developed with the specific requirement of tight real-time capabilities. Those networks are typically used in industrial environment. They have been named field-buses. Generally, field-buses can be categorized as local area networks. However, many different types of field-buses co-exist, ranging from very small and primitive networks that are usually installed in cars (e.g., CAN [1]) to more sophisticated networks used for factory communication (e.g., PROFIBUS [2]). This results in a wide diversity of applications that are served by field-buses. However, they share the requirement of very tight timing conditions.

This paper focuses on field-buses for factory communication. Smaller and more dedicated field-buses as, for example used in cars, are not directly addressed. With respect to factory communication, field-buses must be capable of covering a physical area, such as a medium to large factory hall or a complete factory building. Thus, they are - to some extent - becoming comparable to traditional local area networks with respect to geographical extension. Generally, field-buses are derived from traditional LAN technologies. Since field-buses are limited to the local area and since they serve a dedicated range of applications, a „thin“ protocol stack is sufficient [3]. Internetworking and specific transport protocols are not needed since communication takes place on a single dedicated link. Removing protocol layers also leads to potentially more efficient systems. This is strongly required for real-time communications with very tight timing requirements.

Field-buses have to handle deterministic response times for time critical processes being part of factory and building automation and production technology. A prominent example - at least in Europe - is the PROFIBUS. Recently, an increasing demand for additional services (e.g. management) on field-buses can be observed. Furthermore, the interconnection of different field-bus-islands is required. A typical example can be seen in traffic flow management at highways or within cities.

ATM could be used as underlying networking technology for a new generation of field-buses. Moreover, it could be used to interconnect different field-buses.

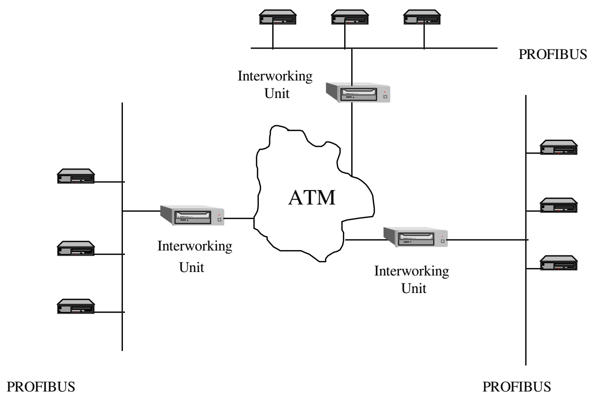

Figure. 1 Interworking PROFIBUSes through ATM

Since the emerging ATM technology is discussed with respect to a variety of networks (e.g. wireless, cable networks), we investigate its usage in the context of field-buses. Figure 1 depicts a scenario with field-buses that are interconnected through ATM. ATM is especially interesting, since it provides a variety of services. Thus, using ATM links to interconnect different field-buses can break the limits of nowadays field-buses. Currently, the longest distances between two field-bus devices is in the order of few kilometers only. The control panel for a production plant has to be situated near the technical process. The longer the distance the lower has to be the data rate. Due to this, each production process, i.e., an assembly line, has its own controller unit. It is difficult or even impossible to centralize administration tasks. To split up a field-bus and connect the parts via an ATM link breaks up the distance-limitations of existing field-buses. On the other hand summarizing two or more independent operating field-buses to one system enables a centralized controlling.

This paper is structured as follows. Section 2 introduces the main issues related to interworking of field-buses. Particularly, special aspects of field-buses are discussed. Section 3 describes the model of a virtual PROFIBUS consisting of separated segments interconnected through an ATM network. An approach for interconnection of independent operating PROFIBUSes through ATM is introduced in section 4.

2 INTERWORKING FIELD-BUSES

The basic scenario of interconnected field-buses is depicted in figure 1. It shows an ATM network with multiple interworking units attached to it. Generally, two different interworking scenarios can be distinguished:

- a virtual field-bus, or
- autonomously interconnected field-busses

Both approaches will be discussed within this paper. The corresponding interworking unit will be presented in some detail. Their characteristics are highly dependent on the field-bus technology and on ATM. Furthermore, the required QoS support influences the design. In the case of a virtual field-bus all relevant packets from one segment are forwarded to all other segments belonging to the same field-bus. Especially, timing requirements of the field-bus are extended to the virtual field-bus. The approach is somewhat similar to virtual LANs [4],[5].

Autonomously interconnected field-buses operate completely independent from each other. The approach more or less complies to traditional bridged networks. Routing is not further considered since field-buses do not have a network layer. Furthermore, timing requirements are extended across the overall network including the ATM portion.

Before discussing these two approaches in some detail, the relevant properties of the involved components (i.e., field-bus, ATM and interworking unit) are outlined.

2.1 Field-buses

Field-buses have been derived from traditional LAN systems with the objective to design a more efficient communication system that provides real-time capabilities. In order to achieve this a „thin“ protocol stack is needed. Thus, most field-buses only implement layers 1, 2 and 7 according to the OSI reference model. This leads to less protocol overhead and, thus, to faster

	Virtual PROFIBUS	Bridged PROFI-BUSes
Bridging Model	Remote Bridge	Multiport Bridge
Interconnected segments in basic model	2	2
Interconnecting more than 2 segments	yes	yes

Table1. Interworking models

processing within field-bus devices. Furthermore, packets in field-buses are typically very small compared to traditional data networks. They mainly contain only a few bytes representing an integer state variable of a technical process, as an example.

Typically, three traffic classes of packets are distinguished within field-buses:

- periodically generated real-time traffic,
- randomly generated real-time traffic, and
- non-real-time traffic.

Periodical real-time traffic is generated by data acquisition tasks. Control tasks and sporadic events (e.g., an alarm) generate real-time traffic at random points of time. Finally, non-real-time traffic typically relates to file transfers in order to upload data bases.

Real-time traffic requires deterministic media access. Thus, the use of field-buses under real-time conditions implies the provision of maximum waiting times for applications, even in worst-case scenarios. Therefore, special attention has to be paid to quality-of-service parameters, such as transmission delay, response time and throughput. The media access mechanism of a field-bus needs to ensure these QoS parameters. Thus, PROFIBUS [2], the example that will be considered throughout this paper, uses a token passing method and distinguishes between master and slave devices. The more complex master devices (e.g., controllers) take part in token passing and are allowed to initialize data transfers, whereas slave devices (e.g. sensors) react to data requests. As opposed to traditional data networks, PROFIBUS is parameterized according to its operational configuration. Dynamic changes in the configuration are unusual and require re-parameterization. Before a PROFIBUS system will be implemented its devices are initialized with global parameters, i.e., station address, token target rotation time and control timers, based on the application purpose. A connection list, residing in each station, contains its pre-defined communication relations to other devices, including both masters and slaves. This more ore less static configuration allows for a deterministic behavior of a PROFIBUS network. Moreover either forecasting the duration of message cycles consisting of a request from a master and the

immediate response from the requested slave device or fast reactions to alarms become available.
In the following we describe some timing aspects of PROFIBUS that are relevant to further considerations.
During a message cycle T_{MC} an addressed station has to respond within a bounded time interval.

$$T_{MC}=T_{S/R} + T_{SDR} + T_{A/R} + T_{ID} + 2*T_{TD} \quad (1)$$

$T_{S/R}$: Send/Request frame time
$T_{A/R}$: Acknowledgment/Response frame time
T_{SDR} : Station delay responder
T_{TD} : Transfer delay
T_{ID} : Idle time

In a PROFIBUS system the token-cycle-time T_{TC} calculates as follows:

$$T_{TC} = T_{TF}+T_{TD}+T_{ID} \quad (2)$$

T_{TF} : Frame time
T_{TD} : Transmission delay
T_{ID} : Idle time

The token-target-rotation-time is one of the parameters defined during the design phase of the PROFIBUS-application. It equals the system response time and is determined by

$$T_{TR}= na* (T_{TC+} \text{high } T_{MC}) + k * \text{low } T_{MC} + mt * T_{MC} \quad (3)$$

na : Number of active stations (masters)
k : Number of message-cycles with low priority
T_{TC} : Token-cycle-time
T_{MC} : Message-cycle-time
mt : Number of retransmissions

In order to ensure system stability, PROFIBUS uses control timers. The most important is the slot-time T_{SL} : the maximum time the requester waits for the response during a message cycle before initializing a retransmission.

$$T_{SL} = 2 * T_{TD} + \max T_{SDR} + 11 \text{ Bit} + T_{SM.} \quad (4)$$

T_{SM}: safety margin.

A second control time taken into account is the time-out-time, which is derived from slot time. If the time-out-time is reached, the bus is assumed to be inactive and the system has to be restarted.

2.2 ATM networks

ATM [6] is characterized by data transmission in cells with of 53 byte fixed length. The transmission itself is based on connections (virtual path, virtual channel) that are established. Central points of an ATM network are the switches. They consist of several input and output ports and forward the cells. The architecture of the switching fabric determines the main properties of a switch. During a connection establishment phase service parameters can be negotiated according to service categories.
Within the ATM Forum five service classes are defined: Constant Bit Rate (CBR), real time Variable Bit Rate (rtVBR), non real time Variable Bit Rate (nrtVBR), Unspecified Bit Rate (UBR) and Available Bit Rate (ABR). According to [7] CBR is intended for real time applications that request a constant amount of bandwidth during the lifetime of a connection. The VBR category can be used by applications which have bursty characteristics. They are characterized in terms of Peak Cell Rate (PCR), Sustainable Cell Rate (SCR) and Maximum Burst Size (MBS). For example, an application may generate a data flow with a peak to average ratio between 3 and 10. These values may justify statistical multiplexing of many data flows from which applications may benefit. The UBR category is focused on applications not requiring tightly constrained delay and delay variation. UBR service does not specify traffic related service guarantees. ABR is intended for applications that are satisfied if they receive a data rate above a minimum amount. However, the ABR service tries to provide the application with as much data rate as possible. Service categories are defined by a combination of service parameters. Peak Cell Rate, Sustainable Cell Rate, Burst Tolerance (BT), Cell Delay Variation and Cell Loss Ratio [7],[8].
One issue in designing an interworking unit can be seen in the mapping of the QoS parameters of ATM and the parameters related to the field-bus, respectively.
allows existing LAN applications to run in an ATM environment.

2.3 Interworking Unit

Various types of interworking units exist that could be applied to the basic model of interconnecting field-buses through ATM. The expected functionality of the internetworking unit is to transparently deliver data between the field-buses. Since field-buses lack layer 3 functionality, routers cannot be directly applied. Bridges interconnect different subnetworks at layer 2. Different types of bridges exist, that will be considered in the following. Basically it can be distinguished between transparent bridges and source routing bridges. In the following we will concentrate on transparent bridges, since source routing is not transparent to the end devices located in the field-buses. Specific types of transparent bridges, so-called remote bridges, according to the MAC bridging standard [9] are used to interconnect two dedicated networks. This type of bridges is currently discussed for general usage of LAN interconnection across ATM as a basis for so-called virtual LANs. Thus, they also seem to be a proper candidate that should be discussed in conjunction with the interworking of field-buses through ATM networks.

Figure 2 shows the protocol architecture of a remote bridge. To reach a station on a remote field-bus, packets have to be segmented, if necessary, and encapsulated in ATM cells. The cells are transmitted over an ATM link to the distant interworking unit. They will be decapsulated, reassembled and forwarded to the station on the remote field-bus. This happens transparently, with respect to the devices on the field-bus. They are not aware of the situation that the field-bus segments are interconnected via an ATM network.

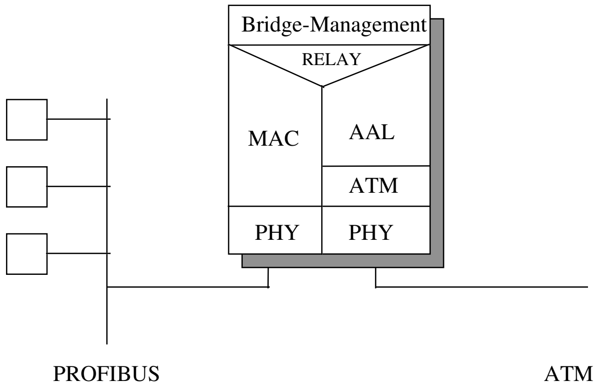

Figure 2: Interworking Unit - Protocol Architecture

3 VIRTUAL PROFIBUS

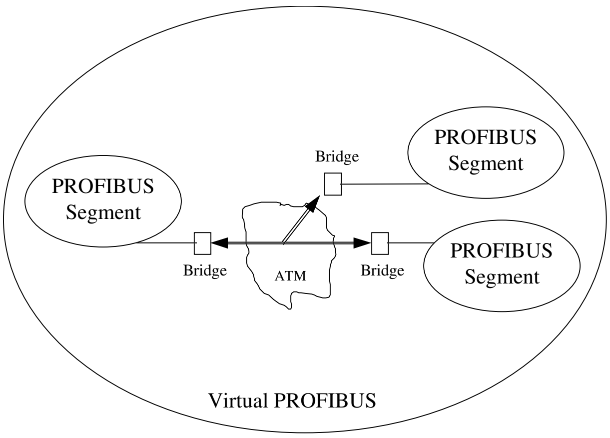

Figure 3: Remote Bridge, 3 separated PROFIBUS segments forming a virtual PROFIBUS

3.1 Bridge Operation

The PROFIBUS segments depicted in Figure 3 are interconnected in order to form a virtual PROFIBUS via an ATM network. The remote bridge consists of a PROFIBUS part and an ATM part as shown in figure 2. In order to transfer data between the bridges an ATM connection has to be established. The PROFIBUS part deals with reading and writing functions of the field-bus. It neither functions as slave nor as master. However, it is involved in the token passing mechanism used in the PROFIBUS MAC mechanism. The token passing method ensures the assignment of the bus access right within a precisely defined time interval. The token is circulated in a pre-configurable maximum token rotation time between all masters. The only station which is permitted to send is the token-holder. Under normal conditions the master station has to wait until it receives the token and then sends the data request. Regarding the scenario depicted in figure 3, the bridge-station on the side of the requester in one PROFIBUS segment scans the bus and delivers each packet to all other bridges. The bridging-devices on the remote segments have to put the packets on their segment right away. Because no other station has the permission to send, the bridge is able and permitted to do so. If the delivered packet is the token, the addressed master will adopt it. This needs to be independent of the location of the communicating devices with respect to PROFIBUS segments in a virtual PROFIBUS.

Moreover, to work properly and according to the PROFIBUS standard each station permanently has to scan the medium. This means that each packet has to reach each station in the virtual PROFIBUS.

In the following, we will concentrate on a virtual PROFIBUS consisting of only two connected segments, because this will be the main operational field.

3.2 Timing Requirements and QoS mapping

As described in section 2 communication on the PROFIBUS is subject to very tight timing requirements. If the master requests a slave station it waits for the immediate response, i.e., the addressed slave-station has to respond within a bounded time interval. If the response fails to arrive within the slot-time a retransmission will be initiated. In case the ATM-network has to be crossed, an additional delay will be added twice, once for each direction. For simplicity reasons it is assumed that the transfer delay in both directions is identical. Therefore, two new parameters are introduced.

- T_{SDB} (Station Delay of the bridging device) and
- T_{TDA} (Transfer Delay of the ATM connection).

The transmission delay caused by the transfer through the ATM network and the station delay of both remote-bridge stations has to be included in the calculation of a message cycle.

$$T_{MC}=T_{S/R}+T_{SDR}+T_{A/R}+T_{ID}+2*T_{TD}+4*T_{SDB}+2*T_{TDA} \quad (5)$$

A further time-critical function is token forwarding. The forwarding master likewise waits a slot-time for a bus-activity of the subsequently addressed master. With respect to the virtual PROFIBUS, the token-cycle lasts

$$T_{TC}= T_{TF} + T_{TD} + T_{ID} + 2* T_{SDB} + T_{TDA} \quad (6)$$

The token-target-rotation-time increases because of the processing delay within the bridging device and the transfer delay within the ATM network already contained in T_{TC} and T_{MC}. Finally, the predefined slot-time should be increased by $4 * T_{SDB} + 2 * T_{TDA}$ at least. Because of the possibility to provoke deadlock situations, adjusting the slot-time is a meaningful task.

A number of cumulative factors affect the delay within an ATM network and the QoS parameters or can lead to cell loss [4]. The physical media which transports the bits comprising ATM cells causes a propagation delay dependent upon distance. Furthermore the physical media introduces random or bursty bit errors. Some aspects of switches that affect data flows are switch matrix design, its characteristics under load and the buffering strategy. The number of nodes a particular connection traverses has to be considered, too.
In general the delay between two endstations is mainly affected by the time a cell needs to traverse the switches on its path across the ATM network. Thus, to roughly estimate T_{TDA} we have to consider the propagation delay between the endstations, which is 5µs/km, the number of switches to cross and the switch transit delay for each switch, which is for example less than 10 µs for a Fore Runner ASX-200 Switch. Under normal conditions, i.e., no cell loss occurs, an upper bound on T_{TDA} is in the range of several 10 µs.

In order to interconnect field-buses across an ATM network, proper service categories of ATM need to be identified together with a suited mapping between the QoS parameters. Especially, the high timing requirements associated with field-buses drive the selection of an appropriate service class.
To bring field-buses and ATM to a joint level one of the main aspects is the investigation for suitable traffic descriptors. The load behavior of field-buses is the key to find a model to map the tightly constrained real-time requirements with corresponding ATM service parameters. Figure 4 shows the activity on a PROFIBUS-segment during a message cycle. A requesting station receives the token and begins to send after a station delay caused by protocol processing. A second station delay caused by protocol processing within the responding station occurs. After that the responder sends an acknowledgment, after which the initiator needs another time to process the acknowledgment and prepare the next request or token forwarding.
In [12] Funke describes based on extensive measurements a relation between activity and idle times of 30% as heavy load with respect to PROFIBUS. The overall load in a PROFIBUS system is furthermore determined by the number of active stations, the length of data units, depending on the purpose for what the system is intended. Due to this it is difficult to derive a general model for the traffic load of PROFIBUS, but the feasibility of a dedicated application can be determined by summarizing the duration of all message cycles.

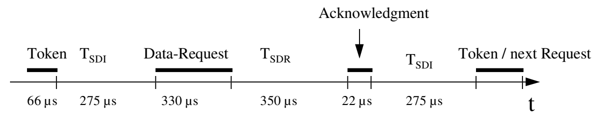

Figure 4: Activity on the bus during a message cycle

In the following, we will briefly reflect on each service category offered by ATM. Due to the fact that field-bus applications require tight timing conditions ABR and UBR are not suited at all. Both service categories are intended for classical best effort applications. The CBR category provides a static amount of bandwidth that is continuously available during the connection lifetime. Under timing consideration for field-bus applications this would be the best choice. However, because field-bus traffic is somewhat bursty, as shown in figure 4, reservation of a fixed amount of bandwidth may be a waste concerning the utilization of an ATM network which carries other data flows, too. Because of the already mentioned idle times ($T_{SDI,}$ T_{SDR}), with respect to the service categories provided by ATM, the nrtVBR service class may be selected to map PROFIBUS traffic to an ATM Quality of Service category. This category takes care of PCR, SCR and MBS as well as of CLR. No delay bounds are associated with this category. The peak cell rate (PCR) specifies an upper bound on the rate at which traffic can be submitted on an ATM connection, whereas the sustainable cell rate (SCR) is an upper bound on the average rate. This bound allows the network to allocate sufficient resources, but less then those based on the PCR and still ensures that the performance objectives can be achieved. The SCR and BT traffic parameters describe the cell flow of an ATM connection in greater detail than just the PCR. BT is conveyed through the Maximum Burst Size which is coded as a number of cells:

$$BT = (MBS - 1) * (\frac{1}{SCR} - \frac{1}{PCR}) \qquad (7)$$

Assuming the maximum length of a PROFIBUS packet is 255 byte it has to be segmented into 6 cells. That leads to a maximum burst of the same amount of cells. However, a data unit rarely exceeds 200 bytes. The PCR can be chosen equal to the transfer rate of PROFIBUS. Of greater importance is the determination of the SCR On one hand the average rate is an important service parameter with end to end relation, on the other hand the SCR has great implications on the utilization of the overall system [10,11].
In PROFIBUS each packet is of the same importance and there is no redundancy within the data units transferred. Therefore, CLR has to be as low as possible. Especially if a lost cell contained the token, the loss leads to an exceptional situation, e.g., restart of the whole system. Most of the data units transferred by PROFIBUS applications have only a few bytes length and therefore, fit in a single ATM cell. This may save time, because no segmentation is needed. However, this

also represents a disadvantage. If a cell contains a 2 byte integer value, for example, 46 bytes are wasted.

During connection establishment, the QoS parameters are negotiated [8]. In case of the acceptance of the parameter combination by the network it can be assumed, that these parameters are guaranteed by the network over the lifetime of the connection.

Using more than one ATM-connection and split up the cell stream leads to no performance enhancement, since there are no parallel data streams.

3.3 Bridge Management

Since PROFIBUS systems are planned during a design phase the remote bridges can be uploaded with ATM addresses of the corresponding devices. Due to this implementation of a learning algorithm is not needed. However, in case of changes in configuration there has to be a method to inform the bridge. Opening a connection between two bridges over the ATM network lasts several milliseconds per ATM-switch involved. For performance reasons it is recommended to open the connections once as an initializing task and not to tear them down during transfer interrupt.

Error recovering, e.g., lost token, should remain a task of the field-bus system. However, the bridges may check for errors occurred within the ATM network, e.g., lost cells. But, between the bridges no retransmissions should be performed. Retransmission will be initiated by the sending PROFIBUS device. The actions initiated by the bridging device have to take care not to confuse the error recovering procedures of PROFIBUS.

Traditional bridged networks with redundant paths implement the spanning tree algorithm [9] in order to have at most one data route between any two endstations. Although the virtual PROFIBUS approach uses bridges as interworking units, no spanning tree algorithm is needed, because within ATM point-to-point connections are used to connect the bridges. Thus, no redundant paths exist.

4 AUTONOMOUS PROFIBUS SEGMENTS

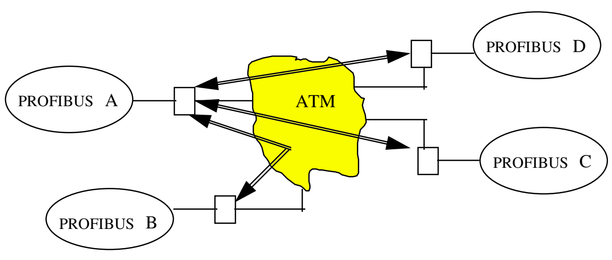

Figure 4. Interconnected PROFIBUSes

4.1 Bridge Operation

In contrast to the virtual PROFIBUS approach, in this section interworking of multiple independent field-buses is discussed. This means, the ATM interconnection is not an extension of a PROFIBUS segment, but interconnects completely autonomous operating PROFIBUSes (A, B, C and D), as shown in figure 4. While planning the PROFIBUS application the desired connections between distant PROFIBUSes have to be determined. As depicted in Figure 4, according to the application PROFIBUS A needs to get in contact with either B, C and D. Therefore connections between these are established. The bridge in A has to know the ATM addresses of all other bridges. Bridges in B, C and D only know of the existence of A because they do not have to send packets to other segments than A.

The main difference to the virtual PROFIBUS approach can be seen in the token handling, due to the completely independent subnetworks. The token is expected to circulate within the respective PROFIBUS only. There is no token transfer across the ATM interconnection. Thus, the token-passing mechanism is not influenced by the interconnection. The bridging device acts like a filter device, which forwards only frames addressed to devices in the remote network. The receiving part of the bridge on the PROFIBUS-side will be transparent for the PROFIBUS. But the sending part has to act like a master device, which has to be able to send frames if it is allowed to. Therefore the PROFIBUS part of the bridge has to have an address belonging to the range of the field-bus it is connected to.

Assuming a situation where a master station belonging to one PROFIBUS requests data from a station belonging to another PROFIBUS. The bridge on the side of the requester takes the frame and forwards it to the bridging device corresponding to the segment-address. (The segment addressing scheme of PROFIBUS is described in section 4.3). The distant bridge receives the frame on its ATM port. The last task, the bridge has to do, is to put the frame on the bus.

Assuming a static consistency of the PROFIBUS system as in most applications the filtering database only contains static entries and no learning algorithm has to be implemented. However, if it is intended that PROFIBUS segments can join or resign from the connected system a dynamic filtering database with aging entries is needed. In case a new PROFIBUS will join the ATM-address of its bridge has to be told to the bridges of segments with stations wanting to contact to stations within the joint PROFIBUS. Implementing this stays an issue for further discussion.

4.2 Timing Requirements

If a bridge receives a frame from a distant PROFIBUS it has to wait until it gets the permission to send according to the token-passing-method. In the worst case this waiting could last the full token-target-rotation-time. This fact is one of the disadvantages of the interconnecting approach, but the problem can be solved. One solution is, if the bridge gets more than one address, it is more often its turn. The addresses should be spread in constant distances over the address range. This leads to a reduced waiting period but increases the overhead. The token should be released right away, if the bridge has nothing to put on the bus. The bridge has to have buffer capacity on the ATM-side because two or more frames originated from several so connected PROFIBuses can appear. Further the bridge has to manage a filtering data base in order to assign the right output ports to the segment addresses. The mentioned master-functionality of the bridging device on the PROFIBUS side has not to be complete according to the standard [2]. It only should have implemented layers 1 and 2 of the PROFIBUS model because there is no data processing within the bridge. But a bridge with a running fieldbus-application is also conceivable.

4.3 Addressing different PROFIBUS-segments

The PROFIBUS standard permits to use a special addressing scheme to support bridging between up to 64 PROFIBUS subnetworks. In a PROFIBUS segment 127 stations are addressable. The most significant bit of the address byte is used to signal the address extension. Thus, the first byte of the data unit contains the extension acting as a segment address. Using the address extension means, that every packet has to carry the extension. Packets without extension byte will not be delivered correctly. The bridge directs the packet to the corresponding ATM connection based on the segment address. Implementing this has great implications to existing PROFIBUS devices. Although defined in the standard [2] current devices do not provide for the segment address recognition, i.e. this functionality has to be added and leads to problems in order to preserve existing investment.

5 SUMMARY AND OUTLOOK

The use of a bridging device connecting two remotely operating field-buses leads to an extension of possible distances between controller unit and the components near the technical process. By means of PROFIBUS a general model was proposed, to separate an existing field-bus system in two or more parts transparently connected through ATM comprising a virtual PROFIBUS. The second model proposes a basic approach for a multiport bridge device enabling the connection of several independent working field-buses of the same kind. With respect to its service categories and its inherent mechanisms it is assumable that an ATM-network is able to provide the functionality to meet the QoS requirements demanded by field-bus applications. But, some issues have to be studied in further detail to make the proposed models more sophisticated. Simulation of different PROFIBUS applications will give a deeper insight in PROFIBUS traffic. The choice of the QoS parameters remains an important fact in order not to bind too much resources, but still ensure a proper quality of service. Based on the rough guess made within this paper a common function to map the demanded QoS parameters by PROFIBUS to the corresponding ATM service parameters has to be introduced.

Together with ATM comes its inherent facility to integrate flows of different sources and brings up the research on how video and audio devices can be added to field-bus systems [14,15]. The common goals to integrate multimedia devices, installed near the technical process, are quality improvement and controlling support. Still pictures provide the operator with information in order to insure product quality commitments. They are useful in situations in which sequences of pictures are not needed. Motion pictures support the user in controlling and diagnostics in addition to the detailed data provided by the PROFIBUS devices. They make it possible to trace system behavior. Audio information are a welcome addition to motion pictures to get a better overview on how the process behaves and to predict or to notice about exceptional situations. In this sense, the integration of multimedia can also be examined together with both bridging approaches discussed in this paper.

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