Review Methods Configuration, Administration and Network Monitoring in High-Rate Onboard Networking Standards

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Abstract

The modern onboard systems reach the big sizes; the setup of each network device is necessary and very important, as the correctness of operation of a system depends on it. In network can be errors which it is necessary to have possibility to process and recover operability of system with minimum loss of information.

In the on-board systems solution to the problem is assigned to configuration, administration and network monitoring. Mechanisms of configuration, administration and monitoring are considered and applied in many network standards. This article reviews the standards SpaceWire, InfiniBand, Fibre Channel, AFDX and MIL-STD-1553 and compare them with the positions of applicability for the onboard systems.

At the beginning of the article discusses the general concepts of configuration, administration and monitoring, and then provides an overview of the standards and their comparison.

Index Terms: SpaceWire, InfiniBand, Fibre channel, AFDX, MIL-STD-1553, Configuration, Administration, Monitoring, Plug and play.

I. INTRODUCTION

The modern onboard systems reach the big sizes and a large number of devices. In this regard is a problem of configuring, administration and monitoring such network. Operability of all network depends on incorrect interaction of whole devices. Therefore, at the moment there is a task of development of the organization of intra network interaction.

It is a question of algorithm which performs the operation without involvement of the user, only deduces a log file by results of operation to pay attention of the operator of a network to failure or a no serviceability of devices. The operator can make necessary actions for recovery a network (for example, changeover of the link, the routing switch or other device of a network).

In this paper the SpaceWire, InfiniBand, Fibre Channel, AFDX, MIL-STD-1553 onboard standards are considered. Each standard provides one or several algorithms of administration, configuration and monitoring. The solutions of problem of administration onboard systems will be noted.

II. CONFIGURATION, ADMINISTRATION AND MONITORING OF AN ONBOARD NETWORK

The first stage after creation of an onboard network is the configuring stage. On this step parameters for each device of a network for its successful functioning are defined. This stage can be based both on some input data, and without any information about

topology and devices. In the second case additional requirements and restrictions (for example, software ability of devices to create packets to send answer and other) are superimposed.

After formation of settings there is a stage of administration of a network, in other words, record to devices. Certainly, at this stage can be record errors, or the device can appear no serviceable. The algorithm shall process correctly such situation and report to the operator about existence of errors.

The third step is a monitoring. Monitoring check operability of devices on a network, traces appearance on a network of new devices, keeps statistical parameters which can be interesting to the network administrator, makes reports on errors in a network and carries log files.

In case of any failures the mechanism of monitoring tries to remove them means of configuring and administration and notifies the network administrator. This stage named - network reconfiguration. It results in need of creation of new settings and parameters (configuration), and also their subsequent record (administration).

The concept Plug and Play completely approaches under the description of this algorithm. It responds with the requirement: settings, record and network tracing.

III. Review of standards

A. InfiniBand

For administration and network monitoring all structure breaks into subnets. For each subnet the chief manager exists (there can be additional managers for each subnet in case the main fails); information for devices is sent by agents who are in each device of a subnet and trace its status. The chief manager executes the following actions: research of physical network topology, assignment of local identifiers to nodes, switches and routers (by means of agents), creation the paths for exchange message to the end nodes, tracing topology change and fulfill of realignment of a subnet if necessary.

Thus, the decentral algorithm with number of chief managers by quantity of subnets turns out, and each manager has at least one reserve "copy" that increases fail safety of such system. Each manager executes administration and monitoring functions for its subnet. There is no need of continuous or periodic inquiry of devices, because in case of change the agent being on the device will report about it to the main [1].

The InfiniBand standard has no restrictions on topology, can support duplicating devices, but superimposes restrictions on used devices and requires serious program software. In each subnet at least two managers are necessary to support, and each device of a network has to support agent. Besides, there is no experience of use of the InfiniBand standard in onboard networks. It was considered as an interesting solution of a problem of configuration, administration and network monitoring.

B. AFDX

The AFDX standard realizes the double redundancy in a network. On the AFDX network there are two independent data communication networks, and end systems send directly two identical packets to two duplicating networks. The redundancy managers on the end system send a packet implement send of duplicating messages. The redundancy manager being on destination end system sorts arriving packets from two networks, deleting copies.

As a result, this standard shows big fail safety, at the expense of double data transfer, but thus requires big hardware and software resources [2].

AFDX standard requires the greatest amount of hardware resources of all review standards, as it is fully redundant communication network. Also on each terminal unit it is necessary to set the manager of redundancy that superimposes restrictions on devices used on a network. Also on a network is a big traffic because of sending duplicating messages, and also there is an arbitration problem.

C. MIL-STD-1553

This standard defines three types of terminal devices that are allowed on the bus:

- bus controller;
- remote terminal;
- bus monitor.

The bus control unit realizes the data stream monitoring for all transactions. The bus can support some controllers, but only one can be active at one time. The bus control unit can change a data stream according to changes which can occur on a network.

The remote device is an interface (hardware or software) for interaction of a subsystem with the bus. It can be implemented as the separate device, and as some superstructure in the subsystem device. The remote device shall be able to process as the protocol and distortion errors arising in the physical channel.

Bus monitor listens to all messages on the bus. This passive device collects data in real time and analyzes the received messages. This device can store as all traffic of the bus or only a part, including errors of the protocol or electrical [3].

Conclusion on this standard: because of existence of the redundant bus, which can become the active at any time as soon as the main will fail, increases fail safety. Functions of control and monitoring are divided between the controller and the bus monitor.

The MIL-STD-1553 standard possesses strictly certain topology, and restriction on number of devices (up to 31). On such network it is rather easy to implement monitoring and administration because we know its topology. But this standard doesn't provide possibility of creation of a large network and requires data transfer arbitration via bus. Among the considered standards MIL-STD-1553 has the most limited use in large onboard systems.

D. Fibre Channel

Level of FC-3 provides Management Services. It accesses to the Fibre Channel network, its topology and configuration data from controlling applications. Controlling applications can specify for example to what N_ports to interact with each other. For the correct configuring of the Fibre Channel network the service of provision of access is provided.

In the Fibre Channel technology use of any of the following topology is provided:

- point-to-point topology with the selected bandpass range;
- a loop with bandpass range division;
- switched topology with scalable bandpass range.

The point-to-point topology can be implemented two methods. In the first case it simple two N_port connected with each other and communicating. In other method for

the organization of connections between pairs of nodes some set the external switch of communication lines is used.

Fibre Channel loop is inexpensive decision allowing several nodes at the same time to use 1-gigabit bandpass range. The loop of the Fibre Channel is autoconfigured and can work both with the switch and without it. Each node of a loop (including the switch port) can automatically determine a configuration and it is correct to interact with other nodes of a loop of the Fibre Channel without operator intervention.

Loops can be made of the nodes directly connected with each other in a ring. However in case of such approach a failure of any node will lead to a failure of all loop. This problem is solved by means of the hub. This device or disconnects the channel (thereby inserting the appropriate node into a loop), or shorts (excepting a node from a loop and guaranteeing operability of a loop even in case of complete failure of a node). Besides, hubs allow inserting and deleting nodes from a circuit in the course of operation.

The switches Fibre Channel are very easy for setting and using, as the Fibre Channel protocol provides self-configurability and self-checking. In case of node or switch Fibre Channel switching on it at first defines that is on other end of the connection cable, and then decides, as with it to interact.

If two nodes are connected, they automatically start to work in a mode a point-to-point. If the node is connected to the switch, it at first registers in the switch and exchanges the configuration information. If the cable connects two switches, they exchange define type of a configuration of a network and network addresses. All these actions are executed automatically, without any interference from the operator [4, 5].

The Fibre Channel standard provides self-configurability (in our concepts it is a configuration and administration) and self-checking (monitoring). On a network there are no special devices «network managers». All functions lay down directly on devices (hubs, switches and nodes). It superimposes certain requirements of the hardware and program parts. During self-checking there is no information collection and directly an output to a log file.

The Fibre Channel standard unlike other standards allows organizing high-productive networks without redundancy. Superimposes additional requirements on devices as they shall trace independently operation of a network and execute necessary settings.

E. SpaceWire.

SpaceWire uses the protocol of remote access to memory (RMAP) to have possibility to interact with remote devices on a network [6]. With use of this protocol some algorithms of administration a network are created. It is necessary to note that at present there is no standardized algorithm of administration for this standard (for its development the special working group SpaceWire-PnP is created).

1) NASA:

The requirements superimposed in this algorithm both as a whole network and to switches operation.

The switch stores the following parameters: unique number of the device, number of ports and their status. It is basic information which the switch shall provide in case of the appropriate requests. As the switch is obliged to track changes of the statuses of the ports (it is connected or not). That is the switch shall fix independently connection or switch-off of devices and to report about it to some processor or several processors which are

responsible for process the administration task by sending of the notification message which shall contain information on the occurred event [7].

Thus, it turns out that the main operation by determination of new devices and study of a network lays down on the switch.

It is assumed that this protocol of operation functions only with the switches SpaceWire. End nodes don't participate in study and network configuring. This protocol can support different types of addressing and minimize the hardware expenses.

In this algorithm it is offered to use the new data transfer protocol on the SpaceWire networks that will lead to change of the existing software of switches and will complicate their functionality. Besides from switches it is required to define the fact of connection and disconnection of devices, so not each SpaceWire switch can be used in described network. In other words, process of monitoring is implemented in this algorithm partially: the switch determines by existence or absence of connections about existence of new devices or error operation of the already certain. But there is no collection of statistics and device testing about its working capacity.

2) Dundee University:

In the offered protocol research and administration of a network lays down on so-called network managers whom can be from 1 and more on a network. These devices use the protocol based on already existing protocol of access to remote data (RMAP). The network can be two types: controlled and open.

At a controlled network there can be only one network manager. It is necessary for devices of this network to support simple functions, for example: detection of devices, network control, configuring of switches and terminal nodes. The network manager directly interacts with devices and executes administration. If at a network there is at least one device which treats this type of a network, all network is considered controlled.

The open network contains several network managers and devices shall support wide range of functions and additional parameters for administration and configuration. Devices in process of study of a network find "owner", the network manager, who will be responsible further for its functioning.

Each network manager contains the configuration agent. This agent is responsible for configuring of devices by other network managers which don't "own" this device. Requests for configuring will be readdressed to the network manager-owner who execute device setup. Thus, access to devices is carried out by means of a special network element – the configuration agent, instead of directly [8].

The algorithm offered by Dundee University superimposes requirements on software and hardware. If on the network there is a device which is not supporting one their features of offered algorithm, the network cannot manage to be set up and it is correct.

The SpaceWire standard allows creating a network without redundancy and with any redundancy. At the expense of simplicity of the data transfer protocol doesn't superimpose on devices of additional restrictions used on a network. However, in case of the organization of administration and monitoring it is necessary to use difficult algorithms for network realignment in case of failure of devices. SpaceWire standard is the easiest to use with the hardware point of view, but requires the development of complex software algorithms for network management.

IV. Conclusion

Limiting by the scope of the monitoring and configuration, we have considered only some of the characteristics of standards SpaceWire, InfiniBand, Fibre Channel, AFDX and MIL-STD-1553.

The article compared the protocols on such criteria as:

- the presence of redundancy in the network,
- hardware and software limitations,
- restrictions on the network topology.

The comparison of standards for topology and redundancy criteria is given in the table.

TABLE I
REVIEWED STANDARDS

	Restrictions on topology	Redundance of a network
InfiniBand	Doesn't have	Duplicating managers of a subnet
Fibre Channel	Doesn't have	Don't have
MIL-STD-1553	Bus	The duplicating bus
AFDX	Doesn't have	The duplicating network
SpaceWire	Doesn't have	There can be any duplicating equipment

The analysis of standards SpaceWire, InfiniBand, Fibre Channel, AFDX and MIL-STD-1553, we can conclude that the standard SpaceWire most promising to use the onboard network systems, due to the low limits for devices. However, the implementation mechanisms of configuration, administration and monitoring of this standard require the study and construction of performance of the algorithm.

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References

[1] "*InfiniBand Architecture*", Specification, Volume 1 Release 1.2, Final Release, October 2004.
[2] Jan Täubrich Bieleschweig, "AFDX Protocol Tutorial Condor Engineering", *Formal Specification and Analysis of AFDX Redundancy Management Algorithms Workshop zum Systems Engineering*, 15-05-2007.
[3] AIM GmbH, "MIL_STD_1553 Tutorial", *Tutorial*, v 2.3, November 2010.
[4] Zoltán Meggyesi, "Fibre Channel Overview", *Research Institute for Particle and Nuclear Physics*, http://hsi.web.cern.ch/HSI/fcs/spec/overview.htm
[5] "Fibre Channel Tutorial", *Journal about open systems of control and monitoring, embeddable systems and real-time systems "World of computer automation On-Line"*, http://www.mka.ru/?p=40030
[6] ESA, "Remote memory access protocol", *standard ECSS-E-50-11* Draft F.
[7] Glenn Rakow, "SpaceWire Plug'n'Play", *IEEEAC paper #1211*, Version 6, Updated January 8, 2007.
[8] Space Technology Centre, University of Dundee, "SpaceWire-PnP Protocol Definition", *Draft A Issue 2.1*, 2009.