SpaceWire Network Support Algorithm as Part of Decentralized Plug-and-Play Algorithm

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Abstract—**Automation is one of the main directions in the construction and exploitation of distributed onboard systems. Plug-and-Play algorithms allow automate the process of configuring and administering onboard systems according to standard SpaceWire. One of the tasks in the development of decentralized Plug-and-Play algorithm is the creation of the algorithm for network managers support, in which the failure of one or more network managers will not cause the fall of the onboard network. This problem rises from the fact that every network manager administrates only its subnet, and in case of manager's failure, its part of network will become uncontrollable, which can lead to failure of the entire network and other negative consequences. At this working stage considered three variants of solving this problem, details of which are given in this article. This is enlargement of the regions in which one of the neighboring managers should assume support of another subnet, duplication managers when each network manager has a duplicate, which may start to operate on this subnet, and the combined method, which combines first two variants. Worth noting that in the future we plan conducting more detailed investigations of the algorithm to support network managers, that is an integral part of a decentralized Plug-and-Play algorithm, in which may be reveal additional features and limitations of the algorithm.**

I. INTRODUCTION

Rapid development of aerospace industry leads to emergence of new and improvement of existing network devices and algorithms for network administration of distributed systems. One of the major development goals is to provide compatibility with different types of equipment and to multifunctional use of finite elements and subsystems. Also, need to pay particular attention to quality indicators such as reliability, durability and precision, which must provide at process of operation the onboard network.

Choice a method configuration and administration influences on efficiency and usability of the distributed system [1]. In this work, administration and configuration will be considered in relation to the SpaceWire standard exceptionally.

II. MAIN PART

A. SpaceWire

SpaceWire standard – is an ECSS standard, which aims to use in the management, development and product quality in aerospace projects. ECSS was created to develop and maintain open standards, and it's a joint project of European Space Agency, National Space Agencies and European industry associations. SpaceWire network consists from three main types of elements: node, link and router.

SpaceWire supports the integration and testing of the onboard systems through the introduction of appropriate hardware directly in the data-processing equipment. Monitoring and testing may conducted without needing to create a separate physical interface to the data-processing hardware [2].

B. Configuration and administration

To the basic methods configuration and administration of routers can be attributed manual and automatic. In manual method configuration and administration is performed by man – network administrator. It's usually divided into local and remote modes of manual configuration and administration. Worth noting that method of manually administration effective only when working with a small size of network, either only with a certain network devices. This is due to the fact that whole responsibility for tracking errors lies on the network administrator, which can detect not timely, for example, reset settings from some device in a network or loss of connection. This may extremely negative affect at overall network performance and lead to negative consequences.

With automated method configuration and administration (Plug-and-Play) when all system devices are working, these devices by special algorithm research and define topology of the distributed network, give to nodes logical addresses, configure routing table and other necessary parameters of system, as well as supplying this information all other network devices that require this. Connection and disconnection of the new devices is also

determined automatically during normal network operation [3].

All Plug-and-Play algorithms are been divided into two types:

- Centralized algorithms. There is one device that initiates and manages the Plug-and-Play process in the system;

- Decentralized algorithms. There are several centers that are responsible for Plug-and-Play process in the system [4].

According to centralized algorithm, network has one network manager, which explores network and can automatically restore operation modes other devices in the network, record necessary values of registers. This algorithm has a significant flaw: due to the fact that network has only one network manager, in case any its malfunction network becomes uncontrollable. This will inevitably lead to negative consequences.

A decentralized algorithm allows to avoid this disadvantage described above, because there can be several network managers. Each of them carries out configuration, administration and monitoring of the network, i.e. in case of failure of one or more managers, system will operate.

C. Decentralized algorithm

Due to its complexity, the decentralized algorithm can divided on following tasks that require in-depth study: data storage about network, manager's memory, manager's communication protocol, algorithm to support network managers, algorithm to tuning adaptively multicast routing, connection/disconnection network devices algorithms, monitoring, and algorithm to administration inside and outside the region. At this stage of work, network support algorithm considered in isolation from other tasks.

There are several network managers in the network, which carry out studying, configuration and network administration, and each manager administers its subnet only (Fig.1).
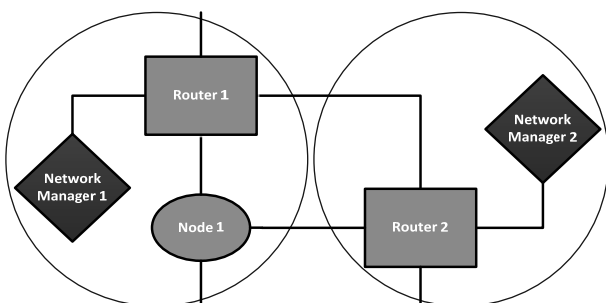

Fig.1. Example SpaceWire network at the decentralized Plug-and-Play algorithm

Managers may be some terminal nodes or personal computers. In memory of each manager are stored variables that are necessary to its work: logical addresses of nodes, paths to the routers and other.

Configuration stage is first step after building onboard network. Parameters are determined for each network devices for its successful operation in this step. Stage of network administration comes after settings formation, which are wrote into devices. The third step is a monitoring. Monitoring - it is supervision for state the network. Monitoring checks the state of network devices, keeps track emergence of new devices in the network, keeps records of statistical parameters that can be interested to network administrator, draws up reports about errors in the network and keeps a log file [5].

D. Network support algorithm

Algorithm to support network managers, which is devoted this work, is an integral part of development a decentralized algorithm, at which there are several network managers in the network.

When managers detect each other at the network, they memorize path addresses to each other, regional and logical addresses. When network is working normally, managers need to exchange status messages, so that if one of them fails, others might respond quickly to this situation. Eventually, there can be happened a situation in the network, when some manager may fail and cannot to interrogate network at certain time. To ensure that this situation didn't cause the fall of work network part, it's necessary to develop an algorithm to support network managers, no matter how many managers are in network.

It is assumed three variants for solving this problem at this stage of work: one of neighbouring managers must "catch" one more subnet (regional enlargement), or this problem may solved by introducing a reserve manager on this subnet (duplication of managers), or it is necessary to combine these two variants (combination method).

1) Enlargement of regions: If response status message from one manager is absent, then a neighbouring manager must take subnet of the failed manager, and it must notify other managers in network. Managers exchange status messages is not chaotic, but successively in a certain order. Each network device (router or terminal node) have network discovery register (NDR), which contains logical address of device's manager. Thus, subnet of failed manager comes under control to a neighbouring manager (Fig.2), which can be defined, for example, through a vote.
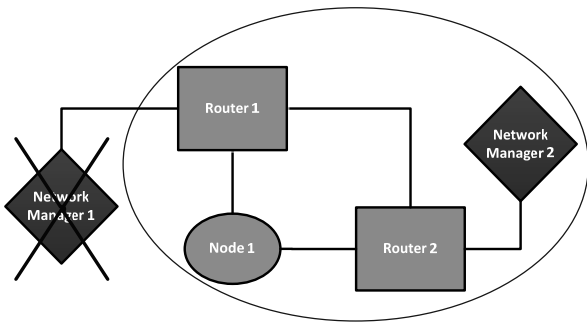
Fig.2. Enlargement of the region with the failed Network Manager 1

2) Duplication of managers: Each network manager has a duplicate manager that receives data from main device after a certain period. If duplicate is not receives a packet from main manager after specified time, it enters work on this subnet instead of main manager. Duplicate has a same logical and regionally logical address like at main manager. Main manager and duplicate connected to router in parallel, where it decides to which manager redirect the packet according to table adaptive group routing. Thus, the parallel connection of two managers it is when the main manager has a reserve manager (Fig.3). It connection will allow to increase reliability of entire network.
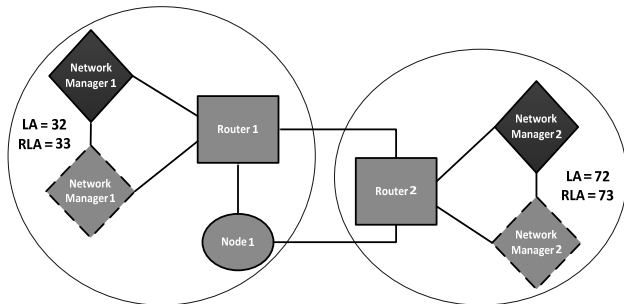

Fig.3. Example SpaceWire network with duplication of managers

There is a concept of the serial connection in reliability theory, when failure at least one element leads to failure of entire equipment as a whole. This kind of connection is a main, most characteristic and widespread for most types of electronic equipment. Parallel or reserve connection of elements is considered in reliability theory as connection in which a hardware failure comes only if all parallel (reserve) included elements will have broken. Therefore, reservation is a way to improve reliability equipment by including into the scheme a number of parallel, reserve elements [6].

Work reliability two parallel-connected network managers, namely probability that at least one of them will be work, equals a sum of three probabilities of possible favourable outcomes:

1) neither the main manager nor the duplicate manager will break down (Fig.4, a);

2) main manager fails, but duplicate manager will be working (Fig.4, b);

3) duplicate manager fails, but the main manager will be working (Fig.4,c).
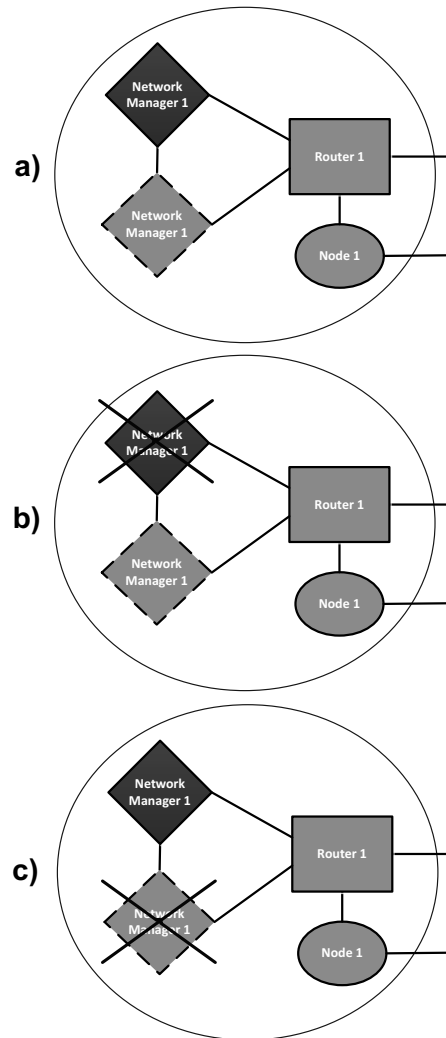

Fig.4. Possible situations in which the subnet of Network Manager 1 will be workable

In addition, do not rule out possibility that failed main manager may resume its work. In this case, duplicate must send data to main manager after a certain time order to main manager should be ready to start work if the duplicate is breaks. Thus, main manager becomes a duplicate, and duplicate is a main manager. This method will help maintain work of entire network, avoid conflicts and arbitration between neighbouring network managers.

3) Combination method: This approach combines two previous methods - enlarging of regions and duplication of managers. Each network manager has a duplicate manager. If main manager fails, then duplicate "pick up" its subnet

(Fig.5,a). If main and duplicate managers are break down, the subnet will come under the control to a neighbouring network manager (Fig.5,b), or several neighbouring managers evenly divide this subnet among themselves.
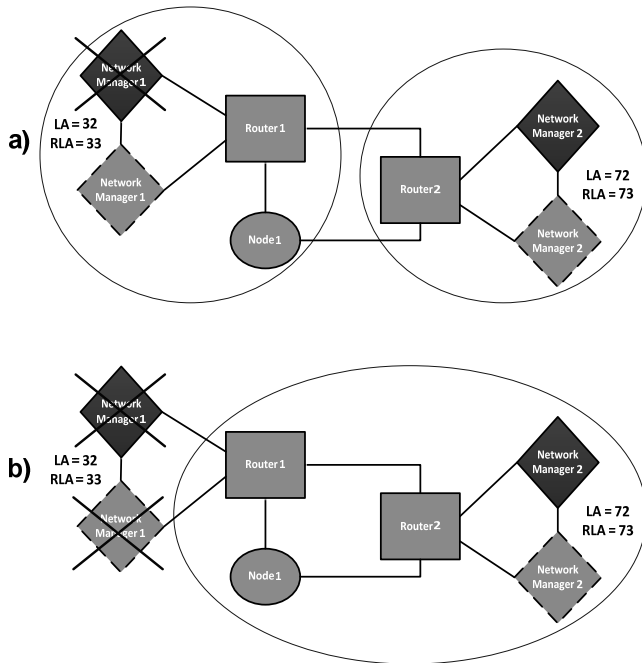

Fig.5. Example SpaceWire network with combined method

Combination method has obvious advantage over the other two methods, since it combines reliability of first two methods and allows saving network control for a long time.

III. CONCLUSION

Using a decentralized algorithm allow to improve network reliability, its setting and monitor status of devices. On the other hand, it imposes additional requirements on the network and managers. Because of their complexity, a decentralized algorithm was divided conditionally into several tasks that require further in-depth and independent study. One of these tasks is to create an algorithm to support network managers. At this stage, three variants are regarded for solving the problem in case failure of one or more managers. It is obvious that most reliable method of the algorithm presented in this work is a combination method. However, he imposes serious requirements to memory, managers and other costs. Duplication of managers can increase network reliability and avoid conflicts between neighbouring managers. However, it is needed twice as many managers to build network, that not always possible to implement at onboard network. Enlargement of regions is an alternative to duplication, however, there are restrictions (due to the limited memory of managers) on maximum number of devices that can be serviced by one manager.

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