QoS Support in Embedded Networks and NoC

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Abstract—**Quality of service (QoS) requirements such as priorities, packet delivery and packet delivery time are important and critical for embedded networks and networks-on-chip (NoC) [1]. We consider mechanisms for QoS support in the SpaceFibre, SpaceWire and GigaSpaceWire protocols, possibility of using them in embedded networks and NoC. In the article we analyze approaches for QoS provision, their feasibility and value of QoS in SpaceWire/GigaSpaceWire and in SpaceFibre networks. Networks with different topologies and traffic pattern are used to study and to evaluate the performance. Various traffic types such as the data packets, streaming data, commands will be transmitted in networks. Data delivery characteristics for SpaceFibre and SpaceWire/GigaSpaceWire networks are analyzed and compared. Also we compare characteristics that are achievable in NoC, which are based on QoS mechanisms of SpaceFibre, SpaceWire and GigaSpaceWire. Hardware costs are one of the main constraints for embedded networks and NoC. Therefore we compare hardware costs of basic SpaceFibre, SpaceWire and GigaSpaceWire routers.**

I. INTRODUCTION

The technology progress addresses to integrate dozens to hundreds of Intellectual Property (IP) blocks, which are basically the components on a chip like, RAM, DSP etc, within a single chip, [2]. The establishment of communication among these blocks is of prime concern. Wires and buses were used to be conventional interconnect between different IP blocks. But as the number of blocks increases so did the wires resulting in large consumption of area as well as other factors such as latency and delay in the communication, [3]. Network on chip (NoC) is the best alternative against the conventional way of interconnection, [2]. NoC are composed by routers, which transport the data from one node to another, links between routers. The NoC structure is a set of interconnected by communication channels nodes and switches, [4].

Three dimensional integrated circuits (3D) and systems-in-package (SiP) are currently being developed to improve existing 2D designs by providing smaller chip/package areas, higher performance and lower power consumption, [5]. 3D network-on-chip architecture alleviates the problem of long wires, [6]. The greatest advantage for 3D NoC is that it can greatly help in reducing the NoC topology diameter thus leading to reduction in packet transfer time and latency. A 3D communication architecture for the NoC can be established by large partitioning a 2D die into smaller segments and stacking them. Decrease in the topology diameter for 3D architecture has a great advantage of reducing the wiring or channel area on the chip, [7].

Embedded systems are designed to perform dedicated specific tasks with real-time processing constraints. Such systems comprise complete devices ranging from portable such as video cameras and set-top boxes, to complex industrial controllers including mechanical parts, [8]. Networked embedded systems are essentially spatially distributed embedded nodes (implemented on a board, or in a single chip in future) interconnected by means of wired or/and wireless communication infrastructure and protocols, interacting with the environment (via sensor/actuator elements) and with each other, and, possibly, a master node performing some control and coordination functions to coordinate computing and communication in order to achieve certain goal(s), [9]. There are wireless, sensor and wired embedded networks, [10].

Quality of service (QoS) becomes important network characteristic for prospective embedded networks and NoCs Many applications require guaranteed delivery of transmitted data. Multitasking distributed nature of onboard applications require reliable control of their processing and communications priorities. Same demand one have in NoC for mixed-critical systems. In real-time closed-loop control guaranteed control data delivery time is required. Typical for embedded systems mixture of different traffic types with high rate data sources and critical command traffic demands controlled network throughput distribution between different information flows.

There are various approaches for QoS provision in networks. For example, QoS as an integrated part of network planning is used for some embedded network, [11]. In other cases, QoS is provided at every data link and node inside the network, some approaches provide QoS features at the network boundary, in its terminal nodes, some combine these approaches in a way.

SpaceWire, SpaceFibre, GigaSpaceWire protocols are widely used in spacecraft design. SpaceWire is established as one of the main standards for onboard data transmission.

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It is used in many Russian, European, American and Japanese spacecraft. SpaceFibre is a newly emerging standard for the SpaceWire technology standards family. GigaSpaceWire link specification is also developed for SpaceWire technology extension. It provides gigabit link technology with longer distances and galvanic isolation capability for SpaceWire networks.

The SpaceFibre follows the approach which supports QoS at every data link and node inside the network. In every data link it has QoS services, providing priorities, guaranteed bandwidth, guaranteed data delivery, scheduled frames transmission. Implementation of these mechanisms is associated with additional overhead such as frame transmission delay, transmitting overhead information such as header and end of frame, traffic planning and dispatching, retransmission in every data link, etc. These factors lead to increasing implementation overheads and packet transmission time, to useful bandwidth degradation.

For SpaceWire/GigaSpaceWire the approach with providing QoS features at the network boundary is evolving. QoS services can be implemented over the basic SpaceWire/GigaSpaceWire network interconnection, e.g. at the Transport layer and at the Network layer, with much more economical implementation and overheads.

The SpaceFibre protocol stack has the Quality layer. It is responsible for providing quality of service and managing the flow of information, [12]. The SpaceFibre standard supports several classes of service at the data link layer: priority; guaranteed throughput; guaranteed packet delivery; scheduling; best effort.

The QoS (Quality of Service) layer of the SpaceFibre standard provides these services. Its sublayer - the Virtual channels sublayer, realizes priority, guaranteed throughput, scheduling and best effort classes of service functionality. It shall be possible to set the quality of service parameters of each virtual channel individually so that different QoS can be applied to different virtual channels.

Maximum number of virtual channels is 256. For each virtual channel (VC) a priority level may be assigned. When some virtual channels have data to transmit, data from the VC with the highest priority will be sent first. Unique priority level can be assigned to every VC or one priority level may correspond to some VCs. If a SpaceFibre network is to operate using priority only, each virtual channel could to be assigned a different priority level. Best effort quality of service is obtained when a virtual channel has its priority QoS parameter set to the lowest priority, [12].

For each VC the amount of bandwidth that it can use can be defined. There is a bandwidth credit counter for every virtual channel. If the VC does not transmit any data, the bandwidth credit counter is incremented. If the VC transmits some data, the bandwidth credit counter is decremented (wherein takes into account amount of transmitted data and defined amount of bandwidth for this channel). If some virtual channels with the same priority level have data to transmit, first come data from the VC with the largest bandwidth credit counter value.

Another QoS mode uses scheduled frames transmission. For every virtual channel a list of timeslots, in which it can transmit data, can be defined. Requests from the VC for data transmission during other timeslots are blocked. It gives guaranteed delivery latency for VC traffic.

The SpaceFibre standard draft makes the Retry layer responsible for guaranteed data delivery service. This layer checks correctness of the received frames and retransmit frames that have been received with errors or lost. For it each frame includes a sequence number and the checksum (excluding IDLE frames).

Mechanisms of constrained priority are supported in the SpaceWire/GigaSpaceWire standards. Mechanisms to support other classes of service are not provided by the core SpaceWire/GigaSpaceWire networks. However different service classes support may be implemented on top of their basic layers, at the Transport layer especially. In this paper we consider only variants that do not require implementation of some special functions in routers for SpaceWire and GigaSpaceWire, [13, 14]: priorities; the guaranteed packet delivery between the source and destination terminal nodes; the scheduling mechanism for providing constrained data packet delivery time; best effort.

In the paper we consider and compare: features and characteristics that could be provided by the priority mechanism in SpaceWire/GigaSpaceWire networks and in SpaceFibre networks; mechanisms of guaranteed packet delivery that is based on an acknowledgement scheme between data source and destination terminal nodes in SpaceWire/GigaSpaceWire and retransmission mechanism in data links in SpaceFibre. Also we analyze scheduling mechanisms for guaranteed data packet delivery time for SpaceWire/GigaSpaceWire networks and in SpaceFibre. We use the packets with different size (from 8 to 4096 bytes) in our case studies, that corresponds to different traffic types in embedded systems. On base of obtained timing characteristics the designers can select appropriate packet length for different traffic types to satisfy their system requirements.

II. PRIORITY MECHANISMS

In the SpaceFibre standard draft priorities are assigned to virtual channels. Each VC may have its own priority level, [15]. The priority level affects frames transmission order from different virtual channels to the link. The frame for transmission is selected according to its priority value. If transmission of a lower priority frame has started before the higher priority frame arrival, then the higher priority frame waits until the lower priority frame transmission is finished. The SpaceFibre standard does not use frame transmission interruption. Therefore high priority frame waiting time is up to maximum length frame (256 Nchar) transmission time plus time overheads.

In SpaceWire/GigaSpaceWire a priority level can be specified for packets at the Network layer. Priority level is associated with the packet network address (logical, regional-logical). The priority level affects packet transmission order to the output port. When transmission of a packet with lower priority is started before the packet with higher priority has arrived, the higher priority packet is transmitted after completion of the lower priority packet transfer; SpaceWire/GigaSpaceWire do not use packet transmission interruption. Therefore a high priority packet waiting time depends on the lower priority packet length.

The SpaceWire standard does not limit packet length and in a general case we can't estimate the high-priority packet delay in a hop. Its waiting time depends on data formats used in a specific network. If we limit maximum packet length in the SpaceWire network, we may have reliable estimates of high priority packets waiting time.

To estimate transmission characteristics of high priority traffic in SpaceFibre and SpaceWire/GigaSpaceWire networks consider dependency of high priority packet transmission time in one router from low priority packet size. This dependency is presented in Fig. 1; the high priority packet length is 64 bytes. The SpaceFibre provides VC priority level at the Frame layer. Its dependency on the Fig. 1 looks almost like straight line parallel to X axis with value 2784 ns. High priority packet transmission time in one router for SpaceWire and GigaSpaceWire practically coincides with high priority packet transmission time in one router for SpaceFibre when low priority packet size is less than 256 bytes; after it high priority packet transmission time in one router for SpaceWire and GigaSpaceWire significantly grows.

The results show that high priority packet transmission time for SpaceWire and GigaSpaceWire networks may be close to the value for SpaceFibre networks if low priority packets size would be limited to 256 bytes. This can be achieved by appropriate fragmentation on the Transport layer in terminal nodes.

Now let us consider dependency of low priority message transmission time from the packet size. Charts for this dependency are presented in Fig. 2; data rates are 250 Mbit/s and 312 Mbit/s. The Fig. 2 shows that message transmission time is almost the same when it is transmitted as one packet and by several packets with the size of 256 Nchar. So packets fragmentation practically doesn't worsen the message transmission time inside the network.

Thus for traffic with different priorities in SpaceWire/GigaSpaceWire networks practically the same transmission characteristics as in SpaceFibre can be achieved if packet's data field length would limited to 256 Nchar. It can be implemented at the Transport layer in terminal nodes.

From the functional point of view SpaceWire/GigaSpaceWire networks are more flexible in packet priority mechanism than the SpaceFibre. In them a priority is assigned to logical and regional-logical addresses. Thus different priorities can be assigned for dozens and hundreds of packet streams in a network. In SpaceFibre priorities are assigned to a virtual channel in a data link. While in theory there could be 256 VCs in a data link, due to high hardware overheads for a VC implementation their number in a link would be limited by quite several ones (4-8 VC as an optimistic estimation). Thus only 4-8 data packet streams may have particular priorities in the entire network.

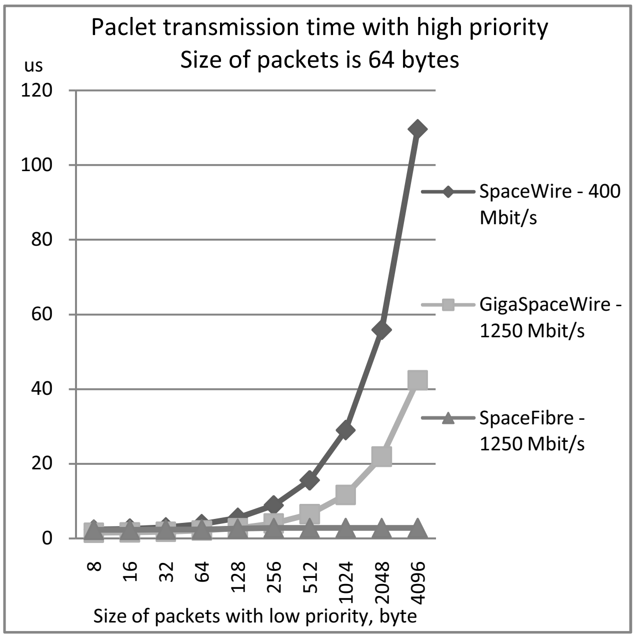

Fig. 1. Dependency of the high priority packet transmission time in one router from low priority packet size. Data rate: 400 Mbit/s in SpaceWire; 1250 Mbit/s in GigaSpaceWire; 1250 Mbit/s in SpaceFibre

III. Packet guaranteed delivery

The guaranteed delivery in SpaceFibre is ensured by checking the frames transmission correctness in every data link at the Retry layer, [16]. Transmitted with errors or lost frames are retransmitted. In SpaceWire/GigaSpaceWire networks it could be done in terminal nodes.

From a functional point of view both options allow to ensure guaranteed delivery of a packet. Difference is in

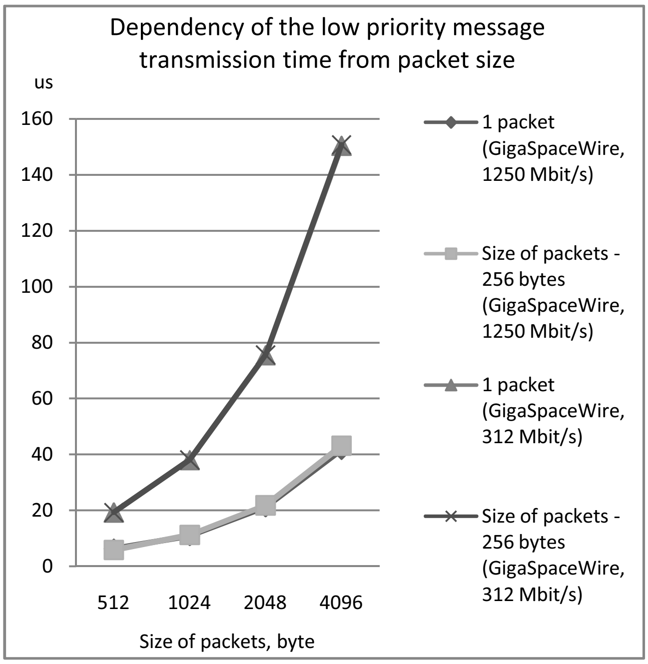

Fig. 2. Dependency of the low priority message transmission time from the packet size

where retransmission is organized – at every data link or at the network boundary, in terminal nodes. These options may have different timing characteristics and hardware costs.

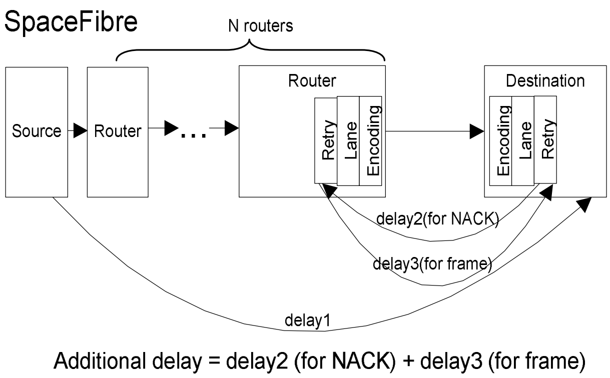

Fig. 3. The illustration of retransmission scheme in SpaceFibre data link layer and corresponding delays

The SpaceWire and GigaSpaceWire do not provide mechanisms for guaranteed packet delivery in a data link. But mechanisms for guaranteed packet delivery can be implemented in terminal nodes, at the Transport layer (the RMAP protocol is an example). Such protocol can include mechanisms for identification of packets that are lost during transmission (for example by sequence numbers), for identification of packets with errors (for example by CRC), for data packets acknowledgement and retransmission of unacknowledged packets (either not been confirmed or timed out in acknowledgement waiting).

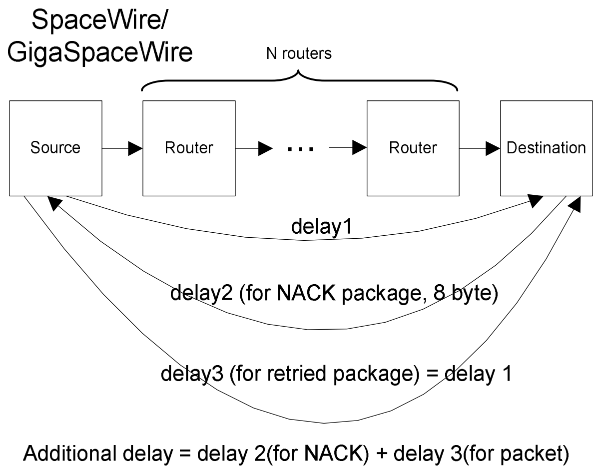

Fig. 4. The illustration of retransmission scheme between source and destination node in SpaceWire/GigaSpaceWire network and corresponding delays

To compare timing characteristics we assume that one error occurs during the packet transmission. In a SpaceFibre network it causes a frame retransmission in the data link. In this case additional transmission time consists of the NACK (Negative Acknowledgement) transmission time and the retransmission time of the frame in the link. We assume that time of NACK formation and time of it operation at the Retry level is negligible.

In SpaceWire/GigaSpaceWire networks an error will cause a full packet retransmission from the source node. In case when one error occurs during the packet transmission, packet retransmission time depends on

- communication protocol organization;
- rules of error detection;
- timeout mechanisms and timeout values;

Timeout values depend on network size, traffic characteristics and transmission paths of different traffics, which intersect with the considered traffic.

Let us first take the case when a packet is delivered to a destination node but contains errors due to errors during transmission. In this case total time of packet delivery is calculated as the sum of transmission between source and destination time, time of packet checking, time of NACK transmission from the receiver to the transmitter and the repeated transmission time. We can assume that the packet checking time is negligibly small as it can be performed on-the-fly during packet receiving.

Dependencies between packet delivery time and number of transient routers in SpaceFibre and GigaSpaceWire networks for the one error case are presented in Fig. 5. These results are based on calculations and modeling. Plots are drawn for different packet sizes: 16, 64, 256, 1024 and 4096 Nchar. The Acknowledge packet size for a SpaceWire/GigaSpaceWire network is equal to 8 Nchar.

As one can see from the Fig. 5, the delivery time of short packets (up to 256 bytes) for a GigaSpaceWire network is less than for SpaceFibre. Further, with increasing the size of packets and with a small number of transit routers, delivery time is better for SpaceFibre. It is interesting that with increasing packet size, the number of transit routers from which SpaceFibre is better also increases. When size of packets is 1024, SpaceFibre is better when the number of routers ≤ 3. When size of packets is 4096, SpaceFibre is better after the number of routers ≤ 8.

Now consider the situation where error occurred during the packet transmission and it led to link disconnection.

In SpaceFibre the time to restore connection is 50 us after a disconnection error occurs. In this case retransmission time is increased by sum of the time to restore the connection and duration of the noise.

In SpaceWire and GigaSpaceWire the time to restore connection is 19,2 us after a disconnection. To evaluate packet transmission time in this case, we assume that the acknowledgment waiting timeout (Tout) consists of packet transmission time between the source and the destination and of the NACK transmission time.

Denote sum of packet transmission time between the source and the destination and NACK transmission time as Tf. We evaluate characteristics when acknowledgment waiting timeout is equal Tf and 3*Tf. We consider the worst case when disconnection happens in the final link.

There are two variants. First: Sum of noise duration and the connection restore time is less than the sum of the acknowledgment waiting timeout and the repeat packet transmission time up to the link, in which the disconnection happens. In this case packet delivery time consists of the acknowledgment waiting timeout and repeat packet transmission time between the source and the destination. Second: Sum of noise duration and the connection restore time is larger than the sum of the acknowledgment waiting timeout and repeat packet transmission time up to the link, in which disconnection happens. In this case packet delivery time consists of the acknowledgment waiting timeout, repeat packet transmission time between the source and the destination and the time to restore the connection.

Dependency between the packet delivery time and the packet size, when the noise duration is 1 us, is presented in Fig. 6. For SpaceWire/GigaSpaceWire in this case acknowledgment waiting timeout is equal to packet transmission time between the source and the destination plus the NACK transmission time.

As one can see from the Fig.6, packet delivery time in SpaceWire is less than in SpaceFibre if size of packets ≤ 1024 bytes. Packet delivery time in GigaSpaceWire is less than in SpaceFibre if size of packets ≤ 2048 bytes.

However this value of acknowledgment waiting timeout for SpaceFibre/GigaSpaceWire networks may be selected in cases when packet and NACK paths do not interfere with packet paths of other traffic. Namely, packet and its NACK don't wait in output ports. If packet and NACK paths interfere with packet paths of other traffic, we should consider waiting time to access an output port also in a value of acknowledgment waiting timeout.

Let us evaluate packet delivery time when acknowledgment waiting timeout is equal 3*Tf. Dependency between the packet delivery time and packet size when the noise duration is 1 us is presented in Fig. 7.

As one can see from the Fig.7, the packet delivery time in SpaceWire is less than in SpaceFibre if size of packets ≤ 512 bytes. Packet delivery time in GigaSpaceWire is less than in SpaceFibre if size of packets ≤ 1024 bytes.

Let's consider the packet transmission time in case when no errors occur during transmission and packets are not retransmitted. The plots of dependency between packet transmission time and the transit routers number are presented in Fig. 9.

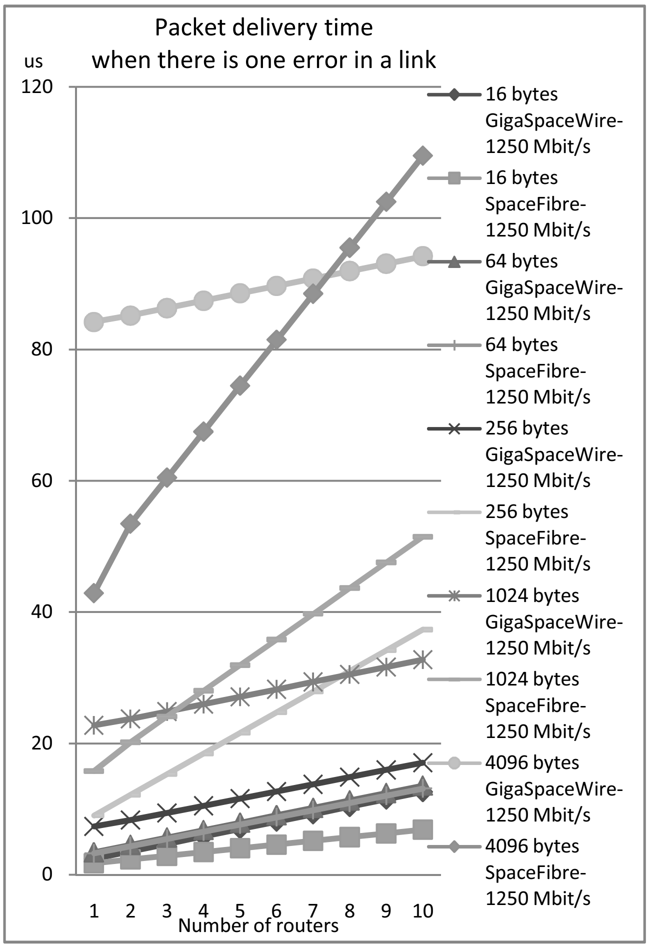

Fig. 5. Dependencies between packet delivery time and number of routers for the one error case (without disconnections)

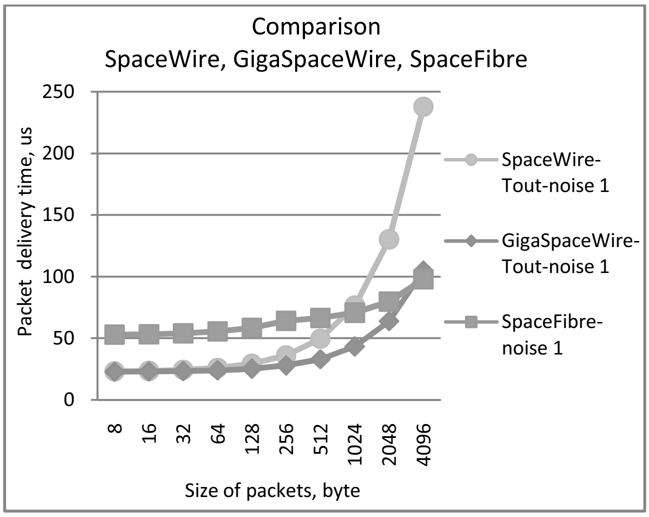

Fig. 6. Dependency between the packet delivery time and the packet size when a transmission error occurs (Tout = Tf)

As can be seen, the packet transmission time (for packets with the considered length) is 1,5 times less for GigaSpaceWire than for a SpaceFibre network. The wormhole routing used in SpaceWire/GigaSpaceWire routers reduces the packet transmission time via network. The packet transmission time in a SpaceFibre network is about 1,5 times bigger due to delays associated with the full frame buffering and CRC checking in each data link. This check is made for all types of traffic, including the traffic for which guaranteed data delivery is not required by an application.

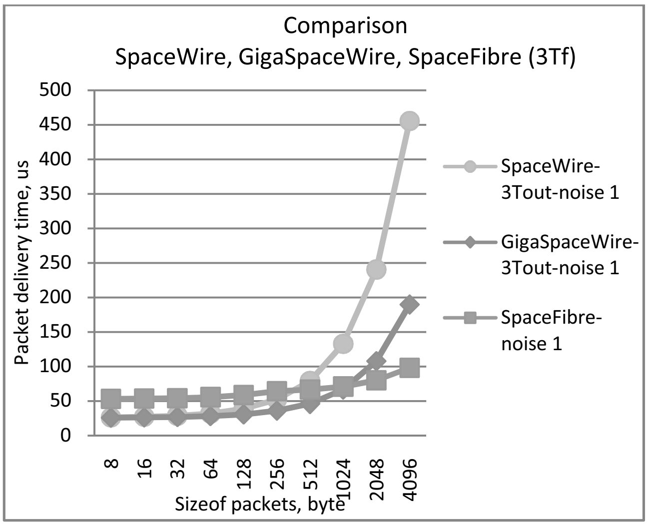

Fig. 7. Dependency between the packet delivery time and packet size when transmission error occur (Tout = 3*Tf)

This delay is especially significant for short packets with less than 256 Nchars length. The transmission time of short packets is bigger for SpaceFibre network with 1250 Mbit/s transmission rate than even for SpaceWire network with 400 Mbit/s transmission rate. Short packets typically are used for command traffic therefore its delivery time is particularly important.

It is important to understand that provided in the SpaceFibre guaranteed delivery mechanism, cannot guarantee a packet delivery if there would be faulty network equipment or links. Therefore for networks with high guaranteed delivery requirements one still need to use mechanisms of packet replication at the hardware level.

If the hardware and data redundancy is used in a SpaceFibre network in combination with standard retry mechanism and recoverable connection breaks, then correct interpretation of the packet replicas that goes via a path with temporary disconnection is very difficult.

Connection recovery in a SpaceFibre link may take a long time – duration of connection procedure is 50 us. The duration of noise may be added to this time. Therefore one copy of packet can reach the destination node with a very noticeable delay (dozens – hundreds of us, dependent on duration of noise) in comparison with other copies that goes via paths without disconnections.

In systems with data duplication for redundant transmission (N replicas of one packet are sent to the network) typically a packet numbering is used. The receiver terminal node determines by the number whether it has already a copy of this packet.

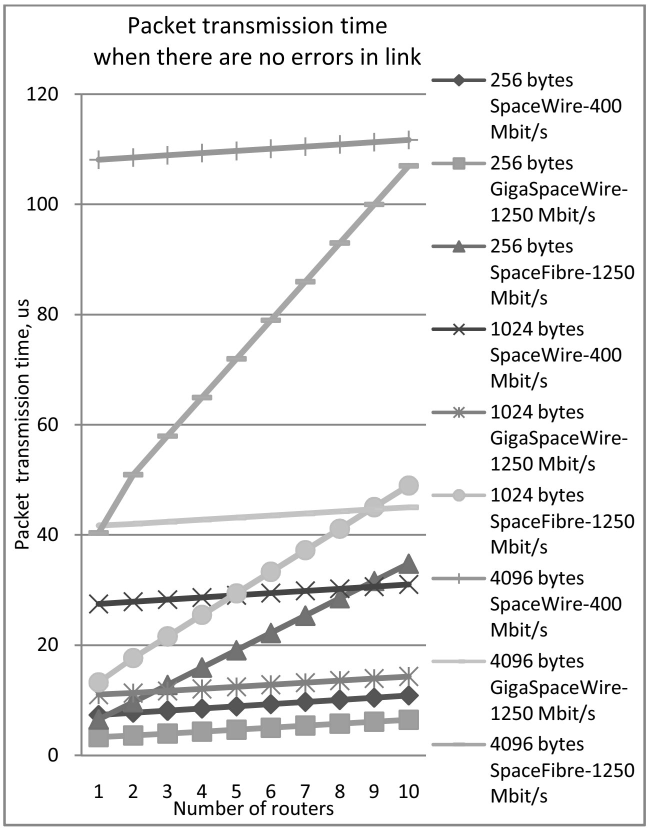

Fig. 8. Dependency between the packet transmission time and the amount of transit routers (without errors during transmission)

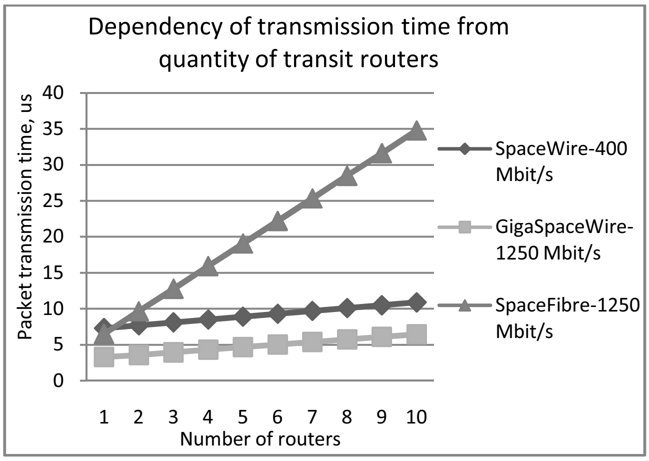

Fig. 9. The dependency of transmission time from quantity of transit routers for packets with 256 Nchars length

The packet number field in the packet structure has constrained size. In short command packets size of this field is typically 3 – 8 bits. Correspondingly the length of the cycle after which numbers will be repeated is small, especially when commands go often. So it could be very difficult to determine by the command sequence number whether the late command is belated, or goes on time or goes with some advance.

IV. Guaranteed packet delivery time

To ensure guaranteed packet delivery time a scheduled packet transmission is used. A list of timeslots for data transmission is assigned for every application, every packet source in a terminal node. Timeslots are linked with destination addresses of the packets. The data transmission path for different packet traffics, which are assigned to one timeslot, should not share data links.

It can be implemented in SpaceWire/GigaSpaceWire networks, [17]. Terminal nodes are responsible for data transmission only in allowable for them timeslots. However, a terminal node (an application in this terminal node) may still start data transmission out of allowable timeslot due to failure/error of time synchronization or due to internal malfunctions (for example distortion of the bits in the timeslots table). It may increase packet delivery time, violate the time constraints for the data packets that are transmitted in time but cross with the packet that runs out of its timeslot. The scheduling and data transmission in corresponding timeslots must be made by the trusted component of the terminal node – by special network controller (not by software) to deal with this problem.

Another source of a packet transmission out of its timeslot is data link disconnection. For example if the packet should be transmitted to a router output port that is currently under connection recovery, the packet will stop for a time until the connection is set; after it the packet will continue its transmission. Meanwhile the time slot could be finished and the packet would run in another, in an alien timeslot.

In packets delivery scheduling one needs to take into account such situation, to set appropriate margins in the time schedule. To determine the margins the network topology, transient faults and errors probability, which can lead to link disconnections, should be considered and took into account. With appropriate margins we can eliminate, with certain probability, sending packets in wrong time slots.

In SpaceFibre time is separated into a series of time-slots during which a virtual channel can be scheduled to send data. The timeslots control is performed in each data link of a router and a terminal node. Scheduling is associated with virtual channels, not with packets. For data flows transmission in predetermined timeslots, data flows should be assigned to different virtual channels and the timeslots table should be assigned to corresponding virtual channels in every data link. During all the other time-slots when the virtual channel is not scheduled to send data, it is not permitted to send any data even when no other virtual channel has data to send, [12].

As the data transfer is controlled in every data link a data transmission out of its timeslot will be quickly stopped in the nearest network node in case of incorrect behavior of a terminal node. Even if a terminal node transmits the data packet out of its timeslot (and this transmission has not been blocked in the SpaceFibre output port of the terminal node itself) the packet goes to the next SpaceFibre router. It will be received in the SpaceFibre router input port, go to an output port, where its further transfer will be suspended until a corresponding timeslot. The Fig. 10 represents plots of the packet delay due to a transmitted out of its timeslot traffic.

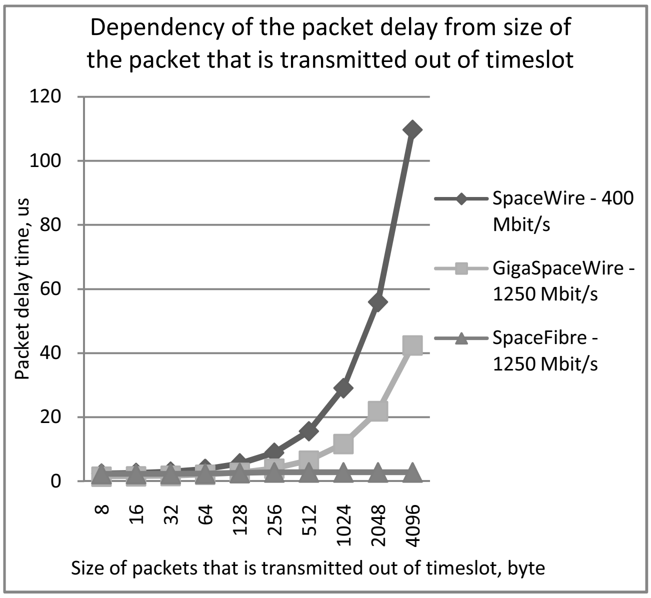

Fig. 10. Dependency of the packet delay in one router from the size of the packet that is transmitted out of his timeslot

If we need to transmit traffic with guaranteed delivery time and traffic without this requirement, one part of time slots can be for traffic with guaranteed transmission time and remaining time slots for other traffics. Transmission paths of the traffic without guaranteed time requirement can share interconnection paths in assigned for them all time slots.

We should take into account also that in SpaceFibre timeslotting is associated with virtual channels, not with packets. As in the priorities case, the quantity of virtual channels in a SpaceFibre data link is constrained by its hardware cost. Typical virtual channels quantity per data link is 4 or, rarely 8. The specified in the SpaceFibre standard draft quantity of 256 VC is practically impossible for implementation in VLSI. Therefore in SpaceFibre there is very limited number of objects for scheduling. Applications' packets flow scheduling and selection of data transmission paths will be essentially complicated in comparison with SpaceWire/GigaSpaceWire networks. The quantity of data flows that can be planned to time slots is very limited.

V. Analysis of hardware cost

Difference between local network and NoC is restrictions of hardware costs. Therefore many standards widely using in local network are not used in embedded networks and NoCs. Many QoS mechanisms have high hardware costs. In this part of paper we consider hardware costs for the basic SpaceFibre and SpaceWire/GigaSpaceWire router implementation.

We are using Cadence RTL Compiler and UMC 65 nm technology library for evaluation of router hardware cost. We evaluate SpaceFibre router area with different ports number (4-16) and virtual channels number (4, 8). Also we are using shortcut frame for SpaceFibre. We evaluate SpaceWire router area with different ports number (4-16). Total buffer size of port is 128-2048 bytes. Area results are represented in Fig. 11. NoC router area should not exceed 20%-30% of node area, [18]. Different types of ARM processors are widely used in modern embedded systems, such as embedded automotive and industrial control systems, smartphones, laptops, tablet and notepad computers. For example, the ARM11 MPCore multicore processor implements the ARM11 microarchitecture and brings multicore scalability with 1 to 4 cores from a single RTL base, enabling simple system design with a single macro to integrate with up to 4x the performance of a single core. ARM11MPCore area is 1,77 mm2 according to 65 nm technology, [19]. Therefore allowable router area should be within 0,35 – 0,53 mm2. As shown in Fig.11, hardware cost of all SpaceWire/GigaSpaceWire routers satisfies this requirement. Also for SpaceFibre routers this requirement was satisfied, where 4 and 8 virtual channels were used and port number is less than 16. Therefore, both SpaceWire/GigaSpaceWire and SpaceFibre could be used in embedded networks and in NoCs.

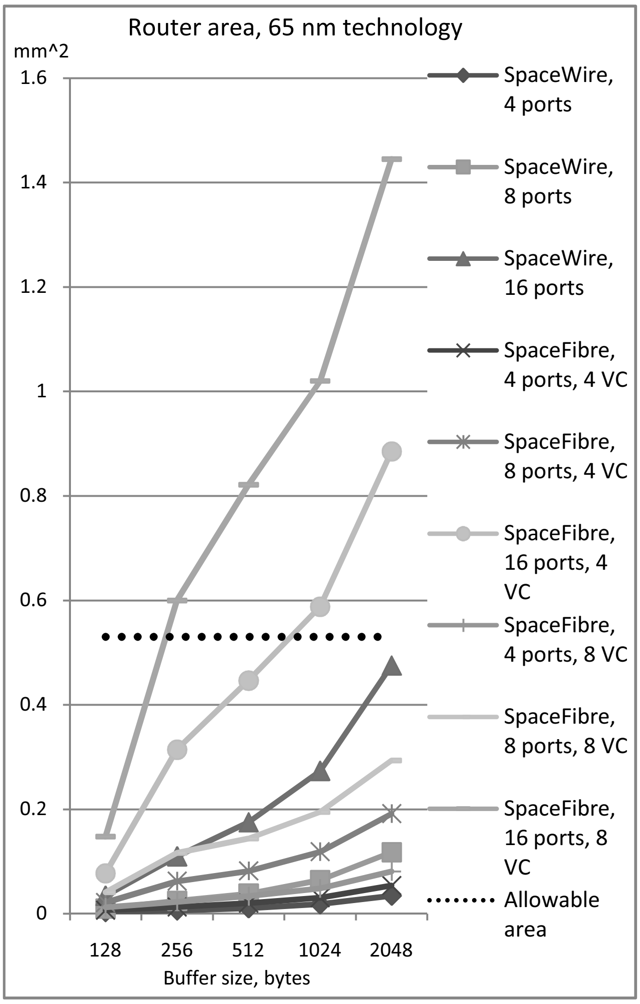

Fig. 11. Hardware cost of base router for different standarts

VI. Conclusion

The results of our studies show that QoS may be implemented both in SpaceFibre and in SpaceWire/GigaSpaceWire networks. If we constrain the packet length in SpaceWire and GigaSpaceWire network by value of 256 Bytes the timing parameters of high priority traffic transmission in these networks and SpaceFibre are similar. This constraint does not affect essentially transmission time of big data objects, which in this case would be sent by multiple packets.

The data transmission time when a network error occurs in SpaceFibre will be better than in SpaceWire/SpaceWire GigaSpaceWire network with retransmission of lost or incorrect packet between the source and destination nodes, for example at the Transport layer. On the other hand, impossibility of turning off for retry mechanism in SpaceFibre leads to essential growing of data packets transmission for traffic without guaranteed delivery requirement (e.g. video data streams). Potential incorrect interpretation of the packets that arrive too late due to waiting of connection recovery in a network with packets duplication is another problem.

For traffic with guaranteed delivery in SpaceWire/GigaSpaceWire networks same characteristics could be reached as for SpaceFibre networks if all data flows will be transferred strictly in the assigned timeslots. If it can happen that some traffic is transmitted out of its timeslots (as a result of malfunctions of terminal nodes or disconnections on links) then SpaceFibre operation will be more reliable. It checks the schedule in every data link and will stop invalid in time transmission in the first network node on its.

Traffic parameters for SpaceWire/GigaSpaceWire networks can be similar to the SpaceFibre ones when SpaceWire packet length is constrained by 256 bytes. In general, in timing characteristics for QoS traffic both SpaceFibre and SpaceWire/GigaSpaceWire area balancing in their gains in relation to network topology, error probability, size and features of target data items. In many cases they could be made rather similar.

The SpaceFibre advantages are in QoS mechanism immersion in every data link that makes them more reliable in case of network components malfunctioning. Drawbacks of the SpaceFibre approach to QoS are much higher implementation costs and longer latencies in packets delivery.

The SpaceWire/GigaSpaceWire QoS approach is considerably cheaper in implementation, gives lower latencies, and may operate over conventional SpaceWire/GigaSpaceWire network backbone. However, without control of packets transmission QoS rules and assignments inside the network backbone, it may be more sensitive to errors and network components malfunctioning. What could be included in a SpaceWire router node for more reliable QoS network operation, without sacrificing the native SpaceWire feature – compactness and simplicity, is a good subject for further research.

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