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FMEA of the IDAMC NoC

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April 10, 2014

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Versioning:
v1.0 – 07.2013
v1.1 – 04.2014

Contents

1 Introduction

Multi-core processors have replaced single-core processors for their superior performance and energy efficiency. Many-core processors are the natural evolution of this approach promising optimal scalability and hence performance scaling resulting from increased transistor densities promised by Moore's Law.

This trend has started in the server and sconsumer electronics markets but is now reaching out into embedded markets like automotive electronics, industrial electronics and aviation. In these markets, embedded processors are often used to implement safety-critical functions like electronic stability program (ESP) in cars or inertial guidance and flight management systems in airplanes. For these markets, the use of many-core processors allows the implementation of advanced safety features and the integration of multiple safety functions on a single platform.

A device implementing a safety-critical functionality is subject to a certification process defined in standards such as [1] and its domain-specific counterparts [2] for automotive electric/electronic systems and [3] for airborne electronic hardware, during which the implementer of the safety function needs to prove that the processing architecture is capable of meeting certain safety goals. For this proof, a failure mode and effects analysis (FMEA) is typically required for each component, which is used to systematically capture all potential faults and their effects [4]. Certification then mandates that all potential faults covered in the FMEA are addressed using corresponding fault-tolerance mechanisms.

A central component of many-core architectures is the interconnect, which is usually implemented as a Network-on-Chip (NoC). Hence, for a NoC that is to be used in a safety-critical application an FMEA must be performed and adequate fault-tolerance mechanisms must be provided.

We have performed an FMEA of a typical Network-on-Chip architecture, the IDAMC NoC [5], whose results are presented here. In order to keep the required effort for the FMEA down to a reasonable level, techniques, such as exploring a minimal network configuration, have been used. The IDAMC NoC's specification, packet formats, and other relevant information are described in Chapter 2. The results of the FMEA of the described NoC is presented in Chapter 3.

2 Configuration

2.1 System Boundaries and System Environment

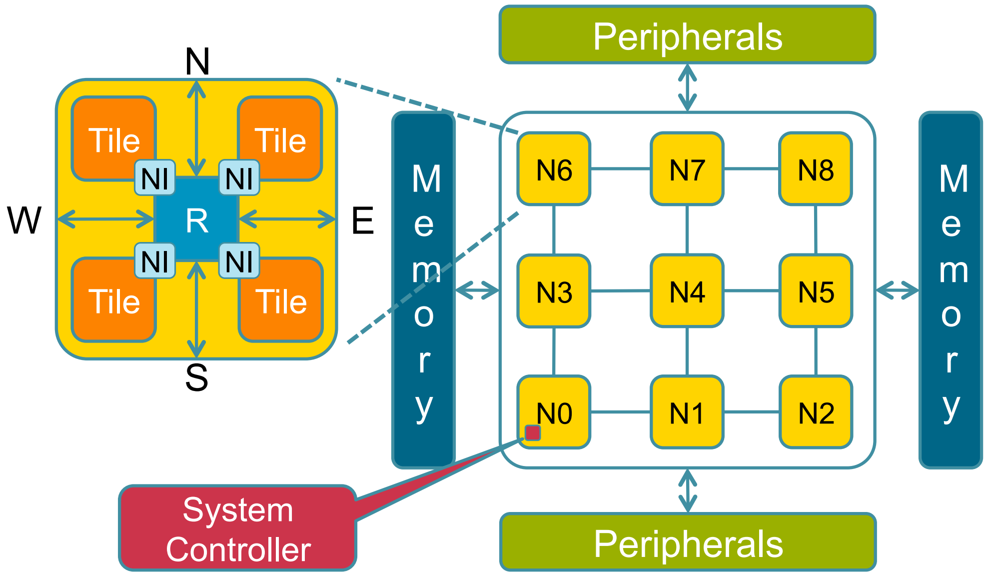

Figure 2.1: IDAMC System Overview

The NoC which we consider is part of a many-core architecture called IDAMC (Integrated Dependable Architecture for Many-Cores) which was presented in [5]. Figure 2.1 shows an overview of the IDAMC which is composed of tiles exchanging messages through the NoC. The tiles are configurable and contain usually a LEON3 processor which is connected via a bus following the AMBA-2.0 AHB/APB standard to other IP cores (memories, peripherals) from Gaisler Research Library [6]. One special AHB-peripheral is the network interface (NI) which facilitates the transmission of messages via the NoC. The NI, being a local, functionally powerful bus participant, hides the overall system structure from the individual tile. Figure 2.2 shows a fully-featured tile. One of the tiles has special privileges and is called the System Controller. It is the only tile which is allowed to reconfigure the system, i.e. write to certain configuration registers in all of the NIs.

As far as system boundaries are concerned, it is apparent from Figure 2.2 that we do not consider the NI to be part of the NoC system. This is reasonable firstly, because NI and NoC functionalities can be clearly separated and secondly, because there may be different NI implementations for different tile types which mandates a separate analysis of the NI.

2.2 Formal Specification of the System Function

When a message shall be transferred between two tiles, their NIs will have to interact as communication partners – one being the sender, the other being the recipient of the message. Once the

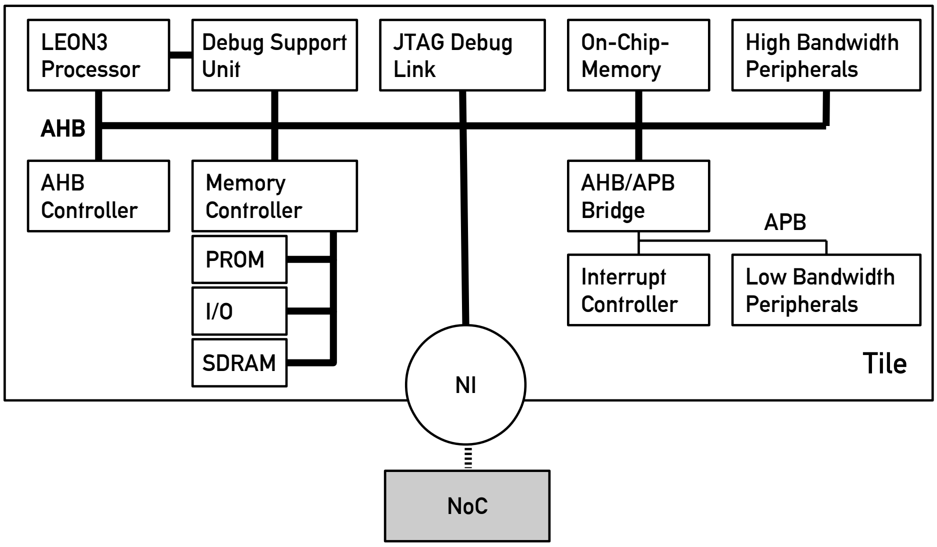

Figure 2.2: Fully-featured tile

sender (*NI X*) has handed over the message in form of a (valid) network packet to the NoC, the NoC is supposed to deliver it to the recipient, which consists of the following tasks:

a) Deliver the network packet to the intended recipient (*NI Y*).

b) Retain message integrity.

c) Ensure quality of service guarantees (e.g. maximum latency or minimum throughput)

d) Adhere to the IDAMC NoC protocol in order to avoid interference with parallel data transmissions.

2.3 Network Topology

For the IDAMC NoC we chose a two-dimensional mesh topology, which may include up to 64 nodes. As can be seen from Figure 2.3, a node represents a switch and an edge embodies a data link. The switches are based on the design presented in [7], which employ wormhole packet switching, meaning that each packet is split into flits on which the flow control is done. A switch has up to four global ports to neighboring switches, depending on its position in the network, which are named after the four compass points. Furthermore, up to 4 tiles can be connected to a switch via NIs, resulting in four supplementary, local switch ports (cf. Figure 2.4). At each input, there are multiple buffers for packets which represent different virtual channels (VC). Each VC is implemented as a separate FIFO buffer into which flits are placed according the VC number in the packet header. The use of virtual channels allows multiple packets to share the same output port and to overtake each other in case one of the packets is blocked.

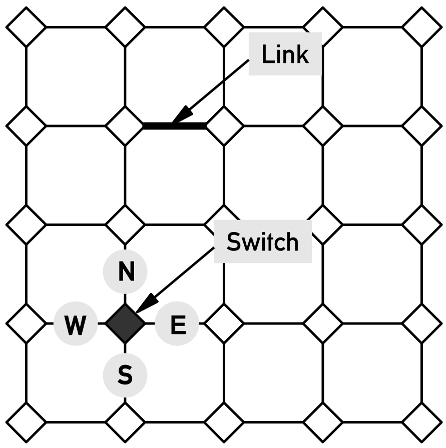

Figure 2.3: Mesh topology

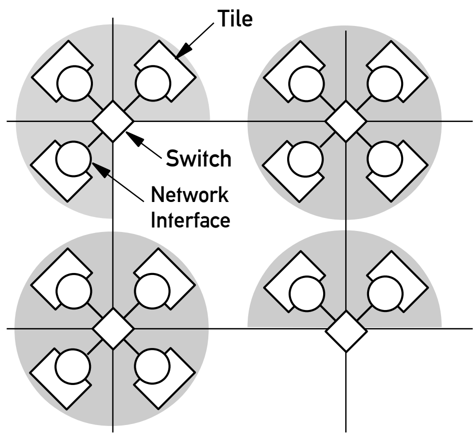

Figure 2.4: Subnetwork

2.4 Network Packet Format

A network packet is composed of Flow Control Units (flits), being 140 bits wide each. In four clock cycles a flit can be transferred from one node to a neighboring node, which implies that the Physical Transfer Unit (phit) comprises 35 Bit. The required number of flits in a packet is determined by the NI which translates the AMBA AHB protocol to the IDAMC NoC packet format. The network packet consists of one Head Flit (HF), $0 \leq n \leq 3$ Body Flits (BF) and possibly one Tail Flit (TF). Packets consisting only of an HF or an HF and a TF are possible. The HF carries the routing information in the first phit, its second phit contains further control information whereas the third and fourth phit are dedicated to payload. BFs and TFs contain control information in the first phit and payload in the remaining phits.

The IDAMC NoC uses deterministic all-at-once routing, i.e. the route of a packet is predetermined by its sender and will not be modified during transmission. The route is encoded as a sequence of up to four *runs* which are tuples of a direction (i.e. a port number) and a count of up to 8 hops (i.e. the number of hops in the same direction). This run-length encoding allows the complete route to fit into the first phit of the head flit so the routing and arbitration in each switch can begin as soon as the first phit of a packet has been received. To enhance the forwarding latency at each switch, the route is modified at each hop so that the current target port can directly be accessed at a predefined bit position. This modification must be considered if an encoding/decoding scheme is to be used to detect packet corruption.

The encoded route is stored in tables at the sending NI that can be configured by the system controller (tile with administrator rights). This configurability allows the selection of different forms of all-at-once routing. One possible realization could be the so called X-Y-routing, which is also assumed for the FMEA. When X-Y-routing is applied, a route between two nodes consists of two sections (runs): At first, all hops in the x-coordinate direction are carried out and only then, all hops in y-coordinate direction will follow. One major advantage of X-Y-routing is the prevention of deadlocks (cf. [8], p. 268).

2.5 Functional Units

The principal functional unit of the IDAMC NoC is the switch (cf. Figure 2.5) which is based on an architecture presented in [7]. In contrast to the passive link, the switch controls actively the data traffic: If, for example, an NI injects a packet, it will shortly after be received at a local input port of a NoC switch. Simultaneously, the switch in question may receive further packets from other input ports.

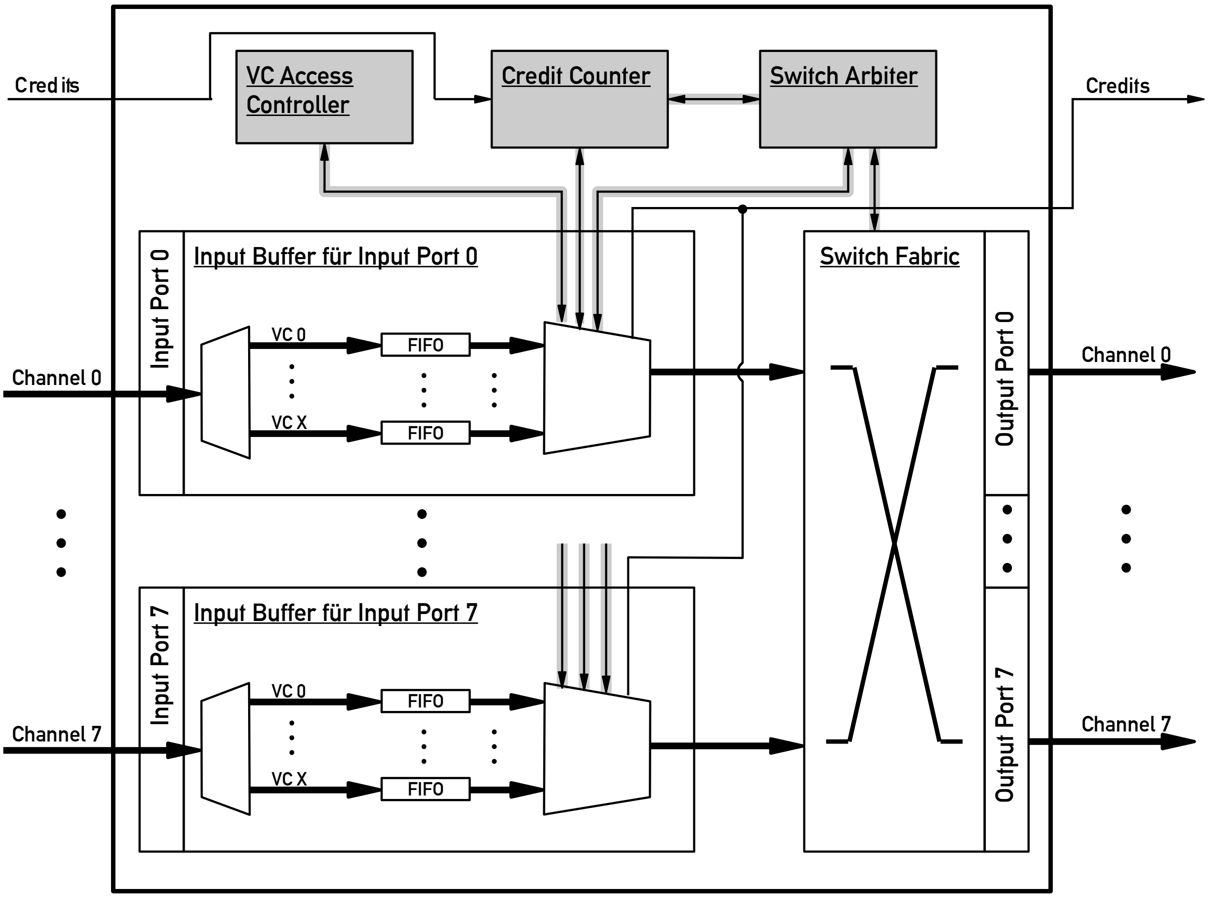

Figure 2.5: Switch Architecture

The forwarding of packets is performed in different phases. First, the switch reads out the routing information of each new packet and identifies the desired output port (routing phase). Second, it tries to reserve the virtual channel at the downstream router in which forwarded flits will be stored (VC allocation phase). It is the VC Access Controller, a control component of the switch, which will grant the request or refuse it for the time being. The latter case occurs if a packet from another input has already reserved the VC. A VC reservation will be canceled by the TF when quitting the switch. To avoid input buffer overflow, neighboring switches exchange credit points to indicate free buffer space. They are registered in each switch's Credit Counter (credit based flow control).

Once the VC has been reserved, the packet will request access to the switch fabric which transfers flits from the input ports to the output ports. The arbitration for the switch fabric is performed following the iSLIP-algorithm [9]. The iSLIP-algorithm uses two separate arbitration stages at the input and output modules, each of which is based on a round-robin arbiter that prioritizes requests that were least-recently served.

We have modified the arbitration scheme to support quality-of-service for different traffic classes – Guaranteed Throughput (GT) and Best Effort Service (BE). Traffic classes are assigned to VC via registers and the arbitration treats different traffic classes separately using the Back Suction scheme presented in [10]. Back Suction prioritizes a GT-data flow until all buffers located along the route are filled sufficiently to ensure the guaranteed throughput even in the presence of BE-data flows. Once this has happened, prioritization is inverted and BE-data flows are privileged, resulting in optimal latency for BE traffic. If the occupancy of a GT-buffer drops below a threshold, prioritization is reverted again. The strength the of concept is that BE-service will profit from low latency and at the same time the GT traffic class, often insensible to latency, will be treated as guaranteed.

2.6 FMEA Methodology

A direct application of the FMEA procedure would result in an explosion of cases to be evaluated. Therefore we elaborated several simplifications to reduce the number of cases and thus reduce the effort for the FMEA. One of these simplifications is to use a minimal network configuration (cf. Figure 2.6) which includes all possible distinct failure modes. The complete methodology is omitted in this technical report. It is presented together with findings in [11].

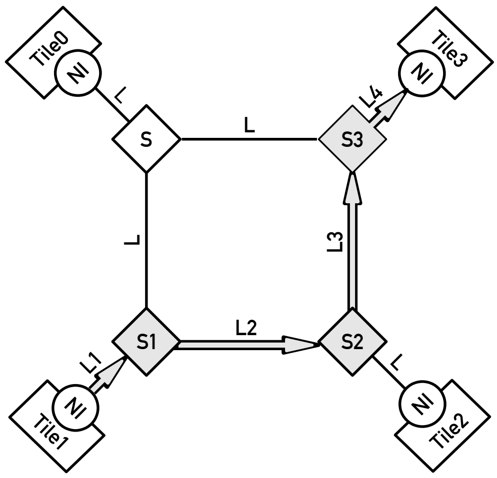

Figure 2.6: Minimal Configuration

3 Results

This chapter presents the results of the FMEA. They contain the system failures that were identified, and that are caused by at least one of all the possible failure modes.

The Sections 3.2 and 3.3 show the results of the analysis of the components switch and link, respectively, structured as a spreadsheet. All instances of a component are addressed in a single spreadsheet, and they are identified with their name when there is need to differentiate between instances.

The Section 3.4 brings the classification of the effects of a failure with respect to duration and isolation violation.

3.1 Legend

Acronyms are to reference system parts in order to reduce text size and improve the readability of the results. The used acronyms are presented in the following tables.

NoC components	
S	Switch
L	Link
NI	Network Interface
T (SC)	Tile (System controller)

Table 3.1: NoC components

Switch components	
STMOD	Switch Top Module
IB	Input Buffer
OB	Output Buffer
CC	Credit Counter
OP	Output Port
VCAC	Virtual Channel Access Controller
SA	Switch Arbiter
SF	Switch Fabric
RBANK	Register Bank

Table 3.2: Switch components

3.2 Results of FMEA for the Switch

The results of the analysis of the switch its instances are structured as a spreadsheet. The rows contain different failure modes of the component, for a particular instance (e.g. in the switch instance S1) and its

NI components	
DP	Depacketizer

Table 3.3: NI components

Flit types	
SF	Single Flit
HF	Head Flit
BF	Body Flit
TF	Tail Flit

Table 3.4: Flit types

Prefixes	
Prefix	**Meaning**
PRE.Component	Previous component of the one being analyzed (predecessor)
SUCC.Component	Next component of the one being analized (successor)
SUCC.SUCC.Component	Successor of the successor

Table 3.5: Prefixes

combination with the distinct system states (when they present different outcomes – e.g. when transmitting a BF of a packet, or a SF packet). The columns show the local effects, the global effects of a failure mode on the test packet and the background traffic, and the Failure ID.

See next page.

Component: SWITCH	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
S-ERROR/IB/ ib_be_port_req(S-IB*)(S-OP*) The S-IB* generates a wrong ib_be_port_req(S-IB*)(S-OP*) signal. This Signal informs S-OP*-SA if S-OP* is requested from S- IB* for a BE packet.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly ib_be_port_req(S-IB*)(S-OP*)=1 AND ib_gs_port_req(S-IB*)(S-OP*)=1 AND gs_selected=1	Due to gs_selected=1, BE port requests are disregarded by S-OP*-SA.	S-IB-1-A1	-	-
	wrongly ib_be_port_req(S-IB*)(S-OP*)=1 AND ib_gs_port_req(S-IB*)(S-OP*)=1 AND be_selected=1	Due to be_selected=1, GS port requests are disregarded by S-OP*-SA. Nevertheless S-OP* might be granted to IB* due to (wrongly) ib_port_req(S-IB*)(S-OP*)=1. But vc_req(VC*)=0 is set in the IB*-VC-Arbiter because only BE requests are regarded. Therefore S-OP* is not granted.	S-IB-1-A2	-	-
S-ERROR/IB/ ib_gs_port_req(S-IB*)(S-OP*) S_IB* generates a wrong ib_gs_port_req(S-IB*)(S-OP*) signal. This signal informs S-OP*-SA if S-OP* is requested from S- IB* for a GS packet.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly ib_gs_port_req(S-IB*)(S-OP*)=0	S-OP*-SA does not grant the desired S-OP* because there was no request			
		1. Suction signal for VC* in S not active.	S-IB-2-A1	-	-
		2. Suction signal for VC* in S active.	S-IB-2-A2	violation of QoS guarantees (temporary)	-
S-ERROR/IB/ ib_port_accept(S-IB*)(S-OP*) S_IB* generates a wrong ib_port_accept(S-IB*)(S-OP*) signal. This signal informs S-OP*-SA if S-IB* accepts S-OP*.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly ib_port_accept(S-IB*)(S-OP*)=1	S-OP*-SA sends control data to S-OP*-SF but due to db_out_valid(S- IB*)=0 no data is sent. (Additionally, in case of ib_ib_port_grant(S-IB*)(S-OP*)=0, there is a discrepancy between port_accept and port_grant in S- OP*-SA so that no data is sent also.) Nevertheless S-VC*-CC decrements the credit count for SUCC.S-VC*-IB*/SUCC.NI-VC*-IB; which then has only a buffer depth of 4 Flits from the perspective of S. PREC.S/PREC.NI is signaled, that there is free buffer space at S-VC*-IB*-FIFO. If PREC.S/ PREC.NI then sends a flit, the flit stored in S-VC*-IB*-FIFO will be overwritten.			
		1. Config Flit gets overwritten.	S-IB-3-A1	Packet loss	-
		2. Head Flit gets overwritten. Without the head flit no reservation of S-VC*-OP* can take place. Therefore all flits that follow the HF in S receive the control message ib_vc_access[S-OP*, VC*]=0. Blocking of S-VC*-IB*-FIFO; Potential Back Pressure.	S-IB-3-A2	Packet loss; direct resource blocking (S-VC*-IB*-FIFO)	direct resource blocking (S-VC*-IB*-FIFO); indirect resource blocking
		3. Body Flit gets overwritten.	S-IB-3-A3	Packet corruption	-

Component: SWITCH	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
		4. Tail Flit gets overwritten. The reservation of VC*-OP* in all switches that the packet traversed cannot be released. Thus all VC*-IB-FIFOs can be blocked in the traversed switches, when a next packet requests access to VC*-OP*. In the receiver's NI, the HF and the BFs of the test packet will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-notVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	S-IB-3-A4	Packet loss	direct resource blocking (alle VC*-IB-FIFOs der durchlaufenen Switches, NI-VC*-IB- FIFO, NI-DP), indirect resource blocking
	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly ib_port_accept(S-IB*)(S-OP*)=0	Because of the ib_port_accept=0, the S-OP*-SA assumes that the S-IB* will send no data to S-OP*-SF and sets the according SF-Control signal			
		1. Single Flit gets lost.	S-IB-3-B1	Packet loss	-
		2. Head Flit gets lost AND Switch S → Switch SUCC.S. A reservation of the SUCC.S-VC*-OP* is not possible without a HF, therefore all remaining Flits after HF of the test packet in SUCC.S will receive the control signal ib_vc_access[SUCC.S-OP*, VC*]=0. Blocking of the SUCC.S-VC*-IB*-FIFO; Possible back pressure.	S-IB-3-B2	Packet loss; direct resource blocking (SUCC.S-VC*-IB*- FIFO)	direct resource blocking (SUCC.S-VC*-IB*- FIFO); indirect resource blocking
		2. Head Flit gets lost AND Switch S → Switch SUCC.NI. The SUCC.NI-DP will assume that the next Flit as the HF of the test packet. Wrong data will be read for Route, Tile-ID, Tile-Port, Packet type und Payload.	S-IB-3-B3	Packet corruption, return route corruption	-
		3. Body Flit gets lost.	S-IB-3-B4	Packet corruption	-
		4. Tail Flit gets lost. For more explanation, see S-IB-3-A4	S-IB-3-B5	Packet loss	Direct resource blocking (all VC*-IB-FIFOs of the downstream switches, NI-VC*-IB-FIFO, NI-DP), indirect resource blocking
S-ERROR/IB/ib_port_req(S-IB*)(VC*)(S-OP*) The S-IB* generates a faulty signal ib_port_req(S-IB*)(VC*)(S-OP*). This signal informs S-VC*-VCAC and S-VC*-CC that the VC*-Reservation and the VC*/OP*-Creditcounter for the S-IB* must be checked.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly ib_port_req(S-IB*)(VC*)(S-OP*)=0	The S-VC*-VCAC gives vc_access(S-IB*)=0 back to S-IB* and the S-VC*-CC generates credit_avail(S-IB*)=0, so that the S-IB* eventually doesn't take the granted S-OP*.			
		1. Suction signal for VC* in S not active.	S-IB-4-A1	-	-
		2. Suction signal for VC* in S active.	S-IB-4-A2	violation of QoS guarantees (temporary)	-
S-ERROR/IB/ib_flit_type_req(S-IB*)(VC*) The S-IB* generates a faulty signal	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				

Component: SWITCH	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
The S-IB* generates a faulty signal ib_flit_type_req(S-IB*)(VC*)(S-OP*). This signal informs S-VC*-VCAC which Flit Type from S-VC*-IB* will be sent to S-OP*. (The error doesn't affect the stored Flit Type data field in the Data Buffer of the S-IB*; in SUCC.S/SUCC.NI will be correct.)	ib_flit_type_req(S-IB*)(VC*)= wrongly BF/TF instead of HF/CF OR ib_flit_type_req(S-IB*)(VC*)= wrongly HF/CF instead of BF/TF	The S-VC*-VCAC returns the incorrect vc_access(S-IB*)=0 to S-IB* because of the incorrect Flit Type, so that no request to the S-OP*-SA will be made.			
		1. Suction signal for VC* in S not active.	S-IB-5-A1	-	-
		2. Suction signal for VC* in S active.	S-IB-5-A2	violation of QoS guarantees (temporary)	-
	ib_flit_type_req(S-IB*)(VC*)= wrongly HF instead of CF OR ib_flit_type_req(S-IB*)(VC*)= BF instead of TF	The S-VC*-VCAC generates vc_access(S-IB*)=1 and the Flit is forwarded, however the S-VC*-OP*-Reservation for the testpacket in S will not be released and the following Flits of the test packet will be stuck in the S-VC*-IB*-FIFO.	S-IB-5-B1	-	direct resource blocking (S-VC*-IB*-FIFO); indirect resource blocking
	ib_flit_type_req(S-IB*)(VC*)= wrongly CF instead of HF OR ib_flit_type_req(S-IB*)(VC*)= wrongly TF instead of BF	In the following switches, which transfers the actual HF or BF, maintain the corresponding VC*-OP*-Reservation, because the Flits of the Test Packet, specially the TF, cannot be received. Because of that, all VC*-IB-FIFOs of the downstream switches become blocked, when a packet stored in them requests access also to the VC*-OP*. In the receiver's NI, the HF and the BFs of the test packet will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-notVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	S-IB-5-C1	Packet loss	Direct resource blocking (all VC*-IB-FIFOs of downstream switches, NI-VC*-IB-FIFO, NI-DP), indirect resource blocking
S-ERROR/IB/ ib_vc_status_update(S-IB*)(VC*)(S-OP*) The S-IB* generates a faulty signal ib_vc_status_update(S-IB*)(VC*)(S-OP*). This Signal informs S-VC*-VCAC whether the	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly ib_vc_status_update(S-IB*)(VC*)=0	The S-VC*-OP*-Reservation of the Test Packet is normally cancelled in S when the SF/TF of that packet is sended. This does not happen as expected, therefore the S-VC*-OP* stays blocked for all other packets requests: vc_access=0. Because of that, all S-VC*-IB-FIFOs can be blocked, a packet stored in them requests also access to the S-VC*-OP*.	S-IB-6-A1	-	direct resource blocking (S-VC*-IB-FIFOs), indirect resource blocking

Component: SWITCH	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
reservation entry for the VC*/S-OP*-Combination must be changed.	wrongly ib_vc_status_update(S-IB*)(VC*)=1	The reservation of S-VC*-OP* for the test packet is wrongly released in S. Subsequent flits of the test packet lead to blocking of S-VC*-IB*-FIFO.In the following switches the corresponding VC*-OP*-Reservations are maintained, because the Flits of the Test Packet, specially the TF, cannot be received. Because of that, all VC*-IB-FIFOs of the downstream switches become blocked, when a packet stored in them requests access also to the VC*-OP*. In the receiver's NI, the HF and the BFs of the test packet will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-notVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	S-IB-6-B1	Packet loss	direct resource blocking (alle VC*-IB-FIFOs der durchlaufenen Switches, NI-VC*-IB- FIFO, NI-DP), indirect resource blocking
S-ERROR/IB/db_out_valid(S-IB*) The S-IB* generates a faulty signal db_out_valid(S-IB*). This signal informs S-OP*-SF whether the db_output(S-IB*)-Signal is valid.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly db_out_valid(S-IB*)=0	The S-IB* sends a Flit to the S-OP*-SF, where it will not be forwarded because of db_out_valid=0 and will be therefore lost.			
		1. Config Flit gets lost.	S-IB-7-A1	Packet loss	-
		2. Head Flit gets lost AND Switch S → Switch SUCC.S. A reservation of the SUCC.S-VC*-OP* is not possible without a HF, therefore all remaining Flits after HF of the test packet in SUCC.S will receive the control signal ib_vc_access[SUCC.S-OP*, VC*]=0. Blocking of the SUCC.S-VC*-IB*-FIFO; Backpressure possible.	S-IB-7-A2	Packet loss; direct resource blocking (SUCC.S-VC*-IB*- FIFO)	direct resource blocking (SUCC.S-VC*-IB*- FIFO); indirect resource blocking
		2. Head Flit gets lost AND Switch S → Switch SUCC.NI. The SUCC.NI-DP will assume that the next Flit as the HF of the test packet. Wrong data will be read for Route, Tile-ID, Tile-Port, Packet type und Payload.	S-IB-7-A3	Packet corruption, return route corruption	-
		3. Body Flit gets lost.	S-IB-7-A4	Packet corruption	-
		4. Tail Flit gets lost. The reservation of VC*-OP* in all switches that the packet traversed cannot be released. Thus all VC*-IB-FIFOs can be blocked in the traversed switches, when a next packet requests access to VC*-OP*. In the receiver's NI, the HF and the BFs of the test packet will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-notVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	S-IB-7-A5	Packet loss	direct resource blocking (alle VC*-IB-FIFOs der durchlaufenen Switches, NI-VC*-IB- FIFO, NI-DP), indirect resource blocking

Component: SWITCH	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly db_out_valid(S-IB*)=1	The S-OP*-SF checks which S-IB must be interconnected. It holds that input_port_select/=S-IB*, therefore the signal db_out_valid(S-IB*) will be disregarded.	S-IB-7-B1	-	-
S-ERROR/IB/ db_output(S-IB*) S_IB* generates a wrong db_output(S-IB*) signal. This signal contains a phit of the test packet which will be forwarded to S-OP*- SF.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
		See Link failure modes which are related to the output_data(S-OP*) signal and effects related to L-DATA-X.			
S-ERROR/VCAC/ vc_access(VC*)(S-IB*) S_VC*-Virtual-Channel-Access- Controller generates a wrong vc_access(VC*)(S-IB*) signal. This signal informs S-IB* if the combination S-OP*/VC* is already reserved.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly vc_access(VC*)(S-IB*)=0	Due to vc_access(VC*)(S-IB*)=0, S-IB* denies the request of S-VC*-OP* for the test packet flit and does not forward it to S- OP*-SA.			
		1. Suction signal for VC* in S not active.	S-VCAC-1-A1	-	-
		2. Suction signal for VC* in S active.	S-VCAC-1-A2	violation of QoS guarantees (temporary)	-
	CASE: Switch S → Switch SUCC.S (applies to S1, S2)				
	wrongly vc_access(VC*)(S-IB*)=1 AND ib_port_grant(S-IB*)(S-OP*)=1 AND ib_port_accept(S-IB*)(VC*)(S-OP*)=1 AND CF	The requested combination S-OP*/VC* is granted to the test packet although it is already reserved by another packet P. (wrongly vc_access=1 cannot occur on a BF or TF, because this would be the correct value of the signal.) After transmission the CF blocks SUCC.S-VC*-IB*-FIFO due to ib_vc_access=0 as long as the reservation of the previous packet P is not cancelled. It cannot be cancelled because all flits of P that follow the test CF are buffered in SUCC.S- VC*-IB*-FIFO. Possible back pressure of flits of P an the test packet in all upstream NoC resources.	S-VCAC-1-B1	Packet loss, Direct resource blocking (SUCC.S-VC*-IB*-FIFO)	Direct resource blocking (SUCC.S-VC*-IB*- FIFO), indirect resource blocking
	wrongly vc_access(VC*)(S-IB*)=1 AND ib_port_grant(S-IB*)(S-OP*)=1 AND ib_port_accept(S-IB*)(VC*)(S-OP*)=1 AND HF	See S-VCAC-1-B1 with CF=HF. In addition S-VC*-IB*-FIFO is blocked because the HF did not make a reservation of S-VC*-OP* for the test packet. Following BFs and the TF of the test packet will permanently get ib_vc_access[S-OP*, VC*]=0.	S-VCAC-1-B2	Packet loss, Direct resource blocking (SUCC.S-VC*-IB*-FIFO, S-VC*-IB*-FIFO)	Direct resource blocking (SUCC.S-VC*-IB*- FIFO, S-VC*-IB*- FIFO), indirect resource blocking
	CASE: Switch S → Network Interface SUCC.NI (applies to S3)				
	wrongly vc_access(VC*)(S-IB*)=1 AND ib_port_grant(S-IB*)(S-OP*)=1 AND ib_port_accept(S-IB*)(VC*)(S-OP*)=1 AND CF	The CF is stored in SUCC.NI-VC*-IB-FIFO and there it merges with P, for which the combination S-OP*/VC* was actually reserved. Further it is possible that after forwarding the CF to SUCC.NI-DP the select-out signal of SUCC.NI-IB is changed because the packet from SUCC.NI-VC*-IB-FIFO seems to be processed completely. In that case the test packet may merge with even more packets in SUCC.NI-DP.	S-VCAC-1-B3	Packet loss	Packet corruption

Component: SWITCH	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	wrongly vc_access(VC*)(S-IB*)=1 AND ib_port_grant(S-IB*)(S-OP*)=1 AND ib_port_accept(S-IB*)(VC*)(S-OP*)=1 AND HF	The HF is stored in SUCC.NI-VC*-IB-FIFO and there it merges with P, for which the combination S-OP*/VC* was actually reserved. In addition S-VC*-IB*-FIFO is blocked because the HF did not make a reservation of S-VC*-OP* for the test packet. Following BFs and the TF of the test packet will permanently get ib_vc_access[S-OP*, VC*]=0. Possible back pressure	S-VCAC-1-B4	Packet loss, Direct resource blocking (S-VC*-IB*-FIFO)	Packet corruption, direct resource blocking (S-VC*-IB*-FIFO), indirect resource blocking
S-ERROR/CC/ **credit_avail(VC*)(S-IB*)** S_VC*-Credit-Counter generates a wrong credit_avail(VC*)(S-IB*)- Signal, This signal informs S-IB* if the succeeding S / NI has enough buffer space available for the flit that shall be sent.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly credit_avail(VC*)(S-IB*)=0	Due to credit_avail(VC*)(S-IB*)=0, S-IB* denies the request of S-VC*-OP* for the test packet flit and does not forward it to S- OP*-SA.			
		1. Suction signal for VC* in S not active.	S-CC-1-A1	-	-
		2. Suction signal for VC* in S active.	S-CC-1-A2	violation of QoS guarantees (temporary)	-
	wrongly credit_avail(VC*)(S-IB*)=1 AND ib_port_grant(S-IB*)(S-OP*)=1 AND ib_port_accept(S-IB*)(VC*)(S-OP*)=1	S sends a flit of the test packet although the buffer of SUCC.S-VC*-IB*-FIFO is full.			
		1. HF of the test packet gets overwritten. Without the HF a reservation of SUCC.S-VC*-OP* cannot be made. Therefore the flit that follows the HF of the test packet in SUCC.S receives the control message ib_vc_access[SUCC.S-OP*, VC*]=0. Blocking of SUCC.S-VC*-IB*-FIFO; Possible back pressure.	S-CC-1-B1	Packet loss; direct resource blocking (SUCC.S-VC*-IB*- FIFO)	direct resource blocking (SUCC.S-VC*-IB*- FIFO); indirect resource blocking
		2. BF of the test packet gets overwritten.	S-CC-1-B2	Packet corruption	-
		3. CF of packet P gets overwritten.	S-CC-1-B3	-	Packet loss
		4. TF of packet P gets overwritten. The reservation of all VC-OPs, that are used by P in all subsequent switches, cannot be canceled. This may block all VC-IB-FIFOs in the downstream Switches, if they store packeets which also request the same VC-OP. In the receiver's NI, the HF and the BFs of packet P will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of packet P, makes all NI-notVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO of P waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	S-CC-1-B4	Packet loss, Direct resource blocking (all VC-IB-FIFOs of the downstream switches, NI-VC-IB- FIFO, NI-DP), indirect resource blocking	Packet loss, Direct resource blocking (all VC-IB-FIFOs of the downstream switches, NI-VC-IB- FIFO, NI-DP), indirect resource blocking
	CASE: Switch S → Network Interface SUCC.NI (applies to S3)				
	wrongly credit_avail(VC*)(S-IB*)=1 AND ib_port_grant(S-IB*)(S-OP*)=1 AND ib_port_accept(S-IB*)(VC*)(S-OP*)=1	S sends a flit of the test packet, although the buffer of SUCC.NI-VC*-IB-FIFO is full.			
		1. HF of the test packet gets overwritten. This leads to misunderstanding at SUCC.NI-DP because the flit that follows the HF of the test packet is considered as the HF. Wrong data will be read for Route, Tile-ID, Tile-Port, Packet type und Payload.	S-CC-1-B5	Packet corruption, return route corruption	-
		2. BF of the test packet gets overwritten.	S-CC-1-B6	Packet corruption	-
		3. CF of packet P gets overwritten.	S-CC-1-B7	-	Packet loss

Component: SWITCH	**Local effects**		**Global effects (system failures)**		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
		4. TF of packet P gets overwritten. The following test packet will be concatenated with P in SUCC.NI because the TF of P is missing.	S-CC-1-B8	Packet loss	Packet corruption
S-ERROR/CC/ suction(VC*)(S-IB*) S_VC*-Credit-Counter generates a wrong suction(VC*)(S-IB*) signal. This signal informs S-IB* if Back Suction is active for VC* in S.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly suction(VC*)(S-IB*)=0 AND ib_port_grant(S-IB*)(S-OP*)=1 AND ib_port_accept(S-IB*)(VC*)(S-OP*)=0	S wrongly disadvantages the test packet which leads to loss of the VC arbitration in S-IB*.	S-CC-2-A1	violation of QoS guarantees (temporary)	-
	wrongly suction(VC*)(S-IB*)=0 AND ib_port_grant(S-IB*)(S-OP*)=0	S wrongly disadvantages the test packet which leads to loss of the S-OP* arbitration by S-OP*-SA.	S-CC-2-A2	violation of QoS guarantees (temporary)	-
	wrongly suction(VC*)(S-IB*)=1	S wrongly prefers the test packet at the arbitration of S-VC*-OP*.	S-CC-2-B1	-	-
S-ERROR/SARBITER/ port_grant(S-IB*)(S-OP*) S_OP*-SA generates a wrong port_grant(S-IB*)(S-OP*) signal. This signal informs S-IB* if the requested S-OP* is granted.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly port_grant(S-IB*)(S-OP*)=0	The S-IB* denies all S-OP* requests. No flit will be sent via S-OP* in this round.			
		1. Suction signal for VC* in S not active.	S-SA-1-A1	-	-
		2. Suction signal for VC* in S active.	S-SA-1-A2	violation of QoS guarantees (temporary)	-
	wrongly port_grant(S-IB*)(S-OP*)=1 AND port_grant(S-IB)(S-OP*)=1 AND ib_port_accept(S-IB*)(VC*)(S-OP*)=1 AND ib_port_accept(S-IB)(VC)(S-OP*)=1	Both S-IB* and another S-IB are allowed to send a flit via S-OP* and want to exercise this right.			
		1. Config Flit gets lost.	S-SA-1-B1	Packet loss	-
		2. Head Flit gets lost AND Switch S → Switch SUCC.S. A reservation of the SUCC.S-VC*-OP* is not possible without a HF, therefore all remaining Flits after HF of the test packet in SUCC.S will receive the control signal ib_vc_access[SUCC.S-OP*, VC*]=0. Blocking of the SUCC.S-VC*-IB*-FIFO; Possible back pressure.	S-SA-1-B2	Packet loss; direct resource blocking (SUCC.S-VC*-IB*- FIFO)	direct resource blocking (SUCC.S-VC*-IB*- FIFO); indirect resource blocking
		2. Head Flit gets lost AND Switch S → Switch SUCC.NI. The SUCC.NI-DP will assume that the next Flit as the HF of the test packet. Wrong data will be read for Route, Tile-ID, Tile-Port, Packet type und Payload.	S-SA-1-B3	Packet corruption, return route corruption	-
		3. Body Flit gets lost.	S-SA-1-B4	Packet corruption	-

Component: SWITCH	**Local effects**		**Global effects (system failures)**		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
		4. Tail Flit gets lost. The reservation of VC*-OP* in all switches that the packet traversed cannot be released. Thus all VC*-IB-FIFOs can be blocked in the traversed switches, when a next packet requests access to VC*-OP*. In the receiver's NI, the HF and the BFs of the test packet will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-notVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	S-SA-1-B5	Packet loss	direct resource blocking (all VC-IB-FIFOs of the downstream switches, NI-VC-IB- FIFO, NI-DP), indirect resource blocking
S-ERROR/SARBITER/ input_port_valid(S-OP*) S_OP*-SA generates a wrong input_port_valid(S-OP*) signal. This signal informs S-OP*-SF if the multiplexer control information from S-OP*-SA is valid.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly input_port_valid(S-OP*)=0	S-OP*-SF does not send the test packet's flit from S-IB*.			
		1. Config Flit gets lost.	S-SA-2-A1	Packet loss	-
		2. Head Flit gets lost AND Switch S → Switch SUCC.S. A reservation of the SUCC.S-VC*-OP* is not possible without a HF, therefore all remaining Flits after HF of the test packet in SUCC.S will receive the control signal ib_vc_access[SUCC.S-OP*, VC*]=0. Blocking of the SUCC.S-VC*-IB*-FIFO; Possible back pressure.	S-SA-2-A2	Packet loss; direct resource blocking (SUCC.S-VC*-IB*- FIFO)	direct resource blocking (SUCC.S-VC*-IB*- FIFO); indirect resource blocking
		2. Head Flit gets lost AND Switch S → Switch SUCC.NI. The SUCC.NI-DP will assume that the next Flit as the HF of the test packet. Wrong data will be read for Route, Tile-ID, Tile-Port, Packet type und Payload.	S-SA-2-A3	Packet corruption, return route corruption	
		3. Body Flit gets lost.	S-SA-2-A4	Packet corruption	-
		4. Tail Flit gets lost. The reservation of VC*-OP* in all switches that the packet traversed cannot be released. Thus all VC*-IB-FIFOs can be blocked in the traversed switches, when a next packet requests access to VC*-OP*. In the receiver's NI, the HF and the BFs of the test packet will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-notVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	S-SA-2-A5	Packet loss	direct resource blocking (all VC-IB-FIFOs of the downstream switches, NI-VC-IB- FIFO, NI-DP), indirect resource blocking
	wrongly input_port_valid(S-OP*)=1	Despite input_port_valid=1 no data is sent because S-OP*-SF simultaneously receives the signal db_out_valid=0 from all S-IBs.	S-SA-2-B1	-	-

Component: SWITCH	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
S-ERROR/SARBITER/ input_port_select(S-OP*) S_OP*-Switch-Arbiter generates a wrong input_port_select(S-OP*)- Signal. This signal informs S-OP*-SF which S-IB should be connected to S-OP*.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	input_port_select(S-OP*)= S-IB which does not send a flit instead of S-IB* AND input_port_valid(S-OP*)=1 AND port_grant(S-IB*)(S-OP*)=1 AND ib_port_accept(S-IB*)(VC*)(S-OP*)=1	Despite input_port_valid=1 and the choice of input_port_select no data is sent because S-OP*-SF receives the signal db_out_valid=0 from S-IB. The pending flit of the test packet gets lost.			
		1. Config Flit gets lost.	S-SA-3-A1	Packet loss	-
		2. Head Flit gets lost AND Switch S → Switch SUCC.S. A reservation of the SUCC.S-VC*-OP* is not possible without a HF, therefore all remaining Flits after HF of the test packet in SUCC.S will receive the control signal ib_vc_access[SUCC.S-OP*, VC*]=0. Blocking of the SUCC.S-VC*-IB*-FIFO; Possible back pressure.	S-SA-3-A2	Packet loss; direct resource blocking (SUCC.S-VC*-IB*- FIFO)	direct resource blocking (SUCC.S-VC*-IB*- FIFO); indirect resource blocking
		2. Head Flit gets lost AND Switch S → Switch SUCC.NI. The SUCC.NI-DP will assume that the next Flit as the HF of the test packet. Wrong data will be read for Route, Tile-ID, Tile-Port, Packet type und Payload.	S-SA-3-A3	Packet corruption, return route corruption	
		3. Body Flit gets lost.	S-SA-3-A4	Packet corruption	-
		4. Tail Flit gets lost. The reservation of VC*-OP* in all switches that the packet traversed cannot be released. Thus all VC*-IB-FIFOs can be blocked in the traversed switches, when a next packet requests access to VC*-OP*. In the receiver's NI, the HF and the BFs of the test packet will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-notVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	S-SA-3-A5	Packet loss	direct resource blocking (all VC-IB-FIFOs of the downstream switches, NI-VC-IB- FIFO, NI-DP), indirect resource blocking
S-ERROR/SFABRIC/ output_data_int(S-OP*) The S-OP*-SF sends a phit with corrupt payload to the subsequent Switch/NI.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
	wrongly output_valid_int(S-OP*)=0	output_data_int(S-OP*) is not valid anyway because of output_valid_int(S-OP*)=0.	S-SF-1-A1	-	-
	wrongly output_valid_int(S-OP*)=1	See Link failure modes which are related to the output_data(S-OP*) signal and effects related to L-DATA-X.			
S-ERROR/SFABRIC/ output_valid_int(S-OP*) The S-OP*-Switch-Fabric generates a wrong output_valid_int(S-OP*) signal. This signal informs SUCC,S/ SUCC.NI if the output_data_int(S-OP*) signal is valid.	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
		See Link failure modes which are related to the output_valid(S-OP*) signal and effects related to L-VALID-X.			
S-ERROR/RBANK/ slv_dout(i-PR)/ mst_dout(i-PR)	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				

Component: SWITCH	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
The RBANK generates a wrong slv_dout(VC*-PR) signal or a wrong mst_dout(VC*-PR) signal respectively. One of these signals is used by the SC to read the priority of VC* from S-RB.	wrongly slv_dout(VC*-PR)=BE instead of GS	The SC receives a priority value that differs from the value that was stored for VC* in S-RB. No immediate effects on packet delivery in the NoC.	S-RB-1-A1	-	-
S-ERROR/RBANK/ priority_int(S-IB*)(VC*)	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI				
The RBANK generates a wrong priority_int(S-IB*)(VC*) signal. This signal informs S-IB* about the priority that is assigned to VC*.	wrongly priority_int(S-IB*)(VC*))=BE instead of GS	The priority that is assigned to VC* is lower than the priority that was stored initially for VC* in S-RB. If a transmission error caused the wrong signal then this results in a temporary violation of QoS guarantees. If the wrong signal is caused by a faulty register value in S-RB then the violation of QoS guarantees is permanent.	S-RB-2-A1	Violation of QoS guarantees (temporary oder permanent)	-
S-ERROR/RBANK/ slv_dout(i-DTH)/ mst_dout(i-DTH)	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
The RBANK generates a wrong slv_dout(VC*-DTH) signal or a wrong mst_dout(VC*-DTH) signal respectively. One of these signals is used by the SC to read the downstream threshold of VC* from S-RB.		The SC receives a downstream threshold value that differs from the value that was stored for VC* in S-RB. No immediate effects on packet delivery in the NoC.	S-RB-3-A1	-	-
S-ERROR/RBANK/ downstream_th_int(S-OP*)(VC*)	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
The RBANK generates a wrong downstream_th_int(S-OP*)(VC*) signal. This signal informs S-VC*-CC of the downstream threshold that is assigned to VC*.	Critical CC count AND DTH too low.	The suction signal is not issued by S-VC*-CC in time. If a transmission error caused the wrong signal then this results in a temporary violation of QoS guarantees. If the wrong signal is caused by a faulty register value in S-RB then the violation of QoS guarantees is permanent.	S-RB-4-A1	Violation of QoS guarantees (temporary oder permanent)	-
S-ERROR/RBANK/ slv_dout(i-ITH)/ mst_dout(i-ITH)	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				
The RBANK generates a wrong slv_dout(VC*-ITH) signal or a wrong mst_dout(VC*-ITH) signal respectively. One of these signals is used by the SC to read the internal threshold of VC* from S-RB.		The SC receives a internal threshold value that differs from the value that was stored for VC* in S-RB. No immediate effects on packet delivery in the NoC.	S-RB-5-A1	-	-
S-ERROR/RBANK/	CASE: Switch S → Switch SUCC.S / Network Interface SUCC.NI (applies to S1, S2, S3)				

Component: SWITCH	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
internal_th_int(S-IB*)(VC*) The RBANK generates a wrong internal_th_int(S-IB*)(VC*) signal. This signal informs S-VC*-IB of the internal threshold that is assigned to VC*.	Critical CC count AND ITH too high.	The suction signal is not issued by S-VC*-CC in time. If a transmission error caused the wrong signal then this results in a temporary violation of QoS guarantees. If the wrong signal is caused by a faulty register value in S-RB then the violation of QoS guarantees is permanent.	S-RB-6-A1	Violation of QoS guarantees (temporary oder permanent)	-
S-ERROR/STMOD/ **output_credit_int(S-IB*)(VC*)** Das Switch Top Module generates a wrong output_credit_int(S-IB*)(VC*) Signal. This signal informs PREC.S/PREC.NI if S-IB* has enough free buffer space	CASE: Switch PREC.S / Network Interface PREC.NI → Switch S (betrifft S1, S2, S3)				
		See Link failure modes that are related to the credit(S-OP*)(VC*) signal and effects related to L-CREDIT-X.			

3.3 Results of FMEA for the Link

The results of the analysis of the link its instances are structured as a spreadsheet. The rows contain different failure modes of the component, for a particular instance (e.g. in the link instance L2) and its combination with the distinct system states (when they present different outcomes – e.g. when transmitting a BF of a packet, or a SF packet). The columns show the local effects, the global effects of a failure mode on the test packet and the background traffic, and the Failure ID.

See next page.

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
L-ERROR/credit(SUCC.S/SUCC.NI-IB*)(VC*) The output_credit(SUCC.S-IB*/SUCC.NIIB)(VC*)-Signal corrupted by a transmission error. This signal informs PREC.S/PREC.NI whether there is a free space in the buffer in SUCC.S-IB*- VC*-FIFO or in SUCC.NI-IB-VC*-FIFO.	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S OR Switch PREC.S → Link L4 → Network Interface SUCC.NI				
	wrong output_credit... ...(SUCC.S/SUCC.NI-IB*)(VC*)=0	The SUCC.S/SUCC.NI sends one credit less tp PREC.S/PREC.NI, so that the state of the CC in PREC.S/PREC.NI for the SUCC.S-IB*-VC*-FIFO or SUCC.NI-IB-VC*-FIFO is one unit smaller. This has the result that the Suction signal, which is generated based on this Credit count, will basically be generated too late in PREC.S/PREC.NI.	L-CREDIT-1-A1	Breach of QoS guarantee (permanent)	Breach of QoS guarantee (permanent)
	wrong output_credit... ...(SUCC.S/SUCC.NI-IB*)(VC*)=1	The SUCC.S/SUCC.NI sends wrongly one credit to PREC.S/PREC.NI, making the CC-Stand in PREC.S/PREC.NI for the SUCC.S-IB*-VC*-FIFO or SUCC.NI-IB-VC*-FIFO too high by 1 credit. As a result, the Suction-Signal, which is generated based on the Credit-count, is generated too early in PREC.S/PREC.NI. In addition, PREC.S/PREC.NI is now allowed to send a Flit to SUCC.S/SUCC.NI, although the SUCC.S/SUCC.NI-VC*-IB*-FIFO is already full. A Flit stored in that buffer can therefore be overwritten.			
		1. Single Flit is overwritten.	L-CREDIT-1-B1	Packet loss	Breach of QoS guarantee (permanent)
		2. Head Flit is overwritten in SUCC.S . A reservation of the SUCC.S-VC*-OP* is not possible without a HF, therefore all remaining Flits after HF of the test packet in SUCC.S will receive the control signal ib_vc_access[SUCC.S-OP*, VC*]=0. Blocking of the SUCC.S-VC*-IB*-FIFO; Backpressure possible.	L-CREDIT-1-B2	Packet loss, direct resource blocking (SUCC.S-VC*-IB*-FIFO)	direct resource blocking (SUCC.S-VC*-IB*-FIFO), indirect resource blocking
		2. Head Flit is overwritten in SUCC.NI . The SUCC.NI-DP will assume that the next Flit as the HF of the test packet. Wrong data will be read for Route, Tile-ID, Tile-Port, Packet type und Payload.	L-CREDIT-1-B3	Packet corruption, return route corruption	-
		3. Body Flit is overwritten.	L-CREDIT-1-B4	Packet corruption	-
		4. Tail Flit wird überschrieben. The VC*-OP*-Reservation in all downstream switches cannot be released anymore. Because of that, all VC*-IB-FIFOs of the downstream switches become blocked, when a packet stored in them requests access also to the VC*-OP*. In the receiver-NI are stored the HF and eventually some BFs of the Test Packet in NI-VC*-IB-FIFO and then are forwarded to the NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VC-IB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-nichtVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	L-CREDIT-1-B5	Packet loss	direct resource blocking (all VC*-IB-FIFOs of downstream switches, NI-VC*-IB-FIFO, NI-DP), indirect resource blocking

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
		4. Tail Flit is overwritten. Tail Flit is overwritten but continues being a TF.	L-CREDIT-1-B6	Packet corruption	-
L-ERROR/ valid(PREC.S/PREC.NI-OP*)	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S OR Switch PREC.S → Link L4 → Network Interface SUCC.NI				
The output_valid_int(S-OP*)-Signal, which is generated by PREC.S-OP*-Switch-Fabric, is corrupted by a transmission error. This signal informs SUCC,S/ SUCC.NI whether the output_data_int(PREC.S-OP*)-Signal is valid.	wrong output_valid... ...(PREC.S/PREC.NI-OP*)=0	Because of output_valid(PREC.S/PREC.NI-OP*)=0, SUCC.S/SUCC.NI assumes that no Phit was sent from PREC.S/PREC.NI. In consequence, the respective Phit of the test packet gets lost and the value of the phit_count-Signals in SUCC.S/SUCC.NI doesn't reflect the reality anymore. Therefore, the SUCC.S/SUCC.NI tries to read data from further Phits of the test packet, which is not there. This leads to wrong data about VC-ID, Flit type, Route, Tile-ID, Paket type, Tile-Port and Payload. The SUCC.S/SUCC.NI handles faulty data, which leads to packet loss, corruption, and resource blocking. In case of error propagation in the NoC, other switches and NIs can be blocked. Backpressure possible.	L-VALID-1-A1	Packet loss, Packet corruption, direct resource blocking (SUCC.S-VC*-IB*-FIFO, SUCC.NI-VC*-IB*-FIFO, SUCC.NI-DP), return route corruption	Packet loss, packet corruption, direct resource blocking (VC-IB-FIFOs of the switches and NIs, DPs of the NIs), indirect resource blocking, return route corruption
	wrong output_valid... ...(PREC.S/PREC.NI-OP*)=1	Because of output_valid(PREC.S/PREC.NI-OP*)=1, SUCC.S/SUCC.NI wrongly assumes that PREC.S/PREC.NI sent a Phit. In consequence, a new Phit is created from the invalid data in output_data(PREC.S/PREC.NI), and also the value of the phit_count-Signals in SUCC.S/SUCC.NI doesn't reflect the reality anymore. Therefore, the SUCC.S/SUCC.NI tries to read data from further Phits of the test packet, which is not there. This leads to wrong data about VC-ID, Flit type, Route, Tile-ID, Paket type, Tile-Port and Payload. The SUCC.S/SUCC.NI handles faulty data, which leads to packet loss, corruption, and resource blocking. In case of error propagation in the NoC, other switches and NIs can be blocked. Backpressure possible.	L-VALID-1-B1	Packet loss, packet corruption, direct resource blocking (SUCC.S-VC*-IB*-FIFO, SUCC.NI-VC*-IB*-FIFO, SUCC.NI-DP), return route corruption	Packet loss, packet corruption, direct resource blocking (VC-IB-FIFOs of the switches and NIs, DPs of the NIs), indirect resource blocking, return route corruption
L-ERROR/output_data/hfsf/1ph/ VC(PREC.S/PREC.NI-OP*)	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S				

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
The VC data field modified by a transmission error from PREC.S/PREC.NI to SUCC.S/SUCC.NI. In the fault-free case, VC=VC*.	SF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.S-VCwrong-IB*-FIFO was a TF or a SF of different packet P.	The SF of the Test packet is stored in the SUCC.S-VCwrong-IB*-FIFO. The SF now continues his route through VCwrong.	L-DATA-1-A1	Packet corruption, breach of QoS guarantee (temporary)	Isolation violation, breach of QoS guarantee (temporary)
	SF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.S-VCwrong-IB*-FIFO was a BF or a HF of a different packet P.	1. The data packet P uses the same OP as the SF of the Test packet, namely the SUCC.S-VCwrong-OP*. The SF of the Test packet is stored in the SUCC.S-VCwrong-IB*-FIFO. The SF now continues his route through VCwrong. However, the SF receives ib_vc_access=0, because the desired OP is already reserved for packet P. On the other hand, the TF of the data packet P can be stored according to its forwarding behind the SF of the test data packet in SUCC.S-VCwrong-IB * FIFO, so the VC-OP-reservation of the data packet P can never be released in SUCC.S. Possible blocking of the SUCC.S-VCwrong-IB*-FIFO and backpressure.	L-DATA-1-A2	Packet loss, direct resource blocking (SUCC.S-VCwrong-IB*-FIFO)	Direct resource blocking (SUCC.S-VCwrong-IB*-FIFO), indirect resource blocking
		2. The packet P does not use the same OP used by the SF of the Test packet. The SF of the Test packet is stored in the SUCC.S-VCwrong-IB*-FIFO. The SF now continues his route through VCwrong. (vgl. L-DATA-A1/A2) The SF is stored in SUCC.S-VCwrong-IB*-FIFO somewhere between the HF and the TF of the data packet P. As SUCC.S sends the SF, its route will serve as base for the remaining flits from P that were queued after SF. However, the SF does not reserve the VC-OP for further flits, which causes ib_vc_access=0 for all flits from P that are still unsent. Possible blocking of SUCC.S-VCwrong-IB*-FIFO and backpressure. Part of data packet P (without its TF) propagates through the NoC and cannot release the reservation VCwrong-OP in the traversed switches, because of the missing TF. This can block all VCwrong-IB-FIFOs in the traversed switches when another packet requests access to the same VCwrong-OP. The fragment of the transmitted data packet P is stored in the receiver-NI-VCwrong-IB-FIFO and then are forwarded to the NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VC-IB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-nichtVCwrong-IB-FIFOs to block (never emptied) and the NI-VCwrong-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	L-DATA-1-A3	Packet corruption, possible breach of QoS guarantee (temporary)	Packet loss, direct resource blocking (SUCC.S-VCwrong-IB*-FIFO, all VCwrong-IB-FIFOs in downstream switches traversed by P, NI-VCwrong-IB-FIFO, NI-DP), indirect resource blocking

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	HF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.S-VCwrong-IB*-FIFO was a HF or a BF of a different packet P.	1. The data packet P uses the same OP as the HF of the Test packet, namely the SUCC.S-VCwrong-OP*. The HF of the Test packet is stored in the SUCC.S-VCwrong-IB*-FIFO. The HF now continues his route through VCwrong. However, the HF receives ib_vc_access=0, because the desired OP is already reserved for packet P. On the other hand, the TF of the data packet P can be stored according to its forwarding behind the HF of the test data packet in SUCC.S-VCwrong-IB * FIFO, so the VC-OP-reservation of the data packet P can never be released in SUCC.S. Possible blocking of the SUCC.S-VCwrong-IB*-FIFO and backpressure. The BFs + TF of the Test packet are stored in SUCC.S-VC*-IB*-FIFO. Because the HF of the Test packet has not reserved the SUCC.S-VC*-OP*, these Flits receive ib_vc_access=0 and the SUCC.S-VC*-IB*-FIFO is blocked.	L-DATA-1-A4	Packet loss, direct resource blocking (SUCC.S-VCwrong-IB*-FIFO, SUCC.S-VC*-IB*-FIFO)	direct resource blocking (SUCC.S-VCwrong-IB*-FIFO, SUCC.S-VC*-IB*-FIFO), indirect resource blocking
		2. The data packet P does not use the same OP as the HF of the Test packet. The HF of the Test packet is stored in the SUCC.S-VCwrong-IB*-FIFO. The HF now continues his route through VCwrong. The HF of the Test packet is now stored in SUCC.S-VCwrong-IB*-FIFO somewhere between the HF and the TF of the data packet P. As SUCC.S sends the HF of the Test packet, its route will serve as base for the remaining flits from P that were queued after the HF. This causes the concatenation of the HF of the Test packet and these Flits. The remaining Flits of the Test packet (BFs+TF) are stored in SUCC.S-VC*-IB*-FIFO. However, the HF had not reserved a OP for these Flits, so that they receive now ib_vc_access=0. Possible blocking of SUCC.S-VC*-IB*-FIFO and backpressure. Concerning the propagation of the first part of the data packet P: see L-DATA-1-A4.	L-DATA-1-A5	Packet loss, direct resource blocking (SUCC.S-VCwrong-IB*-FIFO, SUCC.S-VC*-IB*-FIFO)	Packet loss, direct resource blocking (all VCwrong-IB-FIFOs in downstream switches traversed by P, NI-VCwrong-IB-FIFO, NI-DP), indirect resource blocking

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	HF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.S-VCwrong-IB*-FIFO was a TF or a SF of a different packet P. The next flit will be a HF or a SF of another packet Q.	1. The flit (a HF or a SF) of the next packet received on VCwrong uses the same OP as HF of the Test packet. The HF of the Test packet is stored in the SUCC.S-VCwrong-IB*-FIFO. The HF now continues his route through VCwrong. The next flit of the data packet Q will receive only ib_vc_access=0, because the desired OP is already reserved for the Test packet. The TF of the Test packet cannot release the OP reserve because it will be blocked in the SUCC.S-VC-IB*-FIFO. Therefore, the HF of the data packet Q will be blocked in SUCC.S-VCwrong-IB*-FIFO waiting to reserve an OP that will never be released. Possible blocking of the SUCC.S-VCwrong-IB*-FIFO and backpressure. The remaining Flits of the Test packet (BFs+TF) are stored in SUCC.S-VC*-IB*-FIFO. However, the HF had not reserved a OP for these Flits, so that they receive now ib_vc_access=0. Possible blocking of SUCC.S-VC*-IB*-FIFO and backpressure.	L-DATA-1-A6	Packet loss, direct resource blocking (SUCC.S-VC*-IB*-FIFO)	direct resource blocking (SUCC.S-VCwrong*-IB*-FIFO, SUCC.S-VC*-IB*-FIFO, all VCwrong-IB-FIFOs in downstream switches traversed by HF of the Testdatenpaket, NI-VCwrong-IB-FIFO, NI-DP), indirect resource blocking
		2. The flit (a HF or a SF) of the next packet received on VCwrong uses a different OP than HF. The HF of the Test packet is stored in the SUCC.S-VCwrong-IB*-FIFO. The HF now continues his route through VCwrong. The HF of the Test packet will reserve a OP and be transmitted. The next HF (or SF) of packet Q will allocate another OP and the remaining flits will correctly follow. The TF of packet Q will correctly release the OP. The remaining Flits of the Test packet (BFs+TF) are stored in SUCC.S-VC*-IB*-FIFO. However, the HF had not reserved a OP for these Flits, so that they receive now ib_vc_access=0. Possible blocking of SUCC.S-VC*-IB*-FIFO and backpressure. Concerning the propagation of the first part of the data packet P: see L-DATA-1-A4.	L-DATA-1-A7	Packet loss, direct resource blocking (all VCwrong-IB-FIFOs in downstream switches traversed by Testdatenpaket, NI-VCwrong-IB-FIFO, NI-DP)	Isolation violation, breach of QoS guarantee (temporary), indirect resource blocking
	CASE: Switch PREC.S → Link L4 → Network Interface SUCC.NI				
	SF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.NI-VCwrong-IB-FIFO was a HF or a BF of a different packet P.	The SF of the Test packets is sorted to the SUCC.NI-VCwrong-IB-FIFO. The SF of the Test packet is perceived by the SUCC.NI-DP as a BF of the data packet P. When the SUCC.NI-DP has a HF received, the control logic reacts only when there is a TF - it is not detected when the SF is incorporated to the data packet as a BF.	L-DATA-1-B1	Packet loss	Packet corruption
	SF of the Test packet with wrong VC-ID:	Sorting of the SF of the Test packets in the SUCC.NI-VCwrong-IB-FIFO, and depacketized by SUCC.NI-DP.			

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	VCwrong /= VC* AND The last flit received in SUCC.NI-VCwrong-IB-FIFO was a TF or a SF of a different packet P.	2. Other QoS-guarantees apply to VCwrong than to VC*.	L-DATA-1-B2	Packet corruption but with correct delivery, breach of QoS guarantee	-
	HF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.NI-VCwrong-IB-FIFO was a HF or a BF of a different packet P.	The HF of the Test packet is sorted to the SUCC.NI-VCwrong-IB-FIFO. All the next Flits of the Test packets are stored in the SUCC.NI-VC*-IB-FIFO. The HF of the Test packet is perceived by the SUCC.NI-DP as a BF of the Data packet P. When the SUCC.NI-DP has a HF received, the control logic reacts only when there is a TF - it is not detected when the SF is incorporated to the data packet as a BF. The remaining Flits of the Test packet (BFs+TF)in SUCC.NI-VC*-IB-FIFO form, from the perspective of the SUCC.NI-DP, a new packet, which contains invalid data for Route, Tile-ID, Tile-Port, Paket type and Payload.	L-DATA-1-B3	Packet corruption, return route corruption	Packet corruption, return route corruption
	HF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.NI-VCwrong-IB-FIFO was a TF or a SF of a different packet P.	The HF of the Test packet is sorted to the SUCC.NI-VCwrong-IB-FIFO. All the next Flits of the Test packets are stored in the SUCC.NI-VC*-IB-FIFO, i.e. the Test packet does not have its BFs and specially the TF, which marks the packet's end for the SUCC.NI-DP. Therefore, there is a concatenation of the Test packet with the following packet in SUCC.NI-VCwrong-IB-FIFO. The remaining Flits of the Test packet (BFs+TF)in SUCC.NI-VC*-IB-FIFO form, from the perspective of the SUCC.NI-DP, a new packet, which contains invalid data for Route, Tile-ID, Tile-Port, Paket type and Payload.	L-DATA-1-B4	Packet corruption, return route corruption	Packet loss
L-ERROR/output_data/hfsf/1ph/ FT(PREC.S/PREC.NI-OP*) The data field Flit type is corrupted by an error during the transmission from PREC.S/PREC.NI to SUCC.S/SUCC.NI. In the fault-free case, the Flit type would be a SF or a HF.	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S				
	FT=BF instead of SF/HF OR FT=TF instead of SF/HF	Because of the wrong Flit type, the SUCC.S-VC*-VCAC generates ib_vc_access(SUCC.S-OP*)(VC*)=0 for the requests. This is because a BF or TF is not able to reserve a VC*-OP*. This leads to a permanent blocking of the SUCC.S-VC*-IB*-FIFO e eventually to backpressure.	L-DATA-2-A1	Packet loss	Direct resource blocking (SUCC.S-VC*-IB*-FIFO), indirect resource blocking
	CASE: Switch PREC.S → Link L4 → Network Interface SUCC.NI				
	FT=BF instead of HF	The control logic of the NI-DP tests only if a Flit is a SF or TF. Because of that, changing the type from HF to BF does not change anything. After depacketizing, the Flit Type information is not used anymore.	L-DATA-2-B1	-	-

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	FT=TF instead of HF	The control logic of the NI-DP perceives the Test packet as ended, because of the wrong Flit type data. The remaining Flits of the Test packet (BFs+TF) form, from the perspective of the SUCC.NI-DP, a new packet, which contains invalid data for Route, Tile-ID, Tile-Port, Paket type and Payload.	L-DATA-2-B2	Packet corruption, return route corruption	-
	FT=BF instead of SF	The control logic of the NI-DP does not recognize that the Test packet is complete after the 1. Flit, because of the wrong Flit type data. Because of that, there is a concatenation with the next packet in SUCC.NI-VC*-IB-FIFO.	L-DATA-2-B3	Packet corruption	Packet loss
	FT=TF instead of SF	The control logic of the NI-DP recognizes that the Test packet is complete after the 1. Flit; here, TF and SF have the same effect. After depacketizing, the Flit Type information is not used anymore. However, there will be problems to construct a return route.	L-DATA-2-B4	Packet corruption, return route corruption	-
L-ERROR/output_data/hfsf/12ph/ ROUTE(i) The data field Route is corrupted by an error during the transmission from PREC.S/PREC.NI to SUCC.S/SUCC.NI.	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S				
	One or more bits of the route data are corrupted.	The corrupted Route leads the Test packet through a different path to the same recipient.	L-DATA-3-A1	-	isolation violation
		The corrupted Route leads the Test packet to the wrong recipient.	L-DATA-3-A2	Packet loss	isolation violation
		The corrupted Route makes the Test packet circulate in the Network.	L-DATA-3-A3	Packet loss	isolation violation
		The Route is corrupted in a way that the Test packet deviates from its original route and requests access to a non-instantiated Switch-OP. The requests are handled by the Switch as invalid and the Test packet is not forwarded. Blocking of the IB-FIFO.	L-DATA-3-A4	Packet loss, direct resource blocking (IB-FIFOs of Switches)	direct resource blocking (IB-FIFOs of switches), indirect resource blocking
		The Test packet arrives at the correct destination, but the Return route is not correctly reconstructed because of the route corruption..	L-DATA-3-A5	Return route corruption	-
	CASE: Switch PREC.S → Link L4 → Network Interface SUCC.NI				
	One or more bits of the route data are corrupted.	The corrupted Route leads the Test packet through a different path to the same recipient.	L-DATA-3-B1	-	-
		The Test packet arrives at the correct destination, but the Return route is not correctly reconstructed because of the route corruption..	L-DATA-3-B2	Return route corruption	-
L-ERROR/output_data/hfsf/12ph/ TILE-PORT(i)	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S OR Switch PREC.S → Link L4 → Network Interface SUCC.NI				
	TILE-PORT field corrupted	The data field Tile-Port necessary for the reconstruction of the route.	L-DATA-4-A1	Return route corruption	-

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
L-ERROR/output_data/hfcf/12ph/ SUPERVISOR(i) The field Supervisor is corrupted by an error during the transmission from PREC.S/PREC.NI to SUCC.S/SUCC.NI.	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S OR Switch PREC.S → Link L4 → Network Interface SUCC.NI				
	Access to protected address range AND SupervisorID of the System Controller (the only with access rights) is corrupted	If the SupervisorID is corrupted, a memory access as supervisor can be denied and an error message will be sent.	L-DATA-6-A1	Packet loss	-
L-ERROR/output_data/ hfsf/234ph/bftf/1234ph PL(i) The Payload is corrupted by an error during the transmission from PREC.S/PREC.NI to SUCC.S/SUCC.NI.	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S OR Switch PREC.S → Link L4 → Network Interface SUCC.NI				
		Payload of the 2./3./4. HF/SF-Phit or of the 1./2./3./4. BF/TF is corrupted.	L-DATA-7-A1	Packet corruption	-
L-ERROR/output_data/bftf/1ph/ VC(PREC.S/PREC.NI-OP*) The field VC is corrupted by an error during the transmission from PREC.S/PREC.NI to SUCC.S/SUCC.NI. In the fault-free case, VC=VC*.	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S				
	BF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.S-VCwrong-IB*-FIFO was a TF or SF of a different data packet P.	The BF of the Test packets is sorted to the SUCC.S-VCwrong-IB*-FIFO. There, the BF is not able to reserve a VC-OP, which results in a permanent ib_vc_access==0 for the BF of the Test packet. This causes the blocking of the SUCC.S-VCwrong-IB*-FIFO and possible backpressure.	L-DATA-8-A1	Packet corruption	Breach of QoS guarantee (permanent), isolation violation, direct resource blocking (SUCC.S-VCwrong-IB*-FIFO), indirect resource blocking
	BF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last Flit received in SUCC.S-VCwrong-IB*-FIFO was a HF or BF of a different data packet P.	The BF of the Test packet is sorted to the SUCC.S-VCwrong-IB*-FIFO, which is already reserved for data packet P. The BF of the Test packet is perceived by the SUCC.S as a BF of the data packet P.	L-DATA-8-A2	Packet corruption	Packet corruption, isolation violation

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	TF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.S-VCwrong-IB*-FIFO was a TF or SF of a different data packet P.	The TF of the Test packets is sorted to the SUCC.S-VCwrong-IB*-FIFO. There, the TF is not able to reserve a VC-OP, which results in a permanent ib_vc_access==0 for the TF of the Test packet. This causes the blocking of the SUCC.S-VCwrong-IB*-FIFO and possible backpressure. The other part of the Test packet (HF+BFs) propagates and cannot release the VC*-OP* reservation in the traversed switches because of the missing TF. Because of that, the VC*-IB-FIFOs in the traversed Switches are blocked if a stored packet requests the same VC*-OP*. In the receiver's NI, the HF and the BFs of the test packet will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-nichtVC*-IB-FIFOs block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	L-DATA-8-A3	Packet loss, direct resource blocking (all VC-IB-FIFOs in downstream switches traversed by the Testdatenpaket, NI-VCwrong-IB-FIFO, NI-DP)	Breach of QoS guarantee (permanent), isolation violation, direct resource blocking (SUCC.S-VCwrong-IB*-FIFO), indirect resource blocking

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	TF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.S-VCwrong-IB*-FIFO was a HF or BF of a different data packet P.	The TF of the Test packet is sorted to the SUCC.S-VCwrong-IB*-FIFO, which is already reserved for data packet P. The TF of the Test packet is perceived by the SUCC.S as the TF of the data packet P. By transmitting the TF of the Test packet, the reservation of VCwrong in SUCC.S will be released. This will cause the next BF/TF of the data packet P to always receive ib_vc_access==0. Possible blocking of the SUCC.S-VCwrong-IB*-FIFO and backpressure. The other part of the Test packet (HF+BFs) propagates and cannot release the VC*-OP* reservation in the traversed switches because of the missing TF. Because of that, the VC*-IB-FIFOs in the traversed Switches are blocked if a stored packet requests the same VC*-OP*. In the receiver's NI, the HF and the BFs of the test packet will be stored in NI-VC*-IB-FIFO and then sent to NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VCIB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-nichtVC*-IB-FIFOs block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	L-DATA-8-A4	Packet loss, direct resource blocking (all VC-IB-FIFOs in downstream switches traversed by the Testdatenpaket, NI-VCwrong-IB-FIFO, NI-DP)	Packet corruption, breach of QoS guarantee (permanent), isolation violation, direct resource blocking (SUCC.S-VCwrong-IB*-FIFO), indirect resource blocking
	CASE: Switch PREC.S → Link L4 → Network Interface SUCC.NI				
	BF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.NI-VCwrong-IB-FIFO was a HF or BF of a different data packet P.	The BF of the Test packet is sorted to the SUCC.NI-VCwrong-IB. The BF of the Test packet is perceived by the SUCC.S as a BF of the data packet P.	L-DATA-8-B1	Packet corruption	Packet corruption, breach of QoS guarantee (temporary)
	BF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.NI-VCwrong-IB-FIFO was a TF or SF of a different data packet P.	The BF of the Test packet is sorted to the SUCC.NI-VCwrong-IB. The BF of the Test packet is perceived by the SUCC.NI-DP as the first Flit of a new data packet (i.e. a HF). This causes the concatenation of the BF with the next data packet received in SUCC.NI-VCwrong-IB.	L-DATA-8-B2	Packet corruption	Packet loss, breach of QoS guarantee (temporary)

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	TF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.NI-VCwrong-IB-FIFO was a HF or BF of a different data packet P.	The TF of the Test packet is sorted to the SUCC.NI-VCwrong-IB. The TF of the Test packet is perceived by the SUCC.S as a TF of the data packet P. The remaining BFs+TF from the data packet P form, from the perspective of the SUCC.NI-DP, a new packet that contains invalid control data. The Test packet misses the TF, which marks the end of a packet for the SUCC.NI-DP. Therefore, there is a concatenation of the Test packets with the next packet arriving in the SUCC.NI-VC*-IB-FIFO.	L-DATA-8-B3	Packet corruption.	Packet corruption, packet loss, breach of QoS guarantee (temporary)
	TF of the Test packet with wrong VC-ID: VCwrong /= VC* AND The last flit received in SUCC.NI-VCwrong-IB-FIFO was a TF or SF of a different data packet P.	The TF of the Test packet is sorted to the SUCC.NI-VCwrong-IB. The TF of the Test packet is perceived by the SUCC.NI-DP as the first Flit of a new data packet (i.e. a HF). This causes the concatenation of the TF with the next data packet received in SUCC.NI-VCwrong-IB. The Test packet misses the TF, which marks the end of a packet for the SUCC.NI-DP. Therefore, there is a concatenation of the Test packets with the next packet arriving in the SUCC.NI-VC*-IB-FIFO.	L-DATA-8-B4	Packet corruption.	Packet corruption, packet loss, breach of QoS guarantee (temporary)
L-ERROR/output_data/bftf/1ph/ FT(PREC.S/PREC.NI-OP*) The field Flit type is corrupted by an error during the transmission from PREC.S/PREC.NI to SUCC.S/SUCC.NI. In the fault-free case, the Flit type would be a BF or a TF.	CASE: Network Interface PREC.NI → Link L1 → Switch SUCC.S OR Switch PREC.S → Link L2/L3 → Switch SUCC.S				
	FT=TF instead of BF	The VC*-OP* reservation in SUCC.S will be released after the corrupt Flit is sent. The following Flits of the Test packet cannot be forwarded anymore because ib_vc_access==0. Resouce blocking and possible backpressure.	L-DATA-9-A1	Packet corruption, direct resource blocking (SUCC.S-VC*-IB*)	Direct resource blocking (SUCC.S-VC*-IB*), indirect resource blocking
	FT=BF instead of TF	The VC*-OP* reservation in the switches traversed by the Test packet cannot be released because of the missing TF. Because of that, all VC*-IB-FIFOs of the downstream switches become blocked, when a packet stored in them requests access also to the VC*-OP*. In the receiver-NI are stored the HF and eventually some BFs of the Test Packet in NI-VC*-IB-FIFO and then are forwarded to the NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VC-IB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-nichtVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	L-DATA-9-A2	Packet loss	direct resource blocking (all VC*-IB-FIFOs of the downstream switches), indirect resource blocking

Component: LINK	Local effects		Global effects (system failures)		
Failure Mode	**Fundamental constraint(s)**	**Effect**	**Failure ID**	**Test data packet**	**Background load**
	FT=SF/HF instead of BF OR FT=SF/HF instead of TF	The corrupted Flit cannot be forwarded anymore because ib_vc_access==0 (HF/SF tries to reserve the OP*-VC* again, which is already reserved). Blocking of the SUCC.S-VC*-IB*-FIFO. The VC*-OP* reservation in the switches traversed by the partial Test packet cannot be released because of the missing TF. Because of that, all VC*-IB-FIFOs of the downstream switches become blocked, when a packet stored in them requests access also to the VC*-OP*. In the receiver-NI are stored the HF and eventually some BFs of the Test Packet in NI-VC*-IB-FIFO and then are forwarded to the NI-DP. Generally, only a complete packet can be sent from NI-VC-IB-FIFO to the NI-DP. The other NI-VC-IB-FIFOs follow the same principle. The lack of a TF, which marks the end of the test packet, makes all NI-nichtVC*-IB-FIFOs to block (never emptied) and the NI-VC*-IB-FIFO waits in vain for more incoming Flits. The NI-DP never receives a complete packet and is therefore in a permanent waiting.	L-DATA-9-A3	Packet loss	Direct resource blocking (all VC*-IB-FIFOs of the downstream switches, NI-VC*-IB-FIFO, NI-DP), indirect resource blocking
	CASE: Switch PREC.S → Link L4 → Network Interface SUCC.NI				
	FT=BF/HF/SF instead of TF	The Test packet misses the TF, which marks the end of a packet for the SUCC.NI-DP. Therefore, there is a concatenation of the Test packets with the next packet arriving in the SUCC.NI-VC*-IB-FIFO.	L-DATA-9-B1	Packet corruption	Packet loss
	FT=TF instead of BF	The control logic of the NI-DP perceives the Test packet as ended, because of the wrong Flit type data. The remaining Flits of the Test packet (BFs+TF) form, from the perspective of the SUCC.NI-DP, a new packet, which contains invalid data for Route, Tile-ID, Tile-Port, Paket type and Payload.	L-DATA-9-B2	Packet corruption	Packet corruption, return route corruption
	FT=HF/SF instead of BF	Once the Depacketizer received a HF, the control logic only reacts to a TF. Therefore, this corruption has no impact.	L-DATA-9-B3	-	-

3.4 Classification of the Failures

The Section 3.4 brings the classification of the effects of a failure (Failure ID) with respect to its duration on the NoC (transient or static) and to isolation violation. All discovered failures from both Switch and Link are presented on the same spreadsheet and can be identified by the Failure ID.

The error effects, with respect to duration, can be:

- Transient: the effect vanishes with the affected packet. E.g. packet payload corruption.
- Static: the effect remains in the switch affecting the subsequent transmissions. E.g. a blocked virtual channel in an output port.

An error can also cause the isolation to be compromised:

- Isolation violation: the error, regardless of its duration on the NoC, affects others streams in the NoC. E.g. packet or flit derouting.

See next page.

Failure ID	Global effect on the Test Packet	transient | static	violates isolation
L-CREDIT-1-A1	Breach of QoS guarantee	static	no
L-CREDIT-1-B1	Packet loss	transient	no
	Breach of QoS guarantee	static	no
L-CREDIT-1-B2	Packet loss	static	no
	Direct resource blocking (SUCC.S-VC*-IB*-FIFO)	static	no
L-CREDIT-1-B3	Packet corruption	transient	no
	Return route corruption	transient	no
L-CREDIT-1-B4	Packet corruption	transient	no
L-CREDIT-1-B5	Packet loss	static	no
	Direct resource blocking (all VC*-IB-FIFOs of the downstream switches, NI-VC*-IB-FIFO, NI-DP)	static	no
L-CREDIT-1-B6	Packet corruption	transient	no
L-VALID-1-A1	Packet loss	transient	no
	Packet corruption	transient	no
	Direct resource blocking (all VC*-IB-FIFOs of the downstream switches, NI-VC*-IB-FIFO, NI-DP)	static	no
	Return route corruption	transient	no
L-VALID-1-B1	Packet loss	transient	yes
	Packet corruption	transient	yes
	Direct resource blocking (all VC*-IB-FIFOs of the downstream switches, NI-VC*-IB-FIFO, NI-DP)	static	yes
	Return route corruption	transient	yes
L-DATA-1-A1	Packet corruption	transient	yes
	Breach of QoS guarantee	transient	yes
L-DATA-1-A2	Packet loss	static	yes
	Direct resource blocking (SUCC.S-VCfalsch-IB*-FIFO)	static	yes
L-DATA-1-A3	Packet corruption	transient	yes
	Packet loss	static	yes
	Breach of QoS guarantee	transient	yes
	Direct resource blocking (SUCC.S-VCfalsch-IB*-FIFO, SUCC.S-VC*-IB*-FIFO)	static	yes
L-DATA-1-A4	Packet loss	static	yes
	Direct resource blocking (SUCC.S-VCfalsch-IB*-FIFO, SUCC.S-VC*-IB*-FIFO)	static	yes
L-DATA-1-A5	Packet loss	static	yes
	Direct resource blocking (all VCfalsch-IB-FIFOs in the downstream switches, NI-VCfalsch-IB-FIFO, NI-DP)	static	yes
L-DATA-1-A6	Packet loss	static	yes
	Direct resource blocking	static	yes
L-DATA-1-A7	Packet loss	static	yes
	Direct resource blocking	static	yes
	Breach of QoS guarantee	transient	yes
L-DATA-1-B1	Packet loss	transient	yes
	Packet corruption	transient	yes
L-DATA-1-B2	Packet corruption	transient	yes
	Breach of QoS guarantee	transient	yes
L-DATA-1-B3	Packet corruption	transient	yes
	Return route corruption	transient	yes

Failure ID	Global effect on the Test Packet	transient | static	violates isolation
L-DATA-1-B4	Packet corruption	transient	yes
	Return route corruption	transient	yes
	Packet loss	transient	yes
L-DATA-2-A1	Packet loss	static	no
	Direct resource blocking	static	no
L-DATA-2-B1	-		
L-DATA-2-B2	Packet corruption	transient	no
	Return route corruption	transient	no
L-DATA-2-B3	Packet corruption	transient	no
	Packet loss	transient	no
L-DATA-2-B4	Packet corruption	transient	no
	Return route corruption	transient	no
L-DATA-3-A1	-		
L-DATA-3-A2	Packet loss	transient	yes
L-DATA-3-A3	Packet loss	transient	yes
L-DATA-3-A4	Packet loss	transient	yes
	Direct resource blocking	static	yes
L-DATA-3-A5	Return route corruption	transient	no
L-DATA-3-B1	-		
L-DATA-3-B2	Return route corruption	transient	no
L-DATA-4-A1	Return route corruption	transient	no
L-DATA-6-A1	Packet loss	transient	no
L-DATA-7-A1	Packet corruption	transient	no
L-DATA-8-A1	Packet corruption	transient	yes
	Direct resource blocking	static	yes
L-DATA-8-A2	Packet corruption	transient	yes
L-DATA-8-A3	Packet loss	static	yes
	Direct resource blocking	static	yes
L-DATA-8-A4	Packet loss	static	yes
	Direct resource blocking	static	yes
L-DATA-8-B1	Packet corruption	transient	yes
	Breach of QoS guarantee	transient	yes
L-DATA-8-B2	Packet corruption	transient	yes
	Packet loss	transient	yes
	Breach of QoS guarantee	transient	yes
L-DATA-8-B3	Packet corruption	transient	yes
	Packet loss	transient	yes
	Breach of QoS guarantee	transient	yes
L-DATA-8-A4	Packet corruption	transient	yes
	Breach of QoS guarantee	transient	yes
L-DATA-9-A1	Packet corruption	transient	no
	Direct resource blocking	static	no
L-DATA-9-A2	Packet loss	static	no
	Direct resource blocking	static	no
L-DATA-9-A3	Packet loss	static	no
	Direct resource blocking	static	no
L-DATA-9-B1	Packet corruption	transient	no
	Packet loss	transient	no

Failure ID	Global effect on the Test Packet	transient | static	violates isolation
L-DATA-9-B2	Packet corruption	transient	no
	Return route corruption	transient	no
L-DATA-9-B3	-		
S-IB-1-A1	-		
S-IB-1-A2	-		
S-IB-2-A1	-		
S-IB-2-A2	Breach of QoS guarantee	transient	no
S-IB-3-A1	Packet loss	transient	no
S-IB-3-A2	Packet loss	static	no
	Direct resource blocking	static	no
S-IB-3-A3	Packet corruption	transient	no
S-IB-3-A4	Packet loss	static	no
	Direct resource blocking	static	no
S-IB-3-B1	Packet loss	transient	no
S-IB-3-B2	Packet loss	static	no
	Direct resource blocking	static	no
S-IB-3-B3	Packet corruption	transient	no
	Return route corruption	transient	no
S-IB-3-B4	Packet corruption	transient	no
S-IB-3-B5	Packet loss	static	no
	Direct resource blocking	static	no
S-IB-4-A1	-		
S-IB-4-A2	Breach of QoS guarantee	transient	no
S-IB-5-A1	-		
S-IB-5-A2	Breach of QoS guarantee	transient	no
S-IB-5-B1	Direct resource blocking	static	no
S-IB-5-C1	Packet loss	static	no
	Direct resource blocking	static	no
S-IB-6-A1	Direct resource blocking	static	no
S-IB-6-A2	Packet loss	static	no
	Direct resource blocking	static	no
S-IB-7-A1	Packet loss	transient	no
S-IB-7-A2	Packet loss	static	no
	Direct resource blocking	static	no
S-IB-7-A3	Packet corruption	transient	no
	Return route corruption	transient	no
S-IB-7-A4	Packet corruption	transient	no
S-IB-7-A5	Packet loss	static	no
	Direct resource blocking	static	no
S-IB-7-B1	-		
S-VCAC-1-A1	-		
S-VCAC-1-A2	Breach of QoS guarantee	transient	no
S-VCAC-1-B1	Packet loss	static	no
	Direct resource blocking	static	no
S-VCAC-1-B2	Packet loss	static	no
	Direct resource blocking	static	no
S-VCAC-1-B3	Packet loss	transient	no
	Packet corruption	transient	no

Failure ID	Global effect on the Test Packet	transient | static	violates isolation
S-VCAC-1-B4	Packet loss	static	no
	Direct resource blocking	static	no
S-CC-1-A1	-		
S-CC-1-A2	Breach of QoS guarantee	transient	no
S-CC-1-B1	Packet loss	static	no
	Direct resource blocking	static	no
S-CC-1-B2	Packet corruption	transient	no
S-CC-1-B3	Packet loss	transient	no
S-CC-1-B4	Packet loss	static	no
	Direct resource blocking	static	no
S-CC-1-B5	Packet corruption	transient	no
	Return route corruption	transient	no
S-CC-1-B6	Packet corruption	transient	no
S-CC-1-B7	Packet loss	transient	no
S-CC-1-B8	Packet corruption	transient	no
	Packet loss	transient	no
S-CC-2-A1	Breach of QoS guarantee	transient	no
S-CC-2-A2	Breach of QoS guarantee	transient	no
S-CC-2-A3	-		
S-SA-1-A1	-		
S-SA-1-A2	Breach of QoS guarantee	transient	no
S-SA-1-B1	Packet loss	transient	no
S-SA-1-B2	Packet loss	static	no
	Direct resource blocking	static	no
S-SA-1-B3	Packet corruption	transient	no
	Return route corruption	transient	no
S-SA-1-B4	Packet corruption	transient	no
S-SA-1-B5	Packet loss	static	no
	Direct resource blocking	static	no
S-SA-2-A1	Packet loss	transient	no
S-SA-2-A2	Packet loss	static	no
	Direct resource blocking	static	no
S-SA-2-A3	Packet corruption	transient	no
	Return route corruption	transient	no
S-SA-2-A4	Packet corruption	transient	no
S-SA-2-A5	Packet loss	static	no
	Direct resource blocking	static	no
S-SA-2-B1	-		
S-SA-3-A1	Packet loss	transient	no
S-SA-3-A2	Packet loss	static	no
	Direct resource blocking	static	no
S-SA-3-A3	Packet corruption	transient	no
	Return route corruption	transient	no
S-SA-3-A4	Packet corruption	transient	no
S-SA-3-A5	Packet loss	static	no
	Direct resource blocking	static	no
S-SA-3-B1	Packet loss	transient	yes
S-SA-3-B2	Packet loss	transient	yes

Failure ID	Global effect on the Test Packet	transient | static	violates isolation
S-SA-3-B3	Packet loss	static	yes
	Direct resource blocking	static	yes
S-SA-3-B4	Packet loss	static	yes
	Direct resource blocking	static	yes
	Packet corruption	transient	yes
	Return route corruption	transient	yes
S-SA-3-B5	Packet corruption	transient	yes
	Direct resource blocking	static	yes
S-SA-3-B6	Packet corruption	transient	yes
	Return route corruption	transient	yes
S-SA-3-B7	Packet loss	static	yes
	Direct resource blocking	static	yes
S-SA-3-B8	Packet loss	static	yes
	Direct resource blocking	static	yes
	Packet corruption	transient	yes
	Return route corruption	transient	yes
S-SA-3-C1	Packet loss	static	yes
	Direct resource blocking	static	yes
S-SA-3-C2	Packet loss	transient	yes
	Packet corruption	transient	yes
S-SA-3-C3	Packet loss	static	yes
	Direct resource blocking	static	yes
S-SA-3-C4	Packet loss	static	yes
	Direct resource blocking	static	yes
	Packet corruption	transient	yes
S-SA-3-C5	Packet corruption	transient	yes
S-SA-3-C6	Packet corruption	transient	yes
S-SA-3-C7	Packet loss	static	yes
	Direct resource blocking	static	yes
S-SA-3-C8	Packet loss	static	yes
	Direct resource blocking	static	yes
	Packet corruption	transient	yes
S-SA-3-D1	Packet loss	transient	yes
S-SA-3-D2	Packet loss	transient	yes
S-SA-3-D3	Packet corruption	transient	yes
	Return route corruption	transient	yes
	Direct resource blocking	static	yes
S-SA-3-D4	Packet corruption	transient	yes
	Return route corruption	transient	yes
S-SA-3-D5	Packet corruption	transient	yes
	Direct resource blocking	static	yes
S-SA-3-D6	Packet corruption	transient	yes
	Return route corruption	transient	yes
S-SA-3-D7	Packet loss	transient	yes
	Packet corruption	transient	yes
	Return route corruption	transient	yes
S-SA-3-D8	Packet loss	transient	yes
	Return route corruption	transient	yes

Failure ID	Global effect on the Test Packet	transient | static	violates isolation
	Packet corruption	transient	yes
S-SA-3-E1	Packet loss	static	yes
	Direct resource blocking	static	yes
S-SA-3-E2	Packet loss	transient	yes
	Packet corruption	transient	yes
S-SA-3-E3	Packet corruption	transient	yes
	Return route corruption	transient	yes
	Direct resource blocking	static	yes
S-SA-3-E4	Packet corruption	transient	yes
	Return route corruption	transient	yes
S-SA-3-E5	Packet corruption	transient	yes
S-SA-3-E6	Packet corruption	transient	yes
S-SA-3-E7	Packet loss	static	yes
	Packet corruption	transient	yes
	Direct resource blocking	static	yes
S-SA-3-E8	Packet loss	transient	yes
	Packet corruption	transient	yes
S-SF-1-A1	-		
S-RB-1-A1	-		
S-RB-1-A2	-		
S-RB-2-A1	Breach of QoS guarantee	transient	no
S-RB-2-A2	-		
S-RB-3-A1	-		
S-RB-4-A1	Breach of QoS guarantee	transient	no
S-RB-4-A2	-		
S-RB-5-A1	-		
S-RB-6-A1	Breach of QoS guarantee	transient	no
S-RB-6-A2	-		

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