SpaceWire network functional model

Session: Networks & Protocols

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Introduction

An important task for devices design, network protocols development and distributed systems building is their simulation

For this purpose the SpWNM package was developed

- **It includes basic SpaceWire network elements models: a node, a routing switch and a link,**
- **allows to assemble a SpaceWire interconnection system of required structure,**
- **implements wormhole routing, time-codes and distributed interrupts mechanisms,**
- **generation and transmission of data packets.**

This configurable tool enables to estimate an efficiency and characteristics of SpaceWire based interconnections

SpWNM objectives

SpWNM (SpaceWire network simulation) packet provides means to estimate a wide range of characteristics

Simulation could be used for different research, for example,

- to select a distributed system topology,
- to define parameters (routing table, timeout values, distributed interrupts, time-codes, and so on) in a way, that required system characteristics correspond to requirements specification;
- to investigate load of every router, node and link caused by data flow and control-codes flow with different intensity;
- to validate a SpaceWire network analytical model.

Additional objectives

The SpaceWire simulator can reflect some details of hardware implementation of real devices so it is possible to use simulation results during devices development. For example, we can investigate different output port arbitration schemes in data packet switch, or different buffer size

SpWNM description

The SpWNM package implements:

- generation, receiving, transmission and handling of data packets, control-codes (Interrupt-codes, Interrupt_Acknowledge-codes, Time-codes), NULL, FCT;
- Wormhole routing and symbol flow priority according to the SpaceWire standard;
- Path, logic and regional-logic addressing;
- Adaptive group routing;
- Data packet blocking in switch where output port is unavailable (busy) or has buffer overflow and timeouts for deadlock avoidance
- Timeout mechanism in a switches and nodes for distributed interrupts recovering;
- Error modeling at the channel level

SpWNM package structure

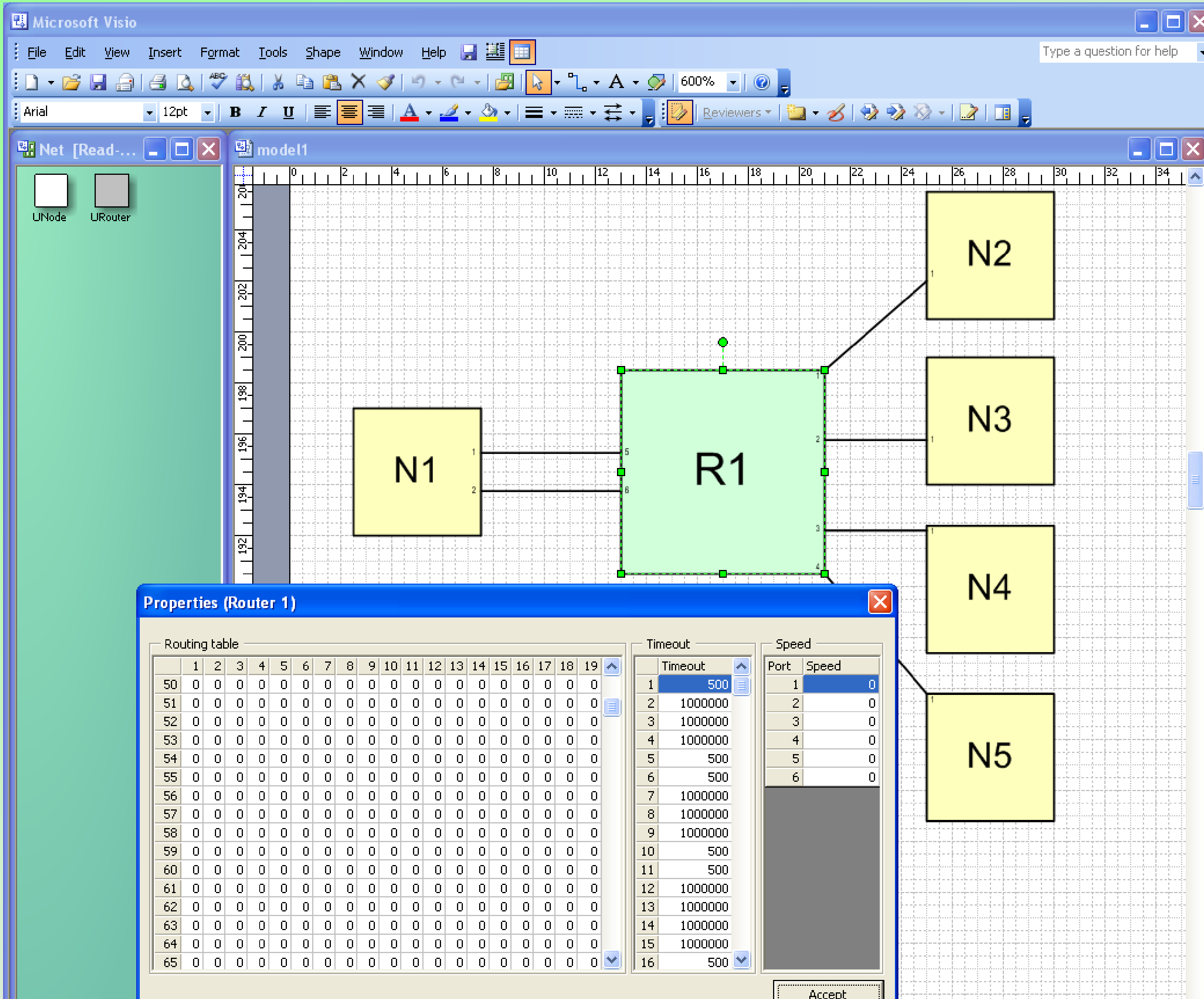
The SpWNM has a user friendly graphical interface

To input distributed system structure (topology) and their parameters the MS Visio based GUI is used.

Software system model tool is written in SystemC. It could be used in different modeling environment where SystemC is supported, for example, in IUS(5.1–5.7) environment (Cadence Design Systems), under Linux Red Hat or MS Visual Studio.

Automatic analysis of system simulation is performed by the special application

MS Visio based GUI



Input parameters settings

SpWNM's structure and parameters which are set in Visio wholly describe SpaceWire network devices.

A user can set:

- **signals transmission rate for every channel;**
- **routing tables and adaptive group routing,**
- **packets' generation parameters and timeouts values;**
- **distributed interrupts and time-codes parameters;**
- **parameters of channels error imitation.**

Before simulation started the SpWNM can be configured for specific devices hardware implementation indexes:

set a lot of time intervals, clocks and buffers size

Setting of these properties is convenient for the user and are separately applied for each device.

SpWNM simulation results

General statistics:

- **The history of the system's simulation in the form of tables, that can be parsed, for example, using filters in Excel;**
- **The channels' workload for every link by symbols of different types – Interrupt-codes, Interrupt_Acknowledge-codes, Time-codes, NULL, FCT and data packets**

Data packets:

- **Distribution of propagation time from sending data packets by concrete node to receiving this packet by it's destination**
- **Distribution of propagation time of channels' blocking inside switches;**
- **Information about data transmission errors in channels**

Control-codes:

Distribution of propagation time for Time-codes, Interrupt-codes and Interrupt_Acknowledge-codes propagation;

Log files examples

Routers' history

Time	ID	Port	In-out	Action	Value	Info
139.000	53	1	in	data	2	1-2
139.000	53	0	out	poll	1	-
140.000	53	1	out	data	1	53-3
140.000	1	0	in	time	8	-
140.000	1	0	in	time	8	-
140.000	55	1	in	data	0	3-2
140.000	2	0	in	time	8	-
140.000	2	0	in	time	8	-
140.000	3	0	in	time	8	-
140.000	3	0	in	time	8	-
141.000	2	1	in	data	eop	54-2
141.000	0	1	in	data	eop	52-2
141.000	54	0	out	poll	2	-
142.000	53	1	in	data	3	1-2
143.000	55	1	in	data	1	3-2
143.000	3	0	in	poll	3	-
144.000	17	0	in	time	8	-

Channel's workload by symbols of different types

```
     time    int     pol    null    fct     data    eop     eep
nodes:
0]
 0)0.0000 0.0000 0.0000 1.0000 0.0000 0.0000 0.0000 0.0000
 1)0.0000 0.0000 0.0345 0.9164 0.0491 0.0000 0.0000 0.0000
 2)0.0000 0.0000 0.0345 0.9186 0.0469 0.0000 0.0000 0.0000
1]
 0)0.0000 0.0000 0.0000 1.0000 0.0000 0.0000 0.0000 0.0000
 1)0.0000 0.0193 0.0000 0.4085 0.0000 0.5653 0.0069 0.0000
2]
 0)0.0000 0.0000 0.0000 1.0000 0.0000 0.0000 0.0000 0.0000
 1)0.0000 0.0197 0.0000 0.4372 0.0000 0.5365 0.0065 0.0000
3]
 0)0.0000 0.0000 0.0000 1.0000 0.0000 0.0000 0.0000 0.0000
 1)0.0000 0.0198 0.0000 0.4822 0.0000 0.4920 0.0060 0.0000
4]
 0)0.0000 0.0000 0.0000 1.0000 0.0000 0.0000 0.0000 0.0000
 1)0.0000 0.0195 0.0000 0.7072 0.0000 0.2700 0.0033 0.0000


routers:
0]
 0)0.0000 0.0000 0.0000 1.0000 0.0000 0.0000 0.0000 0.0000
 1)0.0000 0.0590 0.0345 0.8774 0.0291 0.0000 0.0000 0.0000
 2)0.0000 0.0586 0.0345 0.8793 0.0276 0.0000 0.0000 0.0000
 3)0.0000 0.0585 0.0345 0.8817 0.0254 0.0000 0.0000 0.0000
 4)0.0000 0.0588 0.0345 0.8928 0.0139 0.0000 0.0000 0.0000
 5)0.0000 0.0345 0.0000 0.0012 0.0000 0.9528 0.0115 0.0000
 6)0.0000 0.0000 0.0000 0.0786 0.0000 0.9103 0.0110 0.0000
```

Log files examples

After logs parsing we can get:

```
data:
1]
  0) 4397.500 - 5362.500 : 965.000
  1) 620245.000 - 621242.500 : 997.500
  2) 1180345.000 - 1181365.000 : 1020.000
  3) 1771950.000 - 1773017.500 : 1067.500
  4) 2408740.000 - 2409875.000 : 1135.000
```

```
=> 1053.870
```

```
4]
  0) 11315.000 - 12340.000 : 1025.000
  1) 633070.000 - 634050.000 : 980.000
  2) 1305392.500 - 1306345.000 : 952.500
  3) 1970172.500 - 1971255.000 : 1082.500
```

```
=> 1063.490
```

```
interrupts:
0]
  0) 5.000 - 140.000 : 135.000
  1) 2132.500 - 2272.500 : 140.000
  2) 2625.000 - 2812.500 : 187.500
  3) 3215.000 - 3352.500 : 137.500
  4) 4190.000 - 4337.500 : 147.500
```

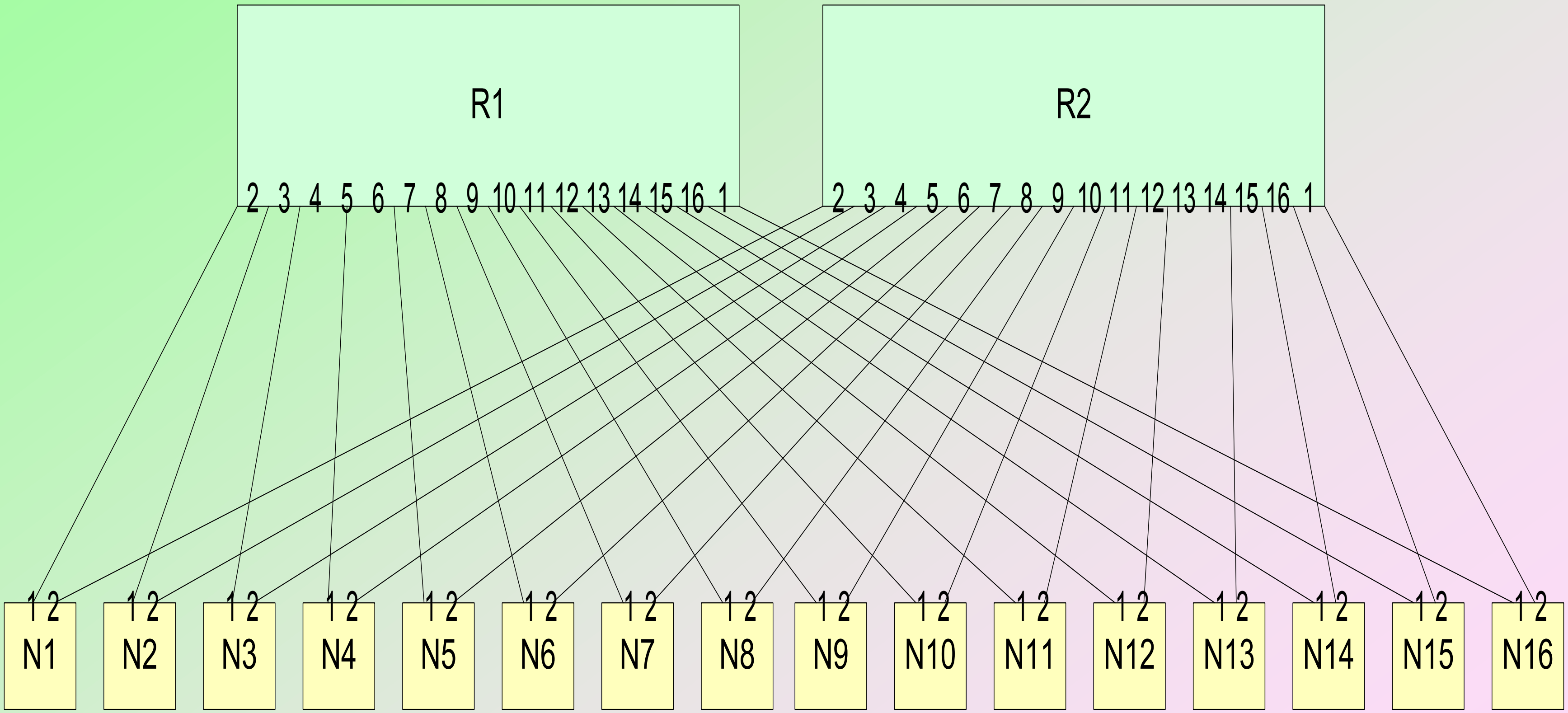
```
1935) 2497980.000 - 2498177.500 : 197.500
1936) 2499457.500 - 2499602.500 : 145.000
=> 163.308
```

```
poll codes:
0]
  0) 242.500 - 397.500 : 155.000
  1) 2375.000 - 2525.000 : 150.000
  2) 2915.000 - 3052.500 : 137.500
  3) 3455.000 - 3595.000 : 140.000
  4) 4440.000 - 4567.500 : 127.500
  5) 5147.500 - 5272.500 : 125.000
```

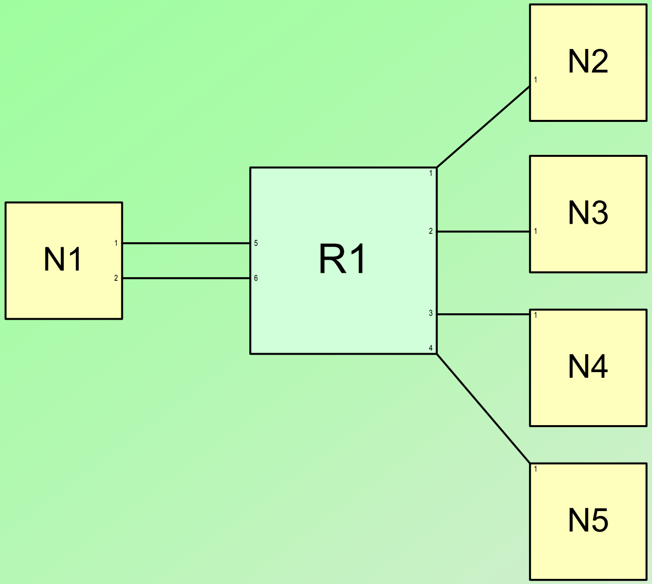
```
1935) 2498280.000 - 2498405.000 : 125.000
1936) 2499705.000 - 2499837.500 : 132.500
=> 137.817
```

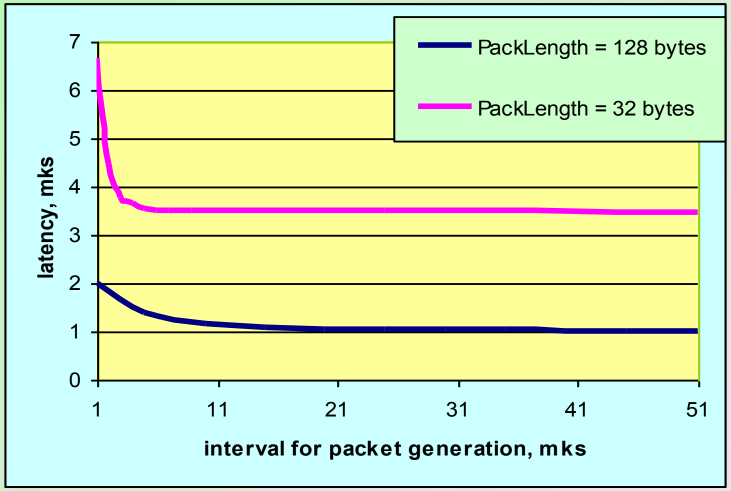
Example

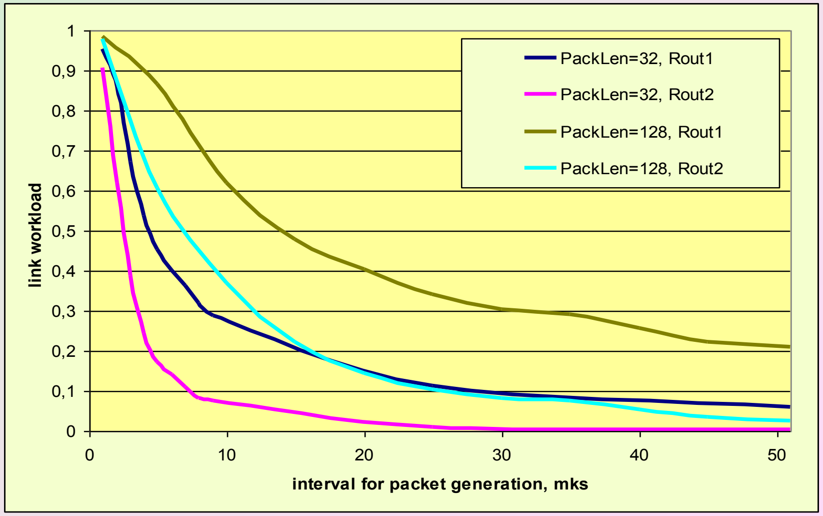
SpaceWire Network – double star (D=1)
with ATCA (Advanced Telecommunications Computing Architecture)



Example







N1 – onboard computer system. It handles all distributed interrupts and it's the destination off all packets

R1 – SpaceWire routing switch

N2-N5 – sensors.

They generate and send Interrupt-codes and data packets

Conclusion

The SpWNM provides an efficient tool for users to compose distributed SpaceWire based system model from ready made configurable modules and set their parameters in a simple way.

As a result of simulation it is possible to estimate a wide range of characteristics that that are useful for research during building distributed systems, to define their parameters.

The results can be used also to validate analytical models and devices in development.