Zhen Zhang and Wendelin Serwe
zhen.zhang@utah.edu

This form is a summary description of the model entitled "UtahNoc" proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given together with property files (possibly, one per model instance) giving a set of properties to be checked on the model.

Description

This Petri net model describes one routing node of a fault-tolerant wormhole routing algorithm for an asynchronous on-chip network communication. Data transmission between two arbitrary nodes is achieved by packets flowing from the their sources to destinations in the network.

The network considered is a two-by-two two-dimensional mesh which has four corner routing nodes, so that each routing node has two neighboring nodes and its own IP. Each IP is responsible for injecting and absorbing packets to and from its routing node. A routing node accepts a packet from its neighbors and/or its IP, computes the forwarding routing direction based on the packet's source and destination, and then transmits it accordingly. Each routing node consists of three routers and three arbiters. A router is responsible for accepting packets from its neighbor or its own IP. An arbiter is responsible for outputting a packet to its neighbor or its own IP.

Links can fail transmitting packets. To make the routing algorithm fault-tolerant, each packet is in general issued with two routing choices, providing an alternative if the first choice fails. Therefore, a router is connected to all three arbiters that are in the same node, and if one arbiter is not available, the router still has chances to communicate with the rest arbiters.

The model specification is written in LNT (*LOTOS New Technology*), which combines functional languages (to describe data types and user-defined functions operating on typed values) and process calculi (to describe concurrent components that synchronize using rendezvous and communicate via message passing). The LNT specification used was the version dated on November 28, 2013, which is 660-line long. The LNT specification was translated to LOTOS, and then to an interpreted Petri net using the CADP toolbox. Finally, the present P/T net was obtained by stripping out all dataflow-related information (variables, types, assignments, guards, etc.) from the interpreted Petri net, leading to a NUPN (*Nested-Unit Petri Net*) model translated to PNML using the CÆSAR.BDD tool.

References

Jian Wu, Zhen Zhang, and Chris Myers. *A Fault-Tolerant Routing Algorithm for a Network-on-Chip using a Link Fault Model*. Proceedings of the Virtual Worldwide Forum for PhD Researchers in Electronic Design Automation, 2011. http://www.async.ece.utah.edu/publications/VW-FEDA2.pdf

Scaling parameter

This model is not parameterized.

Size of the model

number of places:	216
number of transitions:	977
number of arcs:	2905

Structural properties

ordinary — *all arcs have multiplicity one* ..... ✔
simple free choice — *all (different) transitions with a shared input place have no other input place* ..... ✗ [a]
state machine — *every transition has exactly one input place and exactly one output place* ..... ✗ [b]

[a] 944 arcs are not free choice, e.g., the arc from place 1 (which has 40 outgoing transitions) to transition 808 (which has 2 input places).
[b] 473 transitions are not of a state machine, e.g., transition 78.

Zhen Zhang and Wendelin Serwe
zhen.zhang@utah.edu

marked graph — *every place has exactly one input transition and exactly one output transition* ..... ✗ (c)
connected — *there is an undirected path between every two nodes (places or transitions)* ..... ✔ (d)
strongly connected — *there is a directed path between every two nodes (places or transitions)* ..... ✗ (e)
source place(s) — *one or more places have no input transitions* ..... ✔ (f)
sink place(s) — *one or more places have no output transitions* ..... ✗ (g)
source transition(s) — *one or more transitions have no input places* ..... ✗ (h)
sink transitions(s) — *one or more transitions have no output places* ..... ✗ (i)
loop-free — *no transition has an input place that is also an output place* ..... ✗ (j)
conservative — *for each transition, the number of input arcs equals the number of output arcs* ..... ✗ (k)
subconservative — *for each transition, the number of input arcs equals or exceeds the number of output arcs* ..... ✗ (l)
nested units — *places are structured into hierarchically nested sequential units* (m) ..... ✔

Behavioural properties

safe — *in every reachable marking, there is no more than one token on a place* ..... ✔ (n)
deadlock — *there exists a reachable marking from which no transition can be fired* ..... ? (o)
reversible — *from every reachable marking, there is a transition path going back to the initial marking* ..... ?
quasi-live — *for every transition t, there exists a reachable marking in which t can fire* ..... ✔ (p)
live — *for every transition t, from every reachable marking, one can reach a marking in which t can fire* ..... ?

Size of the marking graph

number of reachable markings:	4.7599×10^9 (q)
number of transition firings:	7.7248×10^{10} (r)
max. number of tokens per place:	1 (s)
max. number of tokens per marking:	8 (t)

(c) 204 places are not of a marked graph, e.g., place 0.
(d) stated by CÆSAR.BDD version 1.5.
(e) from place 1 one cannot reach place 0.
(f) place 0 is a source place.
(g) stated by CÆSAR.BDD version 1.5.
(h) stated by CÆSAR.BDD version 1.5.
(i) stated by CÆSAR.BDD version 1.5.
(j) 551 transitions are not loop free, e.g., transition 165.
(k) transition 78 is not conservative.
(l) transition 78 is not subconservative.
(m) the definition of Nested-Unit Petri Nets (NUPN) is available from http://mcc.lip6.fr/nupn.php
(n) safe by construction – stated by the CÆSAR compiler.
(o) found to be false at MCC'2014 by GreatSPN.
(p) stated by CÆSAR.BDD version 2.0.
(q) computed at MCC'2014 by GreatSPN, Marcie, PNMC, and PNXDD; exact value: 4,759,924,249.
(r) computed at MCC'2014 by Marcie; exact value: 77,248,039,202.
(s) stated by the CÆSAR compiler; confirmed at MCC'2014 by GreatSPN and Marcie.
(t) confirmed at MCC'2014 by GreatSPN and Marcie.