

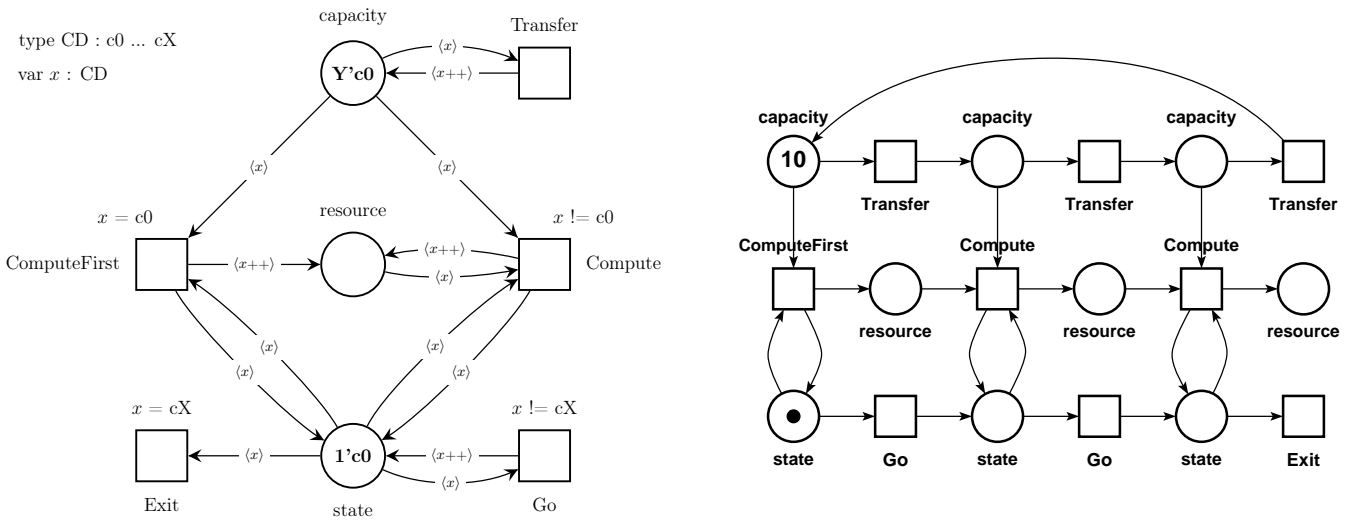
*This form is a summary description of the model entitled “CryptoMiner” proposed for the Model Checking Contest @ Petri Nets. Models can be given in several instances parameterized by scaling parameters. Colored nets can be accompanied by one or many equivalent, unfolded P/T nets. Models are given together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

## Description

This model corresponds to a processing chain with  $X + 1$  steps, each working on a different type of resource, one after another. We provide two different types of instances: CryptoMinerA, which is unbounded; and CryptoMinerB, which is a bounded version of CryptoMinerA obtained by adding a capacity place limiting the number of times a Compute transition can fire.

This is a symmetric net where resources are modelled using a cyclic enumeration type with values  $c0 \dots cX$ . At each step, only one type of resource can be processed, depending on the value of the token in place state, until we can finally fire Exit.

CryptoMinerA is a parametric version of a model used by Serge Haddad on several works about the coverability problem [1], sometimes referred to as “a day in the life of a banana farmer”. We brought this model into the 21st century and propose a symmetric net version representing the life of a cryptocurrency miner. This model was among several benchmarks used to compare the performances of tools for checking reachability problems in [2].



*Graphical representation of CryptoMinerB-COL-DXNY (left) and the derived P/T net (right), for the instance (B, 2, 10). The CryptoMinerA instances are obtained by removing place capacity*

## References

1. Finkel, A., Haddad, S., & Khmelnitsky, I. (2019). *Coverability and termination in recursive Petri nets*. In International Conference on Applications and Theory of Petri Nets and Concurrency. Springer.
2. Amat, N., Dal Zilio, S., & Hujsa, T. (2022). *Property directed reachability for generalized Petri nets*. In International Conference on Tools and Algorithms for the Construction and Analysis of Systems. Springer.

## Scaling parameter

Parameter name	Parameter description	Chosen parameter values
$(A, X)$ or $(B, X, Y)$	$X$ is the number of different resources in the model (used both for CryptoMinerA and CryptoMinerB instances), whereas $Y$ defines the initial capacity (only for CryptoMinerB instances). These parameters affect the initial marking and do not impact the size of the model	$(A, 3)$ , $(A, 5)$ , $(A, 10)$ , and $(B, 3, 10)$ , $(B, 3, 100)$ , $(B, 5, 100)$ , $(B, 5, 250)$ , $(B, 10, 100)$ , $(B, 20, 100)$

## Size of the colored net model

number of places: 2 for CryptoMinerA instances, 3 for CryptoMinerB instances  
 number of transitions: 4 for CryptoMinerA instances, 5 for CryptoMinerB instances  
 number of arcs: 10 for CryptoMinerA instances, 14 for CryptoMinerB instances

## Size of the derived P/T model instances

Parameter	Number of places	Number of transitions	Number of arcs
$(A, X)$	$2X + 2$	$2X + 2$	$6X + 4$
$(B, X, Y)$	$3X + 3$	$3X + 3$	$9X + 7$

## Structural properties

<b>ordinary</b> — <i>all arcs have multiplicity one</i> .....	✓
<b>simple free choice</b> — <i>all transitions sharing a common input place have no other input place</i> .....	✗ <sup>(a)</sup>
<b>extended free choice</b> — <i>all transitions sharing a common input place have the same input places</i> .....	✗ <sup>(b)</sup>
<b>state machine</b> — <i>every transition has exactly one input place and exactly one output place</i> .....	✗ <sup>(c)</sup>
<b>marked graph</b> — <i>every place has exactly one input transition and exactly one output transition</i> .....	✗ <sup>(d)</sup>
<b>connected</b> — <i>there is an undirected path between every two nodes (places or transitions)</i> .....	✓ <sup>(e)</sup>
<b>strongly connected</b> — <i>there is a directed path between every two nodes (places or transitions)</i> .....	✗ <sup>(f)</sup>
<b>source place(s)</b> — <i>one or more places have no input transitions</i> .....	✗ <sup>(g)</sup>
<b>sink place(s)</b> — <i>one or more places have no output transitions</i> .....	✓ <sup>(h)</sup>
<b>source transition(s)</b> — <i>one or more transitions have no input places</i> .....	✗ <sup>(i)</sup>
<b>sink transitions(s)</b> — <i>one or more transitions have no output places</i> .....	✓ <sup>(j)</sup>
<b>loop-free</b> — <i>no transition has an input place that is also an output place</i> .....	✗ <sup>(k)</sup>
<b>conservative</b> — <i>for each transition, the number of input arcs equals the number of output arcs</i> .....	✗ <sup>(l)</sup>
<b>subconservative</b> — <i>for each transition, the number of input arcs equals or exceeds the number of output arcs</i> .....	? <sup>(m)</sup>
<b>nested units</b> — <i>places are structured into hierarchically nested sequential units</i> <sup>(n)</sup> .....	✗

<sup>(a)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(b)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(c)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(d)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(e)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(f)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(g)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(h)</sup> no transition can consume a token of color “cY” from place “resource”; confirmed by [CÆSAR.BDD](#) version 3.7 (place “resource\_c0” is a sink place).  
<sup>(i)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(j)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB); transition “Exit” is a sink transition.  
<sup>(k)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(l)</sup> stated by [CÆSAR.BDD](#) version 3.7 on all 9 instances (CryptoMinerA and CryptoMinerB).  
<sup>(m)</sup> it is true for CryptoMinerB instances but false for CryptoMinerA instances; confirmed by [CÆSAR.BDD](#) version 3.7.  
<sup>(n)</sup> the definition of Nested-Unit Petri Nets (NUPN) is available from <http://mcc.lip6.fr/nupn.php>

## Behavioural properties

<b>safe</b> — in every reachable marking, there is no more than one token on a place .....	<del>X</del> <sup>(o)</sup>
<b>dead place(s)</b> — one or more places have no token in any reachable marking .....	<del>X</del>
<b>dead transition(s)</b> — one or more transitions cannot fire from any reachable marking .....	<del>X</del> <sup>(p)</sup>
<b>deadlock</b> — there exists a reachable marking from which no transition can be fired .....	✓
<b>reversible</b> — from every reachable marking, there is a transition path going back to the initial marking .....	<del>X</del>
<b>live</b> — for every transition $t$ , from every reachable marking, one can reach a marking in which $t$ can fire .....	<del>X</del>

## Size of the marking graphs

Parameter	Number of reachable markings	Number of transition firings	Max. number of tokens per place	Max. number of tokens per marking
$(A, 3), (A, 5), (A, 10)$	$\infty$ <sup>(q)</sup>	$\infty$	$\infty$	$\infty$
$(B, 3, 10)$	10 636 <sup>(r)</sup>	38 126 <sup>(s)</sup>	10 <sup>(t)</sup>	11 <sup>(u)</sup>
$(B, 3, 100)$	3 004 907 847 <sup>(v)</sup>	14 272 062 668 <sup>(w)</sup>	100	101
$(B, 5, 100)$	3 626 541 971 921 <sup>(x)</sup>	23 405 636 097 113 <sup>(y)</sup>	100	101
$(B, 5, 250)$	3.3357E+16 <sup>(z)</sup>	2.2538E+17 <sup>(aa)</sup>	250	251
$(B, 10, 100)$	1.3682E+18 <sup>(ab)</sup>	1.4276E+19 <sup>(ac)</sup>	100	101
$(B, 20, 100)$	1.4625E+26 <sup>(ad)</sup>	2.5790E+27 <sup>(ae)</sup>	100	101

## Other properties

The difficulty when analysing an instance of CryptoMiner lies in the presence of constraints that cannot be derived from the state equation alone. For instance, the presence of a token with value  $c_j$  in place ‘resource’ implies that the value in place ‘state’ is different from  $c_i$  when  $i < j$ . Unfortunately, with symmetric net, it is not possible to distinguish between different values using the MCC property language. With the derived P/T nets, a corresponding formula would be along the line of the invariant formula INV below. This formula can be used with the CryptoMinerA and CryptoMinerB instances interchangeably.

$$\text{INV} : \text{AG} ((\text{state}_{.ci} = 0) \vee (\text{resource}_{.cj} = 0)) \quad \text{where } 0 \leq i < j \leq X$$

<sup>(o)</sup> the initial marking is not safe when  $Y \geq 2$ , which is the case in all our instances.  
<sup>(p)</sup> this is false when  $Y \geq X$ , which is the case in all our instances.  
<sup>(q)</sup> place resource is unbounded; checked by [TINA](#) version 3.7.0 on January 2023.  
<sup>(r)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(s)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(t)</sup> the maximal number of tokens is equal to parameter  $Y$ , which is the initial marking of place capacity; confirmed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(u)</sup> since CryptoMinerB is subconservative, the maximum total number of tokens is  $Y + 1$ , which is observed in the initial marking; confirmed by [TINA](#) version 3.7.0 and by [CÆSAR.BDD](#) version 3.7 on January 2023.  
<sup>(v)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(w)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(x)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(y)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(z)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(aa)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(ab)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(ac)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(ad)</sup> computed by [TINA](#) version 3.7.0 on January 2023.  
<sup>(ae)</sup> computed by [TINA](#) version 3.7.0 on January 2023.