PMR 5237

Modelagem e Design de Sistemas Discretos em Redes de Petri

Aula 9 : Modelagem de sistemas com RdP

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1) *boundedness*, characterising finiteness of the state space.
2) *liveness*, related to potential fireability in all reachable markings. *Deadlock-freeness* is a weaker condition in which global infinite activity (i.e. fireability) of the net system model is guaranteed, but some parts of it may not work at all.
3) *reversibility*, characterising recoverability of the initial marking from any reachable marking.
4) *mutual exclusion*, dealing with the impossibility of simultaneous *submarkings* (p-mutex) or *firing concurrency* (t-mutex).

0) *dead (L0-live)* if t can never be fired in any firing sequence in $L(M_0)$.
1) *L1-live (potentially firable)* if t can be fired at least once in some firing sequence in $L(M_0)$.
2) *L2-live* if, given any positive integer k, t can be fired at least k times in some firing sequence in $L(M_0)$.
3) *L3-live* if t appears infinitely, often in some firing sequence in $L(M_0)$.
4) *L4-live* or *live* if t is *L1*-live for every marking M in $R(M_0)$.

Automating the invariant analysis

Automatic calculation of all place invariants:

- This is possible, but it is a very *complex* task.
- Moreover, it is difficult to represent the results on a *useful form*, i.e., a form which can be used by the system designer.

Interactive calculation of place invaritans:

- The *user* proposes some of the weights.
- The *tool* calculates the *remaining weights* – if possible.

Interactive calculation of place invariants is *much easier* than a fully automatic calculation.

The invariant method in CPN

- The user needs some ingenuity to *construct* invariants. This can be supported by *computer tools* – interactive process.
- The user also needs some ingenuity to *use* invariants. This can also be supported by *computer tools* – interactive process.
- Invariants can be used to verify a system – without fixing the *system parameters* (such as the number of sites in the data base system).

Invariants are a very important feature in CPN Design. However, we should not expect to solve the design problem by just inserting invariant analysis.

Besides those inherent problems with invariants, the difficulty to apply this approach to large systems is still present.

A equação de estado

Finalmente, podemos ter a equação que dá o fluxo de marcas (equação de estado) expressa na forma matricial como,

$$M_i = M_0 + A^T \sum_0^{i-1} T_j = M_0 + A^T \sigma_{i-1}$$

A condição necessária para que um dado estado de marcas $\mathbf{M}_{i+1}$ seja atingível a partir de $\mathbf{M}_0$ é que exista uma soma de vetores de habilitação tal que,

$$\mathbf{A}^T \sum_{j=0}^{i} \sigma_j = \mathbf{A}^T \overline{\sigma} = \mathbf{M}_{i+1} - \mathbf{M}_0 = \Delta \mathbf{M}$$

Multiplicando a equação de estado por uma matriz B_f temos que,

$$\mathbf{B}_f \mathbf{A}^T \overline{\sigma} = \mathbf{B}_f \Delta\mathbf{M} \Rightarrow$$

$$\Rightarrow (\mathbf{A}\mathbf{B}_f^T)^T \overline{\sigma} = \mathbf{B}_f \Delta\mathbf{M}$$

$B_f \Delta M = 0$ determina as soluções da equação homogênea.

Neste caso B_f é uma ponderação na distribuição das marcas tal que estas se conservam na evolução de M_0 a M_{i+1}.

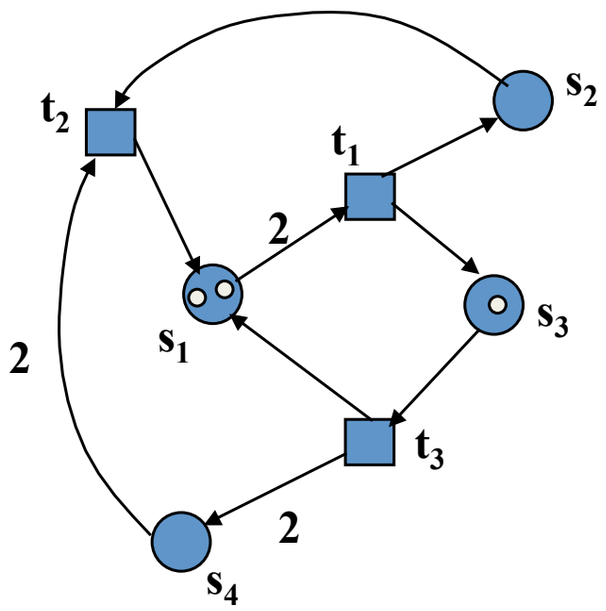
Neste caso, uma solução direta é que $AB_f^T=0$, e os vetores de B_f^T são chamados de S-invariantes.

Determinação de B*f*

$$\mathbf{A} = \begin{array}{c} \begin{matrix} \text{m-r} & \text{r} \end{matrix} \\ \left[\begin{array}{cc} \mathbf{A}_{11} & \mathbf{A}_{12} \\ \mathbf{A}_{21} & \mathbf{A}_{22} \end{array}\right] \begin{array}{l} \text{r} \\ \text{n-r} \end{array} \end{array}$$

$$\mathbf{B}_f = [\mathbf{I}_{m-r} : -\mathbf{A}_{11}^T (\mathbf{A}_{12}^T)^{-1}]$$

Voltando ao exemplo



$$\mathbf{B}_f = [\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} : -\begin{pmatrix} -2 & 1 \\ 1 & -1 \end{pmatrix}\begin{pmatrix} 1 & 0 \\ 0 & -1/2 \end{pmatrix}] =$$

$$= \begin{pmatrix} 1 & 0 & 2 & 1/2 \\ 0 & 1 & -1 & -1/2 \end{pmatrix}$$

$$\mathbf{A} = \begin{pmatrix} -2 & 1 & 1 & 0 \\ 1 & -1 & 0 & -2 \\ 1 & 0 & -1 & 2 \end{pmatrix}$$

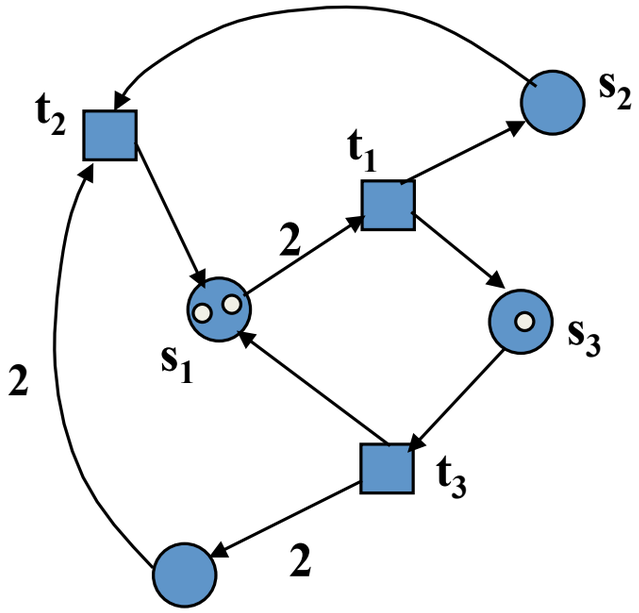
s_1 s_2 s_3 s_4

t_1
t_2
t_3

$$\mathbf{A} = \begin{bmatrix} \mathbf{A}_{11} & \mathbf{A}_{12} \\ \mathbf{A}_{21} & \mathbf{A}_{22} \end{bmatrix} \begin{matrix} \\ \\ \end{matrix} \begin{matrix} \text{r} \\ \text{n-r} \end{matrix}$$

m-r r

$$\mathbf{B}_f = [\mathbf{I}_{m-r} : -\mathbf{A}_{11}^T (\mathbf{A}_{12}^T)^{-1}]$$



$$\begin{pmatrix}2\\0\\1\\0\end{pmatrix} \xrightarrow{t_1} \begin{pmatrix}0\\1\\2\\0\end{pmatrix} \xrightarrow{t_3} \begin{pmatrix}1\\1\\1\\2\end{pmatrix} \xrightarrow{t_2} \begin{pmatrix}2\\0\\1\\0\end{pmatrix} \xrightarrow{t_3} \begin{pmatrix}3\\0\\0\\2\end{pmatrix} \xrightarrow{t_1} \begin{pmatrix}1\\1\\1\\2\end{pmatrix} \xrightarrow{t_3}$$

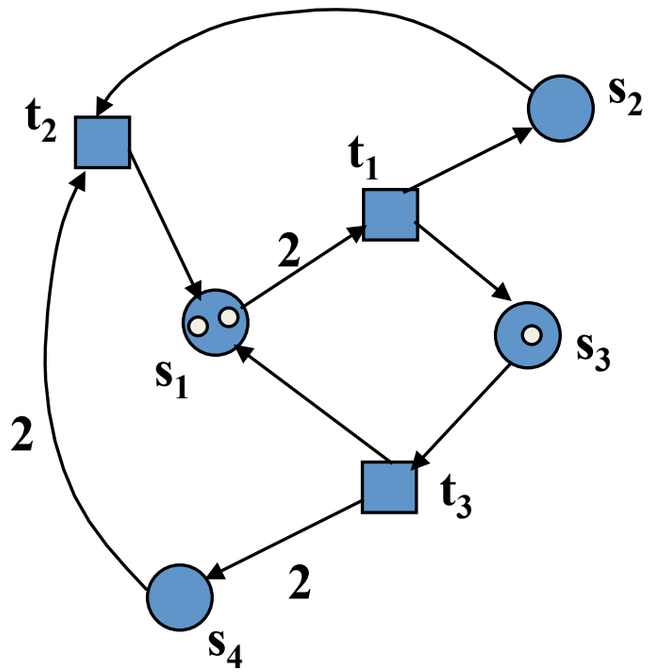
$$\begin{pmatrix}2\\1\\0\\4\end{pmatrix} \xrightarrow{t_2} \begin{pmatrix}3\\0\\0\\2\end{pmatrix} \Rightarrow \ldots$$

Voltando à equação de estado podemos agora investigar a dinâmica da rede, e os ciclos,

$$\mathbf{A}^T \sum_{j=0}^{i} \sigma_j = \mathbf{A}^T \overline{\sigma} = \mathbf{M}_{i+1} - \mathbf{M}_0 = \Delta\mathbf{M}$$

Podemos agora selecionar os ciclos, isto é, estados e sequências de disparo tais que $\Delta M=0$.

À soma dos vetores de habilitação que caracterizam este processo chamamos de T-invariante.



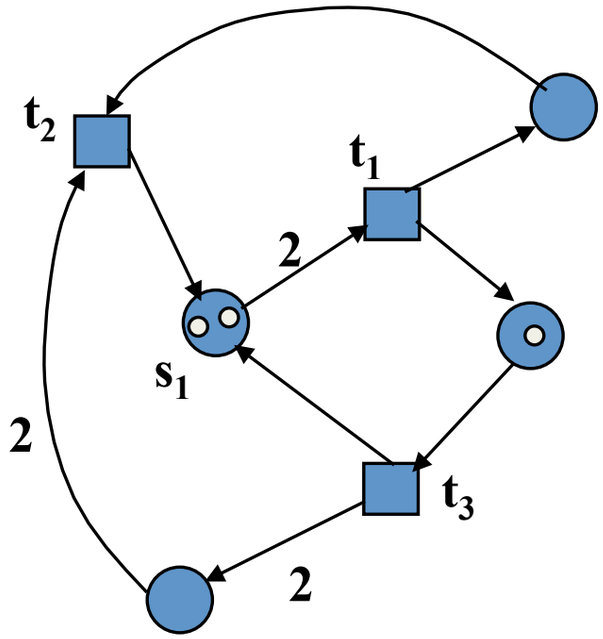
$$\begin{pmatrix} -2 & 1 & 1 \\ 1 & -1 & 0 \\ 1 & 0 & -1 \\ 0 & -2 & 2 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$$

$$x = y = z$$

$$\mathbf{A} = \begin{array}{c} \\ t_1 \\ t_2 \\ t_3 \end{array} \begin{array}{c} \begin{array}{cccc} s_1 & s_2 & s_3 & s_4 \end{array} \\ \begin{pmatrix} -2 & 1 & 1 & 0 \\ 1 & -1 & 0 & -2 \\ 1 & 0 & -1 & 2 \end{pmatrix} \end{array}$$

Em primeira determinação, isto é, fazendo com que x=y=z assuma o menor inteiro positivo, temos que x=y=z=1

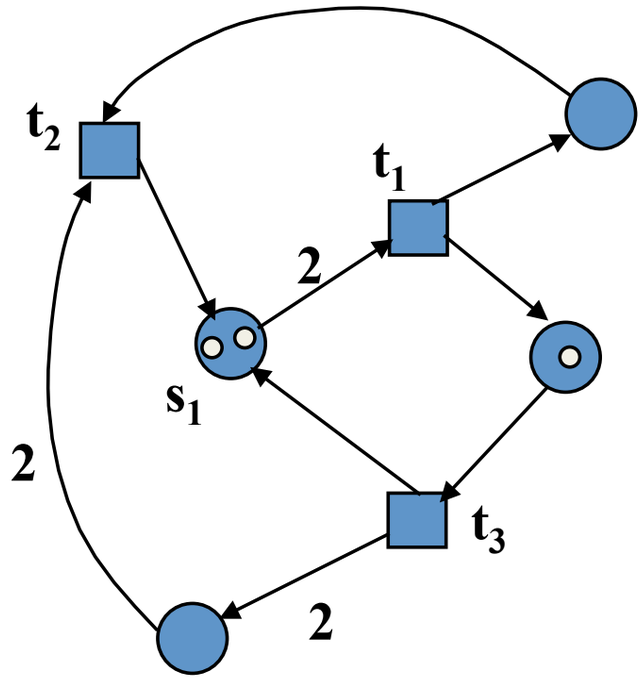
Note que existem passos (string de transições independentes) que levam o sistema ao mesmo estado, isto é, denotam ciclos



$$\begin{pmatrix}2\\0\\1\\0\end{pmatrix} \xrightarrow{t_1} \begin{pmatrix}0\\1\\2\\0\end{pmatrix} \xrightarrow{t_3} \begin{pmatrix}1\\1\\1\\2\end{pmatrix} \xrightarrow{t_2} \begin{pmatrix}2\\0\\1\\0\end{pmatrix} \xrightarrow{t_3} \begin{pmatrix}3\\0\\0\\2\end{pmatrix} \xrightarrow{t_1} \begin{pmatrix}1\\1\\1\\2\end{pmatrix} \xrightarrow{t_3}$$

$$\begin{pmatrix}2\\1\\0\\4\end{pmatrix} \xrightarrow{t_2} \begin{pmatrix}3\\0\\0\\2\end{pmatrix} \Rightarrow \ldots$$

O processo $t_1\ t_3\ t_2$ gera ciclos invariantes
em estados diferentes, como mostrado anteriormente.



$$\sigma_1 = \begin{pmatrix}1\\0\\0\end{pmatrix}, \sigma_2 = \begin{pmatrix}0\\0\\1\end{pmatrix} \text{ e } \sigma_3 = \begin{pmatrix}0\\1\\0\end{pmatrix} \Rightarrow$$

$$\Rightarrow \sum_1^3 \sigma_i = \begin{pmatrix}1\\1\\1\end{pmatrix} \text{ é um T-invariante}$$

CP-nets may be large

A typical *industrial application* of CP-nets contains:

- 10-200 *pages*.
- 50-1000 *places and transitions*.
- 10-200 *colour sets*.

This corresponds to *thousands/millions of nodes* in a Place/Transition Net.

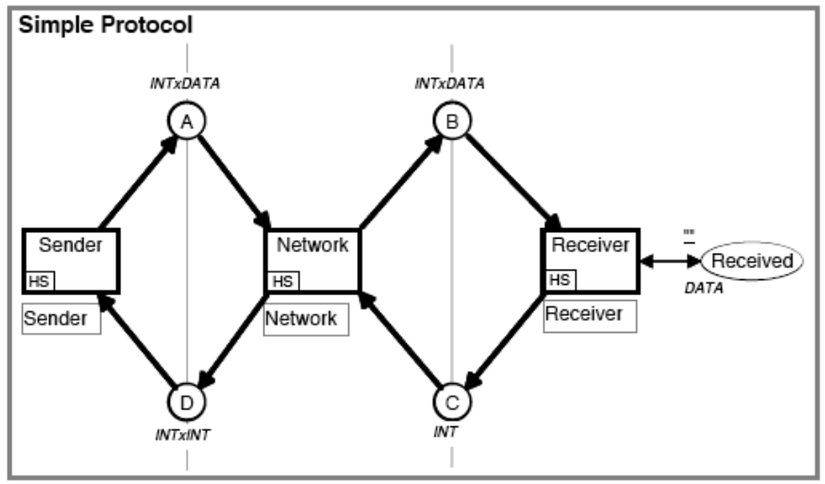
Most of the industrial applications would be *totally impossible* without:

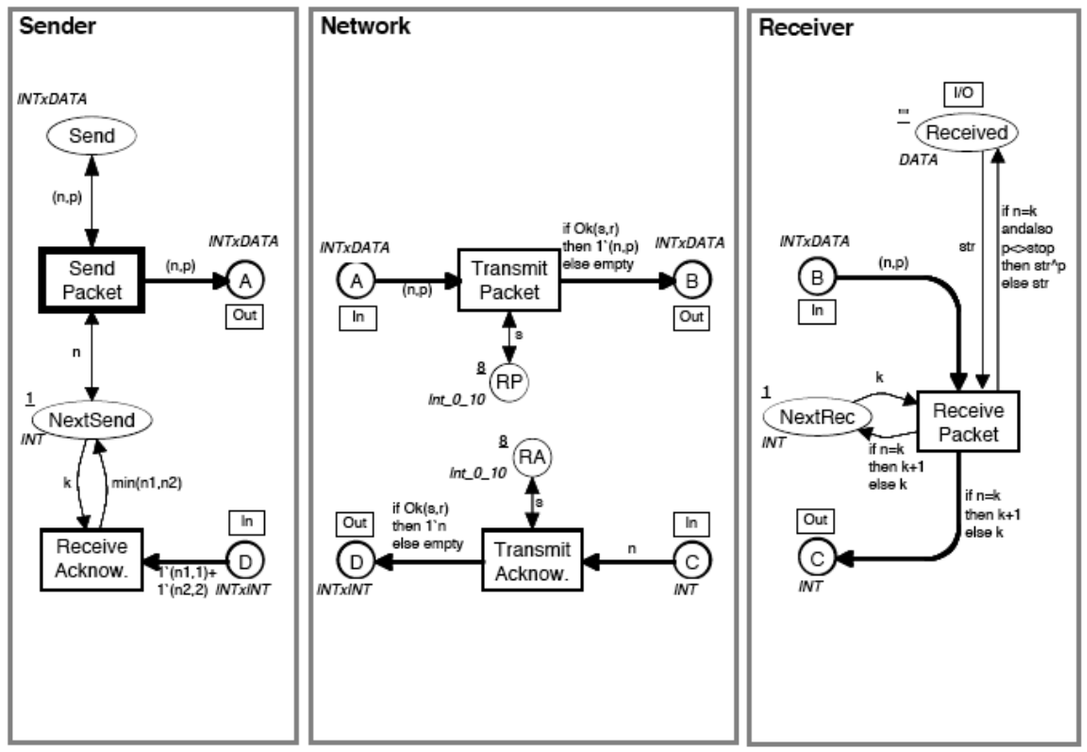
- Colours.
- Hierarchies.
- Computer tools.

A page may contain one ore more *substitution transitions*.

- Each substitution transition is related to a *page*, i.e., a *subnet* providing a *more detailed description* than the transition itself.
- The page is a *subpage* of the substitution transition.

A hierarchical CP-net contains a number of *interrelated subnets*– called *pages*.

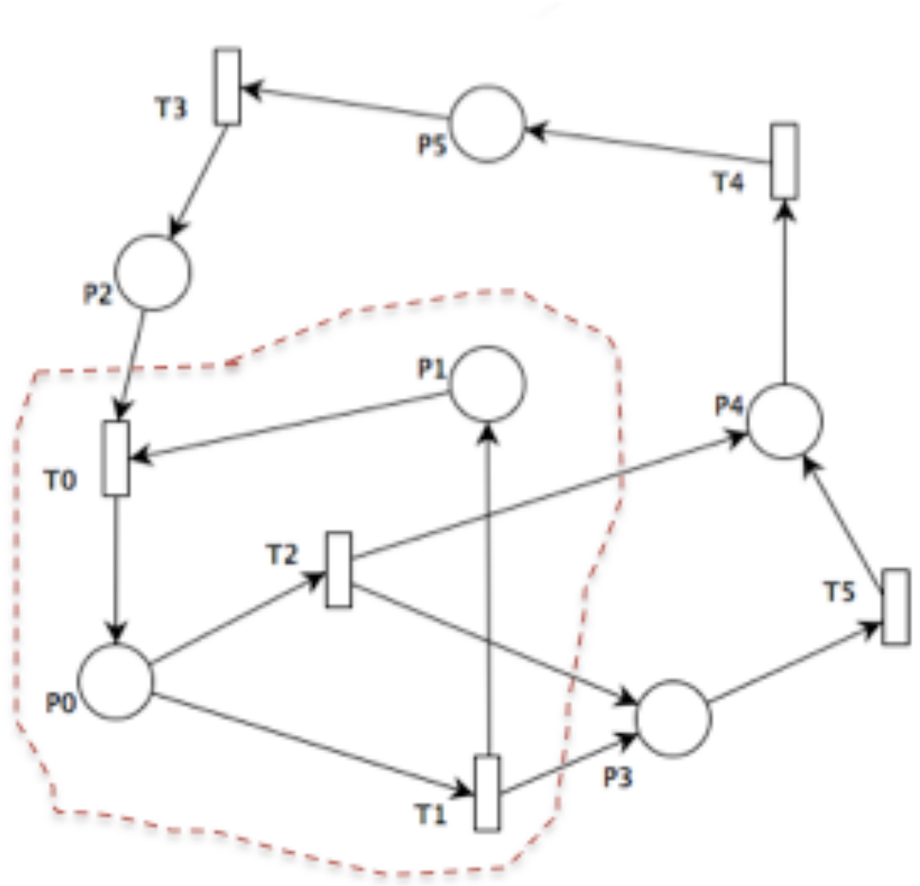




Hierarchy is not anything new and is actually connected with any kind of net, including the classical ones.

In design, hierarchy means to abstract the elements which properties are not relevant in an analysis phases.

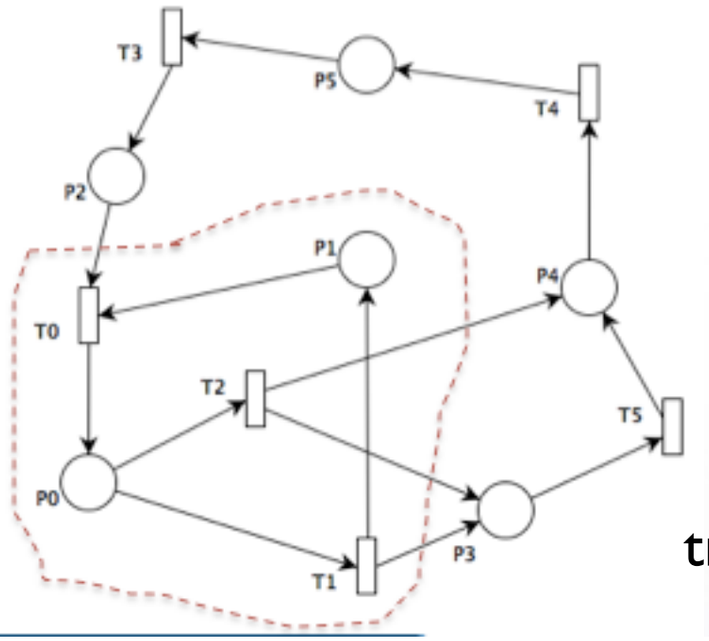
Hierarquia em redes clássicas

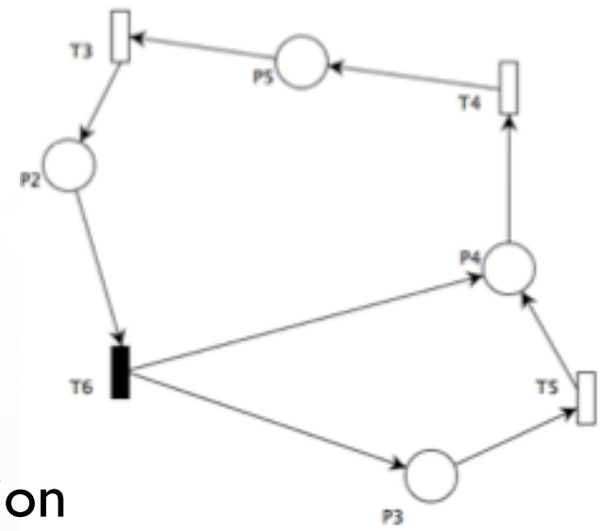


Definition 39

Seja uma estrutura de rede $N = (S, T; F)$. Seja $X = S \cup T$ e um sub-cojunto $Y \subseteq X$. Definimos uma borda de N como o conjunto $\partial(N) = \{y \in Y \,|\, \exists x \notin Y . x \in loc(y)\}$.

Substituição de uma sub-rede

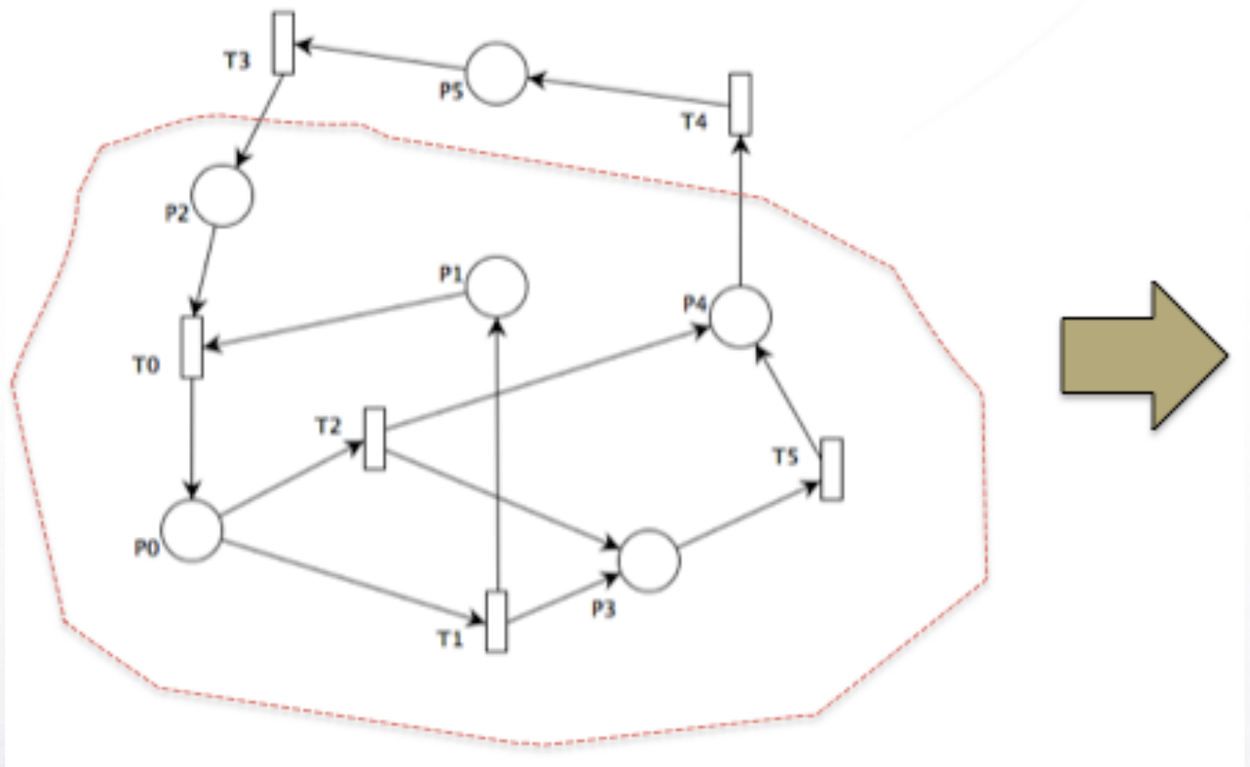


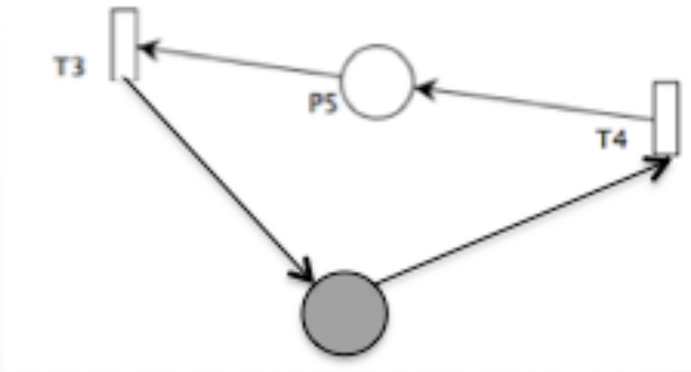


transition bounded substitution

Definition 40

Um sub-conjunto de elementos Y da rede $N = (S, T; F)$ é dito limitado por lugar (place bounded) ou aberto, se e somente se $\partial(Y) \subseteq S$. Similarmente, um sub-conjunto Y desta rede é dito limitado por transição (transition bounded), se e somente se $\partial(Y) \subseteq T$.





place bounded substitution

Se em uma rede com estrutura $N = (S, T; F)$ existe uma sub-rede Y limitada por transição, a substituição desta sub-rede Y gera uma rede $N' = (S', T'; F')$ onde:

(i) $S' = S \setminus Y$;

(ii) $T' = T \setminus Y \cup \{t_y\}$, onde t_y é o novo elemento que substitui Y;

(iii) $F' = F \setminus Int(Y)$ onde $Int(Y)$ é o conjunto dos arcos internos de Y.

.

Similarmente, se a sub-rede Y é limitada por lugar,

(i) $S' = S \setminus Y \cup \{s_y\}$, onde s_y é o novo elemento que substitui Y;

(ii) $T' = T \setminus Y$;

(iii) $F' = F \setminus Int(Y)$ onde $Int(Y)$ é o conjunto dos arcos internos de Y.

Hierarchy is a good abstraction feature. However, the real challenge is to associate that with the property analysis, so that the abstract net preserve the same properties than the expanded one.

The proper requirement is a key issue for that.

Elementos próprios

Seja x_y um elemento genérico (instanciável por t_y ou por p_y). Este elemento é dito *próprio* se e somente se é limitado por transição (lugar), tem somente dois elementos de borda, com pelo menos um processo vivo entre eles.

Se os elementos abstratos são próprios as propriedades da rede subjacente se conservam a menos de um termo aditivo. (J. R. Silva, On The Property Analysis of Abstract and Hierarchical Nets, to appear).

Fundamentos do método estruturado

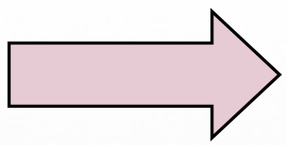
Um ***bloco*** é um conjunto genérico de instruções de programa, onde uma dada instrução é identificada como a <u>entrada</u> do bloco e outra (diferente da primeira) é identificada como a <u>saída</u>.

Se A e B são blocos de um mesmo programa, então A e B são ditos independentes se e somente se $A \cap B = \varnothing$.

Se A e B são tais que $A \cap B \neq \varnothing$ então $(A \subseteq B)$ OU $(A \supseteq B)$

Constituintes próprios e primos

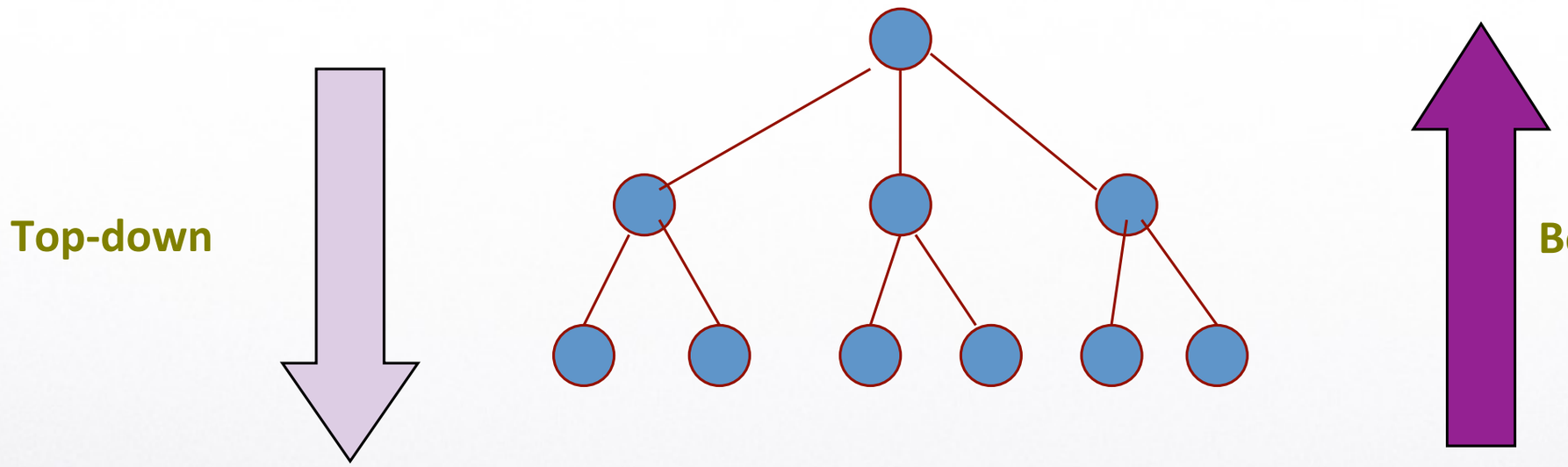
Elementos próprios



Base de elementos constituintes (componentes)

Elementos próprios indivisíveis são chamados primos. Um conjunto LI de elementos primos pode constituir uma base e portanto pode descrever qualquer programa.

Decomposição por refinamentos: o método estruturado



Overview

Apresentamos as redes de Petri como um esquema e uma representação formal para a modelagem e análise de sistemas e processos discretos, pertinentes a uma larga gama de domínios. Em particular, mais de 70% dos sistemas automatizados acabam caindo nesta categoria, e o futuro nos reserva ainda possibilidade de ampliação deste escopo com a difusão dos "sistemas de serviço".

O importante é no entanto a introdução do formalismo de redes de Petri, que como vimos pode ser dividido em dois grandes grupos: o das redes ditas clássicas; o das redes de alto nível ou redes estendidas temporizadas ou orientadas a objeto.

Redes de Petri

Redes Clássicas

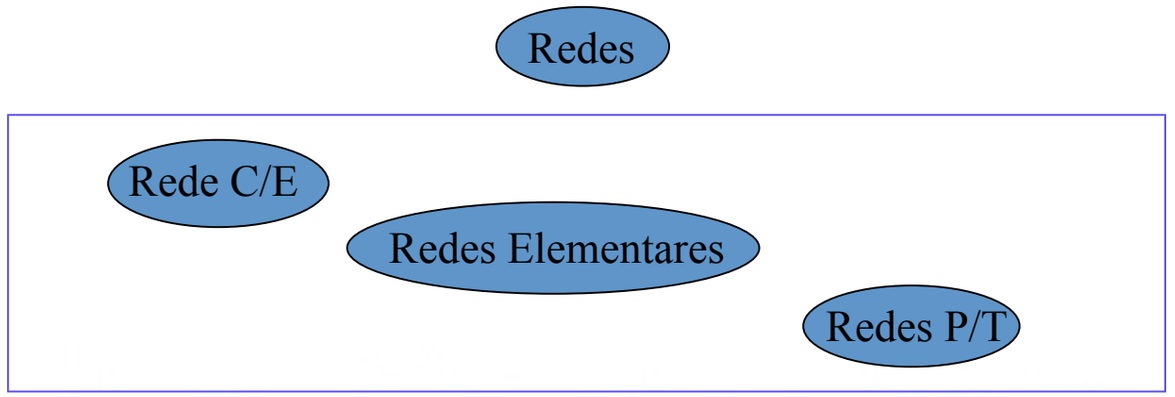
Redes P/T (seriam o padrão)

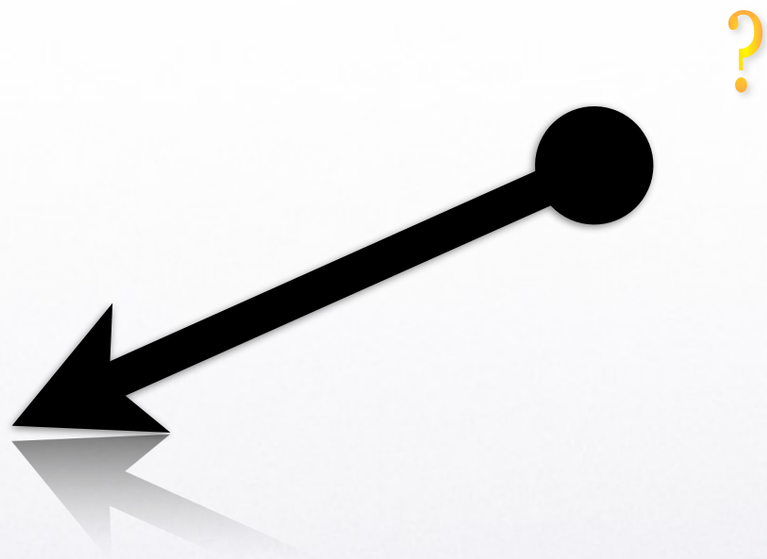
Redes de Alto Nível

(HLPNs, Redes Coloridas, etc)

Redes Estendidas

Redes com elementos estenditos (gates, pseudo-lugares, etc.)
Redes hierárquicas
Redes Orientadas a Objetos
Redes temporais





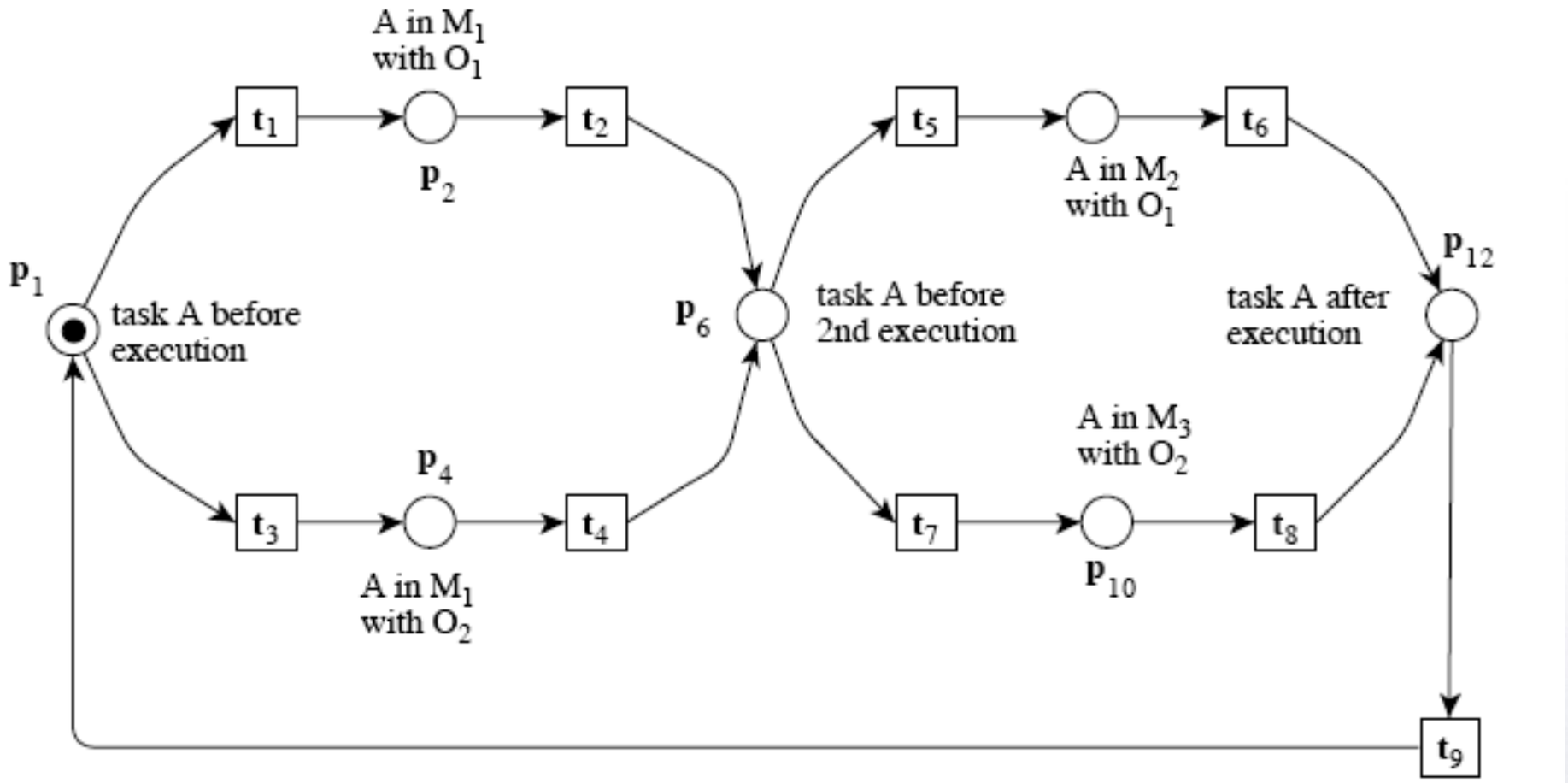
Modelagem de Sistemas Discretos

- Síntese da rede;
- Procedimentos de redução;
- Análise da rede (atingibilidade, deadlock, etc.);
- Simulação.

Procedimento de modelagem e análise

Requisitos do problema: *Seja um sistema de manufatura simples, composto de 3 máquinas DNC: M1, M2 e M3. Estas máquinas podem executar duas operações diferentes, O1 e O2, de modo que O1 pode ser executado nas máquinas M1 e M2 mas não simultaneamente. Similarmente, O2 pode ser executado em M1 e M3 mas não simultaneamente.*

Uma forma de tratar o problema é em primeiro lugar modelar a sequência de operações, sem levar em conta nenhuma restrição e nenhum recurso.



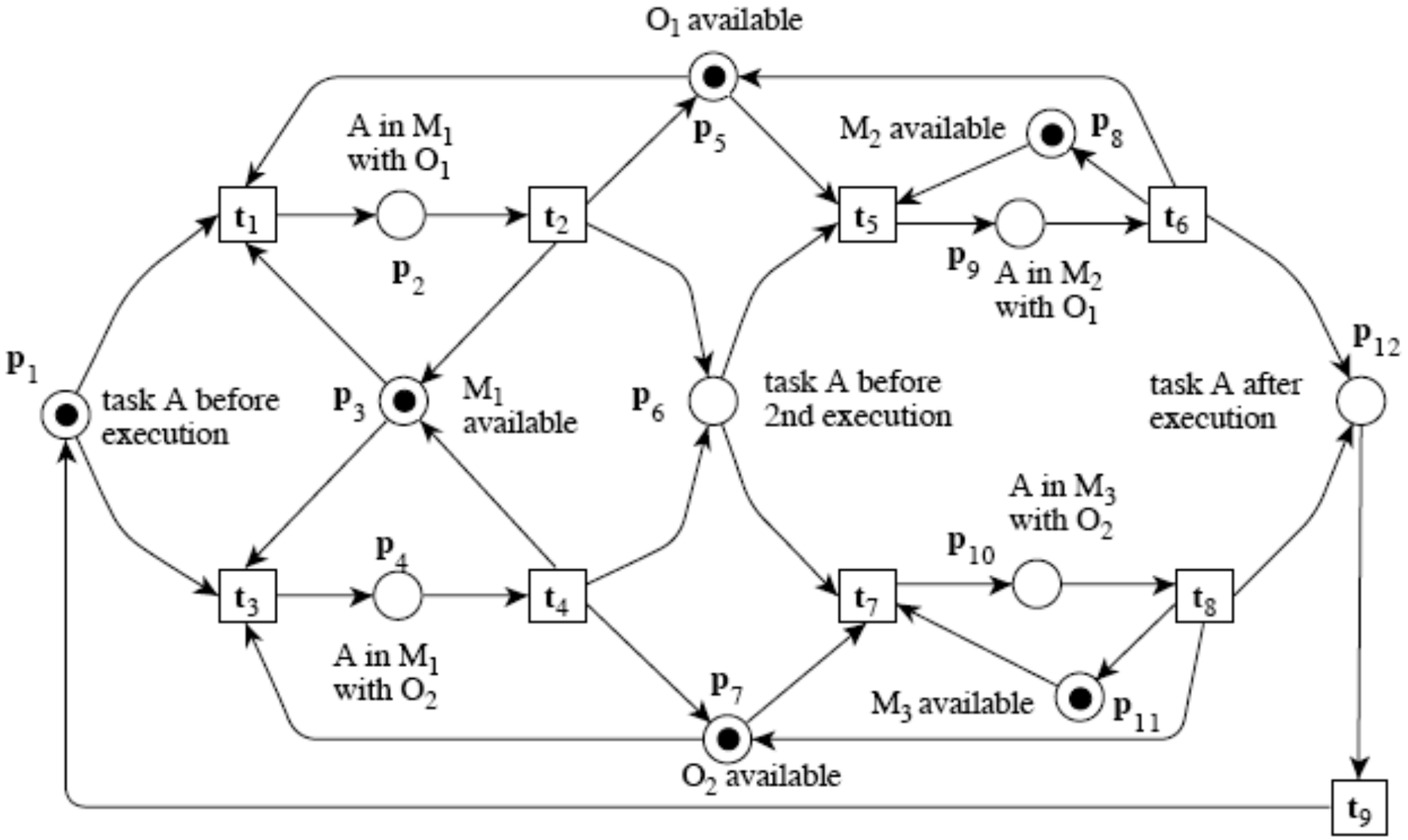
Girauld, C. and Valk, R.; Petri Nets for Systems Engineering, Springer-Verlag, 2003

Análise

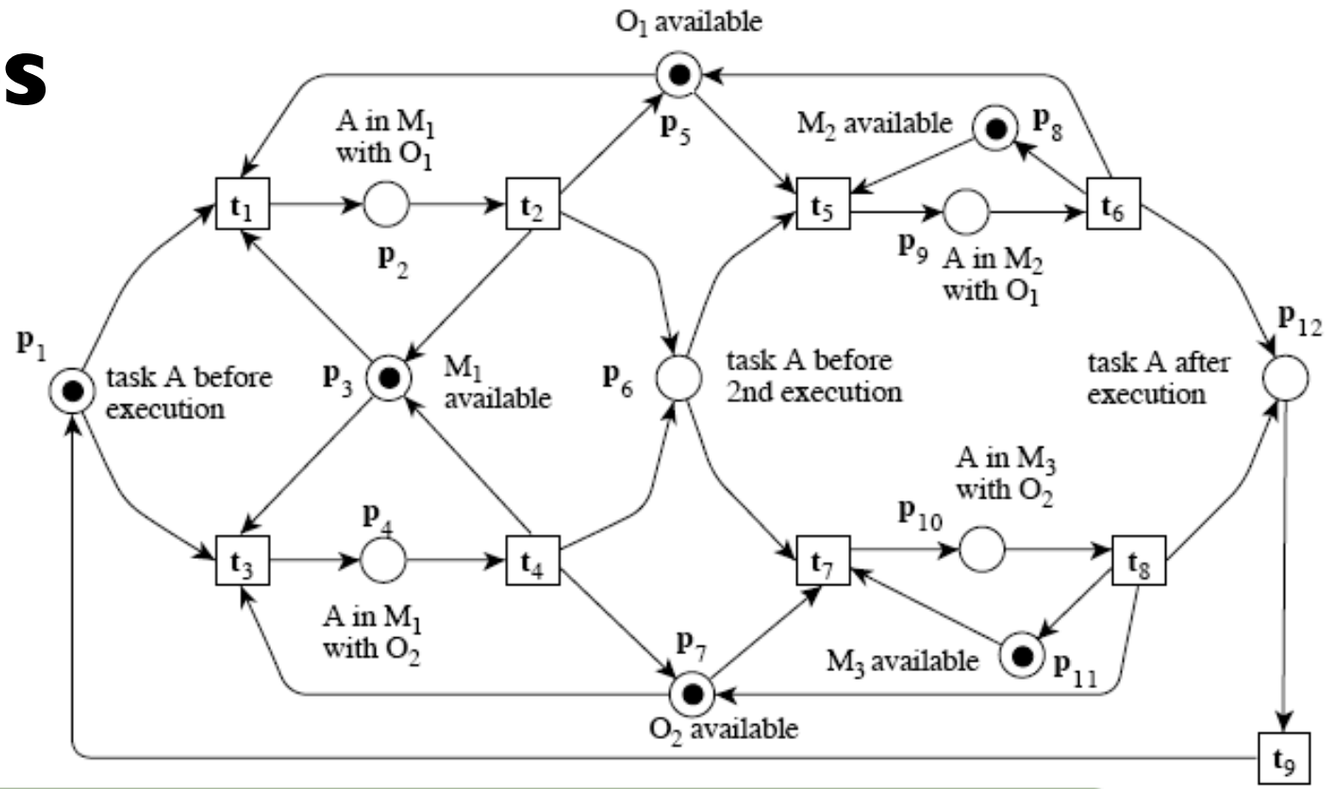
O sistema é cíclico, e permite a combinação das operações em qualquer ordem (e portanto o sistema estaria preparado para implementar qualquer receita de peça). O sistema é conservativo, de modo que cada peça seria representada por uma marca que deve estar em algum dos lugares já especificados.

Na especificação de requisitos, os recursos são representados pela disponibilidade das máquinas e pela sua capacidade de executar cada uma das operações. Uma vez feita a parte sequencial da rede devemos agora introduzir estas restrições, que devem alterar a rede ou a sucessão de estados desta.

Introduzindo os recursos, segundo a especificação de requisitos já apresentada, temos:



Análise de Invariantes



Análise de invariantes

Os invariantes podem ser analisados e servir como forma de verificação para o atendimento dos requisistos

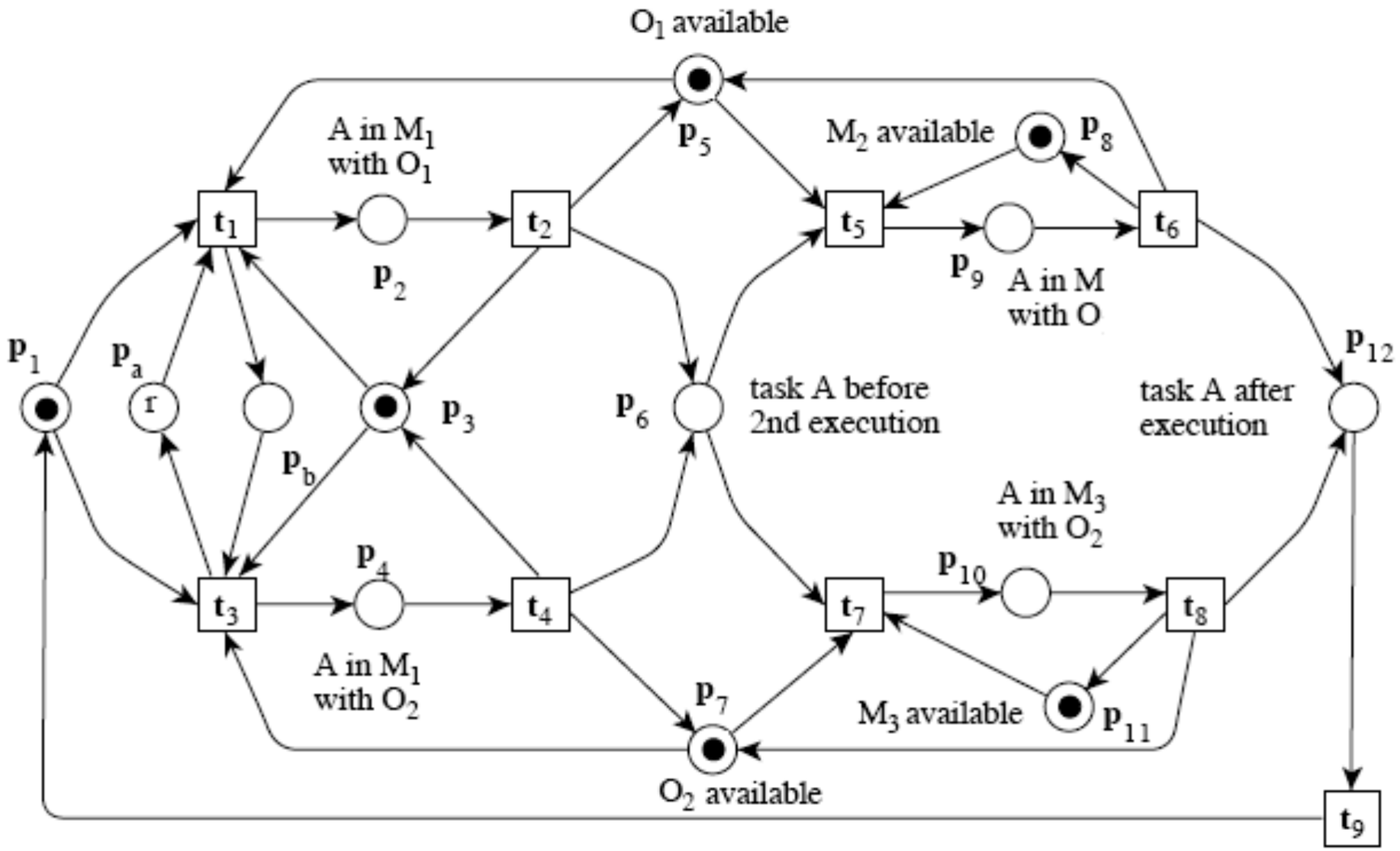
i) $m[p_2] + m[p_5] + m[p_9] = 1;$

ii) $m[p_4] + m[p_7] + m[p_{10}] = 1;$

iii) $m[p_2] + m[p_3] + m[p_4] = 1;$

iv) $m[p_1] + m[p_2] + m[p_4] + m[p_6] + m[p_9] + m[p_{10}] + m[p_{12}] = c$

Introduzindo Sincronização

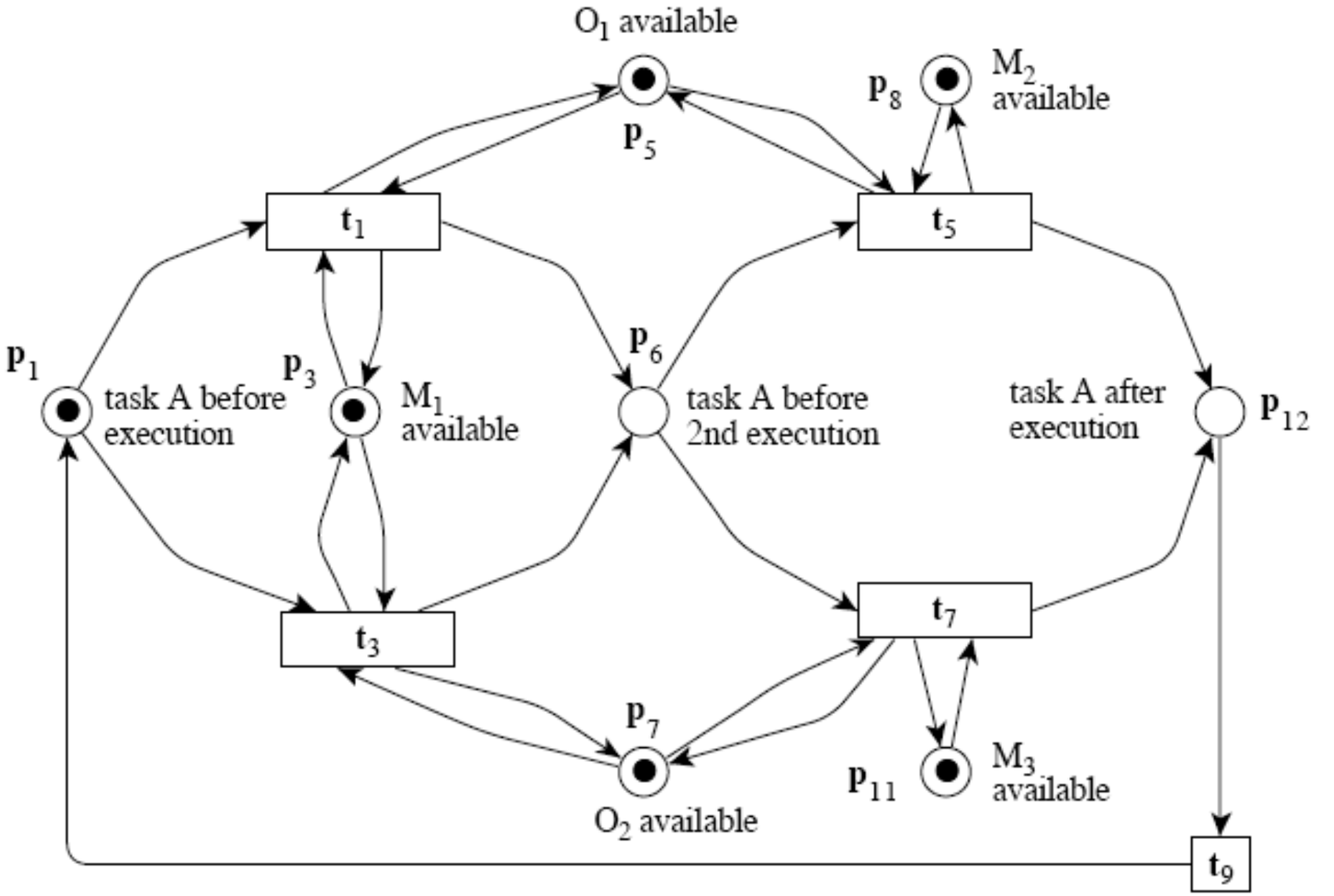


Distância Síncrona

Definition 45

Define-se como a distância síncrona entre duas transições t_1 e t_2 de uma rede P/T (N, M_0), ao número inteiro,
$d_{1,2} = max|\overline{\sigma}(t_1) - \overline{\sigma}(t_2)|$,
onde $\overline{\sigma}(t_i)$ é a variância no número de disparos de t_i.

Reduções


O_1 available
p_5
p_8
M_2 available
t_1
t_5
p_1
task A before execution
p_3
M_1 available
p_6
task A before 2nd execution
task A after execution
p_{12}
t_3
t_7
p_7
O_2 available
p_{11}
M_3 available
t_9

Buscando um processo de projeto

Nos casos em que intuitivamente temos um sistema que é plenamente representado por uma rede clássica, e, mais do que isso, onde este modelo é facilmente e completamente interpretado modelo, é fácil de entender que somente uma demanda por múltiplos casos de simetria ou dobramento nos levaria a apelar para um sistema de alto nível.

No exercício que acabamos de ver poderíamos introduzir vários tipos de peça no processo de fabricação, cuja "receita" seria dada por diferentes combinações das operações utilizadas operando nas diferentes máquinas. Neste caso seria bastante atraente a distinção de marcas por tipos. Mas será esta a sequencia adequada em todos os casos?

Requisitos: o início de um grande problema

Certamente o início de todo projeto bem sucedido é a *eliciação* de um conjunto de requisitos que descreve com precisão as funcionalidades do sistema que deve ser modelado e implementado. Portanto para se chegar a um processo de projeto que termine na modelagem do sistema em Redes de Petri é preciso ter em conta de que este projeto deve começar com uma boa representação de requisitos. A representação mais usada e difundida para isso é com certeza a UML.

Análise de Requisitos, Síntese de redes, Building blocks

Uma hipótese bastante tentadoras seria ter um processo de projeto que pudesse ser reduzido a uma sequencia de transformações de transferência semântica entre linguagens, começando pela UML. Uma rede de Petri derivada de um ou mais diagramas UML poderia servir de base para um processo de **análise destes requisitos** e mais tarde com as devidas mudanças inseridas resultar no modelo do sistema.

Este processo poderia perfeitamente ser combinado com o método conhecido como ***building blocks*** onde várias partes da rede poderiam ser sintetizadas como descrito no parágrafo acima até se ter, por composição o sistema completo.

Partindo dos Casos de Uso

Casos de uso podem ser representados segundo uma forma diagramática como proposto em (Silva e Santos, 2004)

Symbol	Description
●	Start of a process (Use Case)
⦿	End of a process (Use Case)
→	Start of an event of basic flow of process
↳	Start of an event of alternative flow of process
◇	Start of a conditional event
$\rightsquigarrow^n$	Jump of current iteration to iteration ^{n}
||	Sequence of concurrent events

Silva, J.R. e Santos, E.A.; Applying Petri Nets to Requirements Validation, ABCM Symposium Series in Mechatronics, vol 1, pp. 508-517.

Um exemplo: o caixa eletrônico

Caso de uso textual

1. Initiate Withdraw – Customer inserts bank's card in the card reader on the ATM machine
2. Verify Bank Card – The ATM reads the account code from the magnetic strip on the bank card and checks if it is an acceptable bank card
3. Enter PIN – The ATM asks for the customer's PIN code (4 digits)
4. Verify PIN – The account code and PIN are verified to determine if the account is valid and if the PIN entered is the correct PIN for the account. For this flow, the account is a valid account and the PIN is the correct PIN associated with this account
5. Select Withdraw – The ATM displays the different alternatives available at this ATM. In this flow, the bank customer always selects "Cash Withdraw"
6. Enter Amount – The ATM asks for the amount to withdraw. For this flow the customer selects a pre-set amount ($10, $20, $50, or $100)
7. Authorization – The ATM initiates the verification process with the Banking System by sending the Card ID, PIN, Amount, and Account information as a transaction. For this flow, the Banking System is online and replies with the authorization to complete the cash withdrawal successfully and updates the account balance accordingly
8. Dispense – The Money is dispensed
9. Receipt – The receipt is printed and dispensed. The ATM also updates the internal log accordingly
10. Return Card – The Bank Card is returned

1 ● Initiate Withdraw – Customer inserts bank's card in the card reader on the ATM machine; (

1.1 ◇ Is the card valid? – Verify Bank Card – The ATM reads the account code from the magnetic strip on the bank's card and checks if it is an acceptable card;

1.1.1 ↳Send message of invalid card – If the card isn't an acceptable card, send an appropriate message. ⇝1.9

1.2 → Enter PIN – The ATM asks for the customer's PIN code (4 digits);
1.3 ◇ Is PIN Correct? – Verify PIN – The account code and PIN are verified to determine if the account is valid and if the PIN entered is the correct PIN for the account;

1.3.1 ◇ Is the account valid? – Verify account code – The account code is verified;

1.3.1.1 ↳Send message of invalid account – The Banking system returns a code indicating the account could not be found or is not an account which allows withdrawals. ⇝1.9

1.3.2 ◇ Is the final try? – Checks the number of tries – The customer has three tries to enter the correct PIN;

1.3.2.1 ↳Send message of incorrect PIN – The ATM send an appropriate message. ⇝1.2

1.3.3 ↳Retain card – on the final try the card is retained, ATM returns to Ready State, and this use case terminates. ⇝2

1.4 ◇ Have money the ATM? – Select Withdraw – The ATM displays the different alternatives available at this ATM. In this flow, the bank customer always selects "Cash Withdraw";

1.4.1 ↳Send message ATM out of Money – If the ATM is out of money, the "Cash Withdraw" option will not be available. ⇝1.4

1.5 ◇ Sufficient funds and does not exceed the daily limit? – Enter amount – The ATM asks for the amount to withdraw. For this flow the customer selects a pre-set amount ($10, $20, $50, or $100);

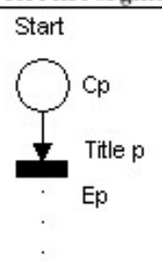
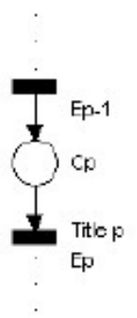
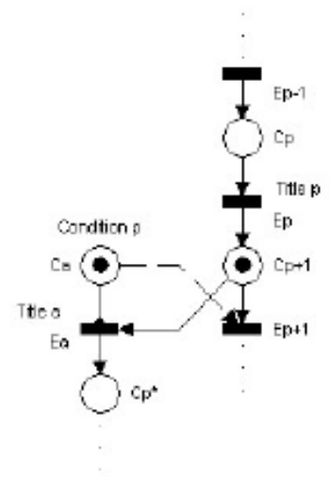
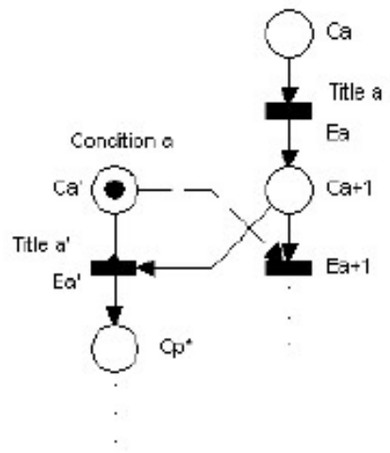
1.5.1 ◇ Sufficient funds? – Check sufficient funds – Check if the funds are sufficient;

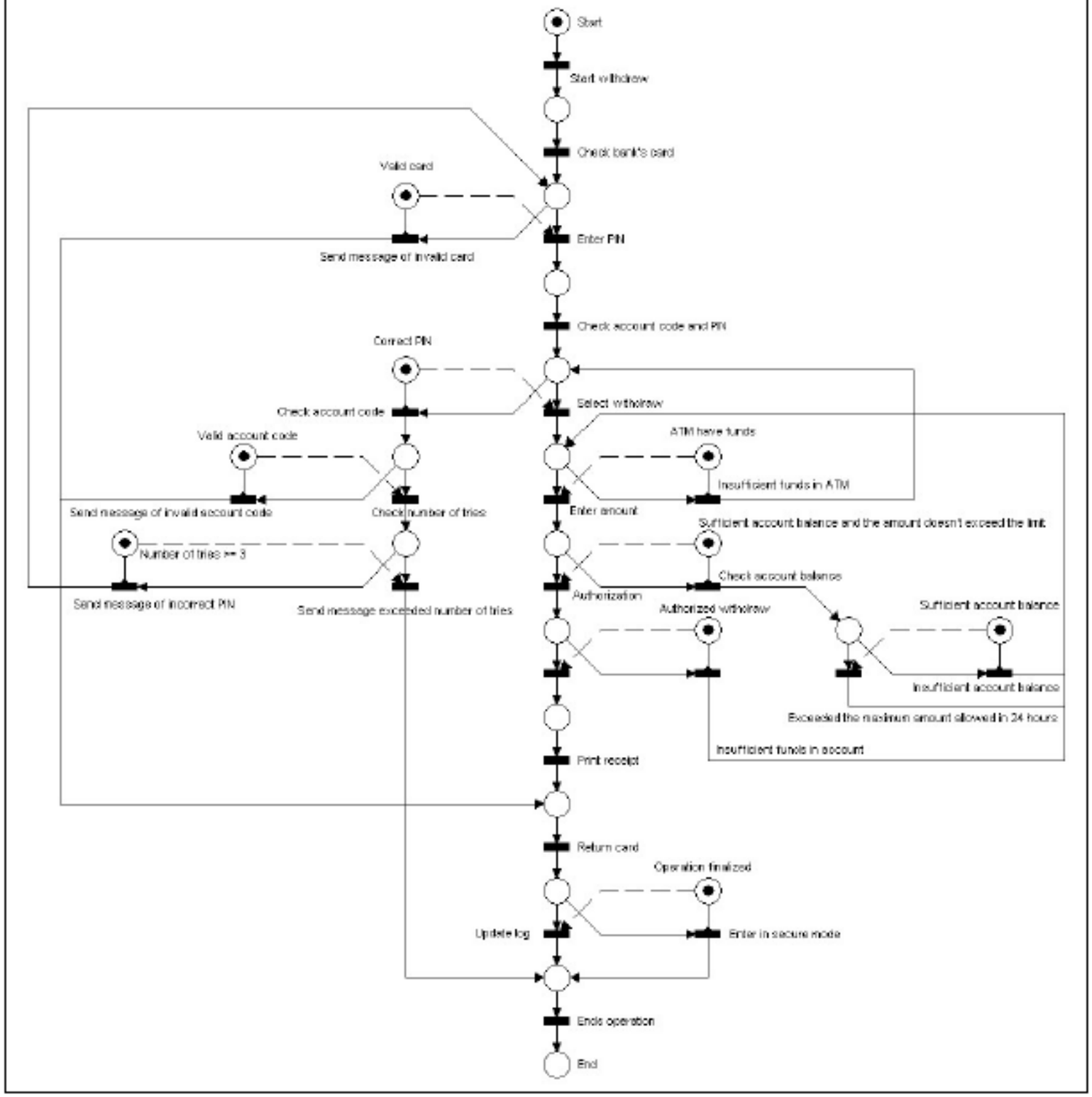
1.5.1.1 ↳Send message insufficient funds in ATM – The ATM contain insufficient funds to dispense the requested amount. ⇝1.5

```
<BF>          ::= <initial> { <event> } <final> { <AF> }
<initial>     ::= <label> "●" <title> "-" <description> ";" "("
<label>       ::= <number> { "." <number> }
<number>      ::= <sequential_number>
<title>       ::= <string>
<description> ::= <string>
<string>      ::= <any_caracter> { <any_caracter> }
<event>       ::= [ <eventB> | <eventA> ]
<eventB>      ::= <labelB> [ ( "→" <title> "-" <description> ";" ) |

                             ( "◇" <condition> "-" <title> "-" <description> ";" <eventA>
                             ) ] { <eventB> } |

                  "||" "(" <eventB> { <eventB> } ")" "(" <eventB> { <eventB> } ")" "||" {
                  <eventB> }
<labelB>      ::= <label> "." <number>
<condition>   ::= <string>
<eventA>      ::= <labelA> [ ( "↳" <title> "-" <description> <branch> ) |

                             ( "◇" <condition> "-" <title> "-" <description> ";" <eventA>
                             ) ] { <eventA> }

<labelA>      ::= <labelB> "." <number>
<branch>      ::= "~" [ <label> | <labelB> ]
<final>       ::= ")" <label> "◉" <title> "-" <description> ";"
<AF>          ::= <eventUA>
<eventUA>     ::= <label> "↳" <title> "-" <description> <branch> { <eventUA> }
```

Where:

- eventB → Event of Basic flow
- labelB → Event id of Basic flow
- eventA → Alternative Event of Basic flow
- labelA → Alternative Event id of Basic flow
- eventUA → Unconditional Event of Alternative Event
- labelUA → Unconditional Event id of Alternative Event

Event	BNF notation	Petri net segment
Initial	p ● Title - Description; (	
Basic	p → Title - Description;	
Basic conditional and alternative normal[1]	p◇Condition-Title-Descript.; a ↳ Title-Description ⇝P*	
Alternative conditional and normal	a◇Condition-Title-Descript.; a′ ↳ Title-Description ⇝P*	


Start
Start withdraw
Check bank's card
Valid card
Send message of invalid card
Enter PIN
Check account code and PIN
Correct PIN
Check account code
Select withdraw
Valid account code
ATM have funds
Send message of invalid account code
Check number of tries
Insufficient funds in ATM
Enter amount
Number of tries == 3
Sufficient account balance and the amount doesn't exceed the limit
Check account balance
Authorization
Authorized withdraw
Sufficient account balance
Send message of incorrect PIN
Send message exceeded number of tries
Insufficient account balance
Exceeded the maximum amount allowed in 24 hours
Insufficient funds in account
Print receipt
Return card
Operation finalized
Update log
Enter in secure mode
Ends operation
End

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Transformation of Usecase and Sequence Diagrams to Petri Nets

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***Abstract*—With the growing use of UML diagrams for software design description and the importance of nonfunctional requirements evaluation at software development process, transforming these diagrams to executable models is considered to be significant. Nonfunctional requirements can not be evaluated directly by UML diagrams. Software designers are not usually familiar with non-functional requirement analysis and are not able to analyze such requirements easily. Therefore the designer should produce an executable model from software design description to be ready for analysis. usecase and sequence diagrams are the most important UML diagrams for software design description. In this paper, we propose new algorithms that enable a designer to transform usecase and sequence diagrams into executable models based on Petri nets and then we show how to use this Petri net models for simulation. Finally, to represent the usage of our proposed algorithms, we consider a case study as an example.**

Keywords-usecase diagram, sequence diagram, executable model, petri net, software design, nonfunctional requirement evaluation

I. INTRODUCTION

Nowadays, one of the most noticeable tasks of a designer

specific nonfunctional quality attributes and specific domains. When we apply them to other quality attributes such as reliability, we should redesign the queuing model to a new one. Elkoutbi et al. have transformed a simple usecase structure to color Petri nets [5] and kamandi et al. has transformed usecase to Object Stochastic Activity Network (OSAN) [6]. However, there have been few researches about transformation of usecase diagram to Petri net. Different approaches have been used for the transformation of sequence diagram to Petri nets. In proposed approach by Bernardi et al. all structures of sequence diagram have transformed to Generalized Stochastic Petri Nets [2]. Ourdani et al. have transformed the simplest structures in sequence diagram to colored petri net [7]. The difference between two transformations is that in Bernardi et al. approach the transformation is based on mapping of messages as well as conveying them, but in Ourdani et al. approach, the transformation is based on message sender and receiver component. Some of these researches have not utilized all structures of usecase and sequence diagrams for transformation. On the other hand, in an executable model based on Petri nets, when we add a quality attribute to be measured, we just attach the values denoting the attribute to tokens and adopt expressions for calculating the quality attribute value from the newly attached values on the tokens

Compositional Semantics for UML 2.0 Sequence Diagrams Using Petri Nets

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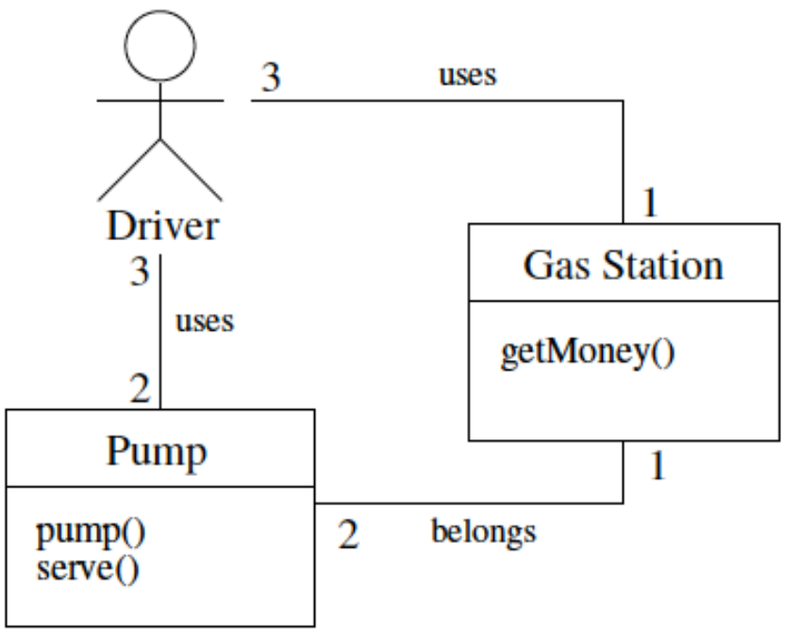
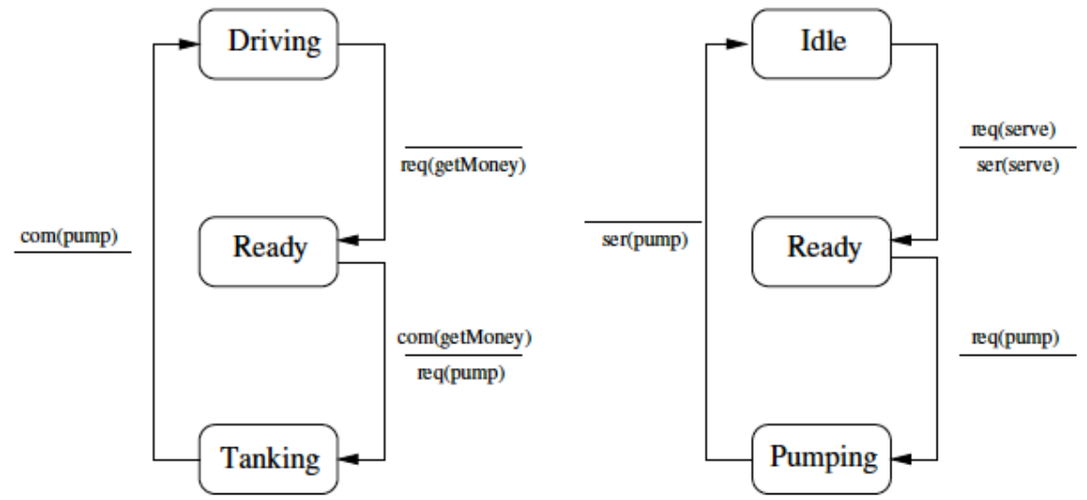
Abstract. With the introduction of UML 2.0, many improvements to diagrams have been incorporated into the language. Some of the major changes were applied to sequence diagrams, which were enhanced with most of the concepts from ITU-T's Message Sequence Charts, and more. In this paper, we introduce a formal semantics for most concepts of sequence diagrams by means of Petri nets as a formal model. Thus, we are able to express the partially ordered and concurrent behaviour of the diagrams natively within the model. Moreover, the use of coloured high-level Petri nets allows a comprehensive and efficient structure for data types and control elements. The proposed semantics is defined compositionally, based on basic Petri net composition operations.

1 Introduction

The long-standing and successfully applied modelling technique of Message Sequence Charts (MSC) [11] of ITU-T has finally found its way to the most widely applied software modelling framework, the Unified Modelling Language (UML) [18]. In its recent 2.0 version, sequence diagrams (SD, interaction diagram) were enhanced by important control flow features. This change is one of

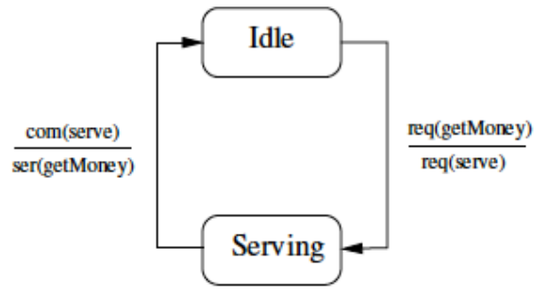
Em um artigo de 2001, Luciano Baresi e Mauro Pezzé propuseram a síntese de uma rede de Petri a partir de diagramas de classe e estado



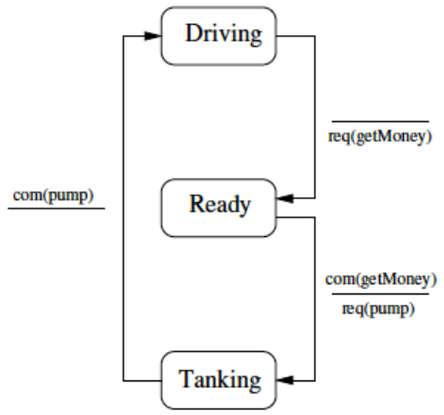


(a) class Driver

(b) class Pump



(c) class Gas Station



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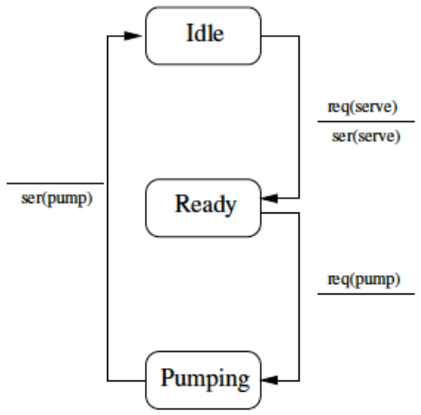
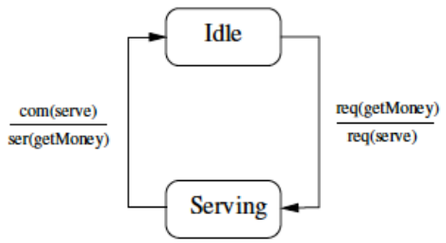


(b) class Pump



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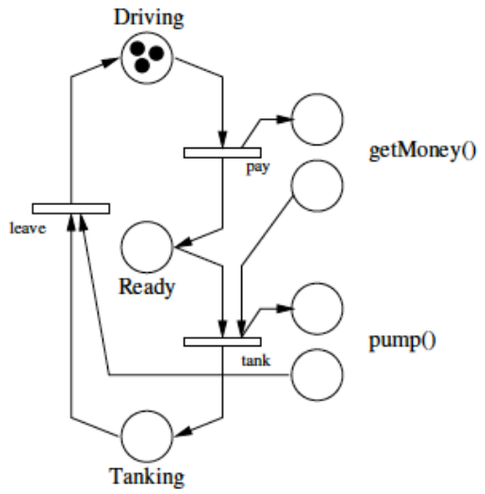

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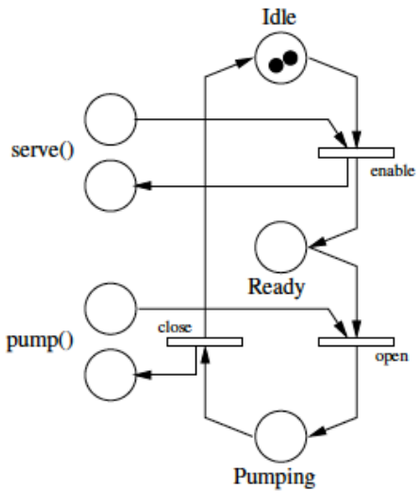
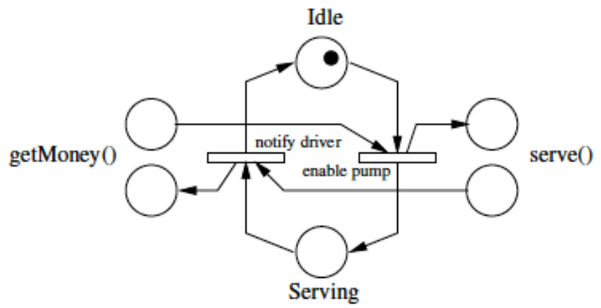
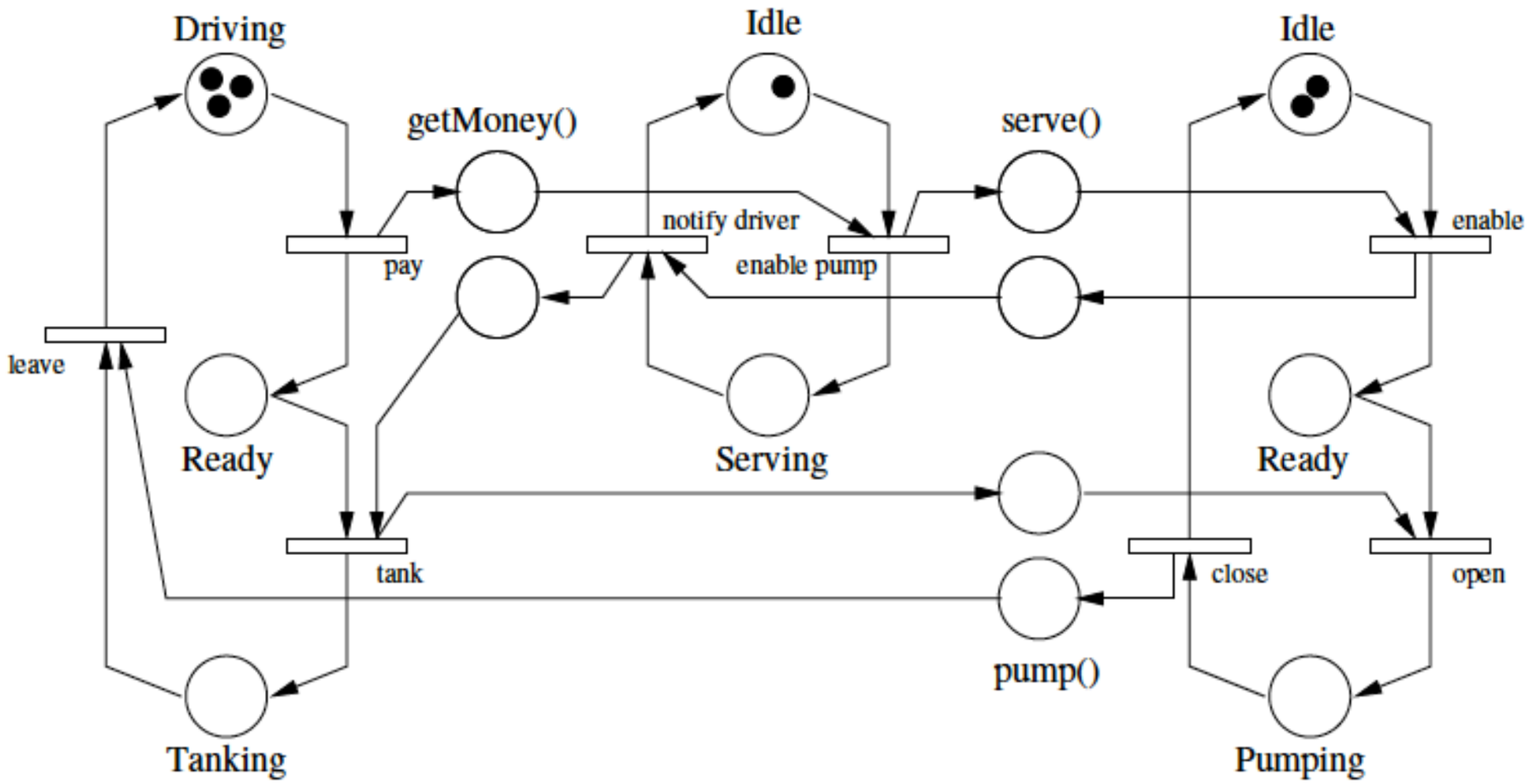


(b) class Pump



(c) class Gas Station


Driving
Idle
Idle
getMoney()
serve()
notify driver
enable
pay
enable pump
leave
Ready
Serving
Ready
tank
close
open
pump()
Tanking
Pumping

Requirement Analysis Method for Real World Systems in Automated Planning

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On the intelligent design field the requirement analysis phase has a fundamental role in automated planning-especially for "real life" systems - because it has the ability to identify or redesign variables which can potentially increase the model accuracy generated by the automated planner. A great effort has been made today in the area of Artificial Intelligence for defining reliable automated planning systems that can be applied for real life applications. That leads to the need for systematic design process, in which the initial phases are not neglected and where Knowledge and Requirement Engineering tools have a fundamental role for supporting designers. This paper intent to investigate design methods as well as perform a more detailed study on the adoption of UML and Petri Nets in the requirement analysis phase using the itSIMPLE framework as a KE tool.

Introduction

Planning characterizes a specific kind of design problem where the purpose is to find a set of admissible actions to

eling language and the place/transition Petri net to derive the UML diagrams. Throught the Petri net the requirement analysis will be performed using the available techniques, such as invariant analysis and equation state matrix (Murata 1989b). The first step detects contradictions and conflicts between the requirements, or the diferent view points in the diagrams. The second step identifies deep inconsistencies, that are hidden in the dinamic perspective of the plans, as well as additional information about the model that could be interpreted for the planners. Such informaton includes, new constraints, invariants, partial solution strategies, characteristics that could help to improve the planner aperformance.

The tool we choosed to use is the itSIMPLE framework (Vaquero et al. 2007b), which currently is not a 100% ready to performe the UML/Petri net translation, but it will be during the devopment of this project.

In the section 2 it will be discussed the advantages os UML in automated planning, followed by a brief description of Petri Nets, after that it will be presented a study case, the results and discussions and the conclusion.

UML for Design of Real Life Problems

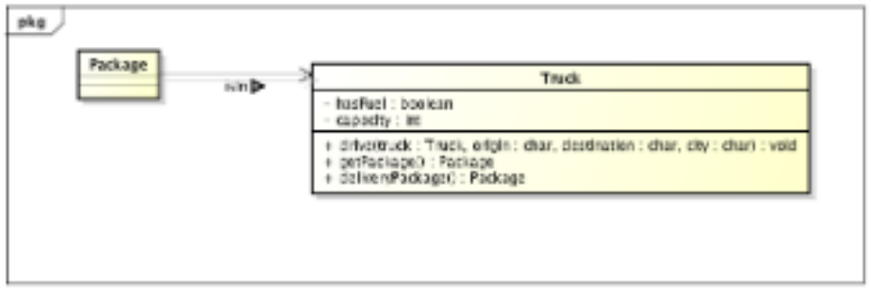


Figure 2: Class Diagram designed to represent the planning problem.

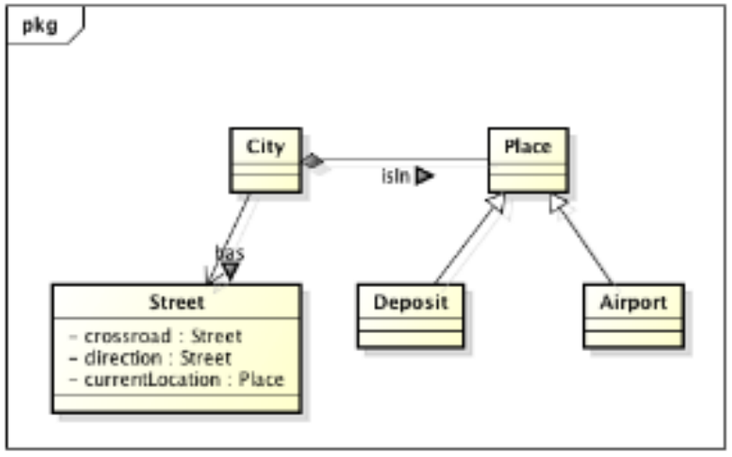


Figure 3: Class Diagram designed to represent the work domain.

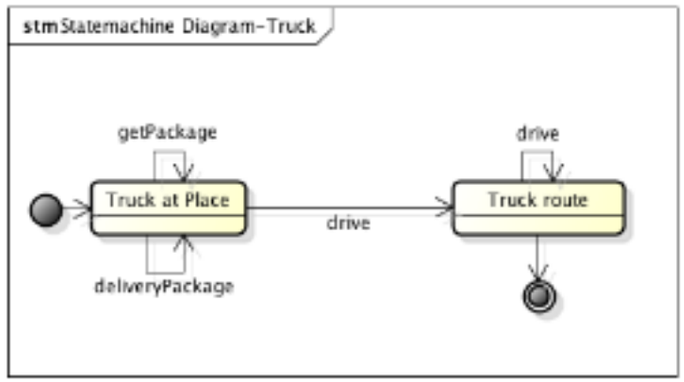


Figure 4: State Diagram designed to represent the planning problem.

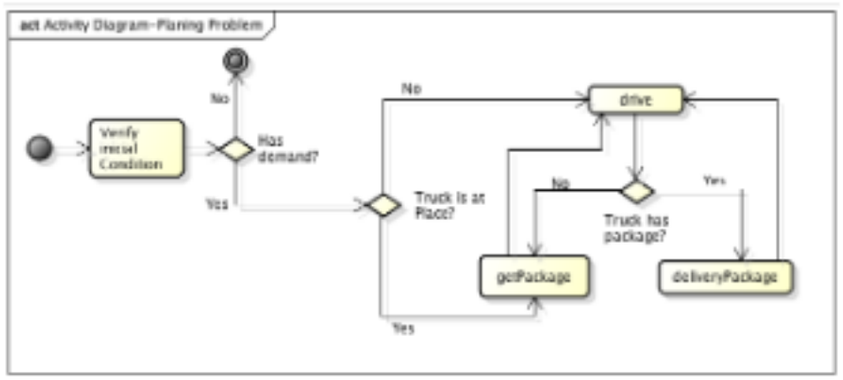


Figure 5: Activity Diagram designed to represent the planning problem.

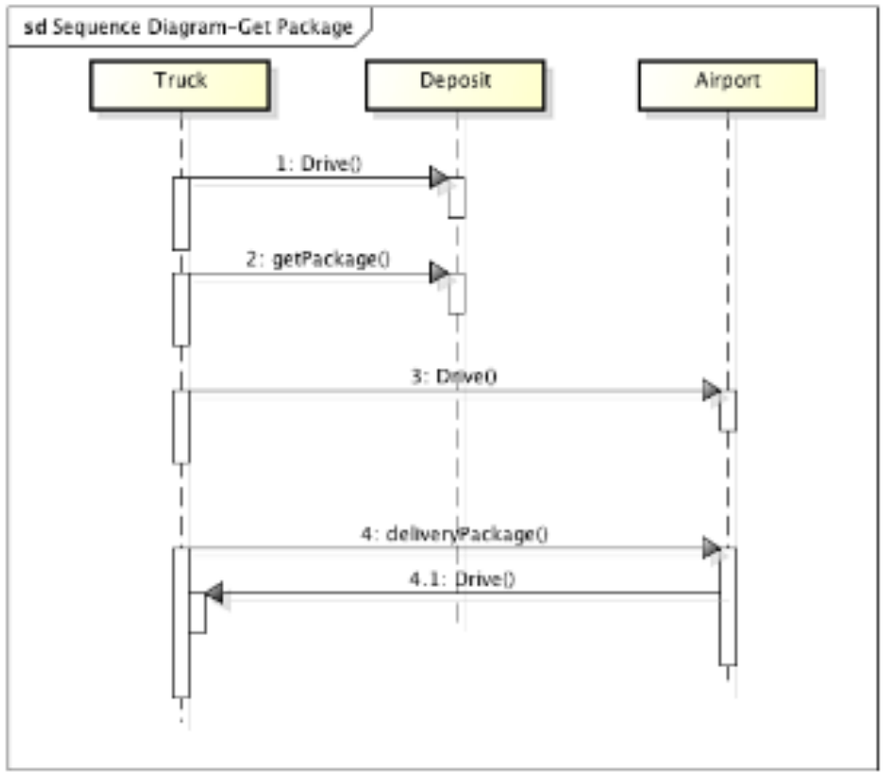
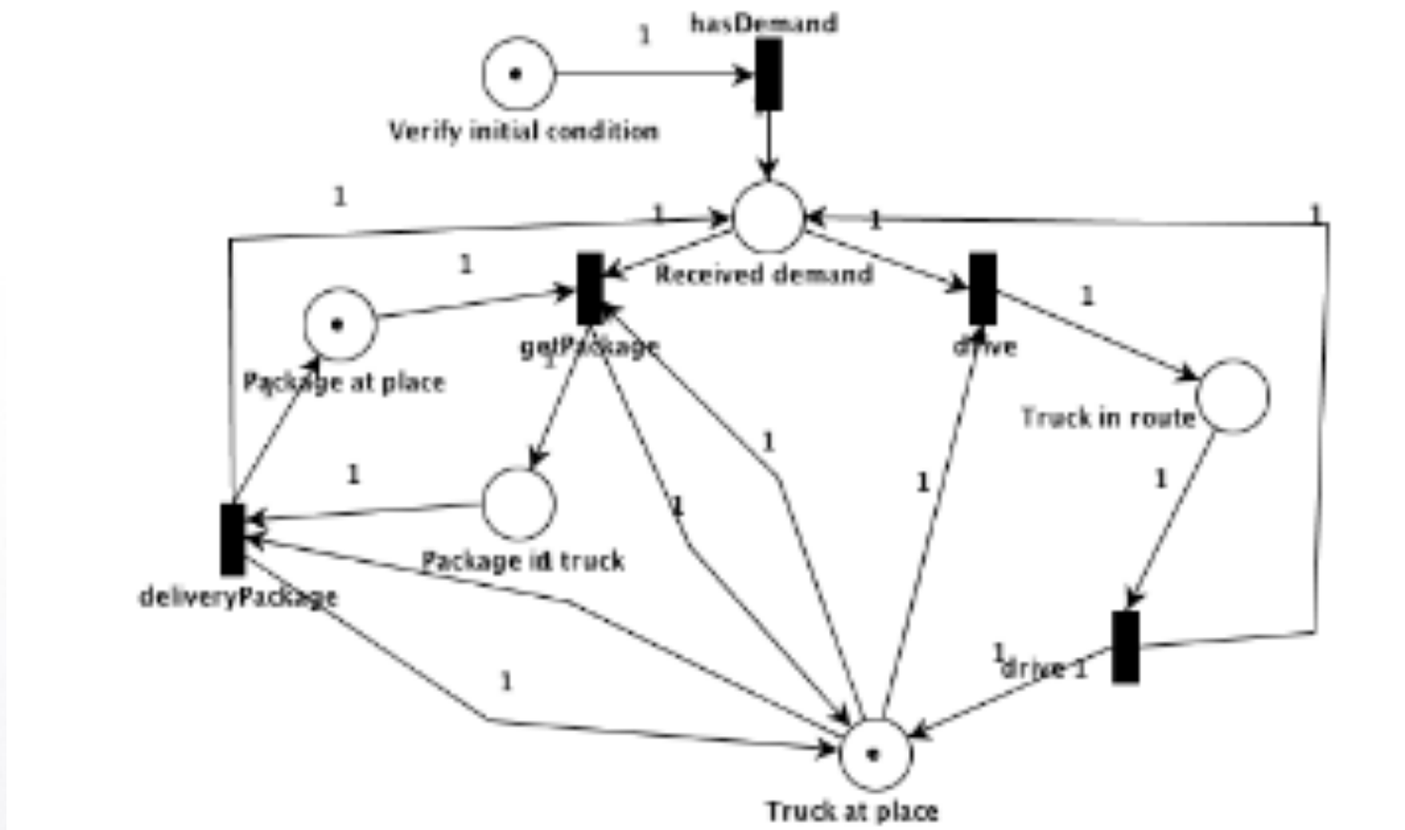


Figure 6: Sequence Diagram designed to represent the planning problem.



Fim