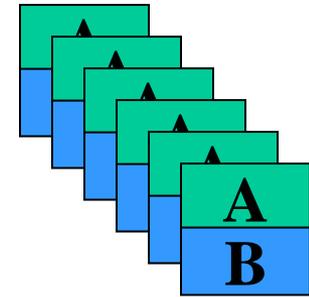
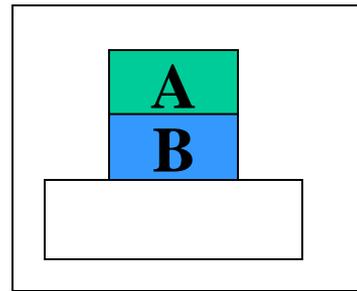
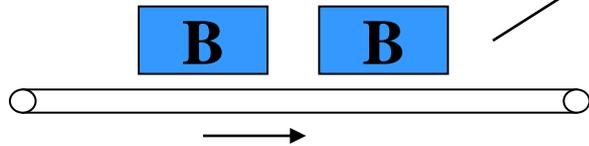
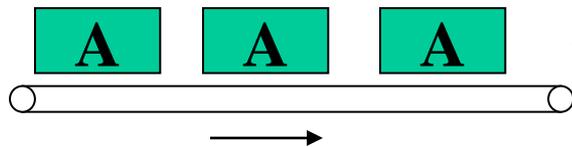




Exemplos de Modelagem utilizando Redes de Petri



Problema:

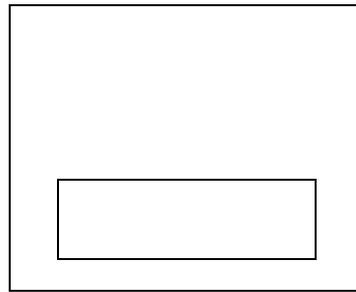


Depósito de
Produtos Acabados

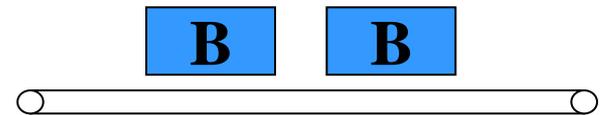


Definindo os Lugares

- Recursos



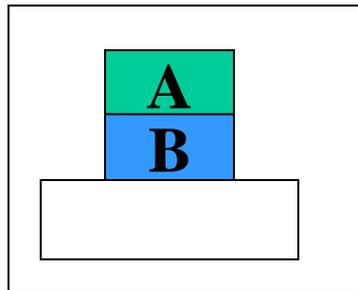
Máquina



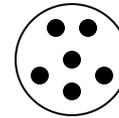


Definindo os Lugares

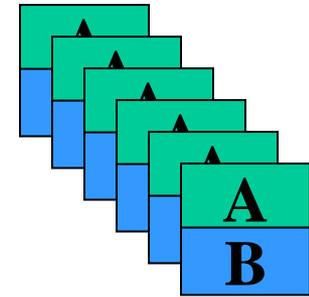
- Produto Montado
- Produto Armazenado



Máquina



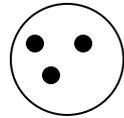
Depósito de Produtos Acabados



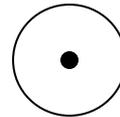
Depósito de Produtos Acabados



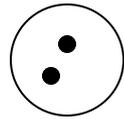
Definindo os lugares



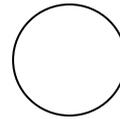
Peça A



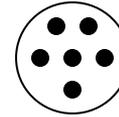
Máquina



Peça B



Produto
Montado

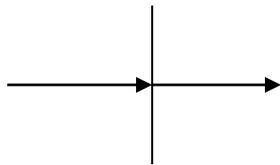
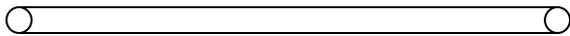


Depósito de
Produtos
Acabados



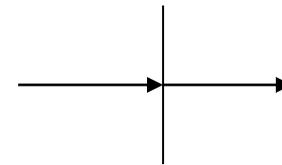
Definindo as Transições

A



Alimentar
Peça A

B

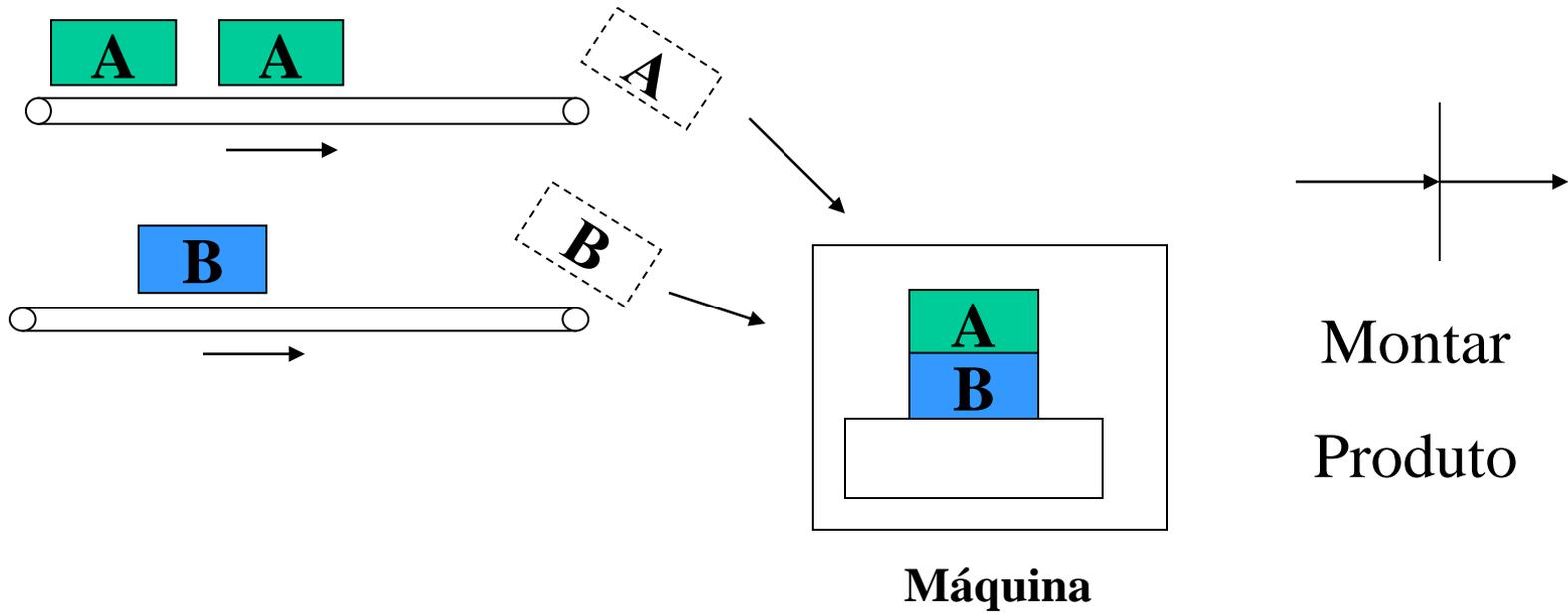


Alimentar
Peça B



Definindo as Transições

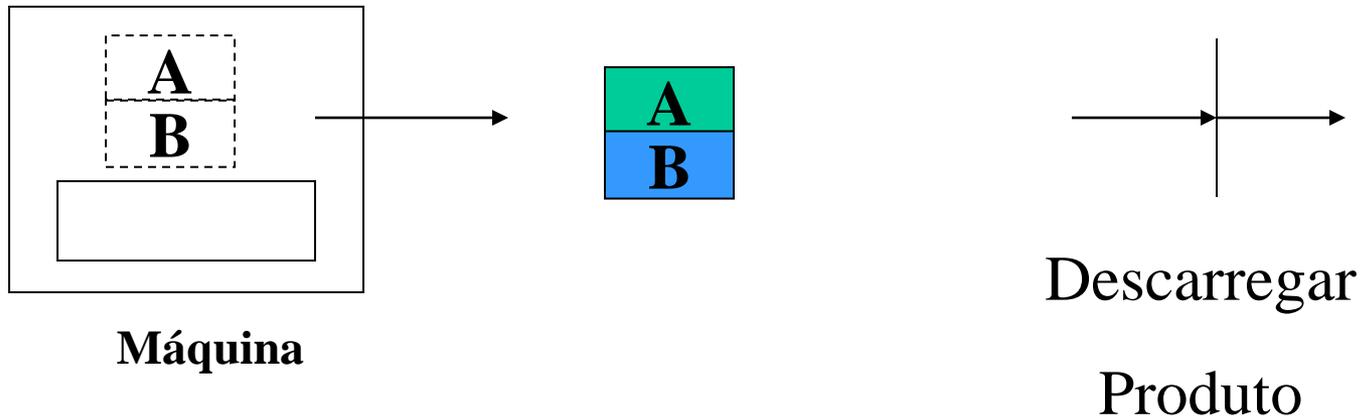
- Montar Produto

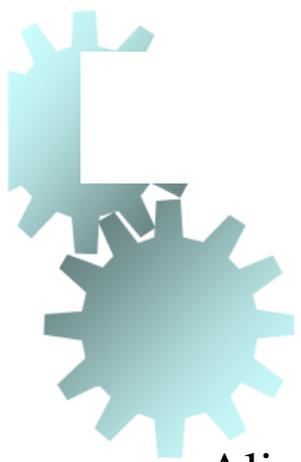




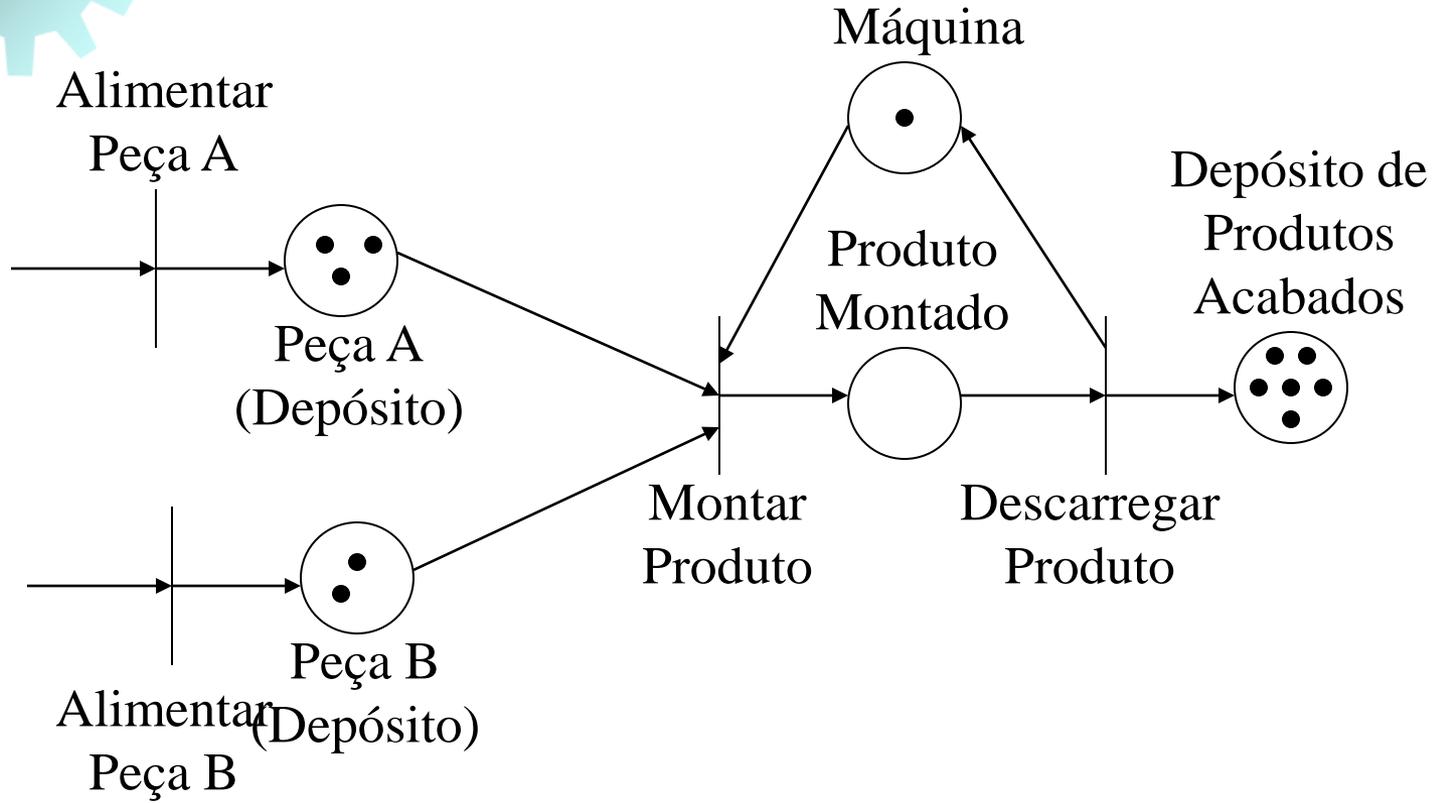
Definindo as Transições

- Descarregar Produto

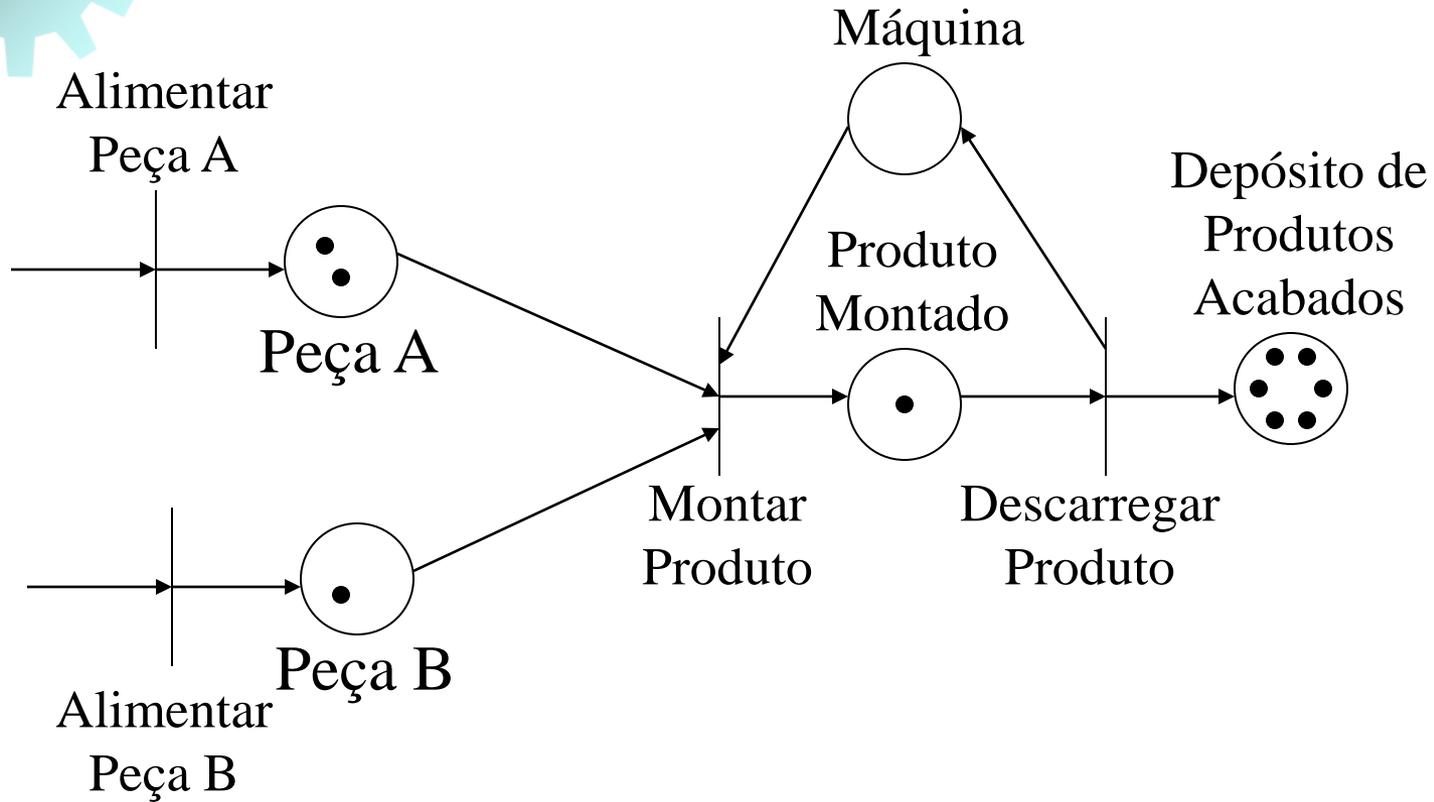




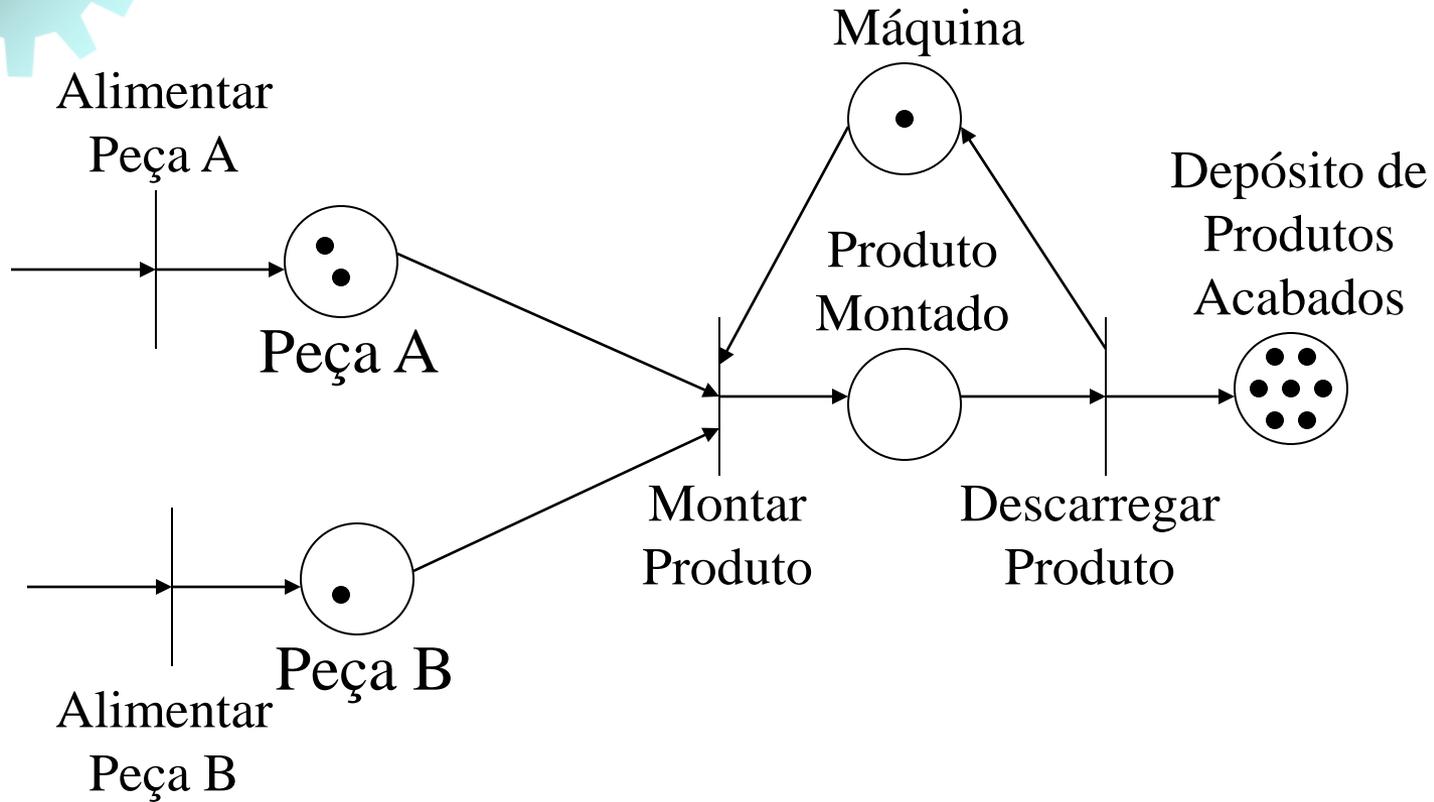
Modelo



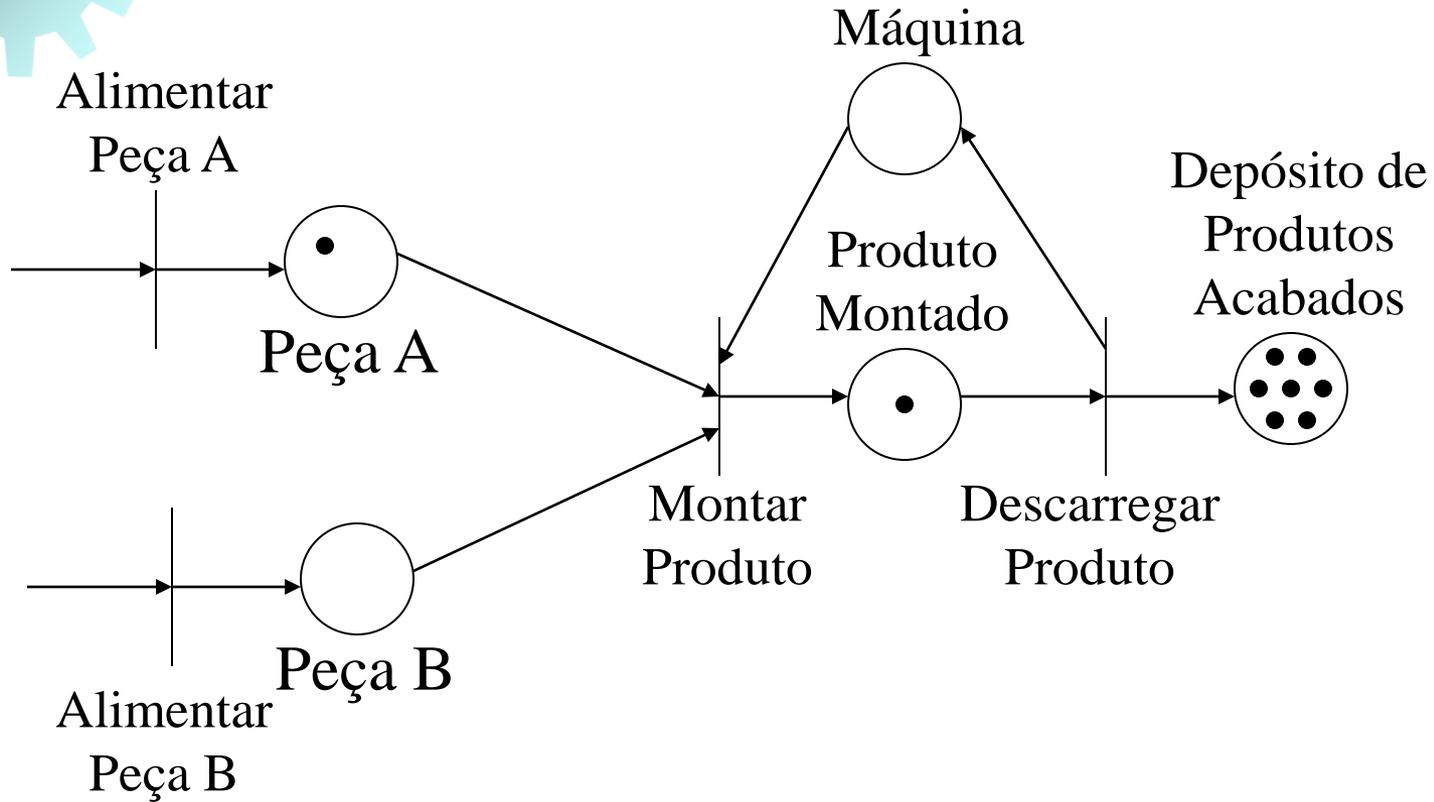
Evolução do Modelo



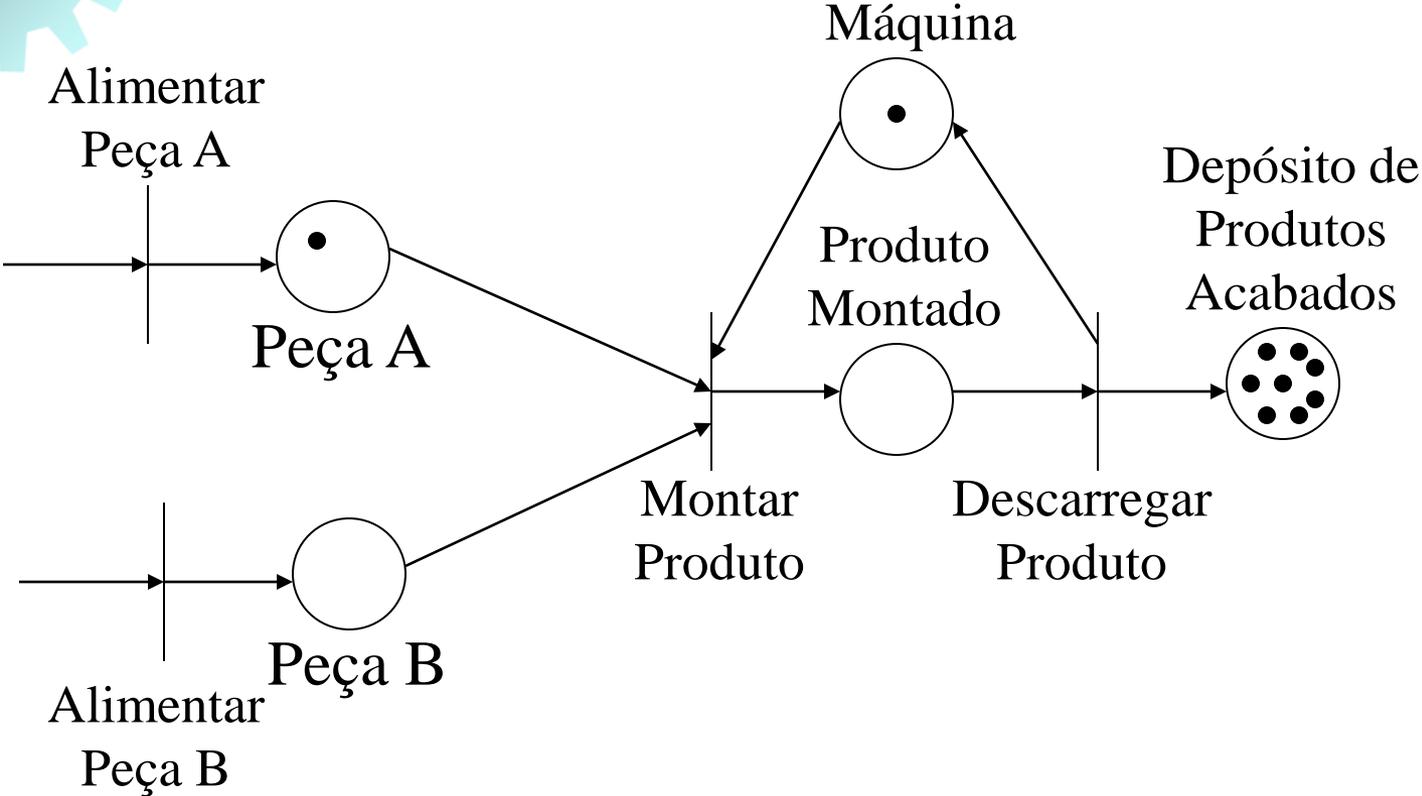
Evolução do Modelo



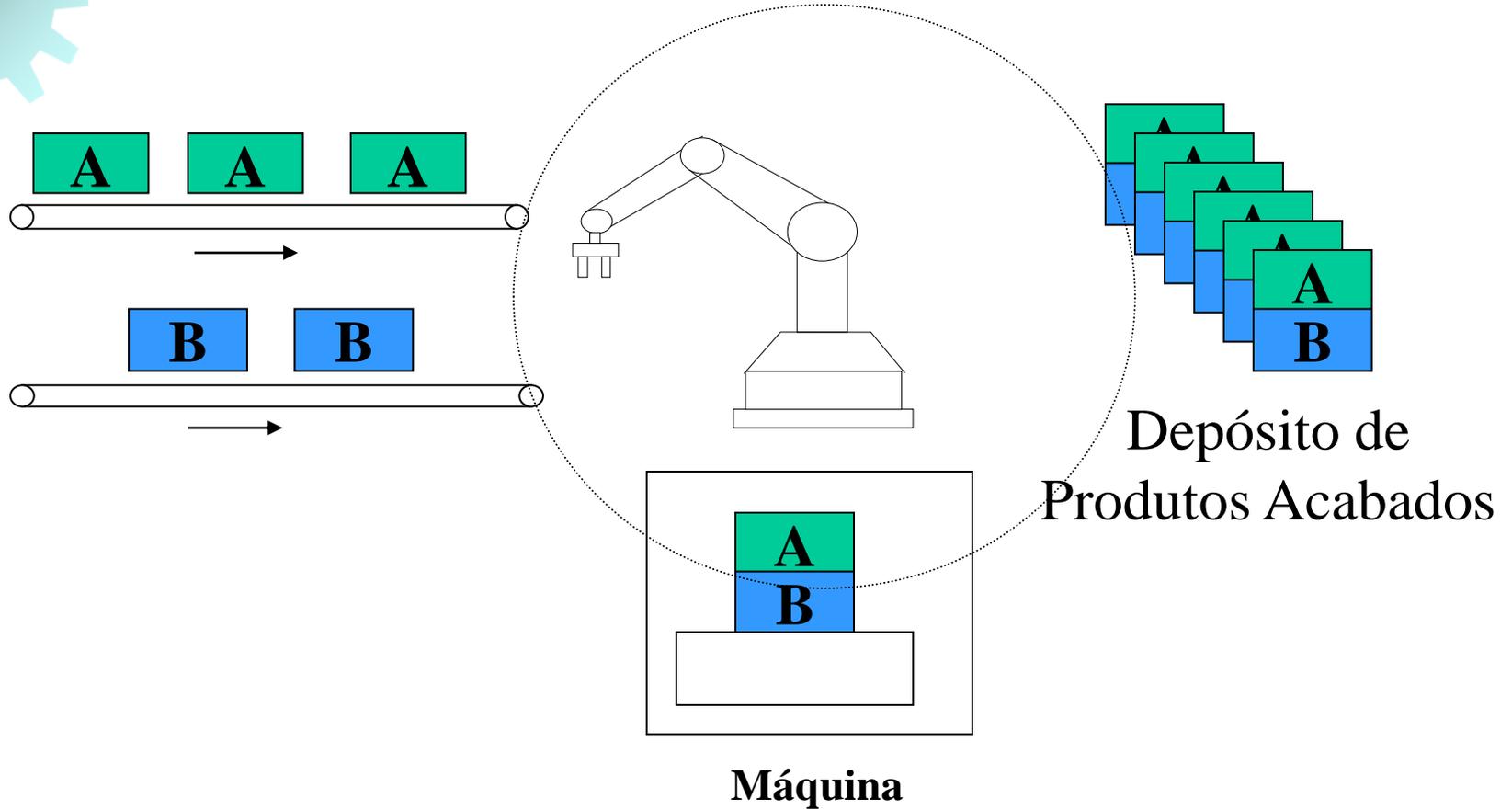
Evolução do Modelo



Evolução do Modelo



Inserindo um Robô Manipulador





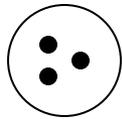
Seqüência de Eventos:

- Robô insere Peça A na Máquina;**
- Robô insere Peça B na Máquina;**
- Máquina Monta produto;**
- Robô Descarrega Produto da Máquina**

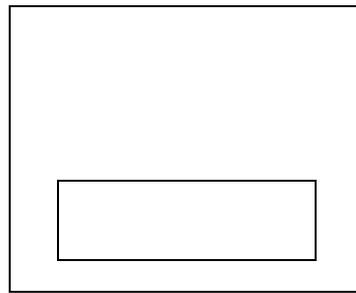


Definindo os Lugares

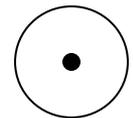
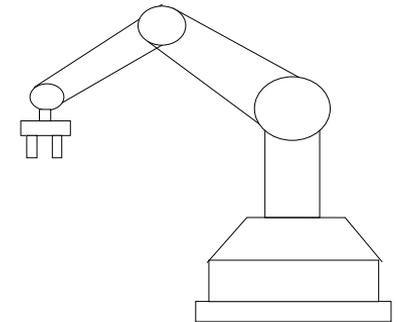
- Recursos



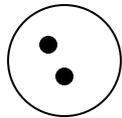
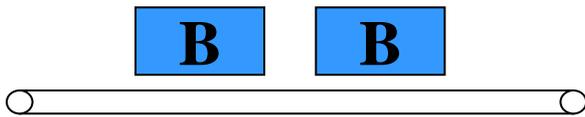
Peça A



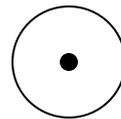
Máquina



Robô



Peça B

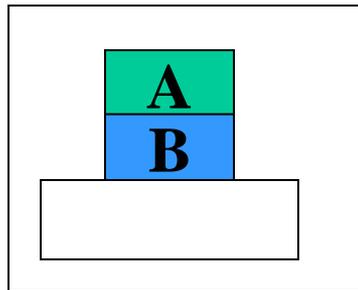


Máquina

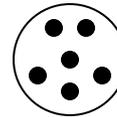


Definindo os Lugares

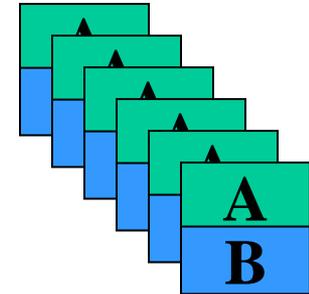
- Produto Montado
- Produto Armazenado



Máquina



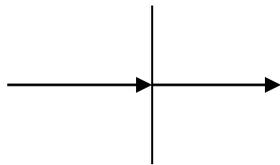
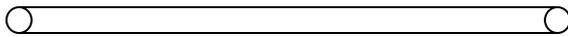
Depósito de Produtos Acabados





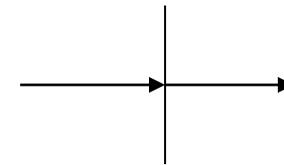
Definindo as Transições

A



Alimentar Peça A (no
Depósito de Peças A)

B

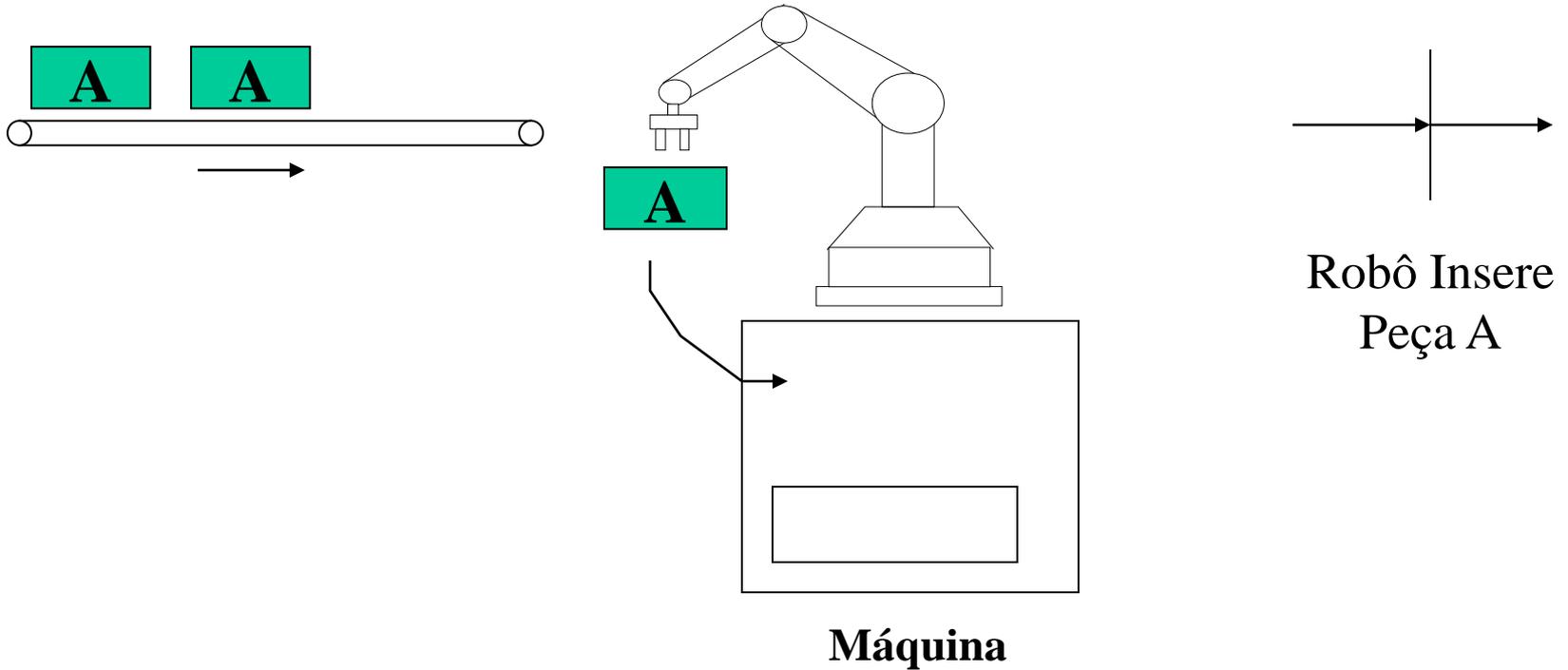


Alimentar Peça B (no
Depósito de Peças B)



Definindo as Transições

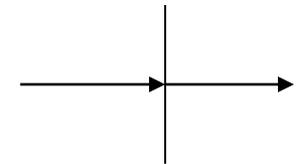
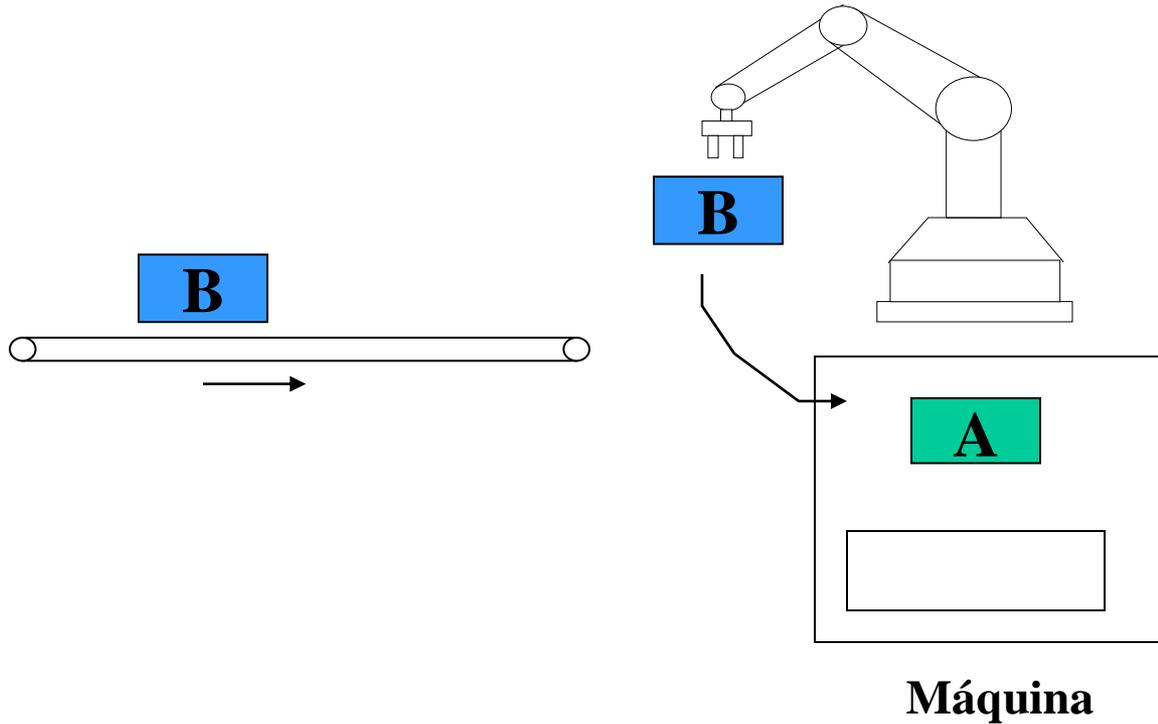
- Inserir Peças na Máquina





Definindo as Transições

- Inserir Peças na Máquina

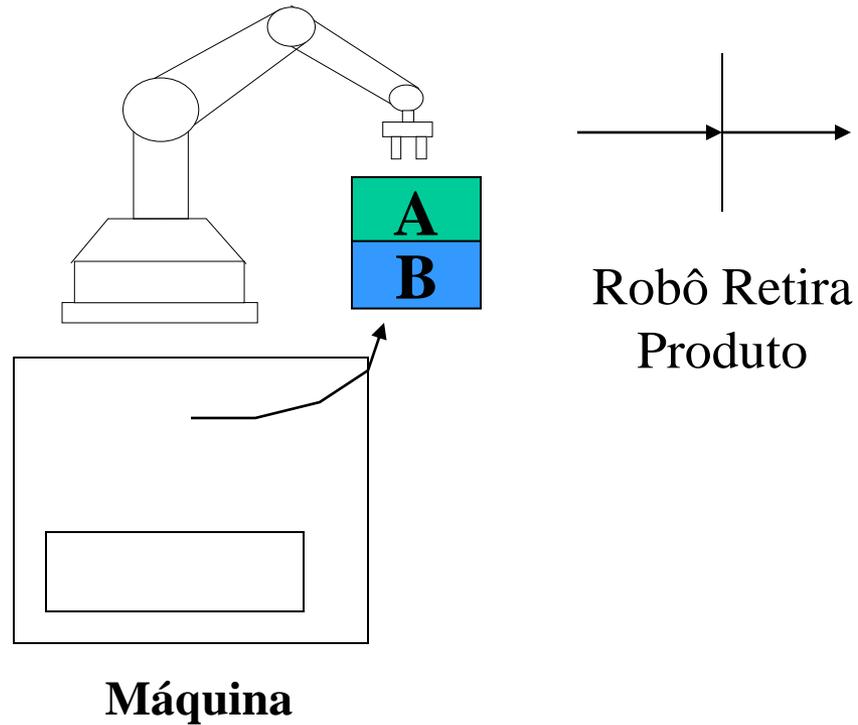


Robô Insere
Peça B



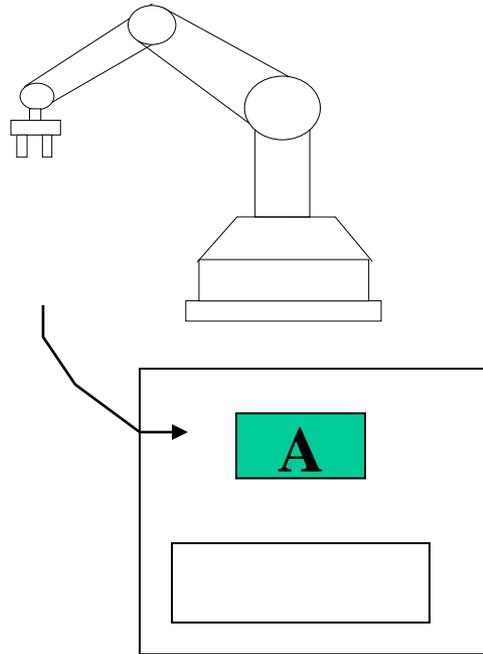
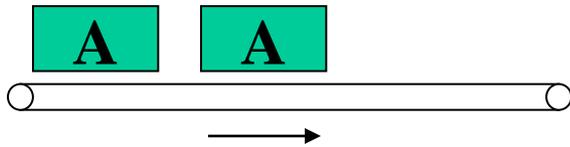
Definindo as Transições

- Retirar Produto da Máquina





Necessidade de Dois Lugares Adicionais

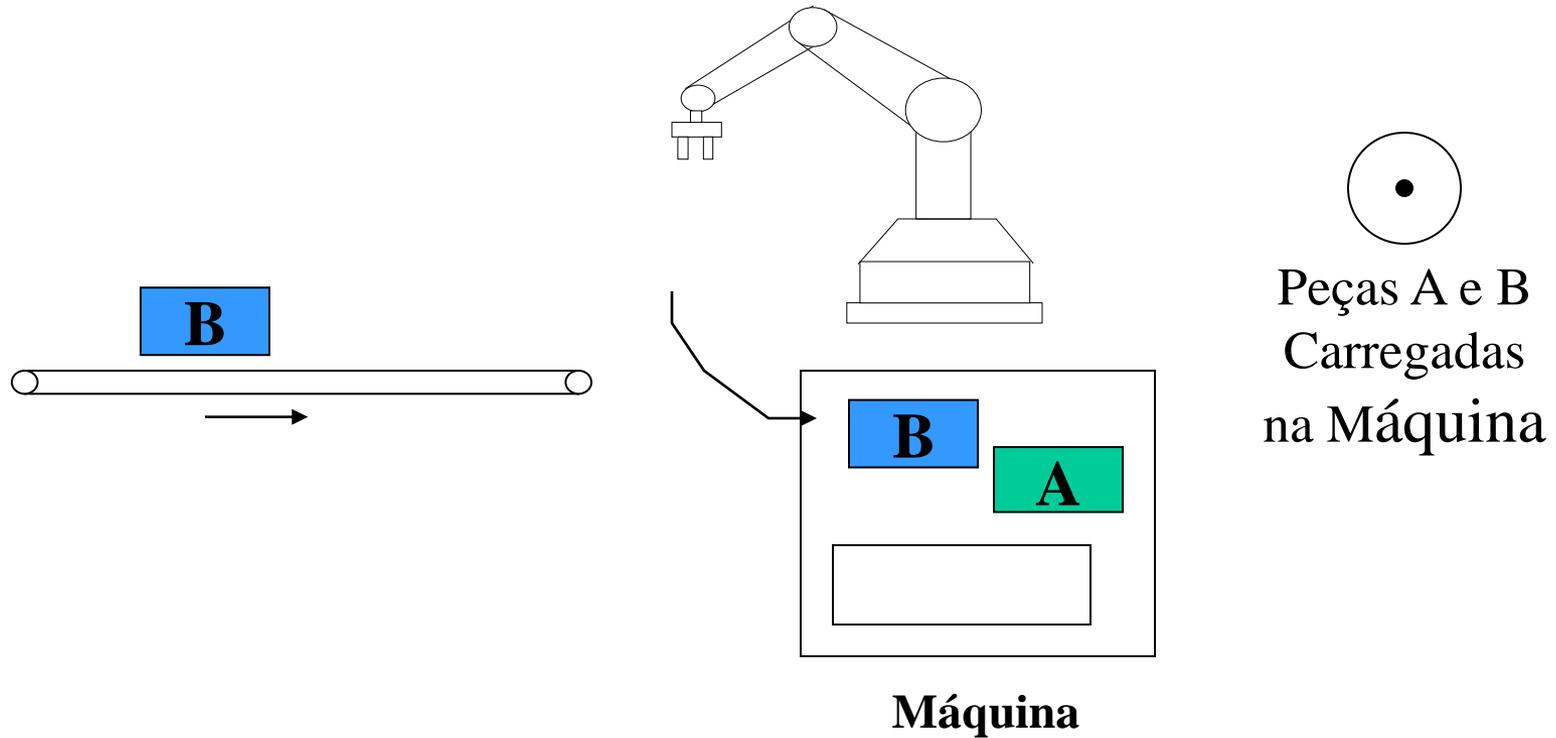


Máquina



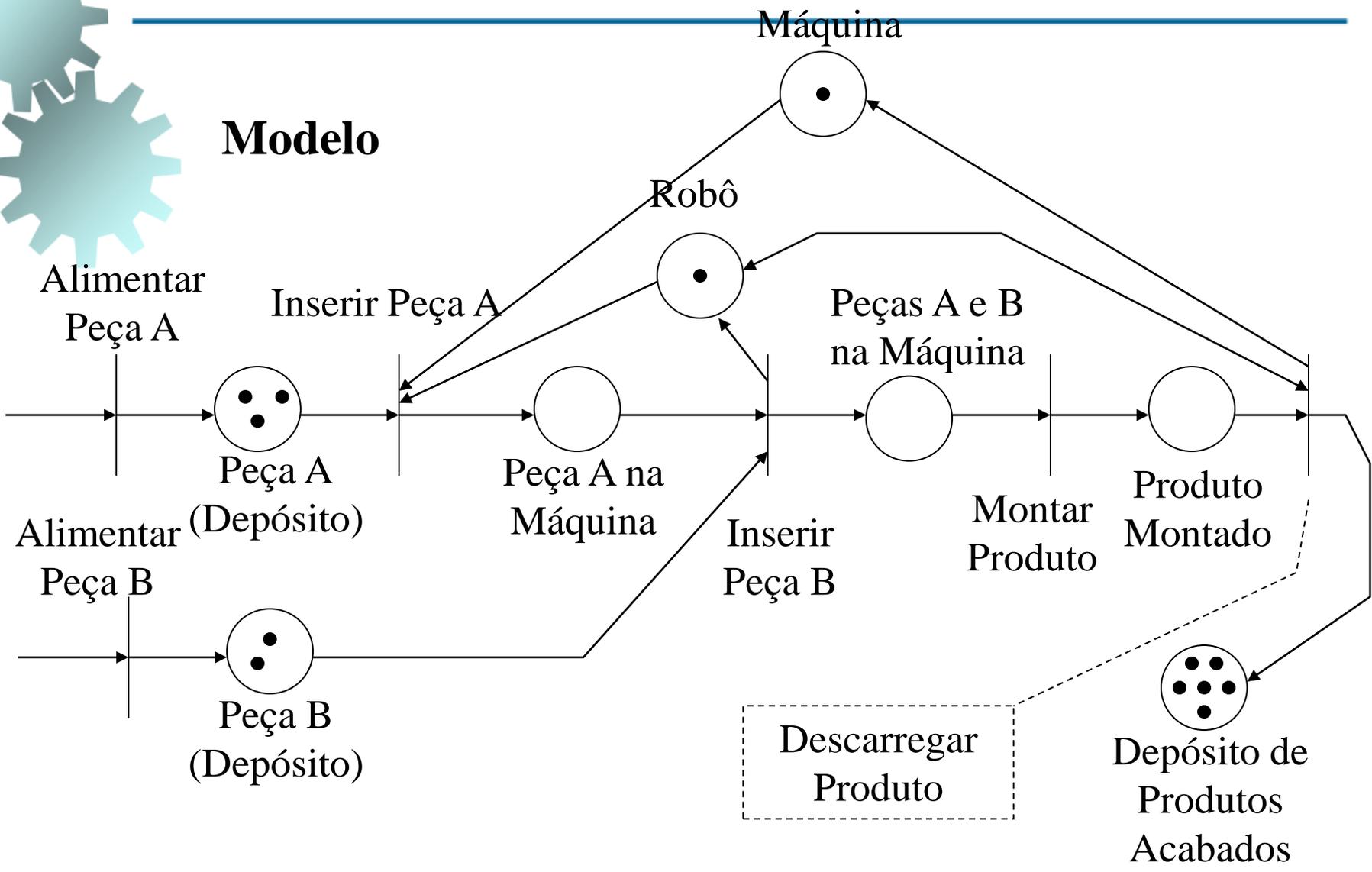


Necessidade de Dois Lugares Adicionais

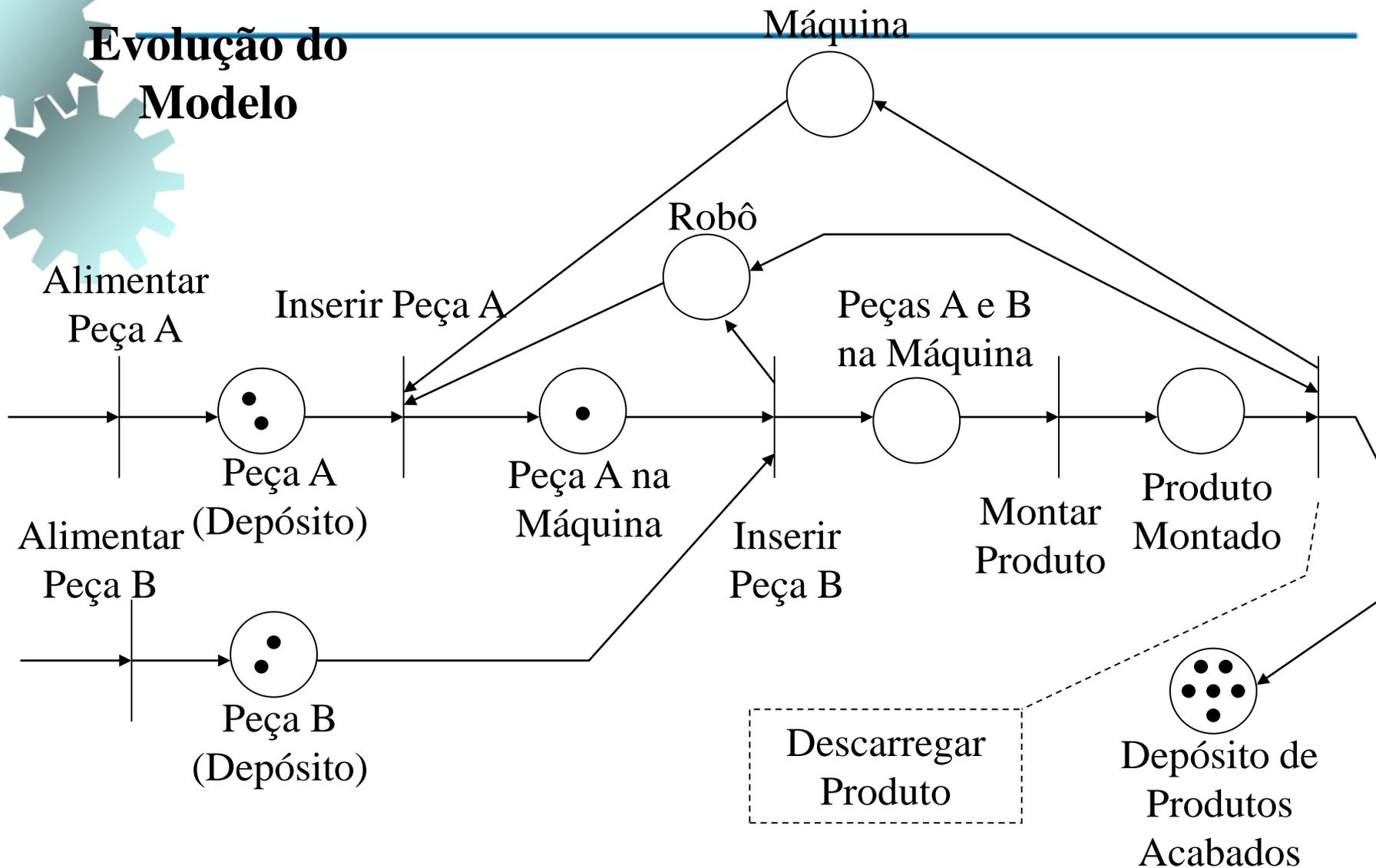




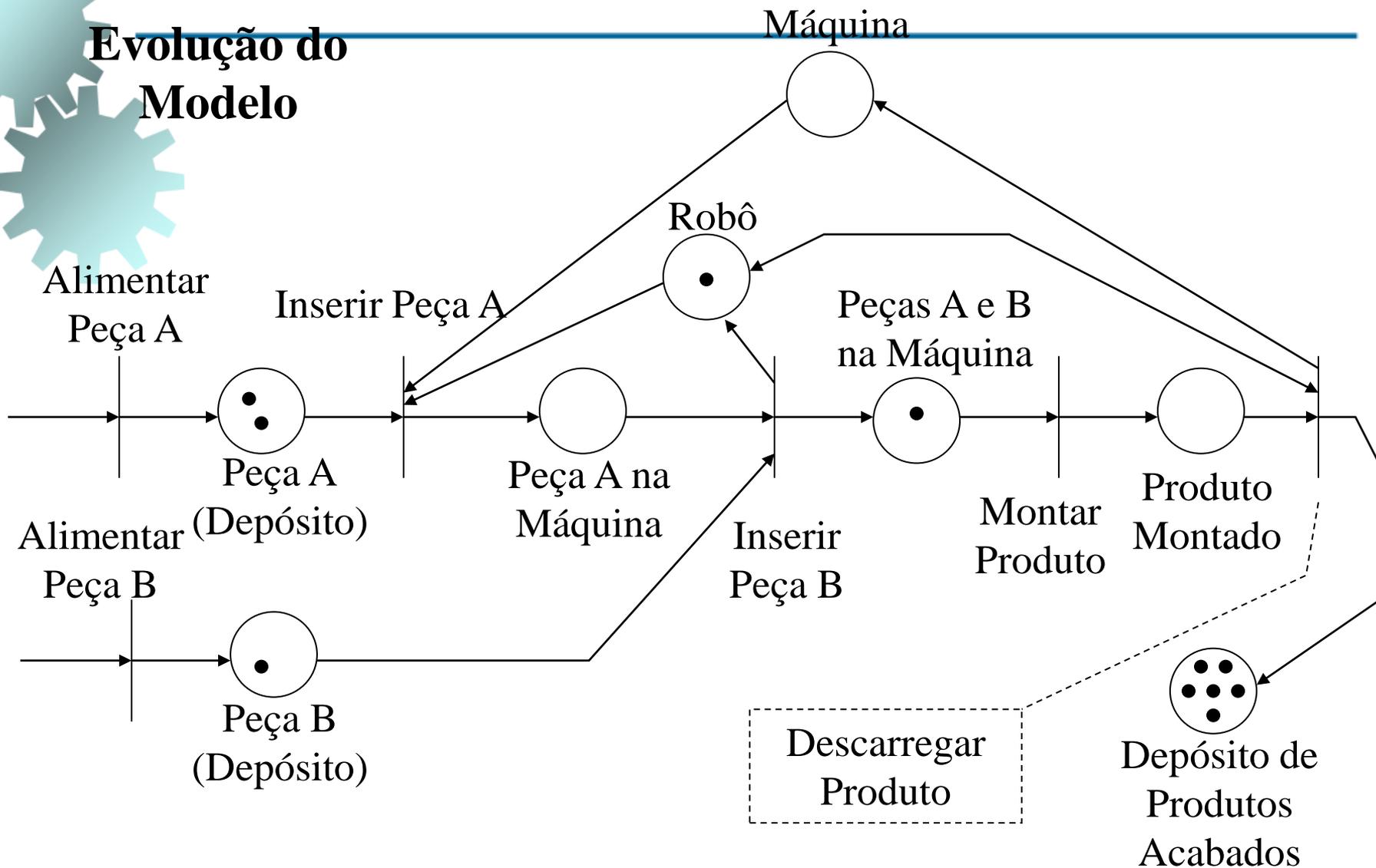
Modelo



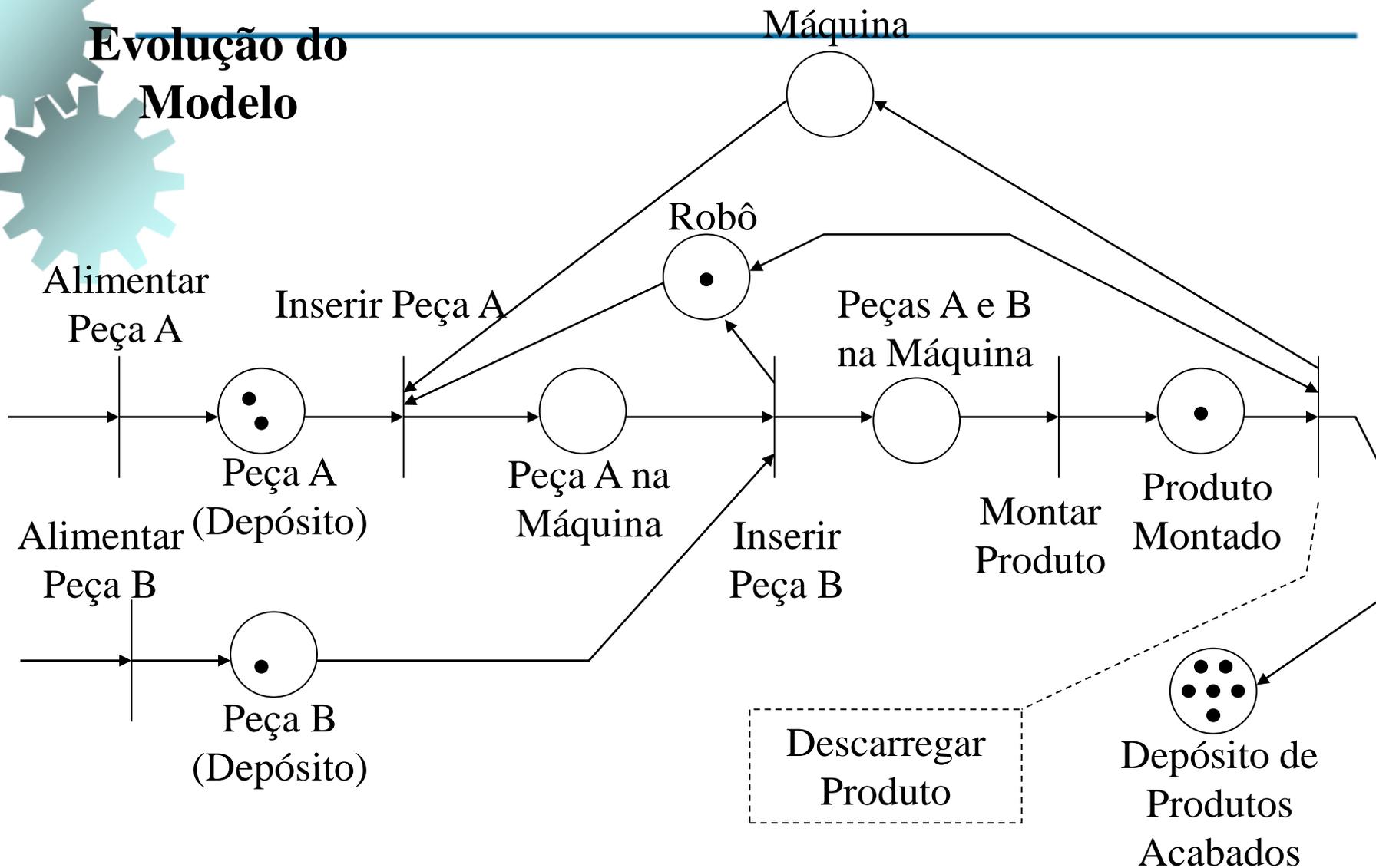
Evolução do Modelo



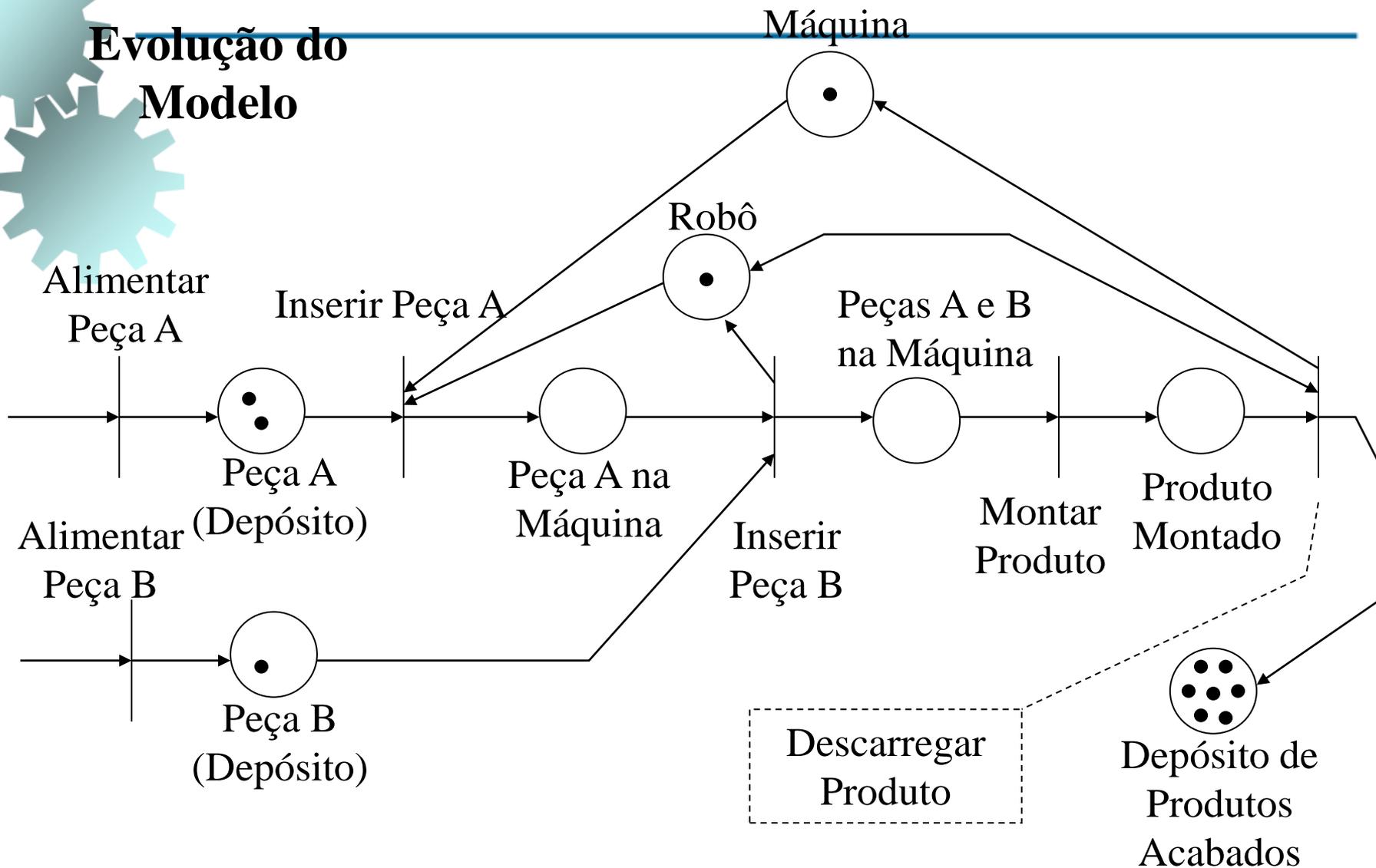
Evolução do Modelo



Evolução do Modelo



Evolução do Modelo





Árvore de Cobertura ?





Lugares:

P1: Depósito de Peças A

P2: Depósito de Peças B

P3: Peça A na Máquina

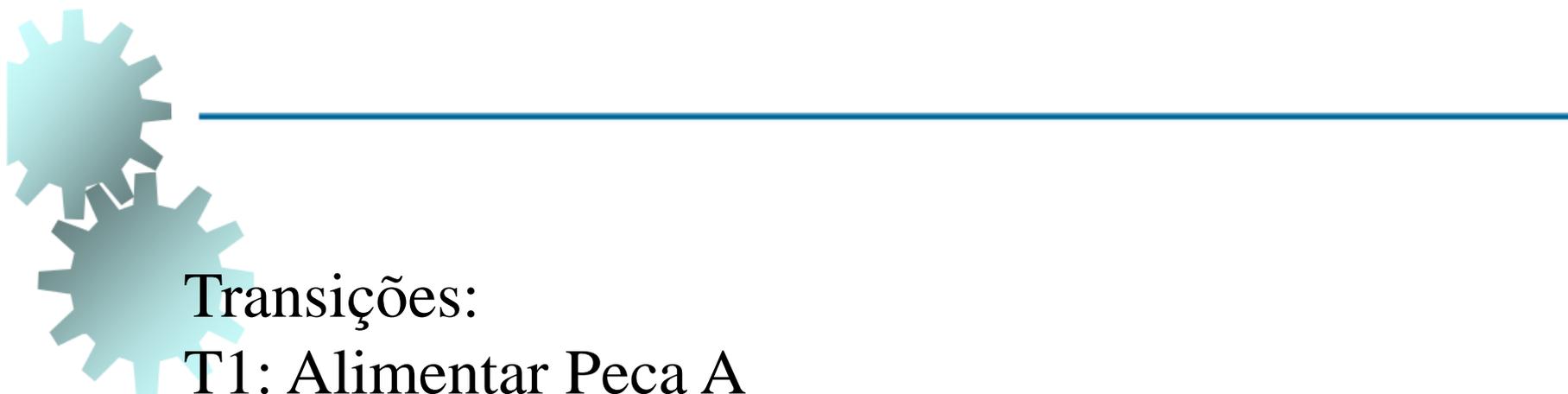
P4: Robô

P5: Peças A e B na Máquina

P6: Máquina

P7: Produto Montado

P8: Depósito de Produtos Acabados



Transições:

T1: Alimentar Peça A

T2: Alimentar Peça B

T3: Inserir Peça A na Máquina

T4: Inserir Peça B na Máquina

T5: Montar Produto

T6: Descarregar Produto

Lugares:

P1: Depósito de Peças A

P2: Depósito de Peças B

P3: Peça A na Máquina

P4: Robô

P5: Peças A e B na Máquina

P6: Máquina

P7: Produto Montado

P8: Depósito de Produtos Acabados

Transições:

T1: Alimentar Peça A

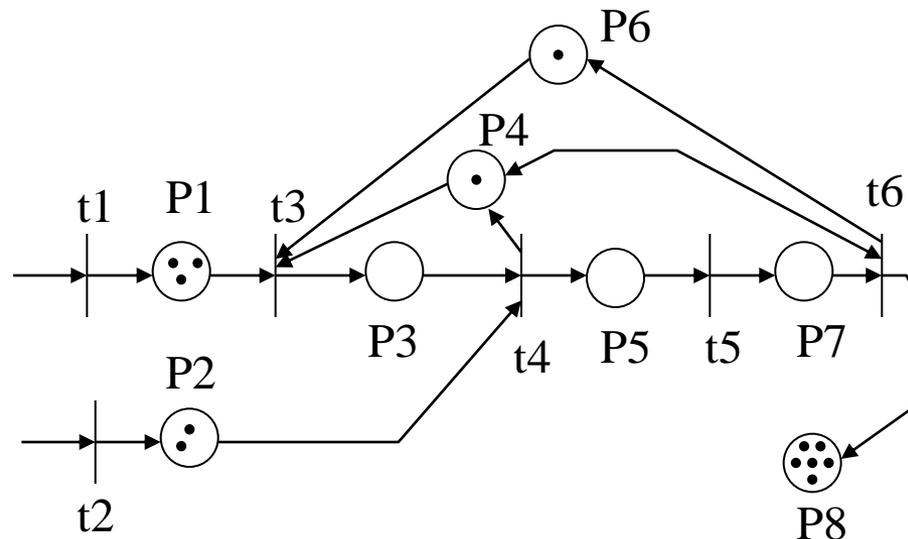
T2: Alimentar Peça B

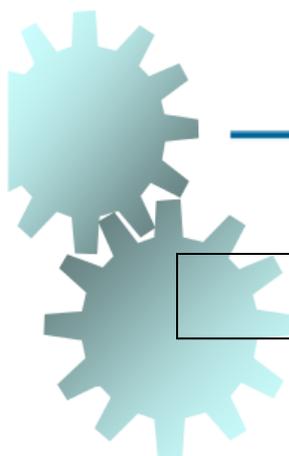
T3: Inserir Peça A na Máquina

T4: Inserir Peça B na Máquina

T5: Montar Produto

T6: Descarregar Produto





3, 2, 0, 1, 0, 1, 0, 6

T1

T2

3, 3, 0, 1, 0, 1, 0, 6

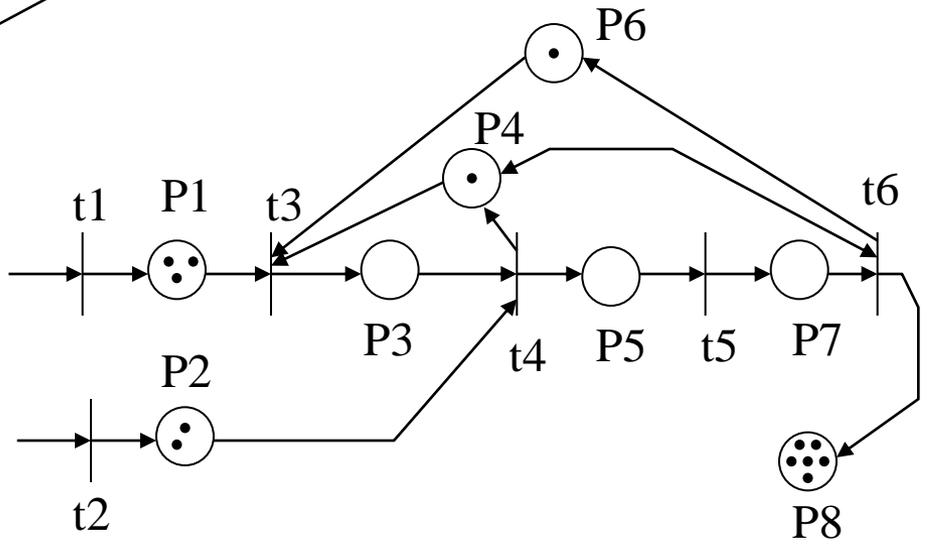
4, 2, 0, 1, 0, 1, 0, 6

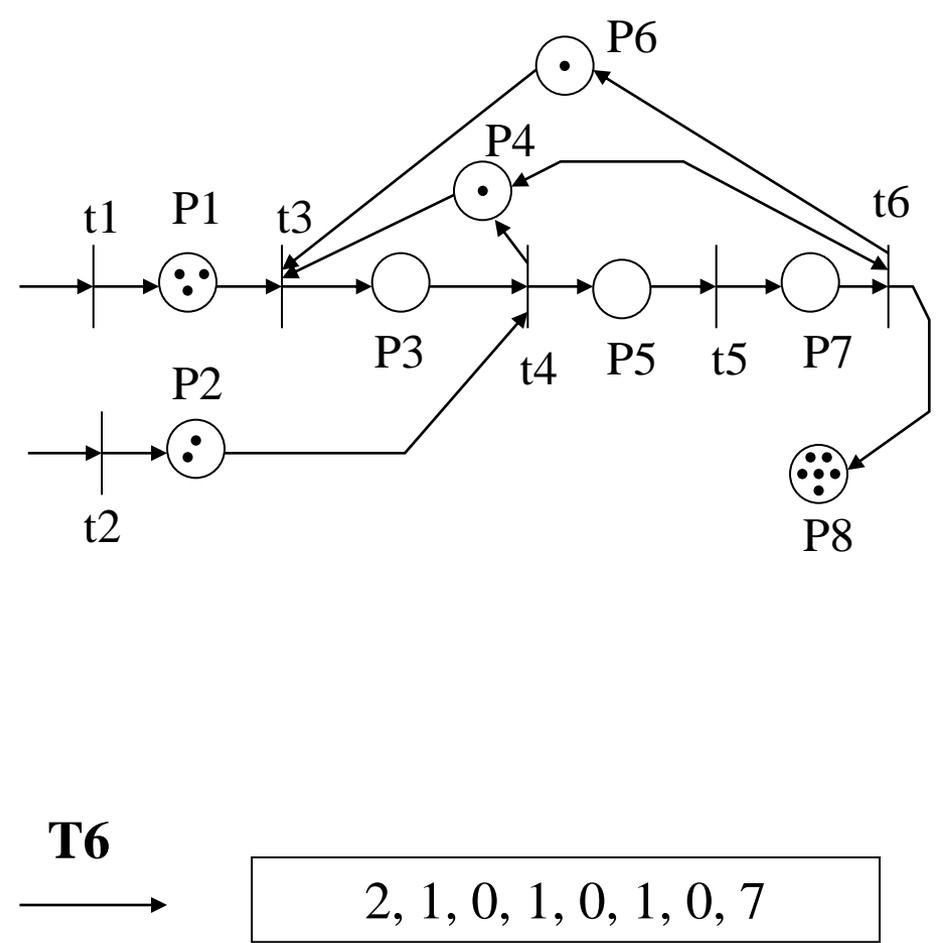
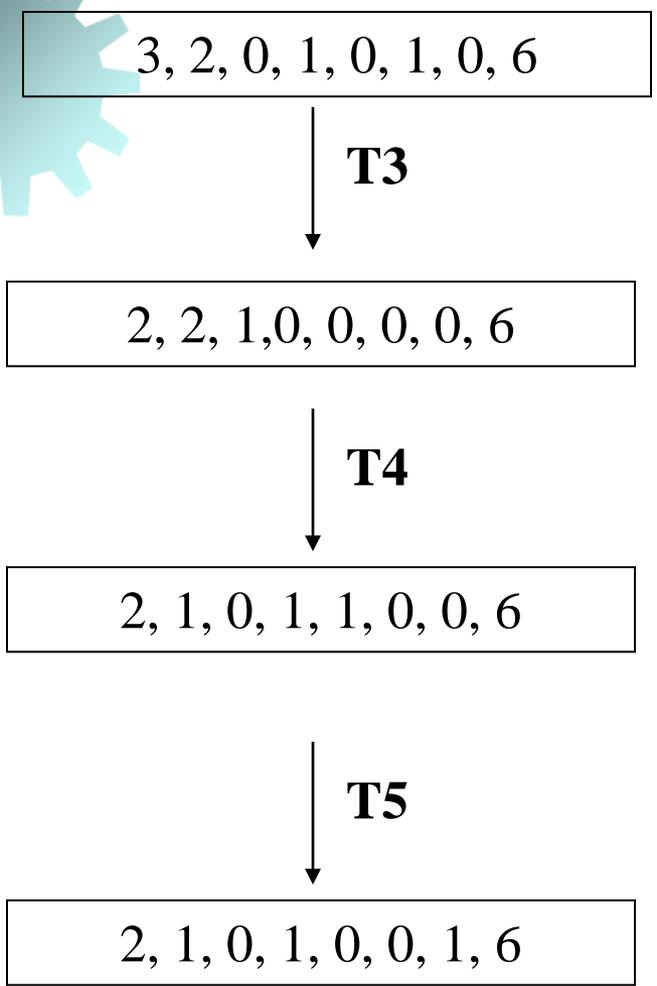
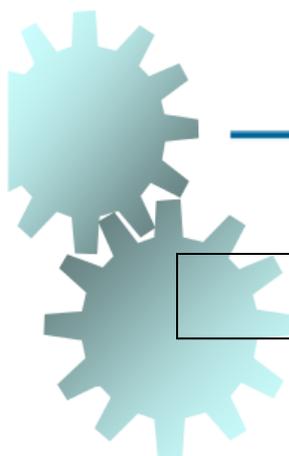
T2

4, 3, 0, 1, 0, 1, 0, 6

w, 3, 0, 1, 0, 1, 0, 6

T1

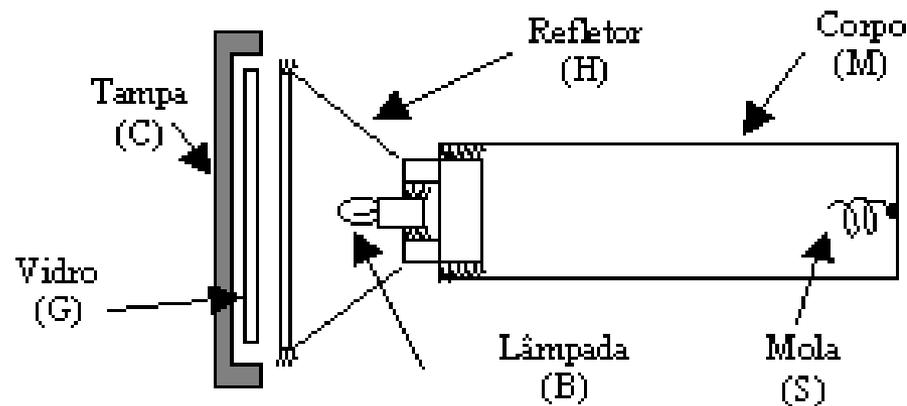


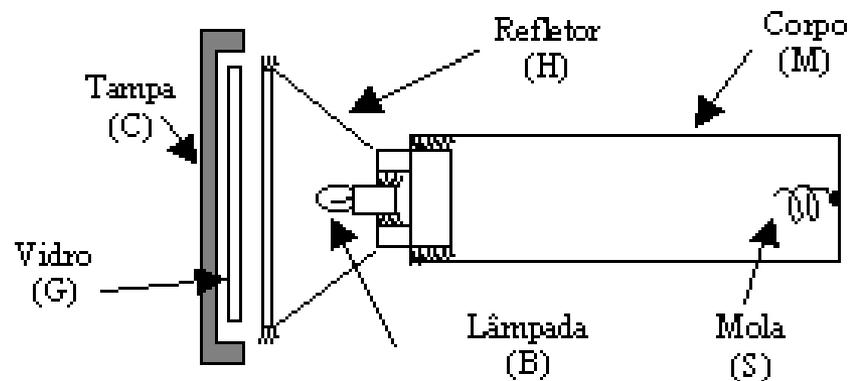




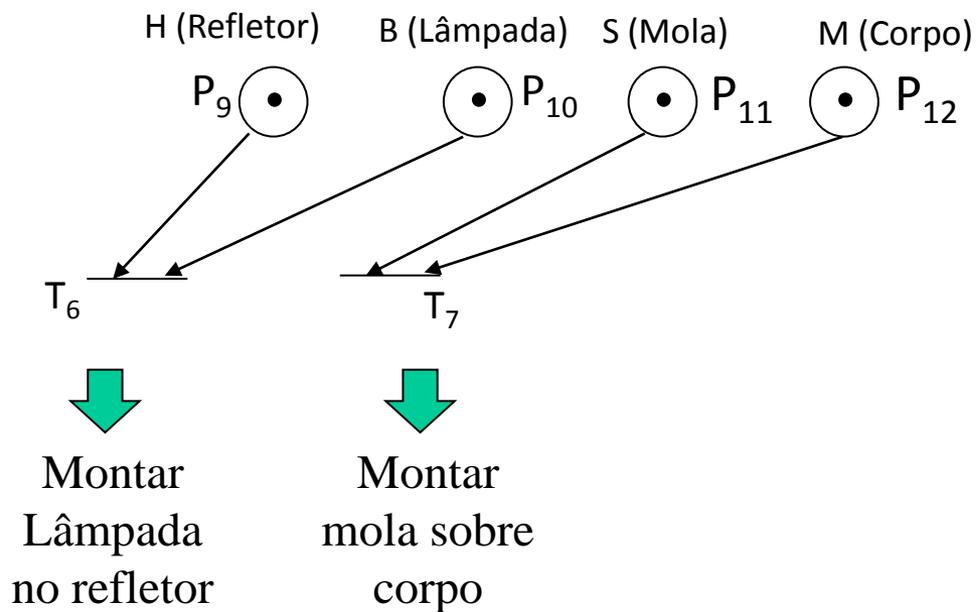
Considere a figura a seguir, representando uma Lanterna. composta por: Tampa (C), Vidro (G), Refletor (H), Lâmpada (B), Mola (S) e Corpo (M). O refletor é rosqueado no corpo; a capa e o vidro são rosqueados no refletor. A mola é fixada no corpo.

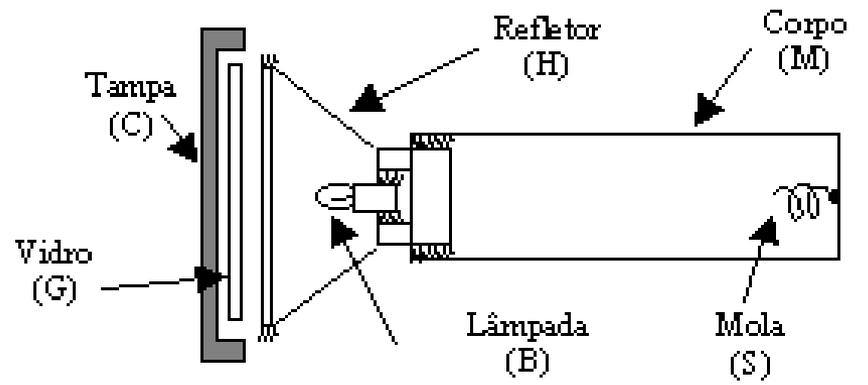
- :
- Desenvolver um Modelo representando o processo de montagem da lanterna;
 - Desenvolver um Modelo representando o processo de desmontagem da lanterna





Montagem



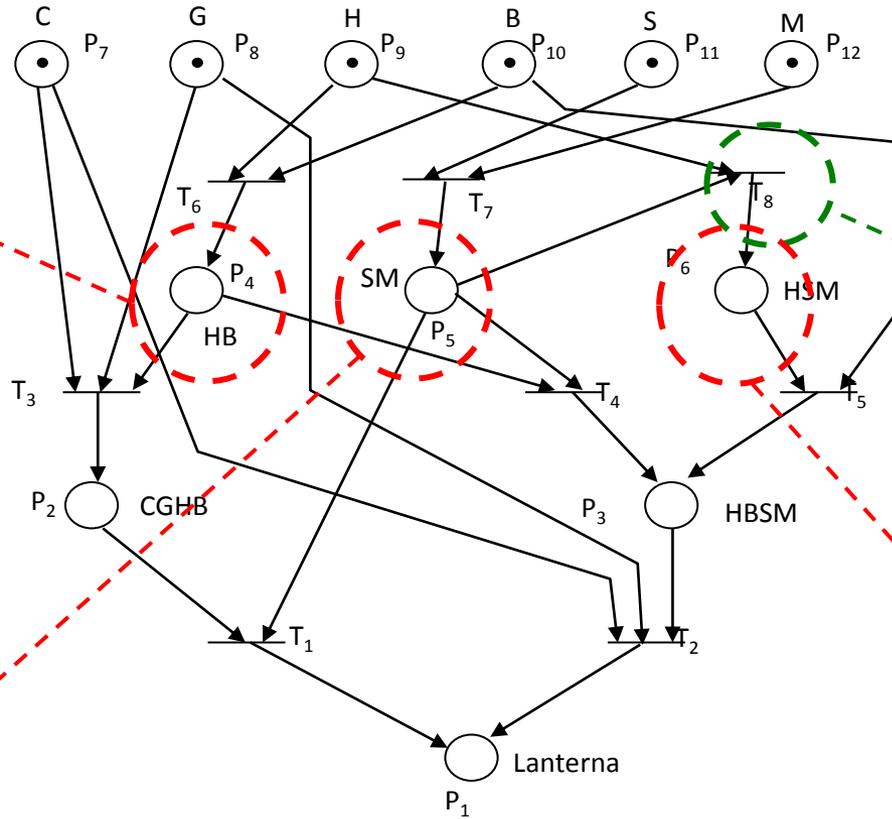


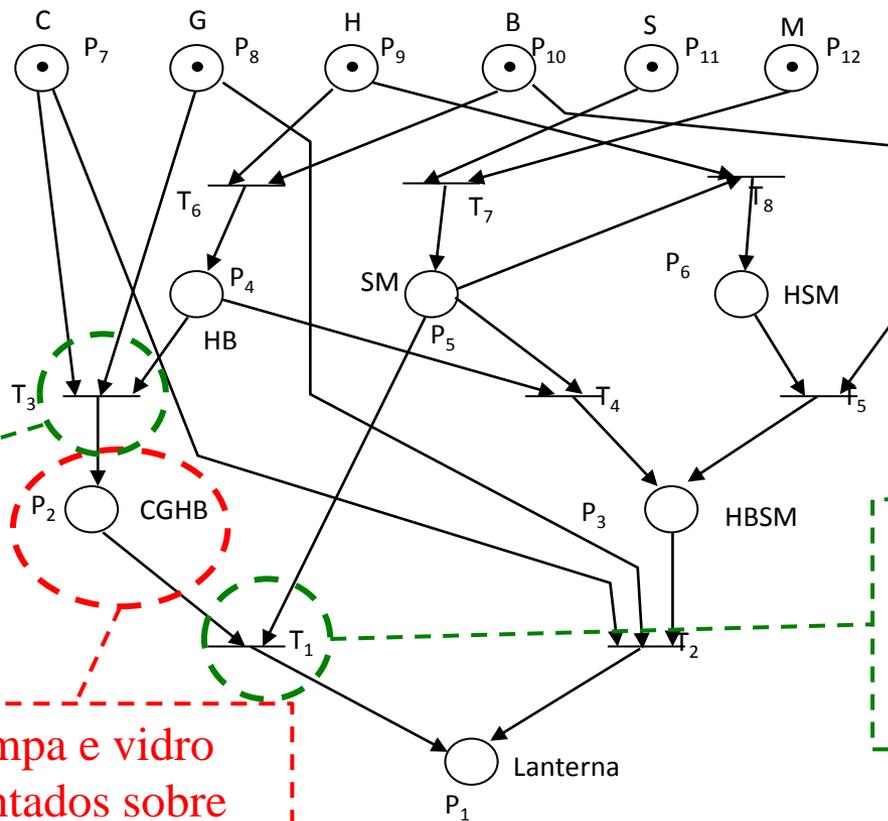
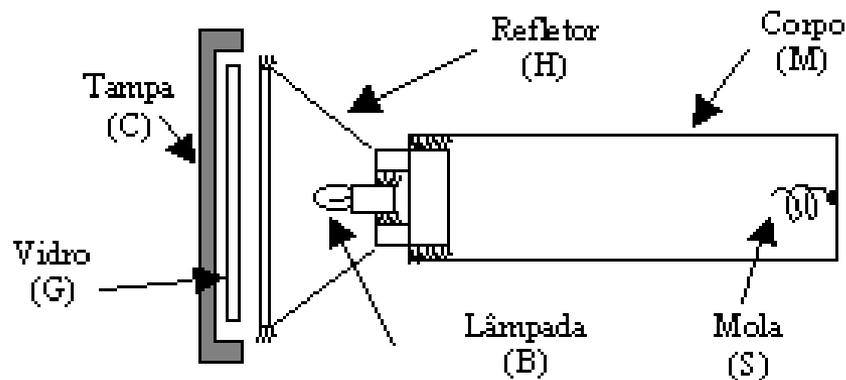
Lâmpada montada no refletor

Montar Refletor no corpo com mola

Mola montada no Corpo

Refletor montado no Corpo com mola

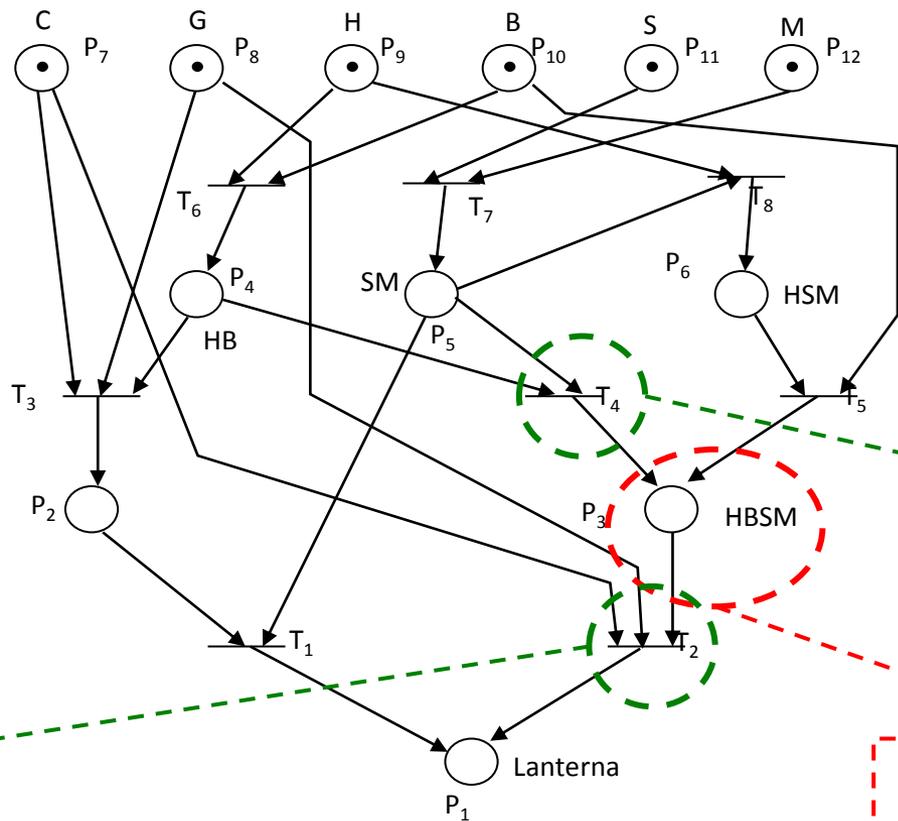
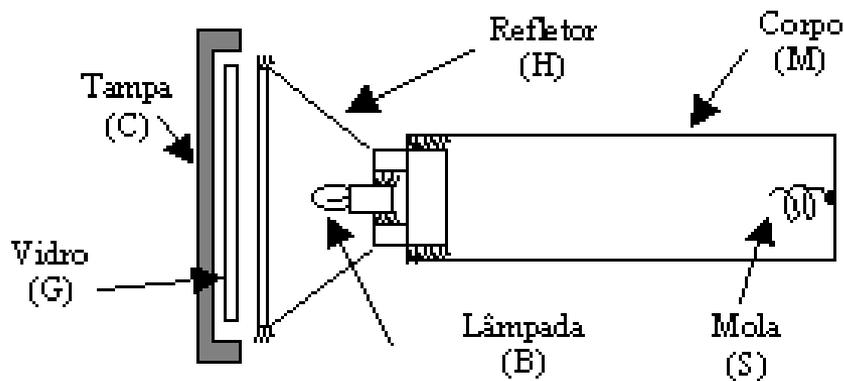




Tampa e vidro montados sobre refletor com lâmpada

Tampa e vidro montados sobre refletor com lâmpada

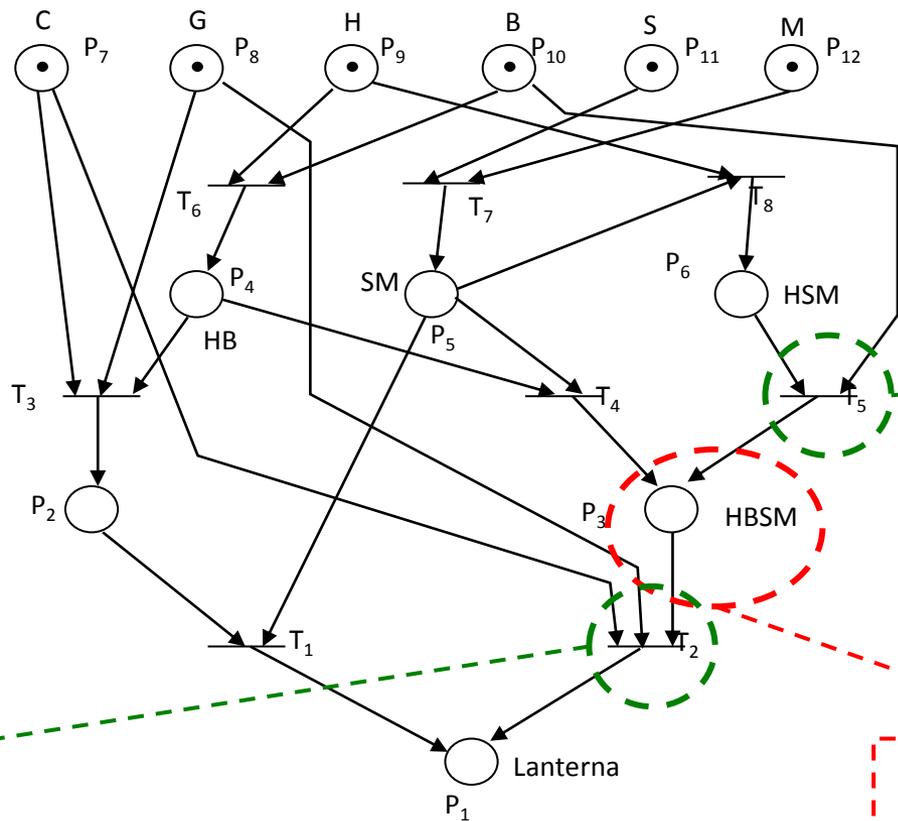
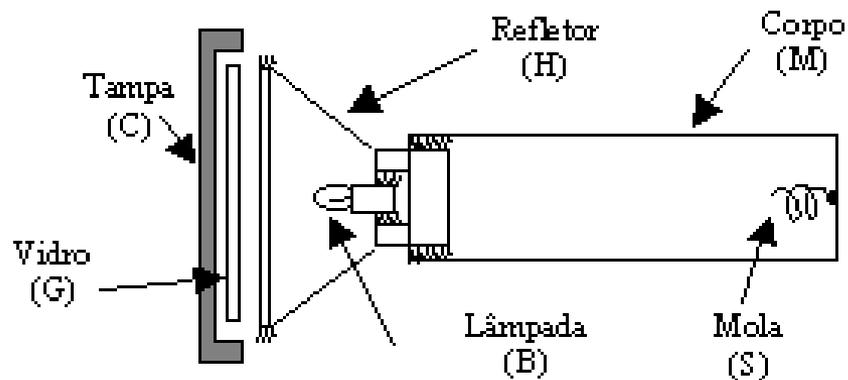
Montar conjunto Tampa/Vidro/Refletor/Lâmpada sobre o corpo com mola



Montar Tampa e Vidro sobre Refletor com Lâmpada e Corpo com Mola

Montar Refletor com Lâmpada sobre Corpo com Mola

Refletor com lâmpada montado sobre Corpo com Mola



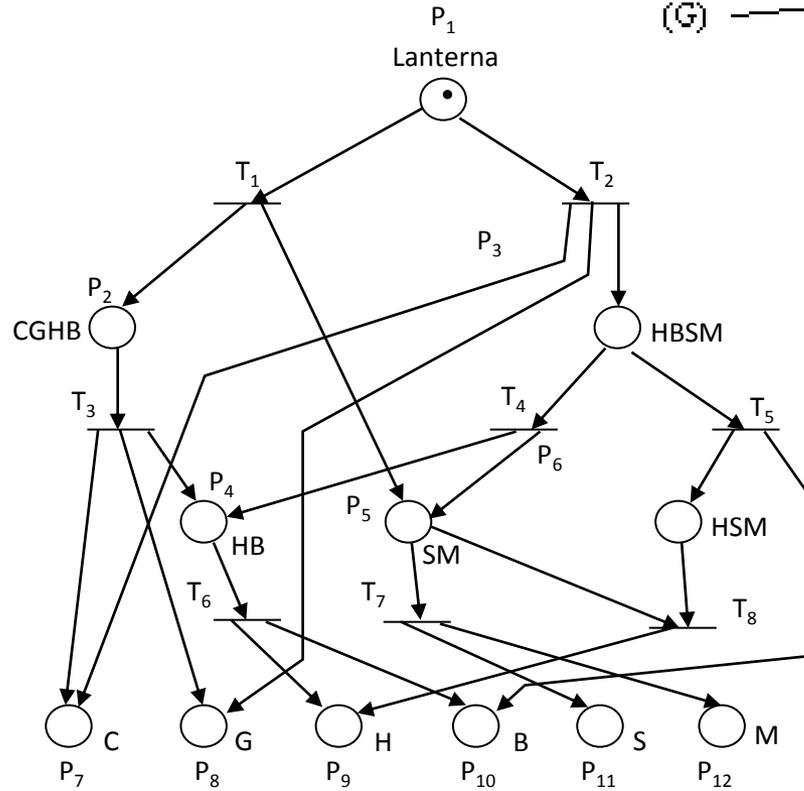
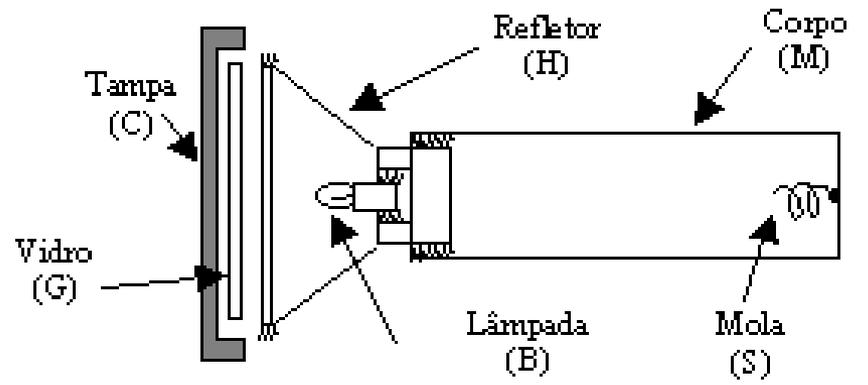
Montar Tampa e Vidro sobre Refletor com Lâmpada e Corpo com Mola

Montar Lâmpada sobre Refletor sobre Corpo com Mola

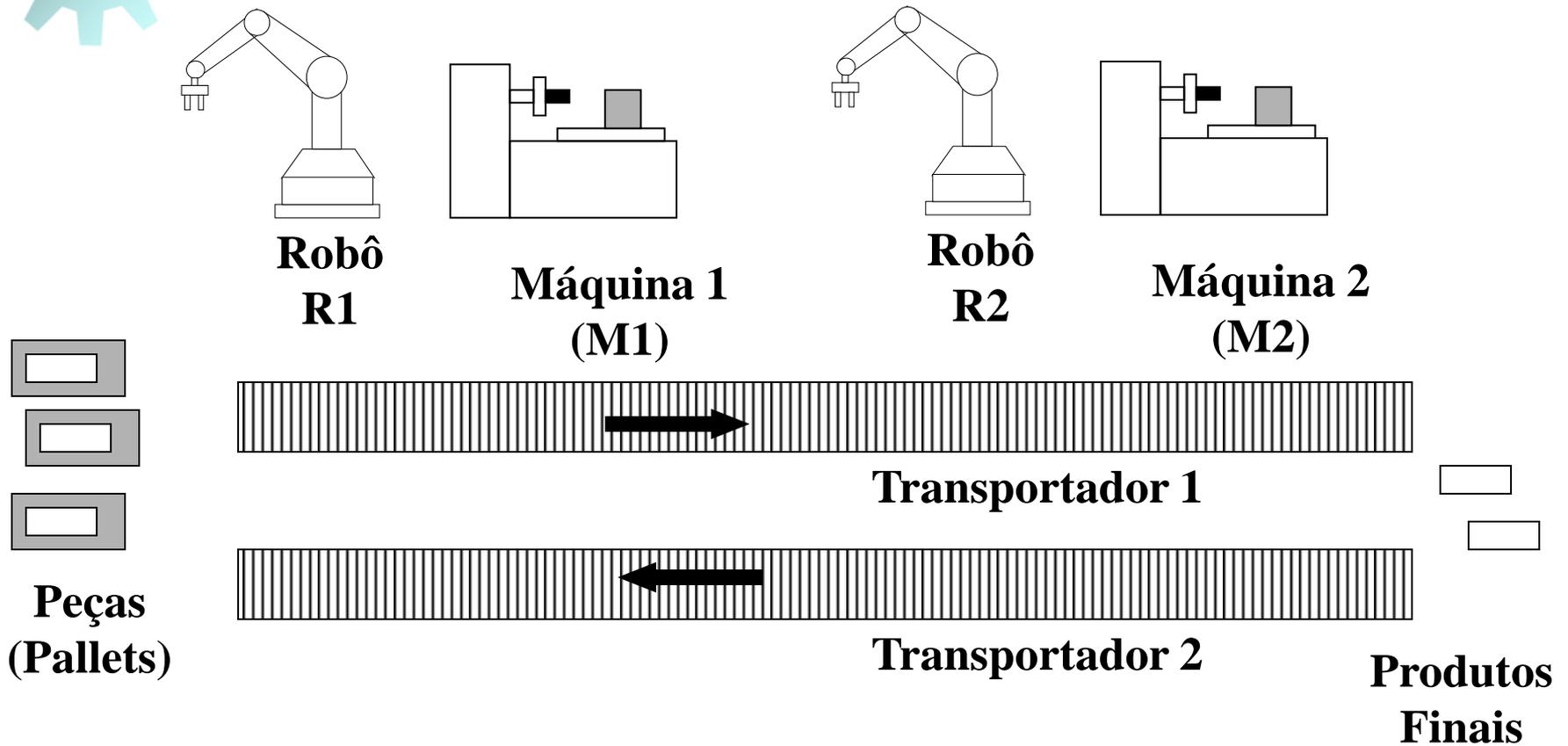
Refletor com lâmpada montado sobre Corpo com Mola

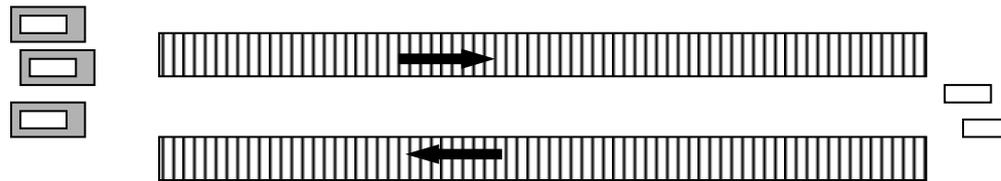
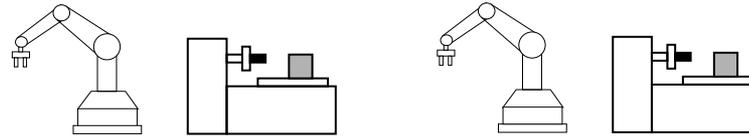


Desmontagem

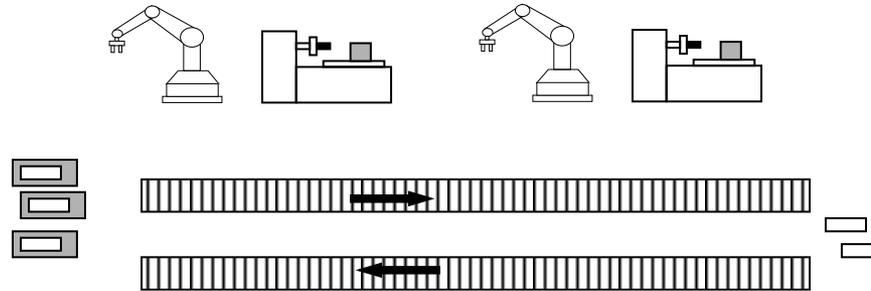


Segundo Exemplo: Linha de Produção





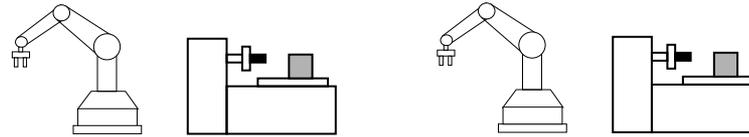
Cada Máquina é servida por um Robô dedicado, o qual realiza tarefas de carga e descarga



Dois Transportadores:

- um para transportar peças (montadas em pallets), com um número máximo de duas ao mesmo tempo
- o outro transporta pallets vazios

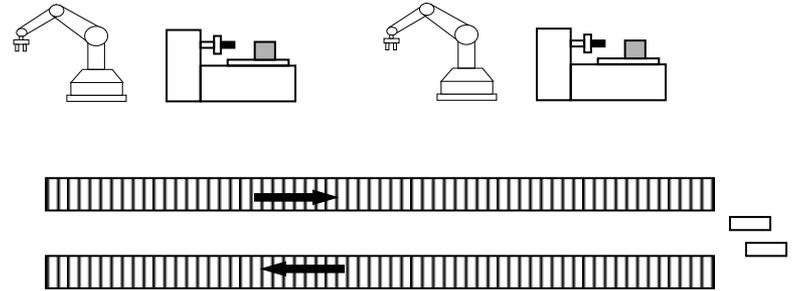
Existem 03 pallets disponíveis no sistema



Cada peça é processada em M1 e M2,
nesta ordem

Peça Bruta → **M1** → **M2** → **Produto Acabado**

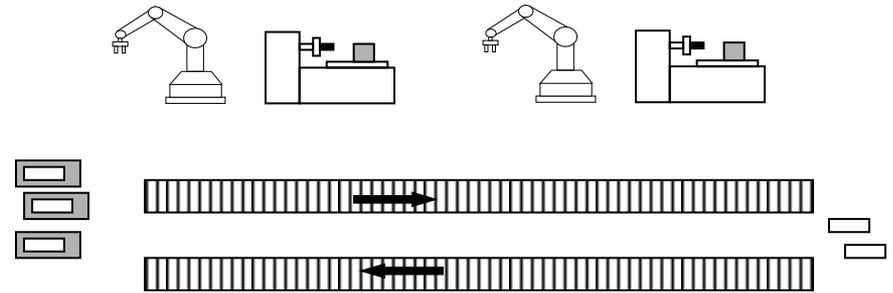
Passos de Modelagem



Atividades Principais:

- R1 carregando;
- M1 processando;
- R1 descarregando;
- R2 carregando;
- M2 processando;
- R2 descarregando.

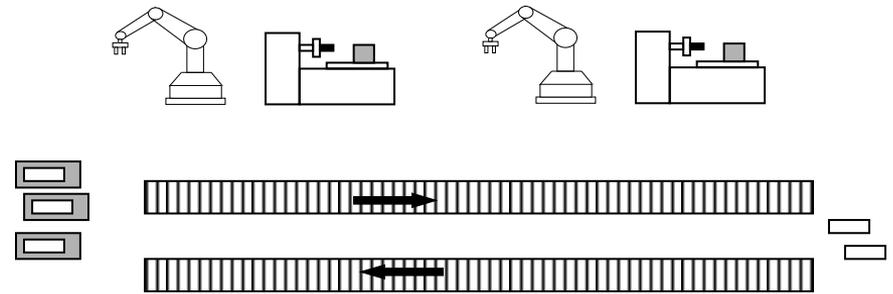
Passos de Modelagem



Recursos:

- Matéria Prima (peças em pallets);
- Transportadores;
- M1;
- M2;
- R1;
- R2.

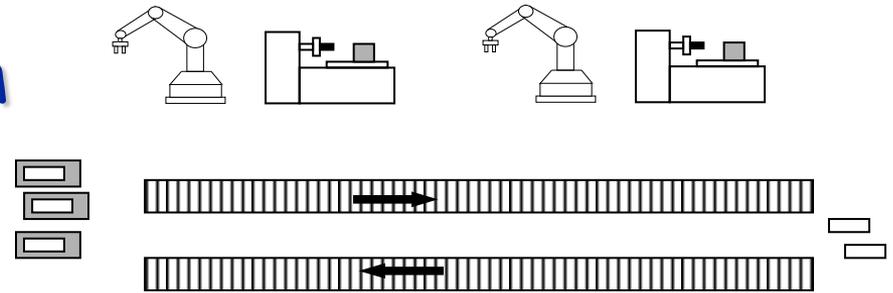
Passos de Modelagem



Implementação de transições para quatro operações:

- R1 carregando;
- R1 descarregando;
- R2 carregando;
- R2 descarregando.

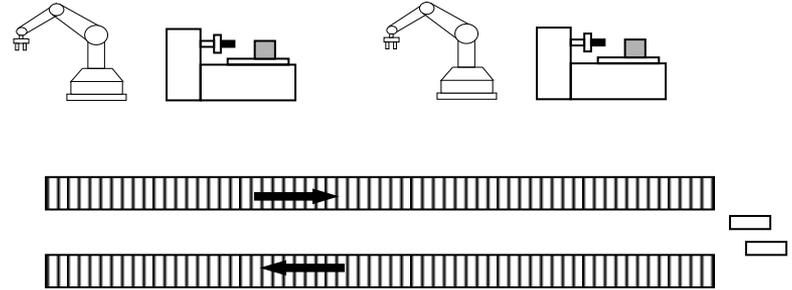
Passos de Modelagem



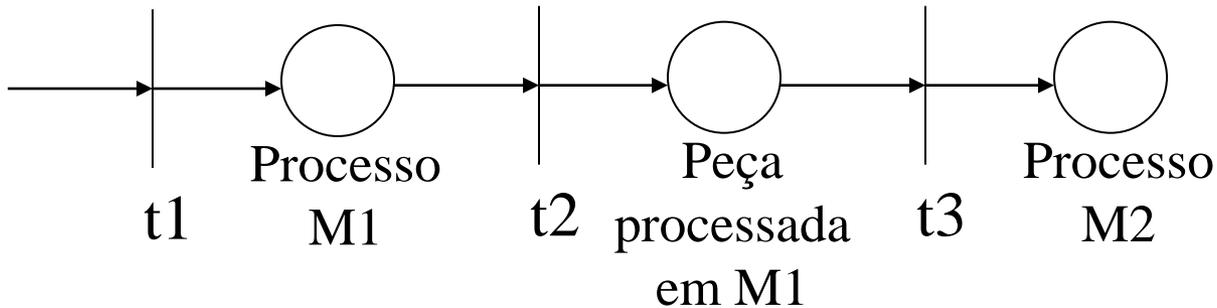
Implementação de lugares

- para as operações de M1 e M2
- para peças no transportador (para M2)

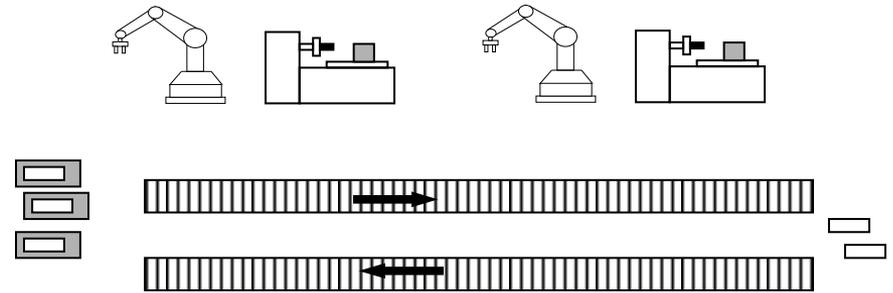
Passos de Modelagem



Devido às relações estritamente seqüenciais, os lugares são conectados com arcos diretos



Passos de Modelagem

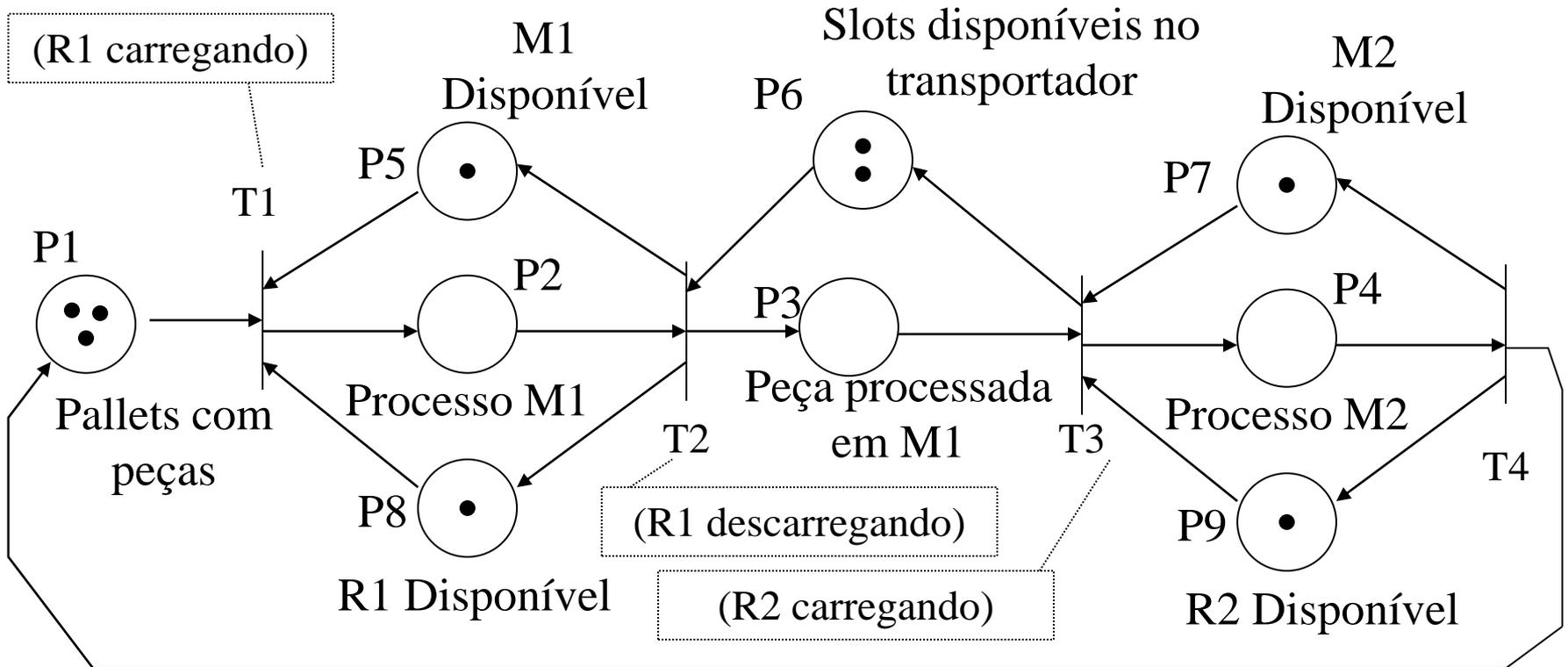
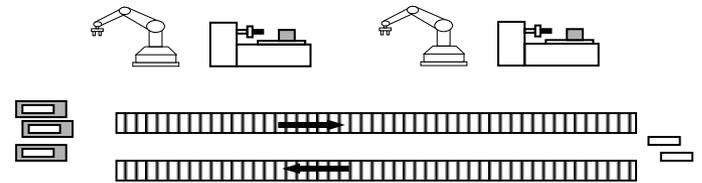


Próximo Passo: Designar seis lugares para representar seis recursos

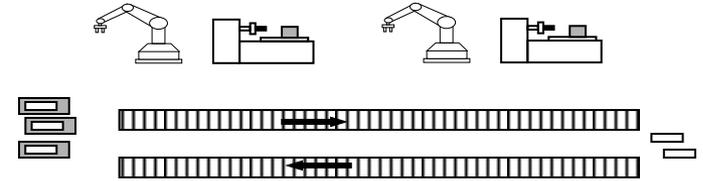
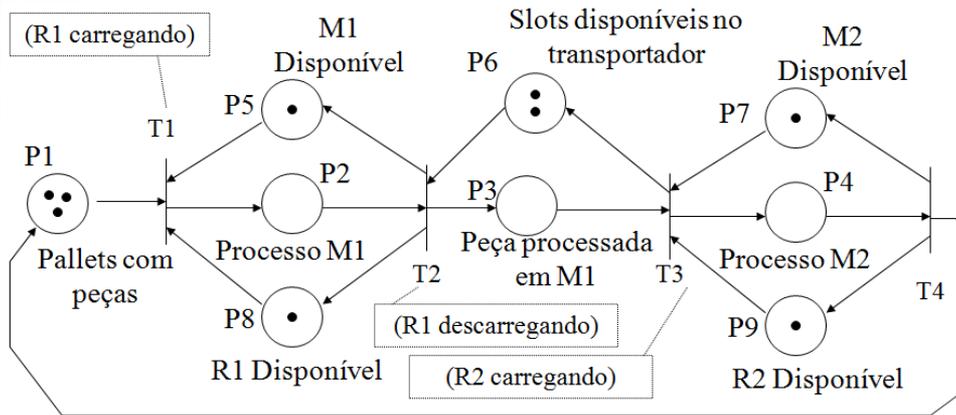
- peças em pallets;
- transportador para peças intermediárias;
- M1 e M2;
- R1 e R2.

Adicionar arcos para cada início/término de cada operação

Modelo



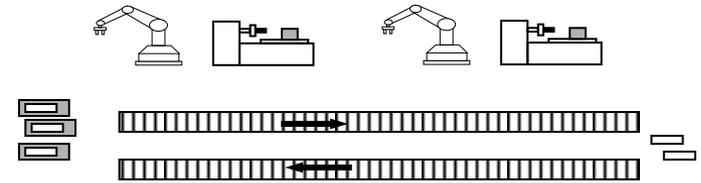
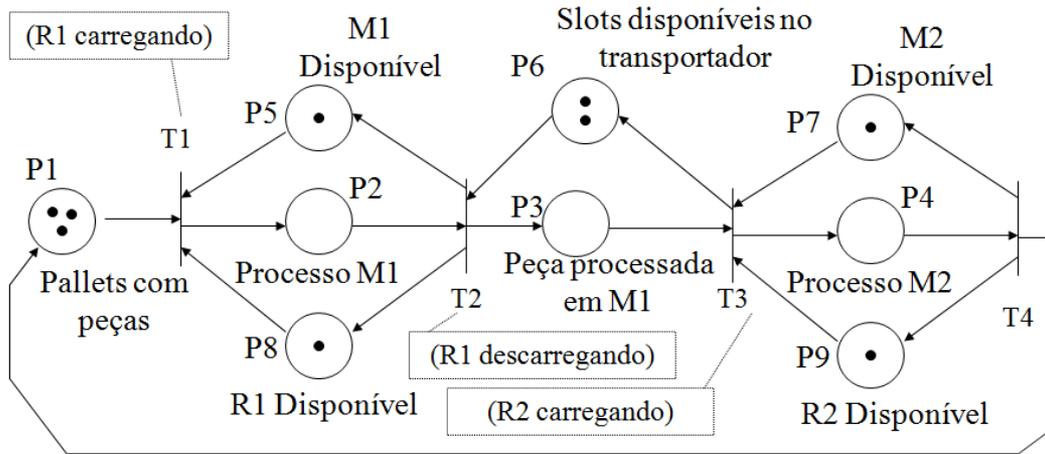
Modelo



Os arcos de P1, P5 e P8 a T1 são
construídos devido ao fato de que Iniciar
R1 Carregando requer a disponibilidade de:

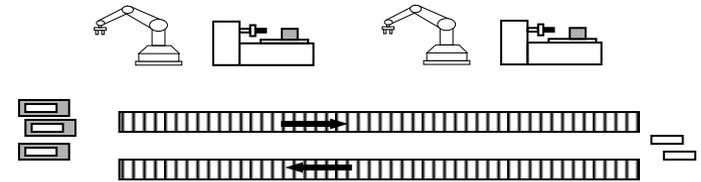
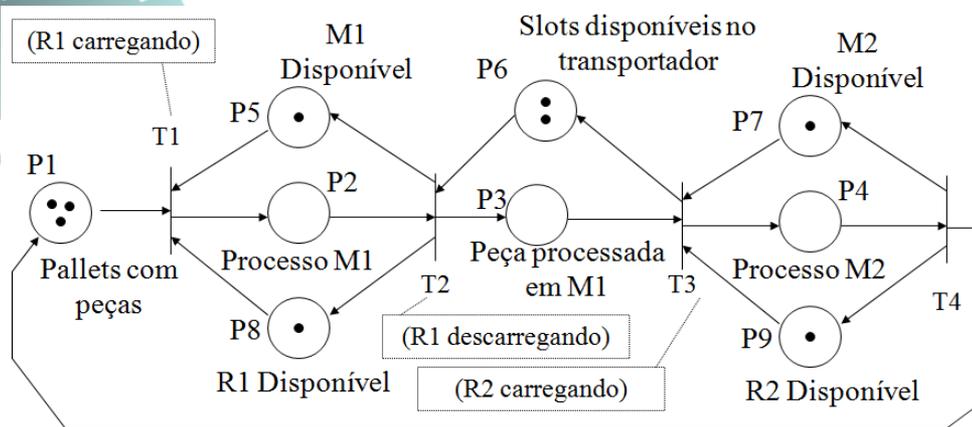
- Pallet com peça (P1);
- M1 (P5);
- R1 (P8).

Modelo



O arco de T1 para P2 é inserido devido à relação precedente entre R1 carregando (t1) e M1 processando (P2)

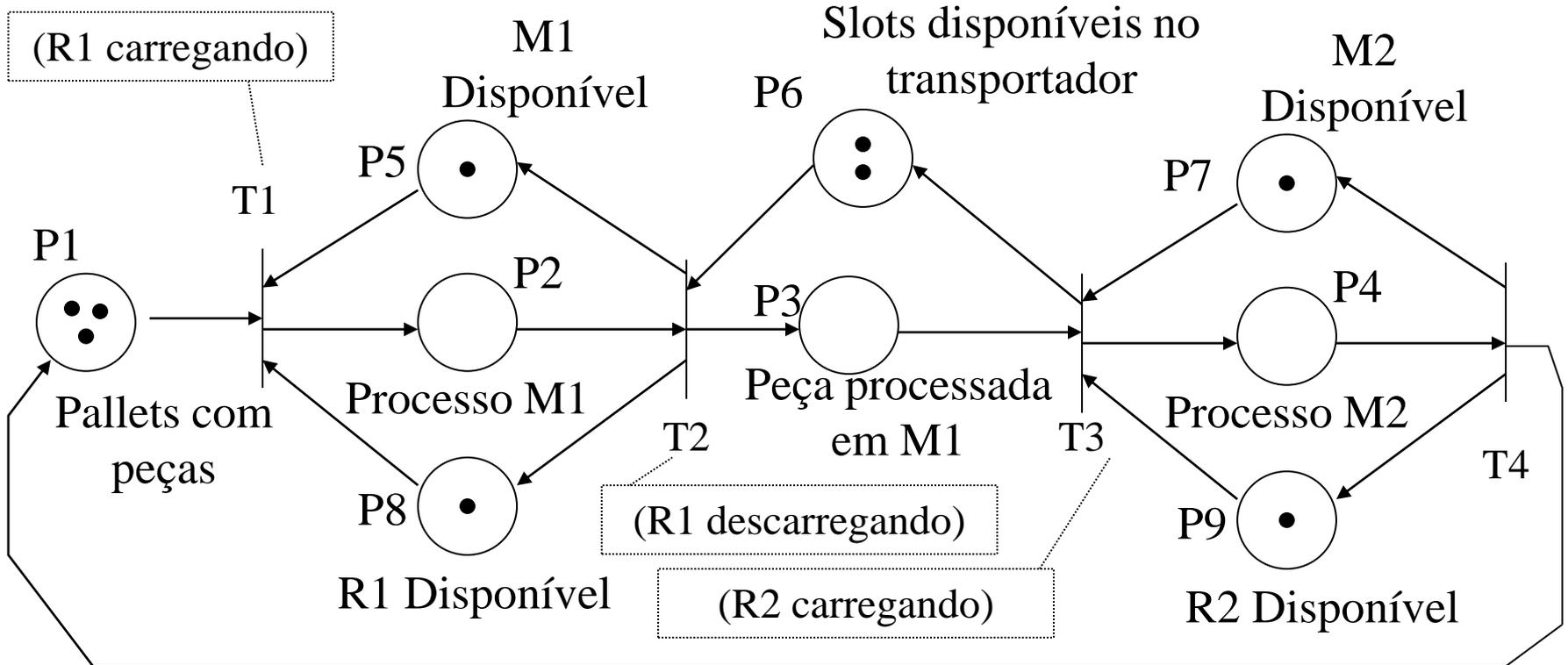
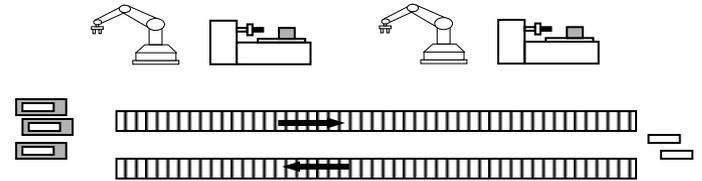
Modelo



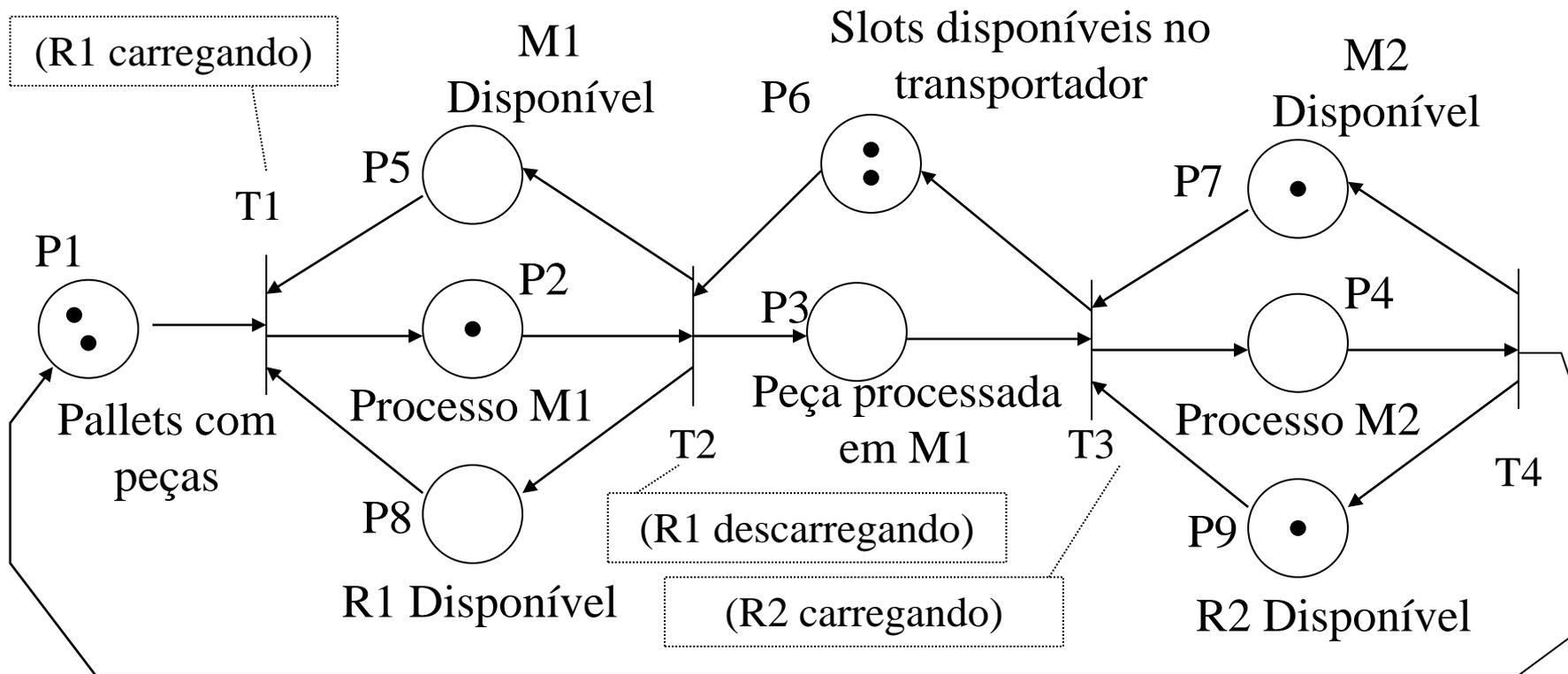
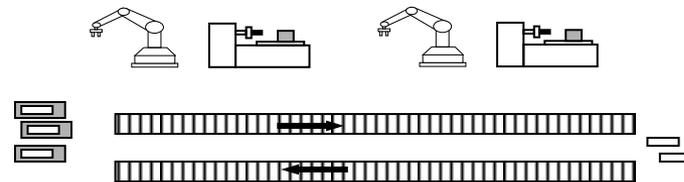
As marcações dos lugares são baseadas nos recursos disponíveis. Ex:

- Existe somente uma Máquina M1 (uma marca em P5);
- Existem três pallets disponíveis (três marcas em P1).

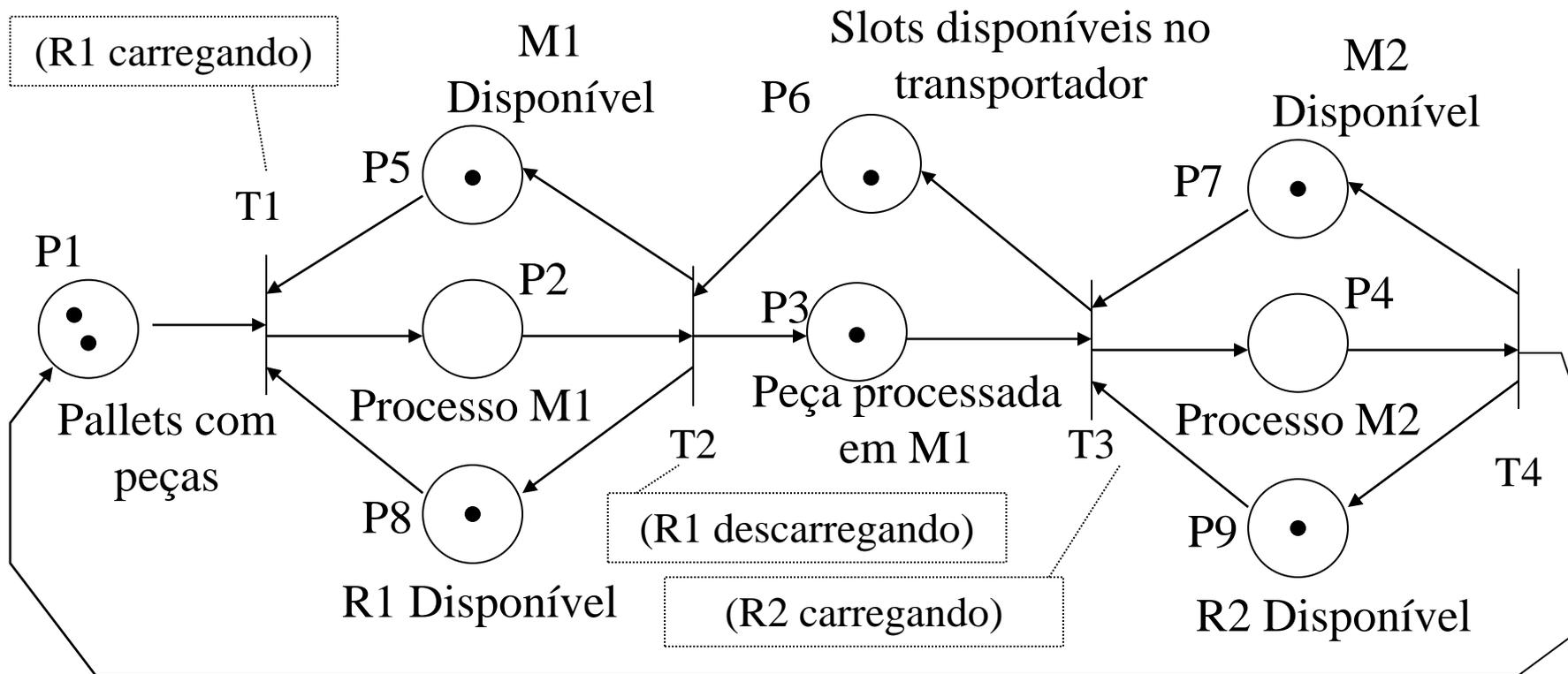
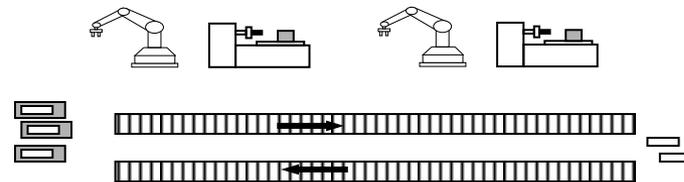
Evolução do Modelo



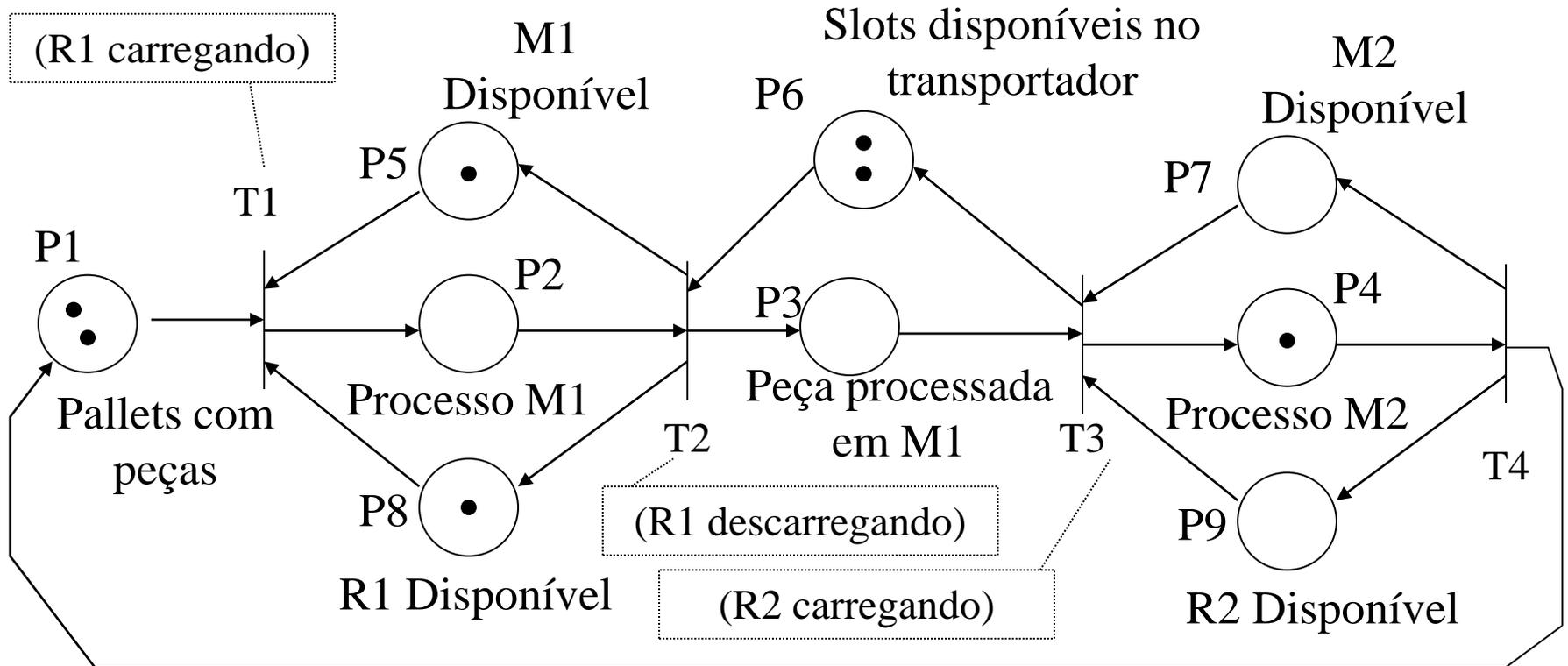
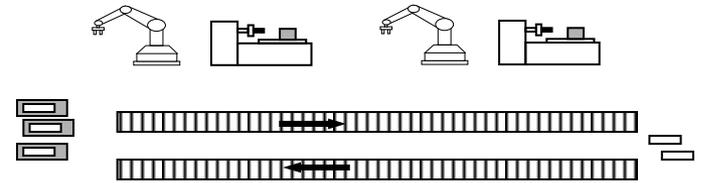
Evolução do Modelo



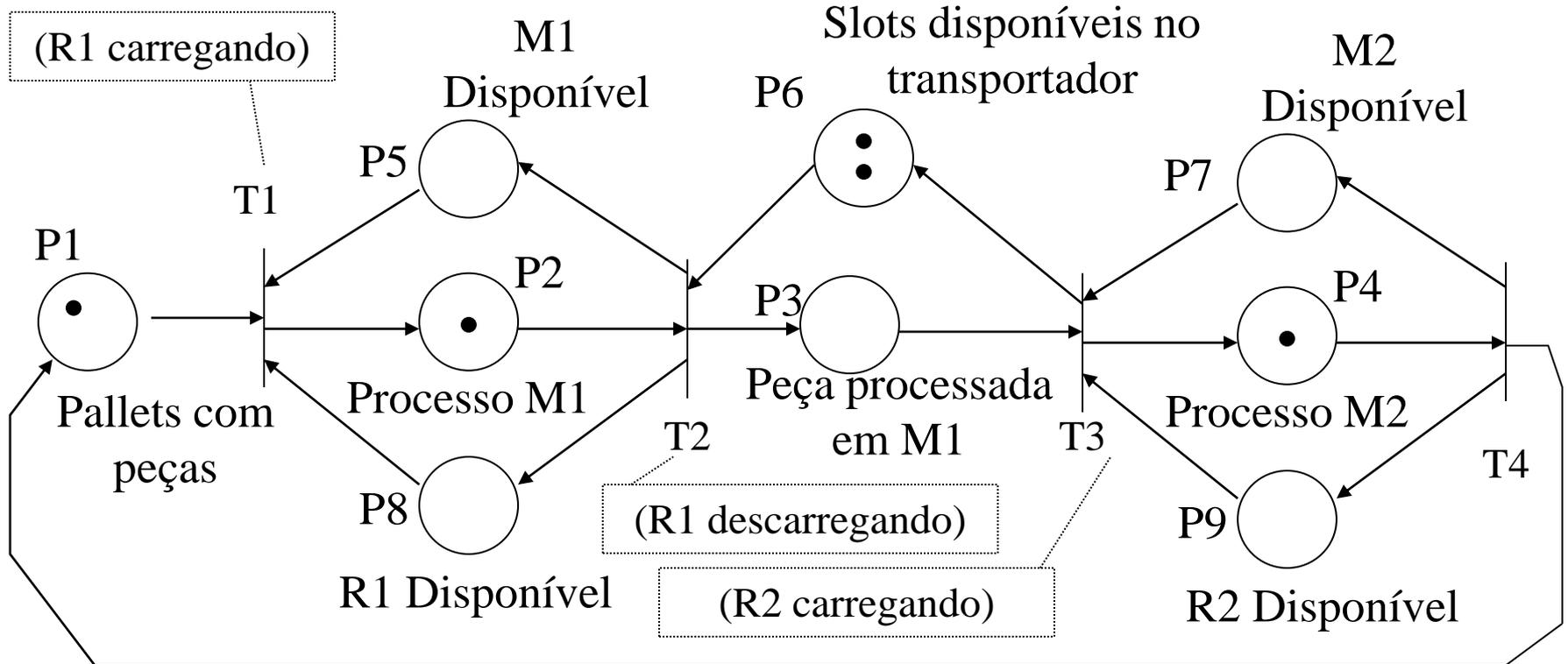
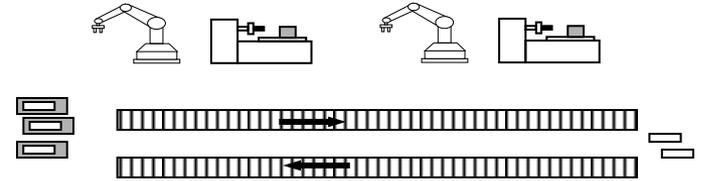
Evolução do Modelo



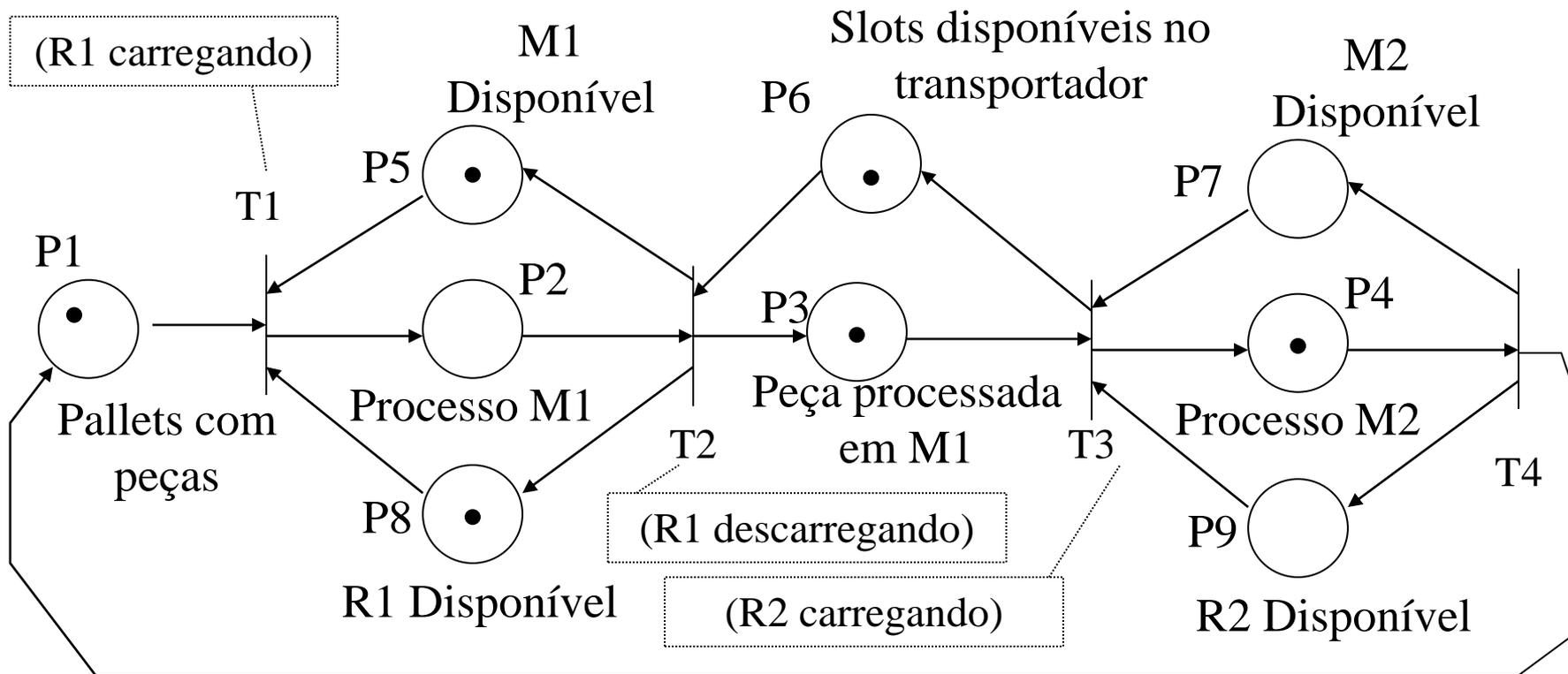
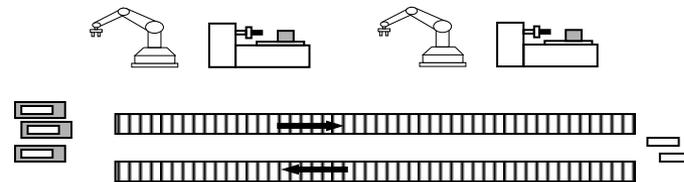
Evolução do Modelo



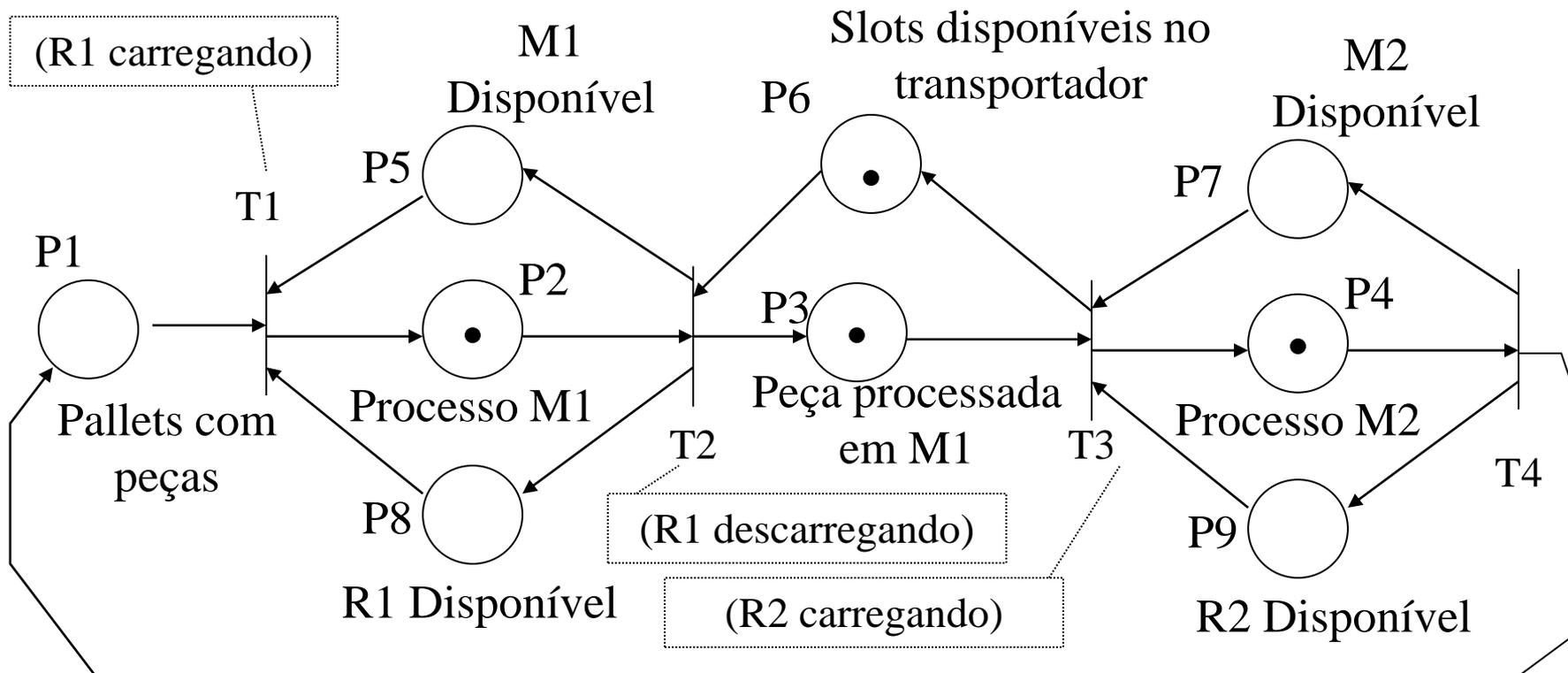
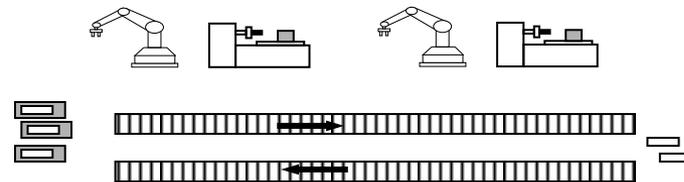
Evolução do Modelo



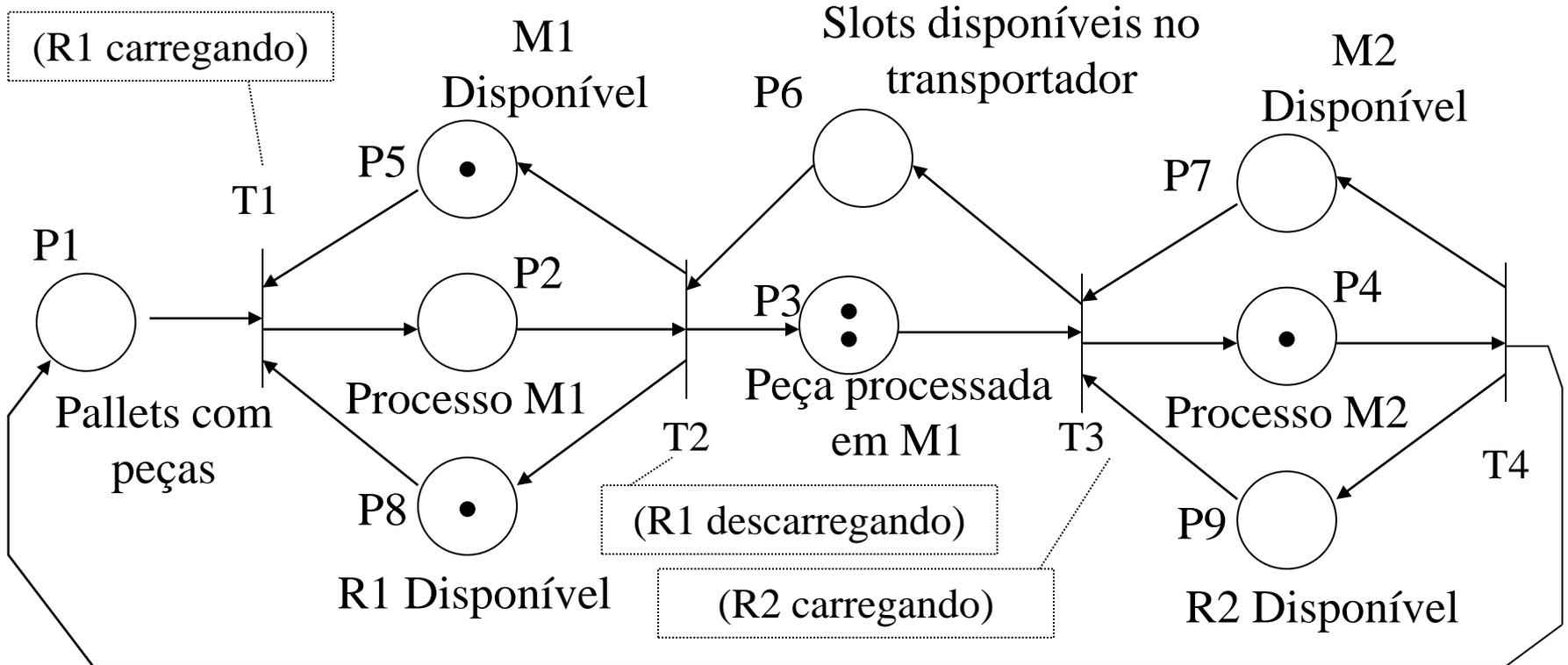
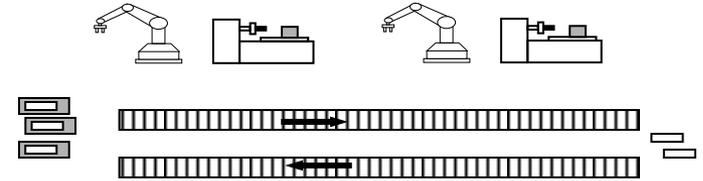
Evolução do Modelo



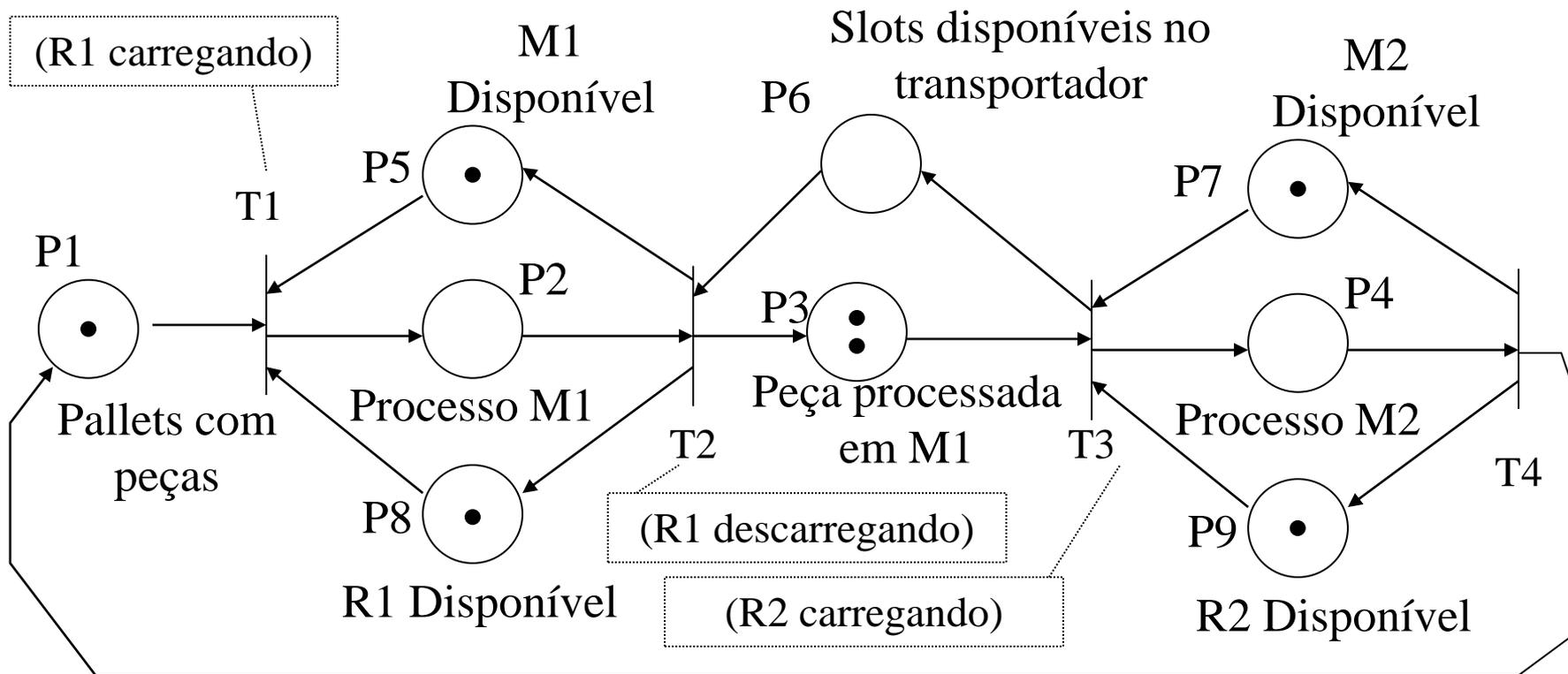
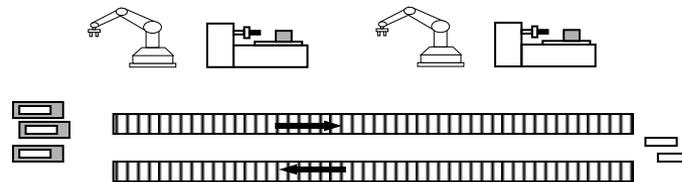
Evolução do Modelo



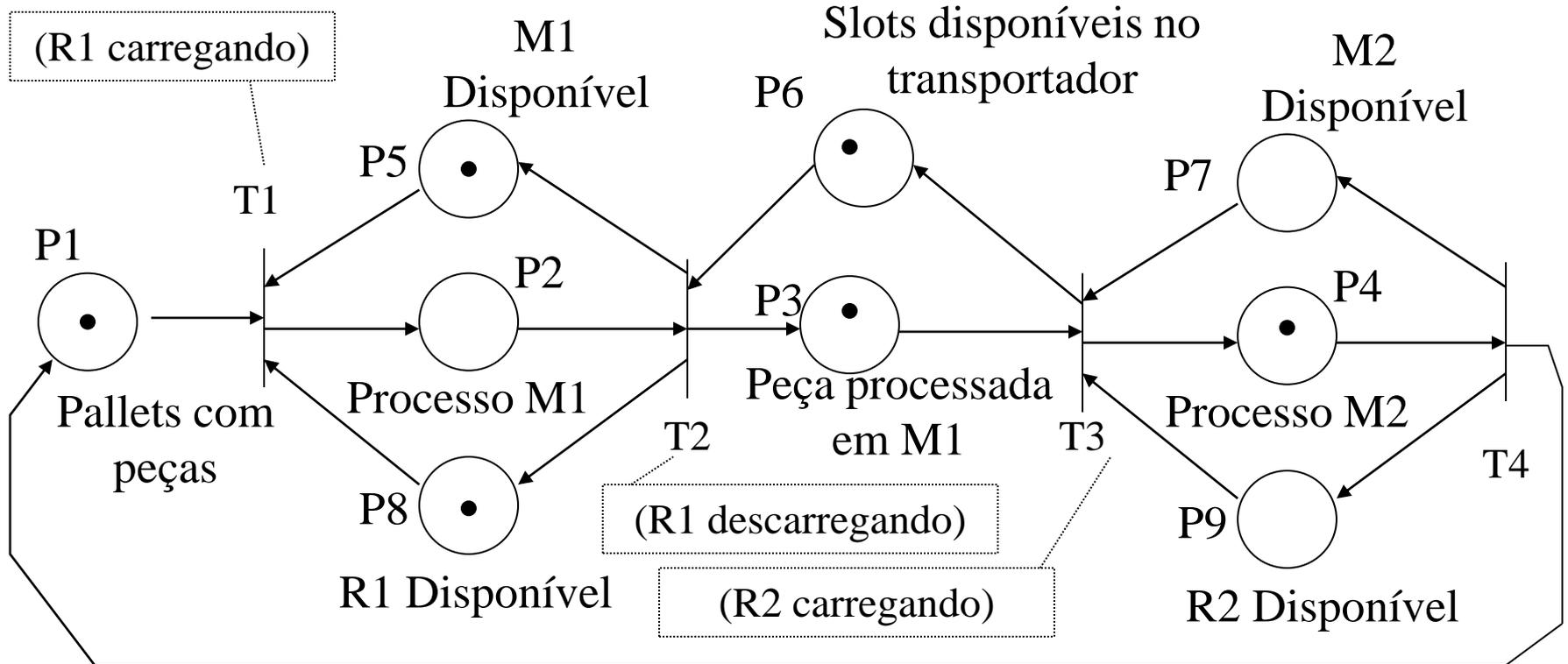
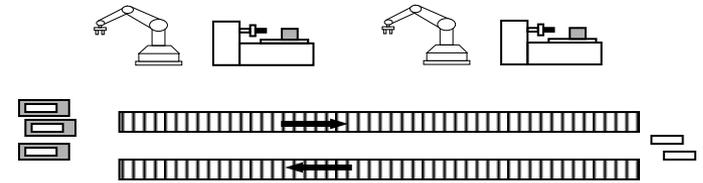
Evolução do Modelo



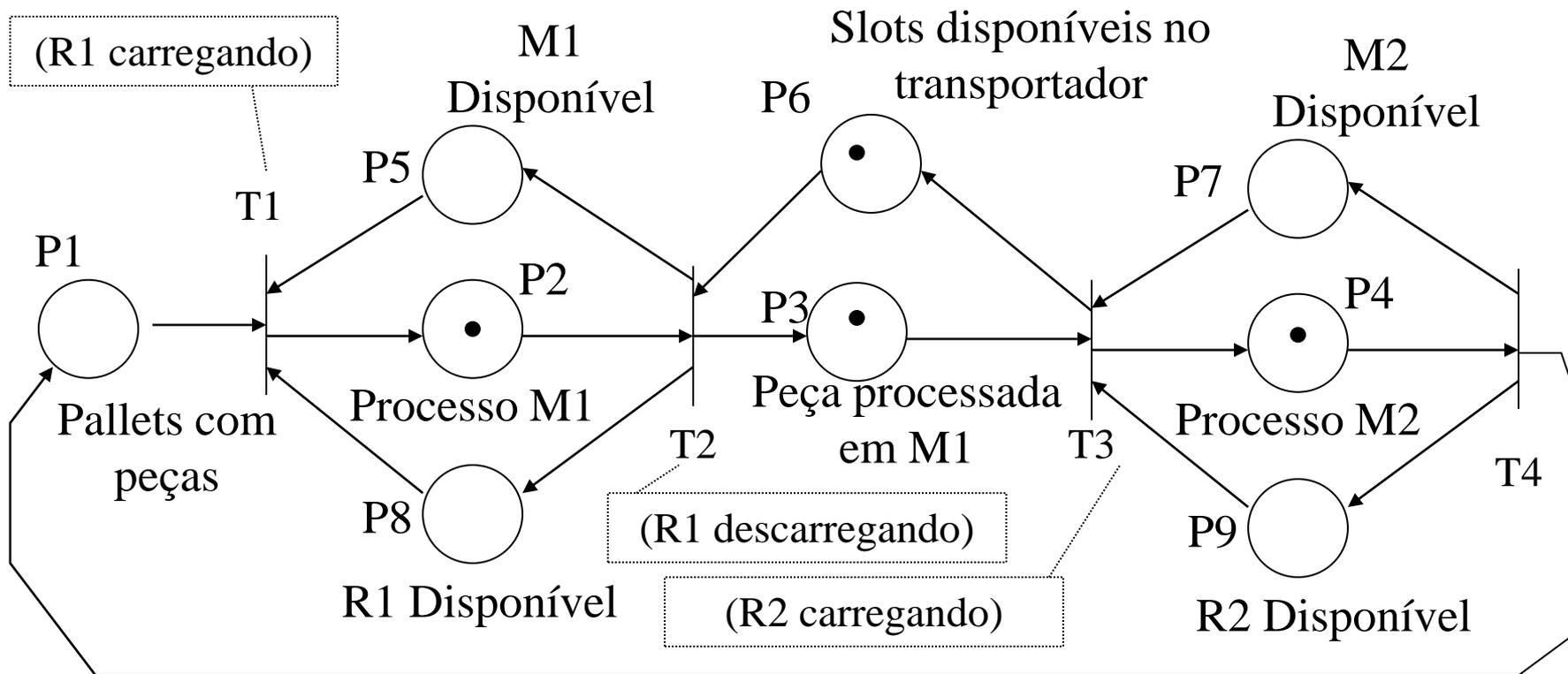
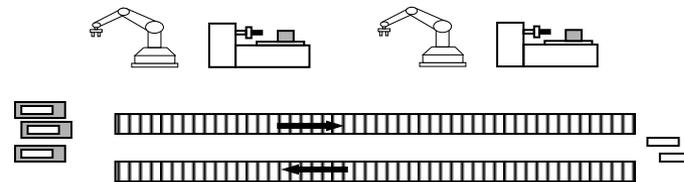
Evolução do Modelo



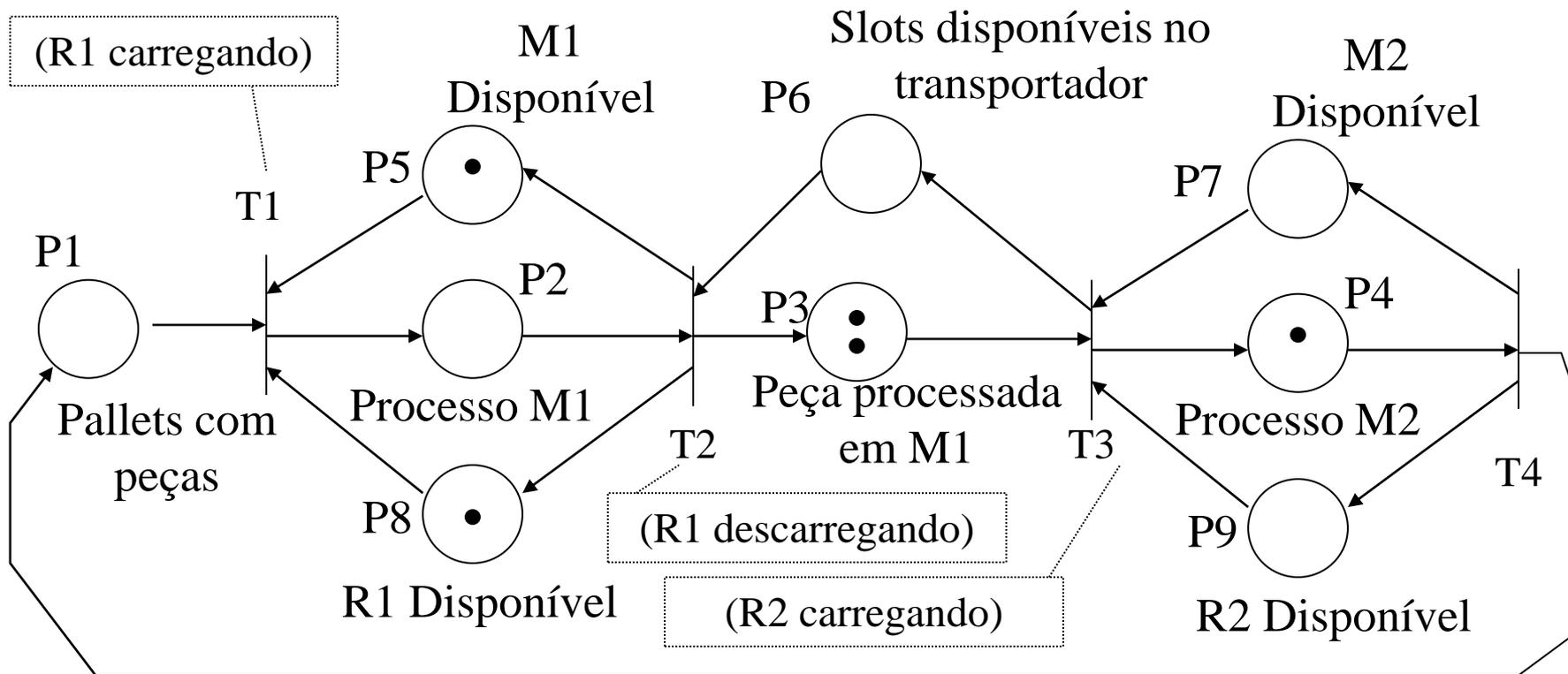
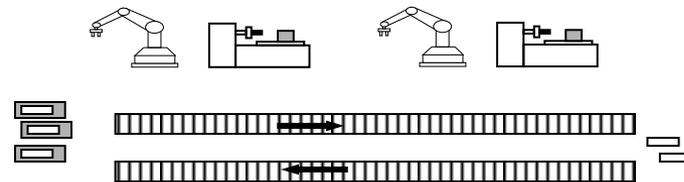
Evolução do Modelo



Evolução do Modelo



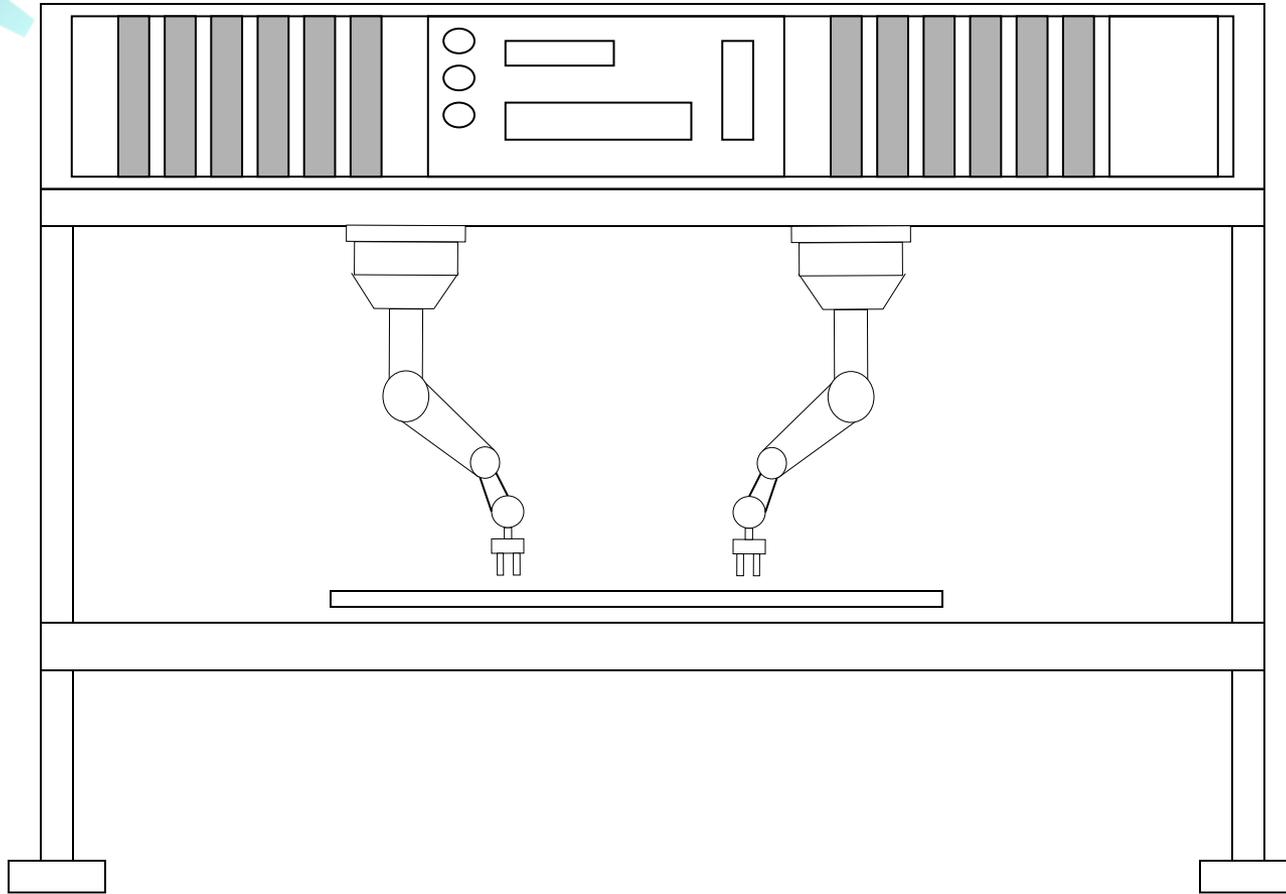
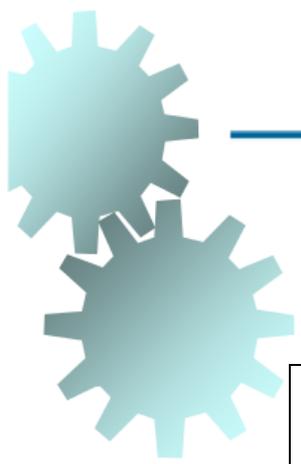
Evolução do Modelo

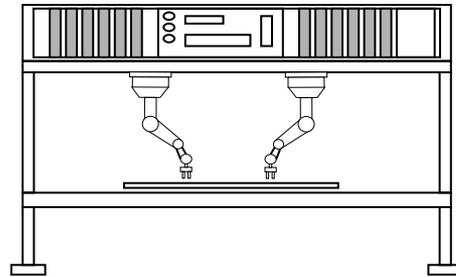




Terceiro Exemplo: Workstation
Flexível para montagem de Placas de
circuito impresso em alto volume e
baixo custo de produção (FWS-200 da
AT&T)

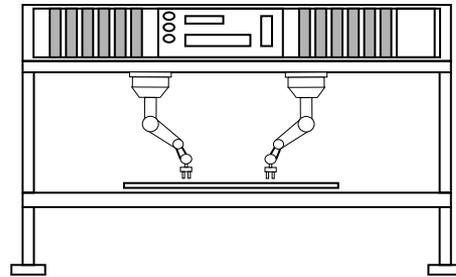
Possui dois robôs acoplados a um
sistema de visão artificial





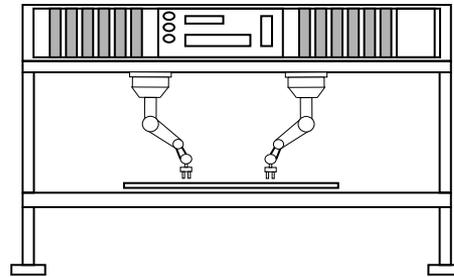
Cada Robô realiza separadamente as seguintes operações:

- coletando;
- movimentando-se na área da placa;
- inserindo;
- movimentando-se fora da área da placa.



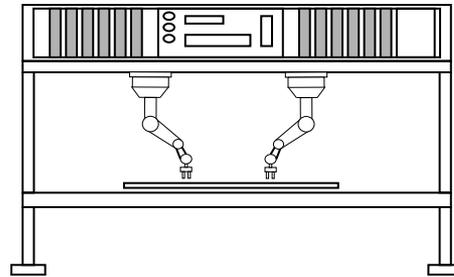
Para utilizar a área comum de trabalho (workspace), cada robô tem que:

- requisitá-la;
- acessá-la;
- deixá-la.



Os recursos incluem:

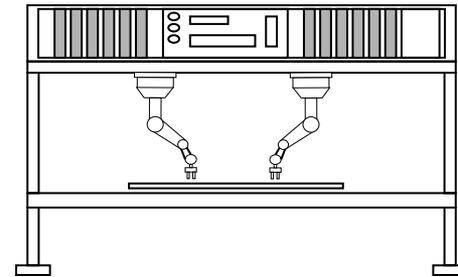
- Área Compartilhada de alimentação de componentes;
- Área Compartilhada da Placa de Circuito impresso;
- Dois Robôs.



Obs.:

Como os dois robôs trabalham na mesma placa de Circuito Impresso e obtém componentes da mesma área de alimentação, colisões devem ser evitadas!!

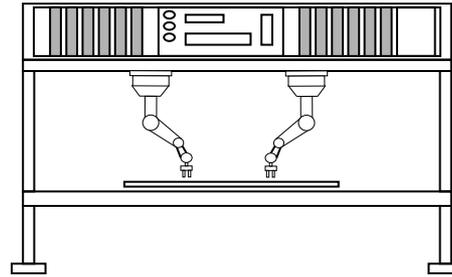
As relações para cada robô são sequenciais.



O início da "pega" para R1 e R2 assim como a movimentação na área da placa de circuito impresso para inserção de componentes são mutuamente exclusivos, evitando colisões dos robôs



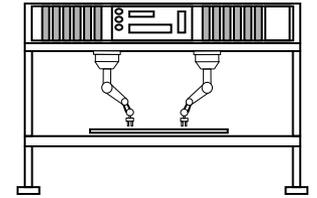
Modelagem



Implementar, para cada Robô, quatro lugares para as operações e cinco transições, para seu início/fim, arranjadas de maneira seqüencial.



Modelagem



R1
Coletando



R1 Movendo-se na Placa



R1 Inserindo



R1 Movendo-se fora da Placa



R2
Coletando



R2 Movendo-se na Placa



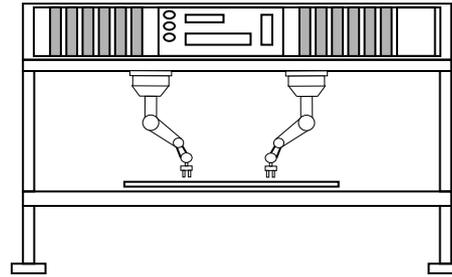
R2 Inserindo



R2 Movendo-se fora da Placa



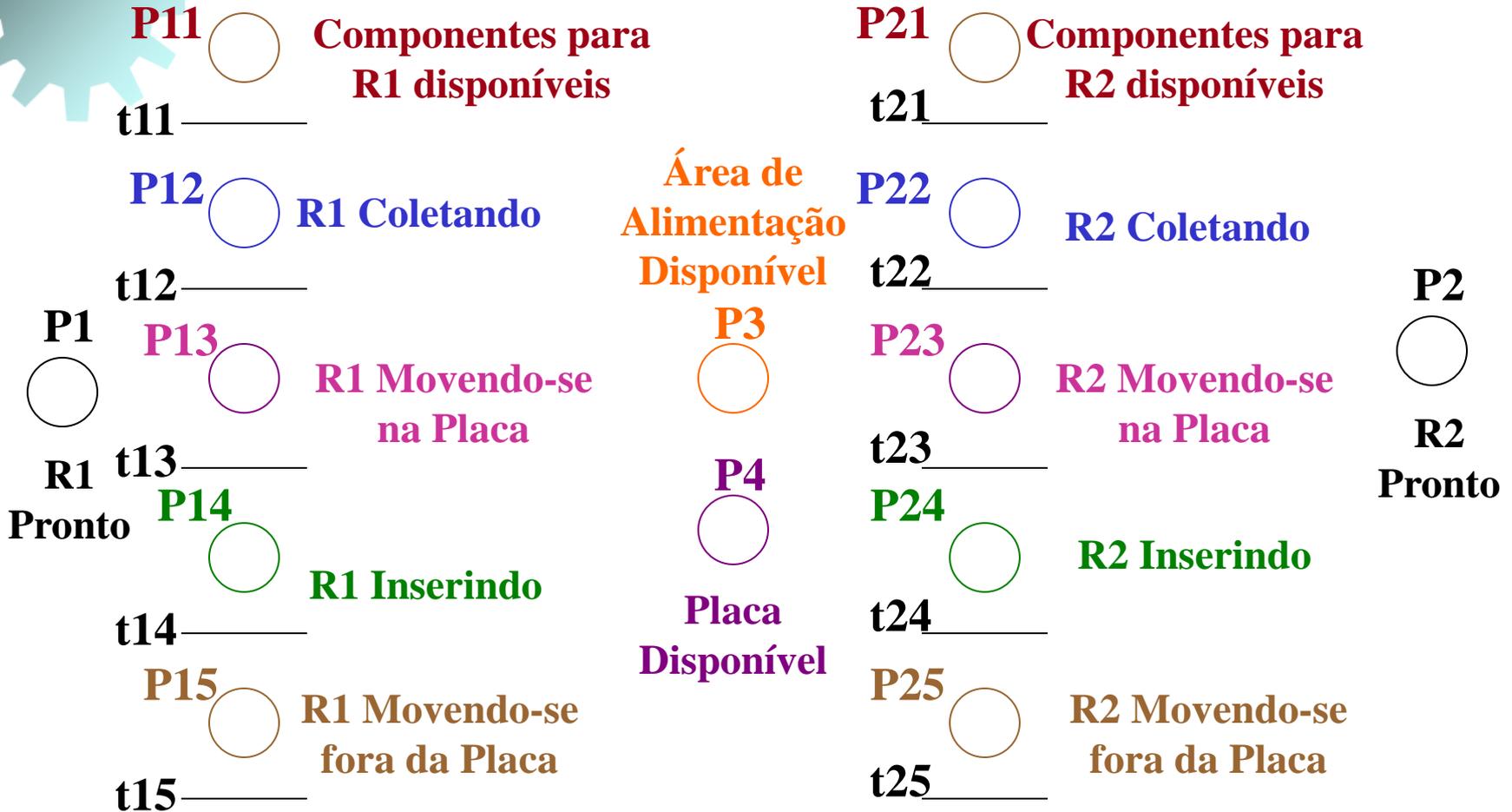
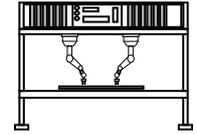
Modelagem



Designar seis lugares para representar:

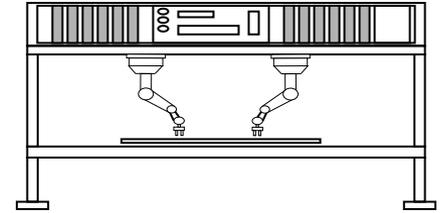
- a disponibilidade dos dois robôs;
- dois tipos de componentes;
- área de alimentação de componentes;
- área da placa de circuito impresso.

Modelagem





Modelagem

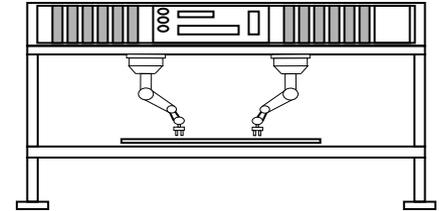


Adição de Arcos:

- Devido às relações precedentes entre "coletando", "movendo", "inserindo" e "movendo", são adicionados os arcos de t_{i1} para P_{i2} , P_{i2} para t_{i2} , T_{i4} para P_{i5} e P_{i5} para t_{i5} ($i=1,2$);



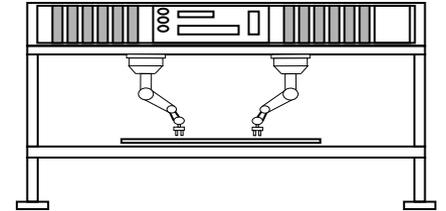
Modelagem



- como a habilitação de t_{i1} requer a disponibilidade da área de alimentação, do robô R_i e dos componentes para R_i , os arcos de entrada de P_3 , P_i e P_{i1} são adicionados a t_{i1} ;

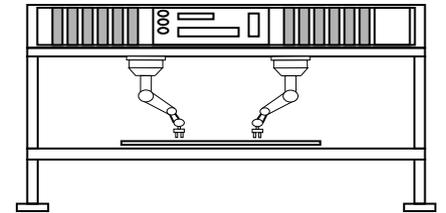


Modelagem



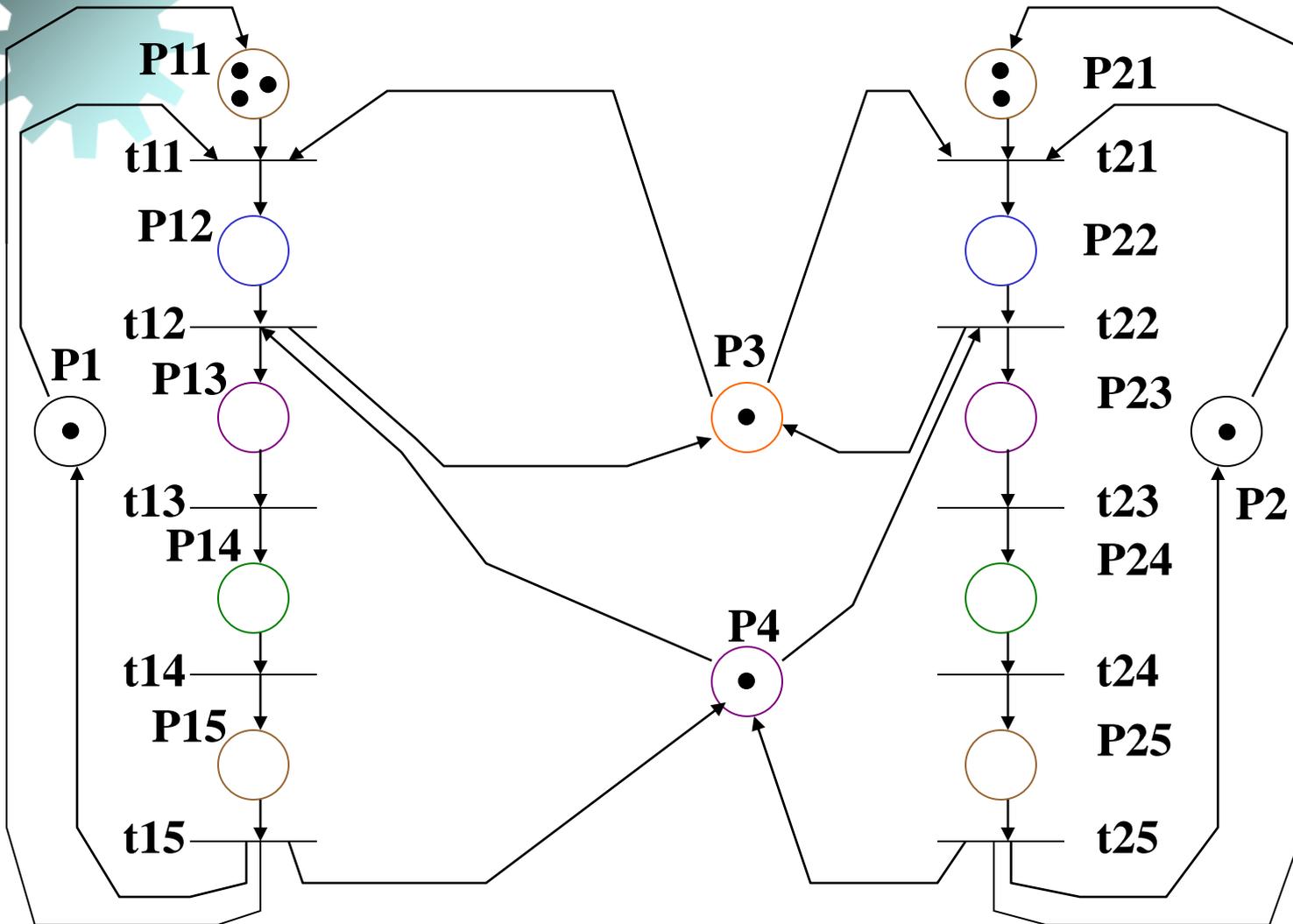
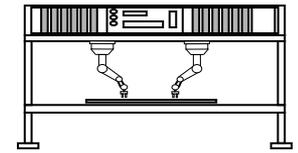
- o disparo de t_{i2} torna a área de alimentação disponível, portanto o arco de saída de t_{i2} para $P3$ é formado;

Modelagem



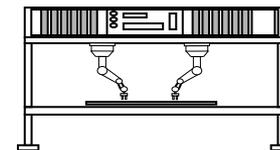
- a habilitação de ti2 requer a disponibilidaae da área dda placa de Circuito Impresso; portanto o arco de entrada de P4 para ti2 é formado;
- continuar o processo para os demais arcos.

Modelo Final

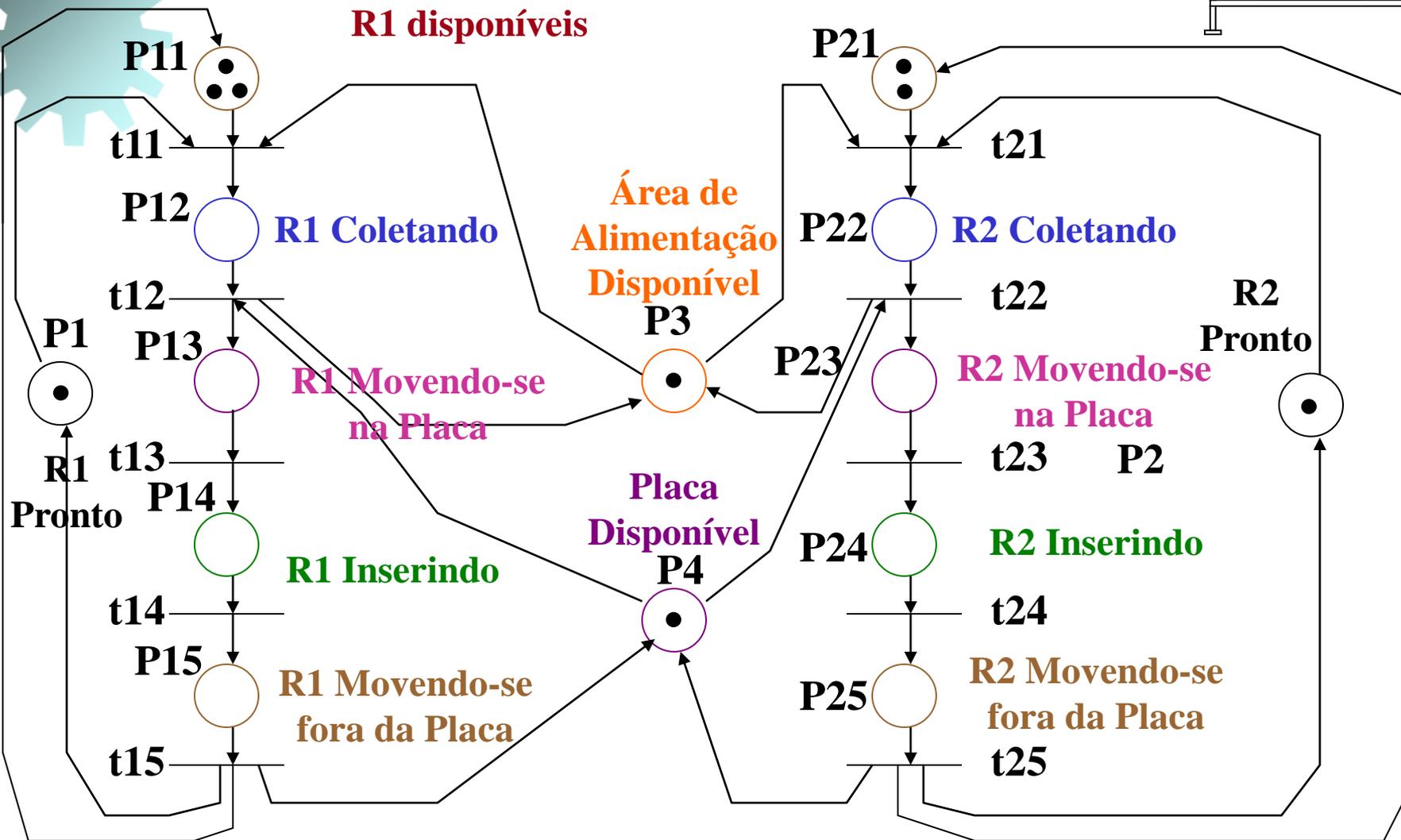


Evolução do Modelo

Componentes para R2 disponíveis



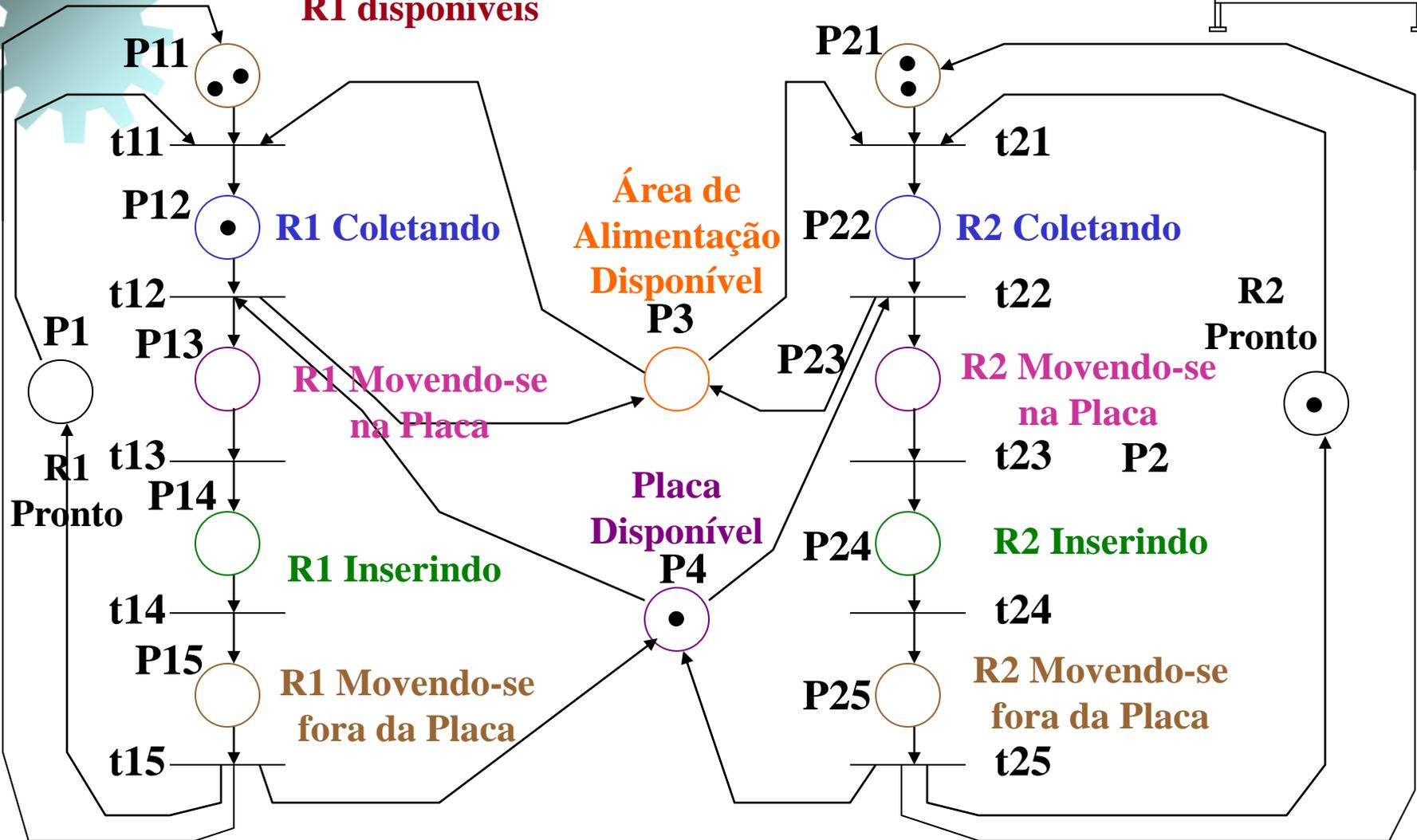
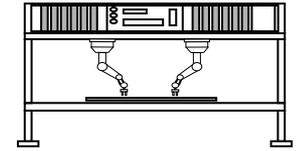
Componentes para R1 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

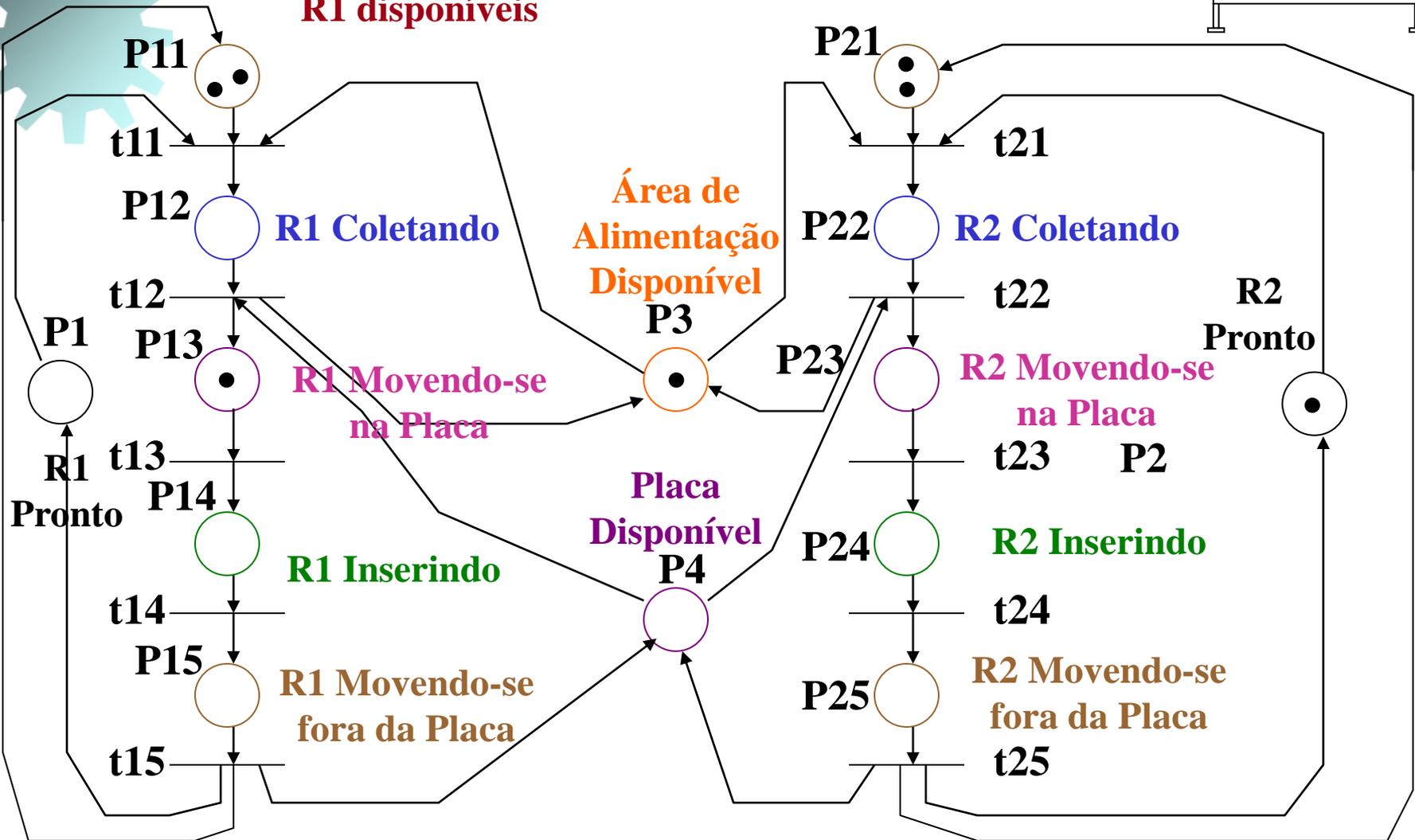
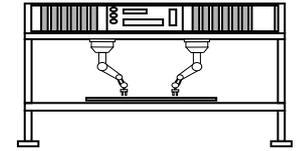
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

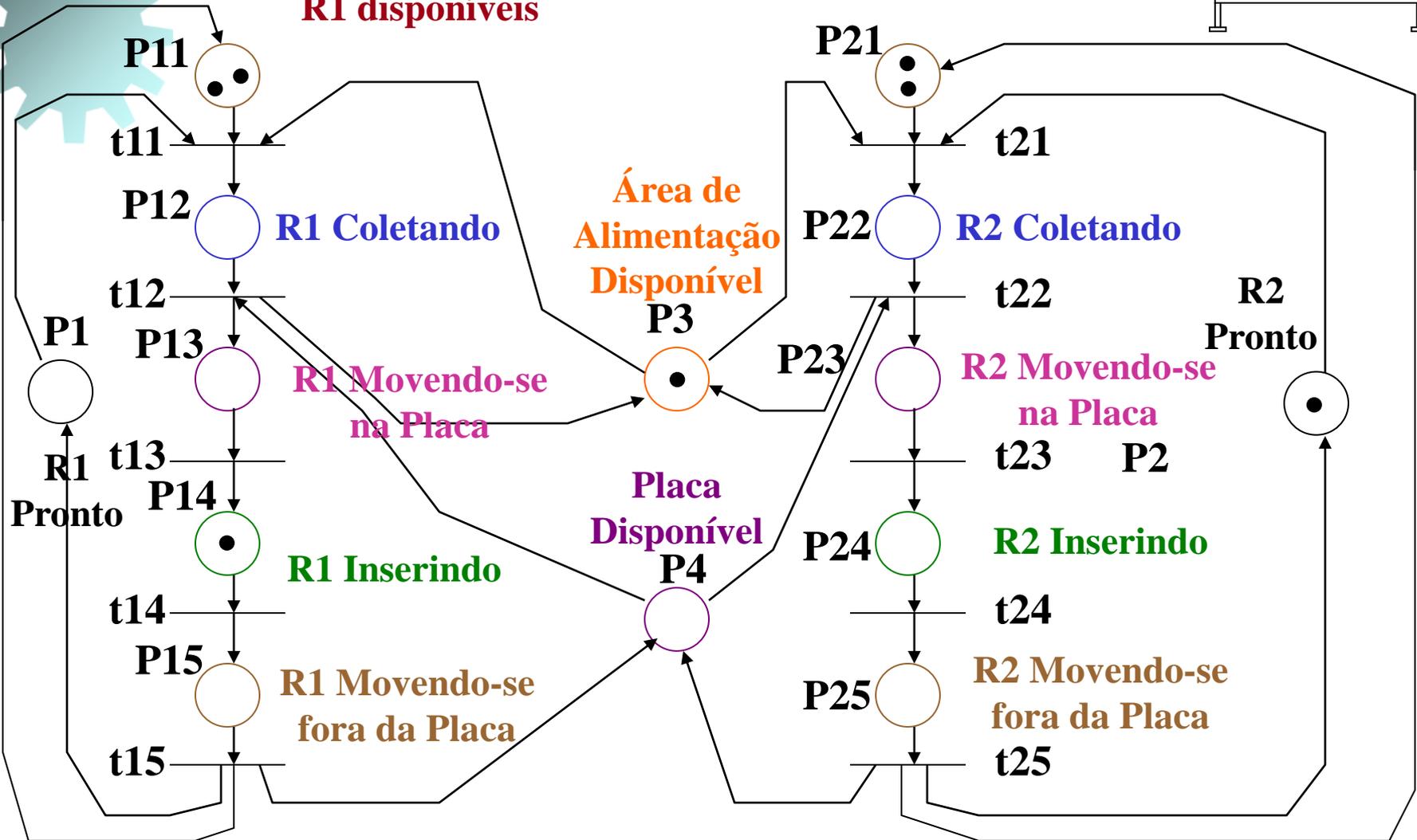
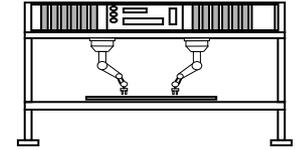
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

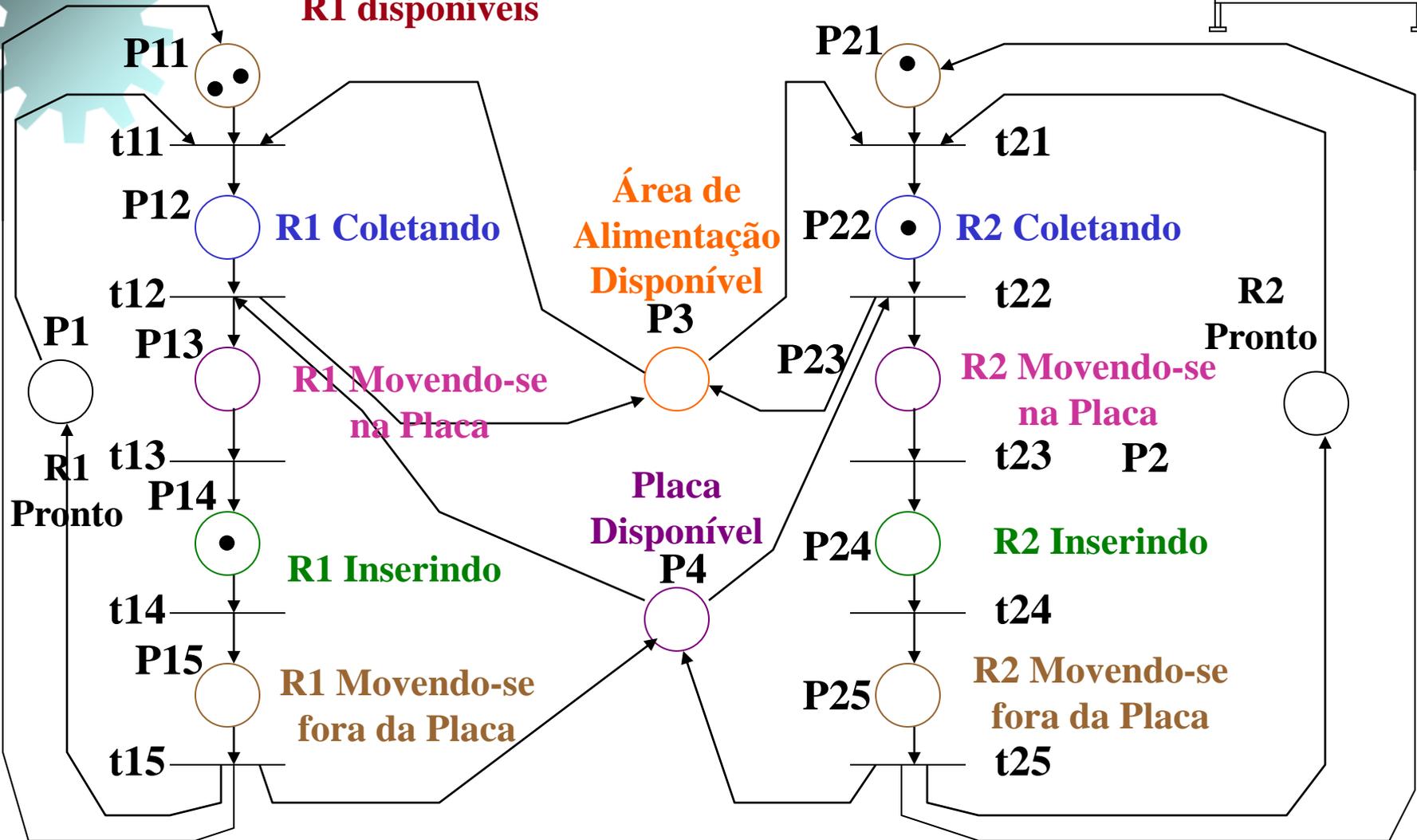
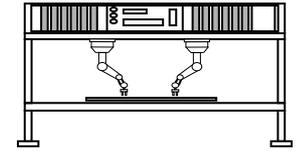
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

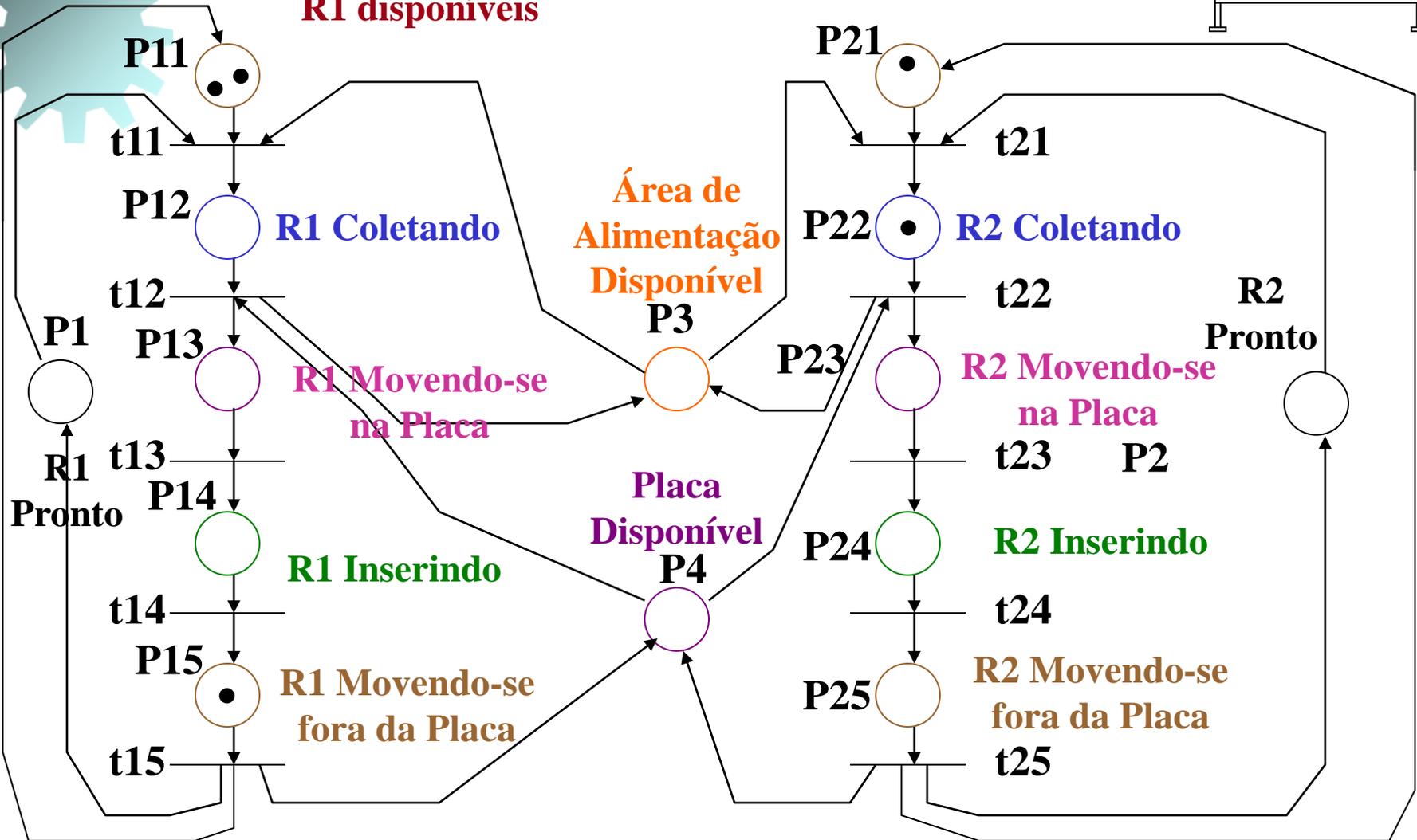
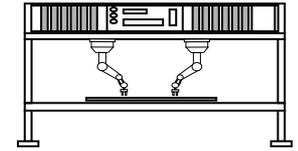
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

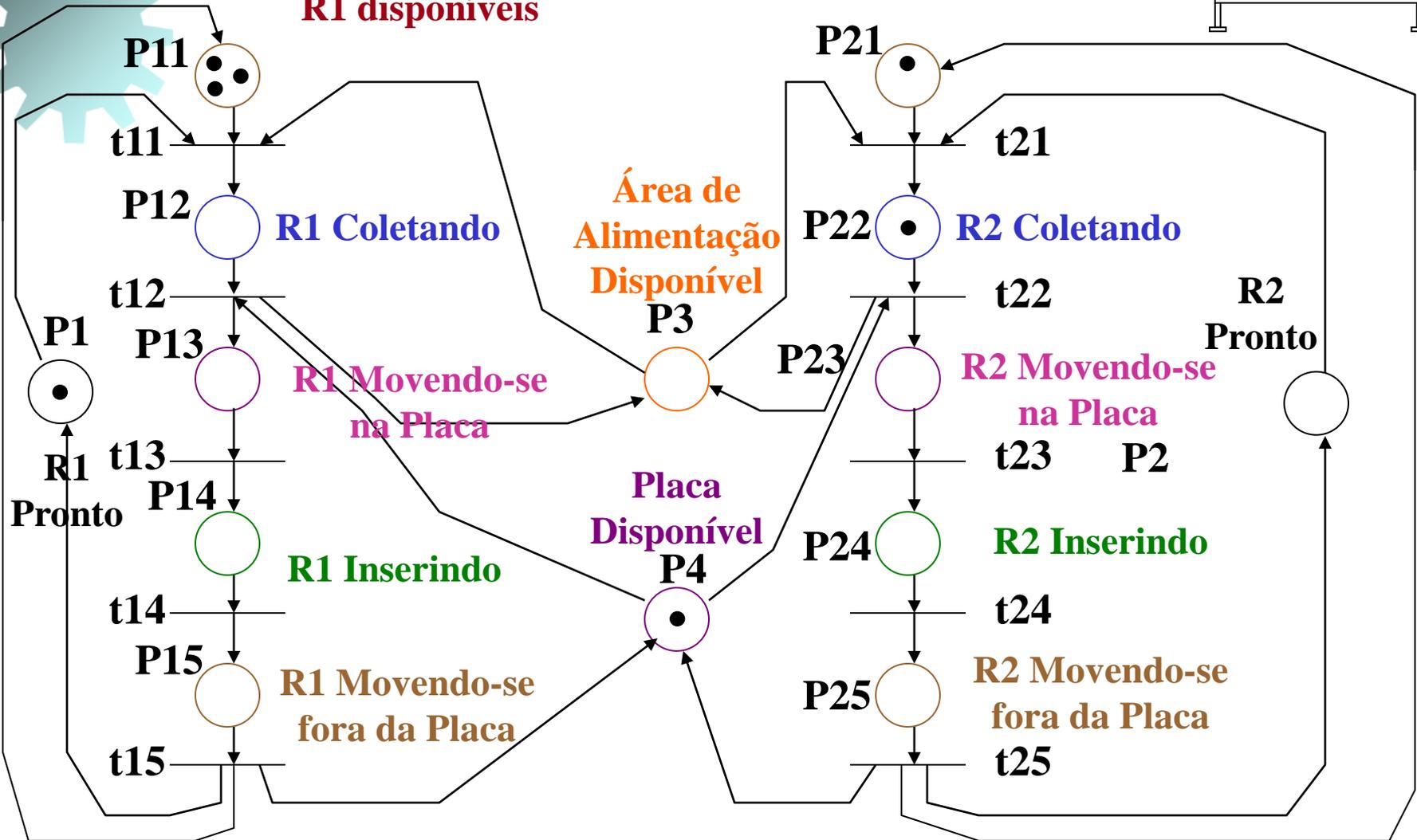
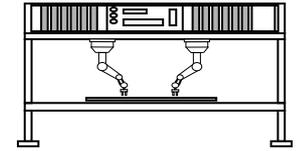
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

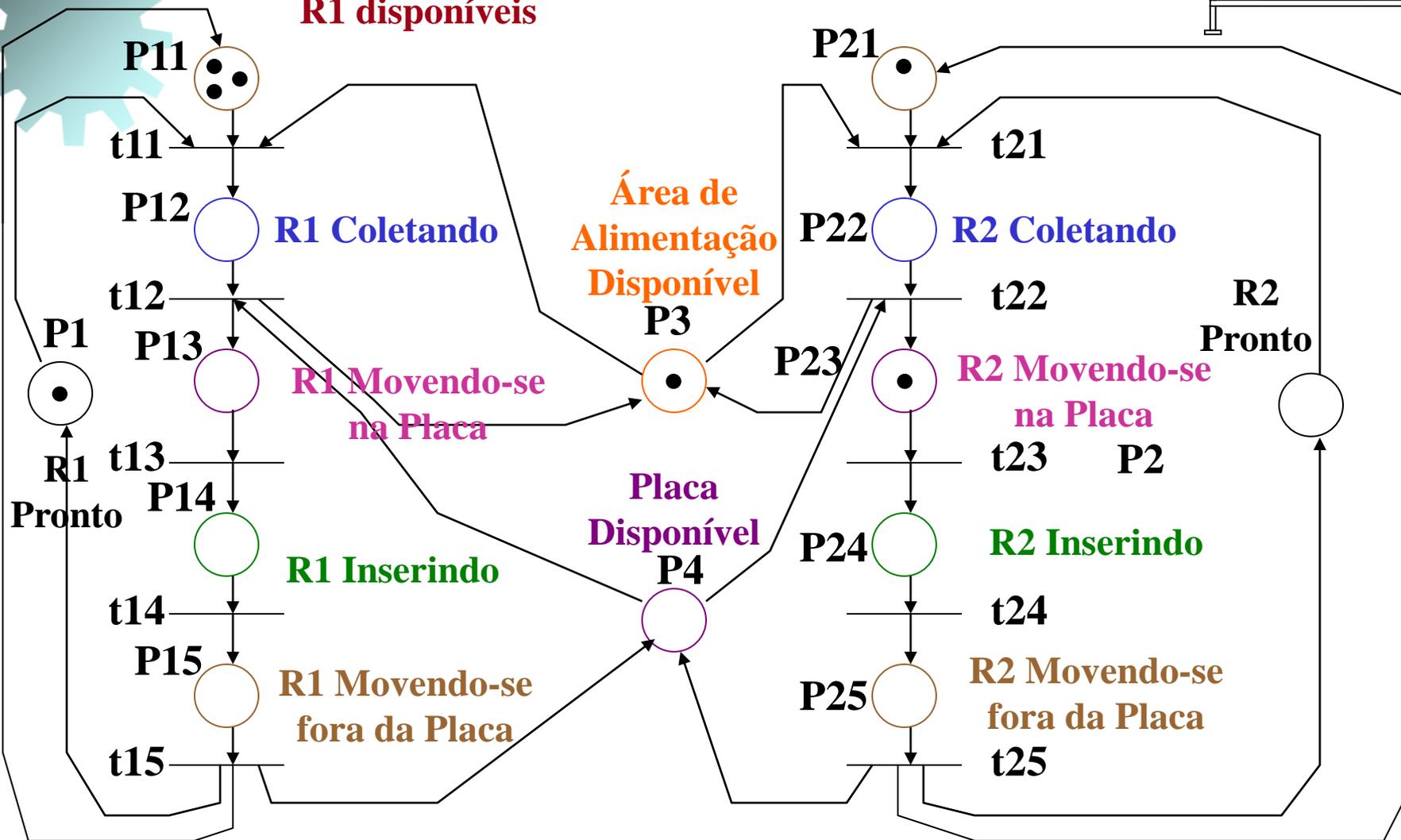
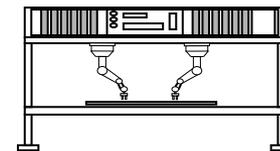
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

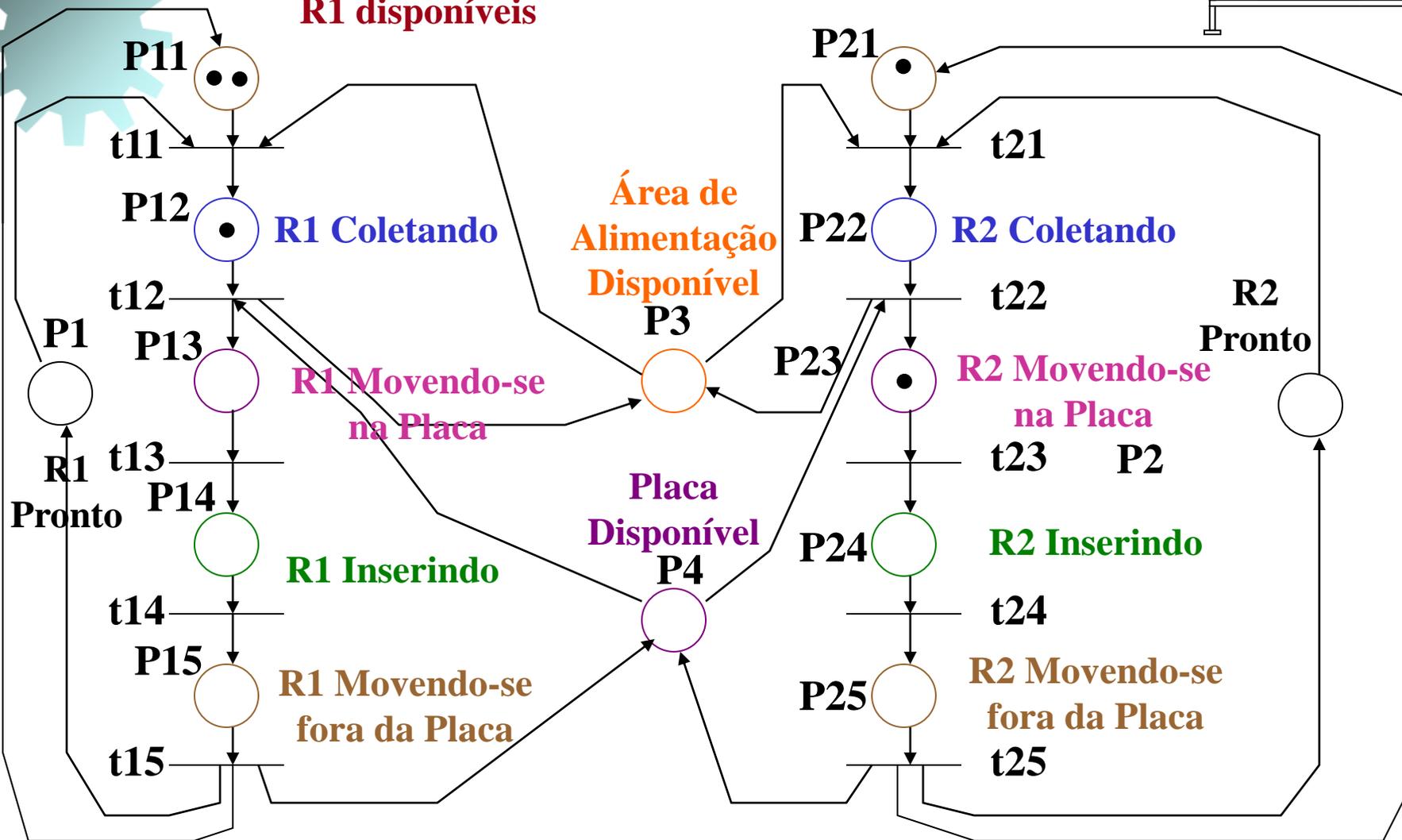
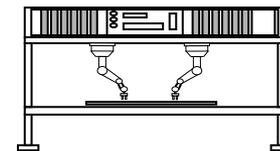
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

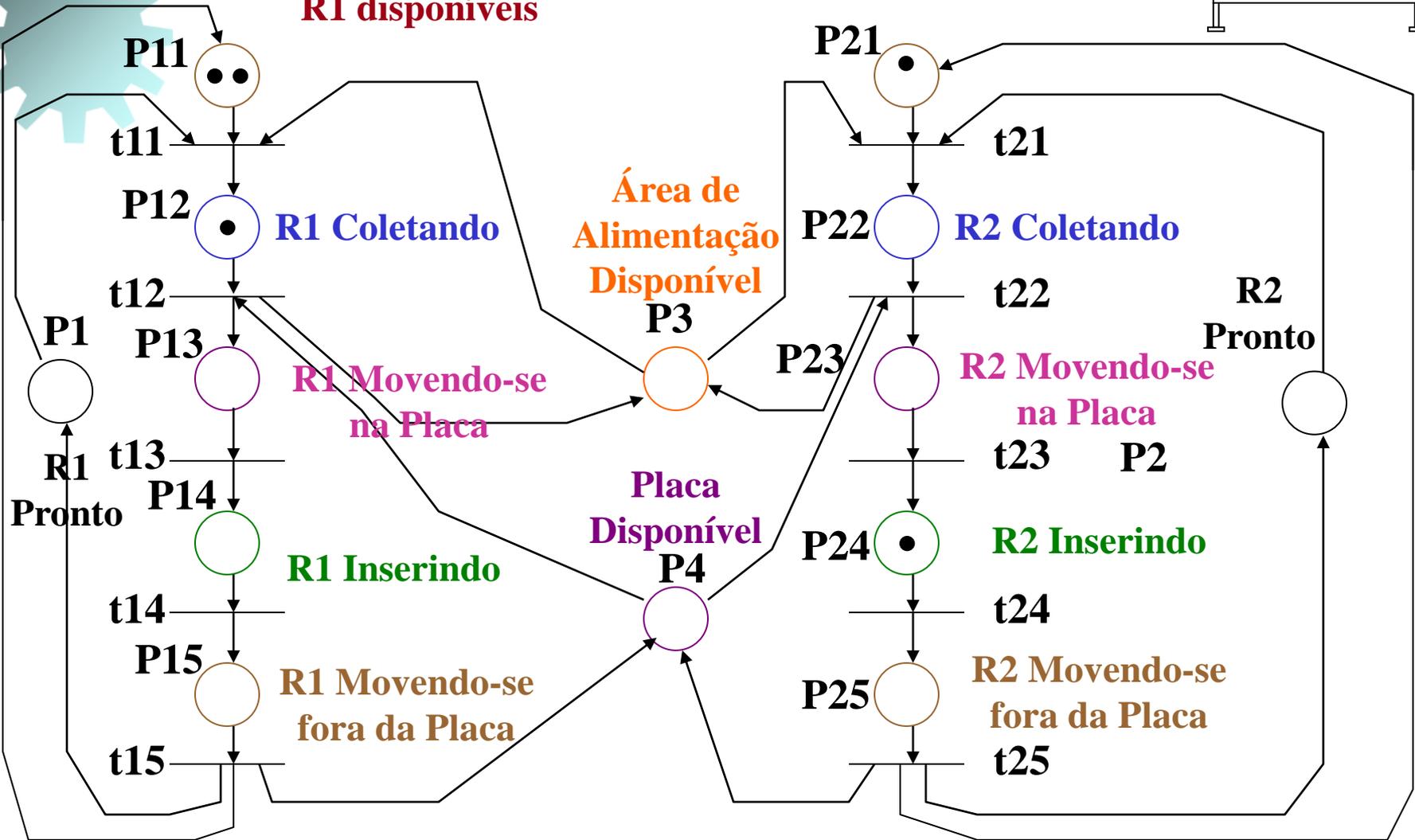
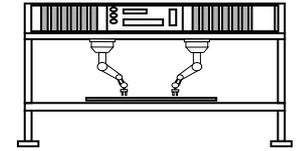
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

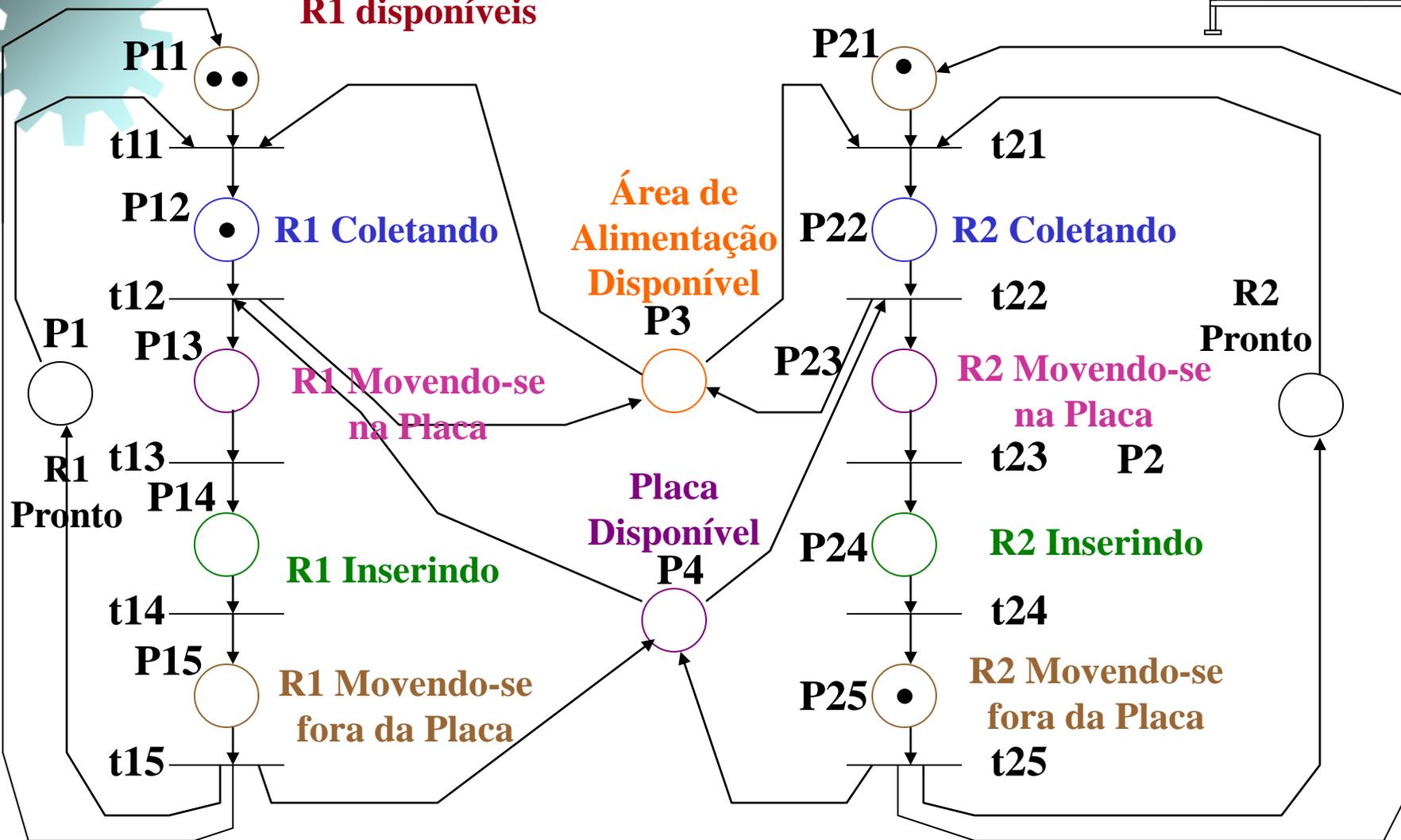
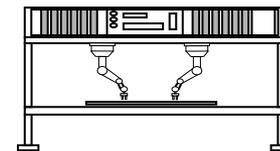
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

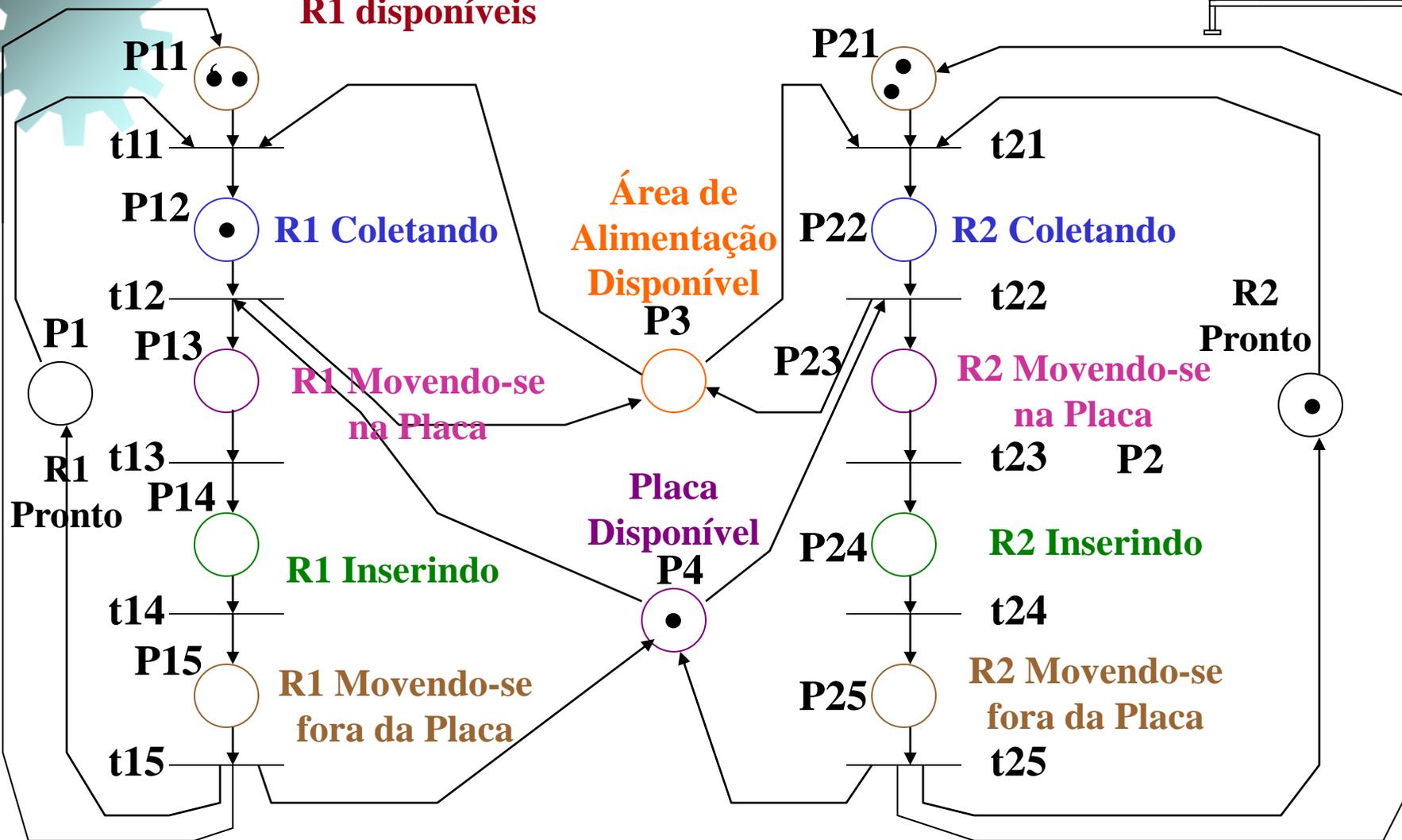
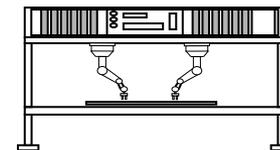
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

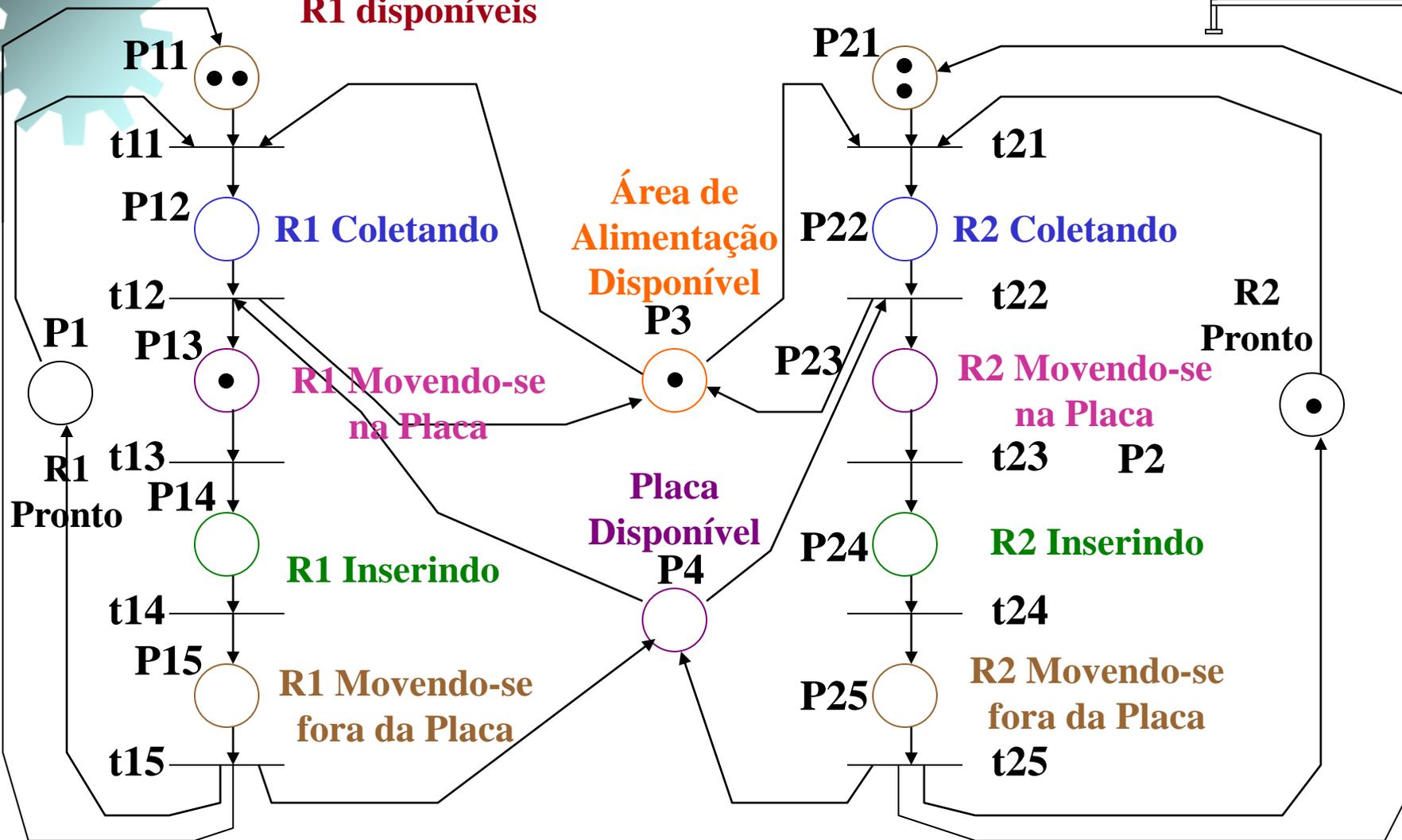
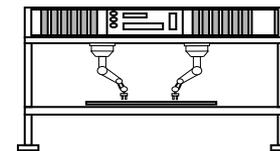
Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

Componentes para
R2 disponíveis



Evolução do Modelo

Componentes para
R1 disponíveis

Componentes para
R2 disponíveis

