MPB 2010/11 – Towards the Exam of May 2, 2011

(a)   (b)
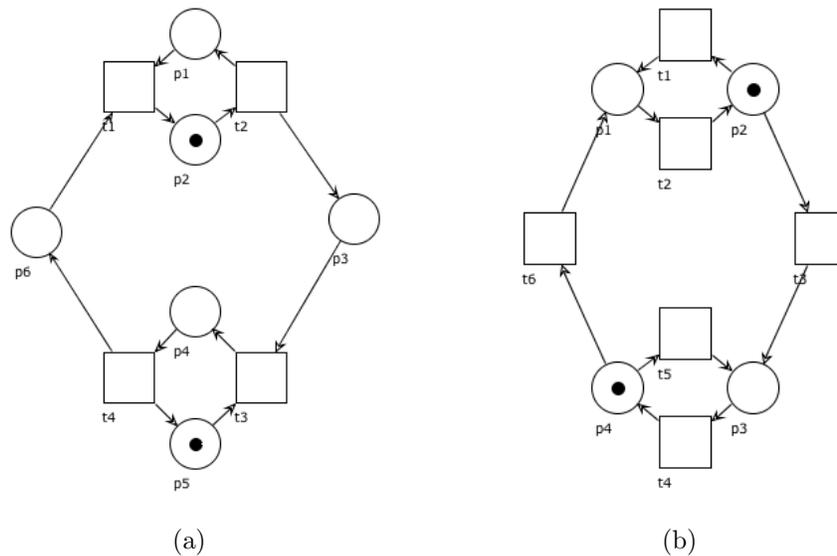
Figura 1: Two systems

[Ex. 1 (6 pt)]

1. Describe the origin and key idea that motivated the paradigm shift to process orientation.

2. Describe the Process Design Methodology.

[Ex. 2 (6 pt)]
Give the formal definitions for Petri net, pre- and post-set, marking, enabling, firing, firing sequence and reachable marking. Then, illustrate them over an example.

[Ex. 3 (6 pt)]
Consider the net system in Figure 1(a). Say if it is live, deadlock-free, bounded, safe, cyclic.

[Ex. 4 (8 pt)]
Give the formal definition of S-invariant and describe its fundamental property. Then, illustrate the above concepts over an example. Show a counterexample to the conjecture that the existence of a positive S-invariant implies liveness.

[Ex. 5 (6 pt)]
Consider the net in Figure 1(b). Find an S-invariant to prove that $M = p_1 + p_2 + p_3$ is not reachable from $M_0 = p_2 + p_4$.

MPB 2010/11 – Exam May 2, 2011

(a)   (b)
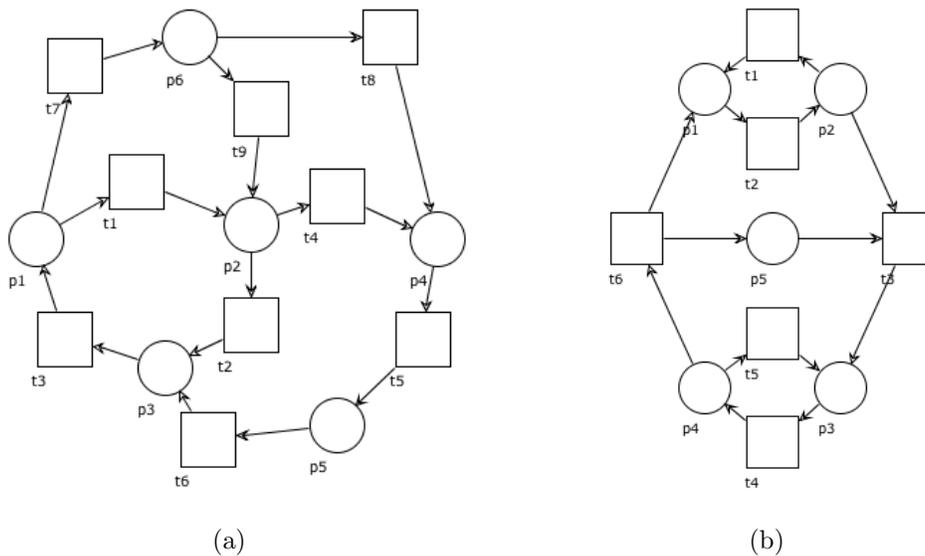
Figura 1: Two systems

[Ex. 1 (6 pt)]

1. Describe the Business Process Lifecycle.

2. Define the basic terminology of business processes.

[Ex. 2 (6 pt)]
Give the formal definition of liveness and deadlock-freedom. Then, illustrate them over some examples that cover all possible combinations of the two concepts.

[Ex. 3 (6 pt)]
Consider the net in Figure 1(a), say if it is strongly connected, an S-net, a T-net, a free-choice net, or none of them. (Motivate your answers).

[Ex. 4 (8 pt)]
Which of the following sentences is true? Exhibit a simple counterexample for any false sentence.

- existence of a semi-positive S-invariant implies boundedness

- existence of a positive S-invariant implies safeness

- existence of a positive S-invariant implies boundedness

[Ex. 5 (6 pt)]
Consider the net in Figure 1(b). Which of the following are S-invariants?
$\mathbf{I}_1 = [\,1\ 1\ 0\ 0\ 0\,]$; $\mathbf{I}_2 = [\,0\ 0\ 1\ 1\ 1\,]$; $\mathbf{I}_3 = [\,1\ 1\ 2\ 2\ 1\,]$; $\mathbf{I}_4 = [\,2\ 2\ 1\ 1\ 1\,]$;
$\mathbf{I}_5 = [\,1\ 1\ 1\ 1\ 0\,]$; $\mathbf{I}_6 = [\,0\ 1\ 0\ 1\ 1\,]$. (Explain.)

MPB 2011/12 – Exam November 21, 2011

(a) (b)
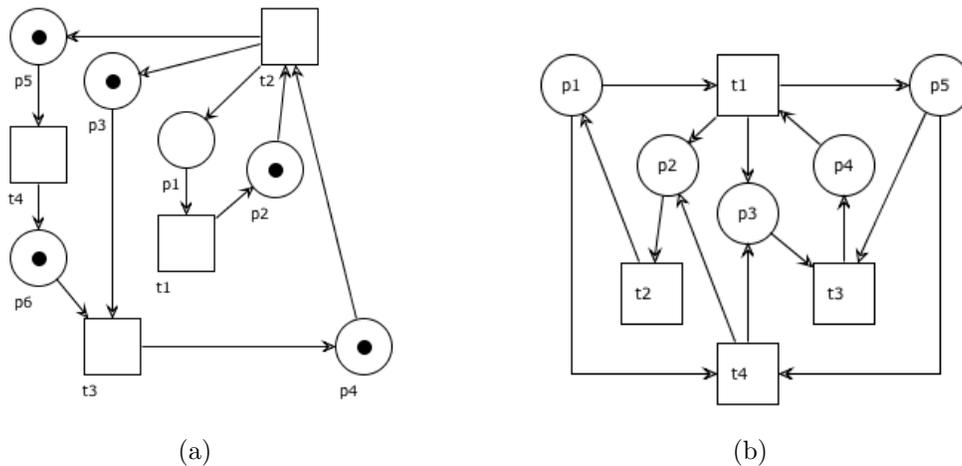
Figura 1: A T-system and a net

[Ex. 1 (6 pt)]
Describe the key terminology, principles and advantages of Service-Oriented Architectures and of the Enterprise Service Computing.

[Ex. 2 (7 pt)]
Give the formal definitions for net, S-net, T-net and free-choice net. Then:

1. Draw an S-net that is also a T-net (if it exists).
2. Draw an S-net that is not a T-net (if it exists).
3. Draw a T-net that is not free-choice (if it exists).
4. Draw a net that is not free-choice (if it exists).

[Ex. 3 (8 pt)]
Consider the T-system in Figure 1(a), with $M_0 = p_2 + p_3 + p_4 + p_5 + p_6$.

1. Is it strongly connected? Is it safe? Is it bounded? (explain)
2. Does any place belong to a circuit? Is it live? (explain)
3. Explain why $M = p_2 + 2p_3 + p_4 + p_5$ is not reachable from M_0.

[Ex. 4 (5 pt)]
Let (P, T, F, M_0) be an S-system and $\mathbf{M} = \{M \mid M(P) = M_0(P)\}$.
Is $\mathbf{M}$ a stable set? Under which condition does $\mathbf{M} = [\,M_0\,\rangle$? (explain)

[Ex. 5 (6 pt)]
Consider the net in Figure 1(b).

1. Which of the following are S-invariants? (explain)

$$\mathbf{I_1} = [\,1\ 1\ 0\ 0\ 0\,] \qquad \mathbf{I_2} = [\,0\ 0\ 1\ 1\ 1\,] \qquad \mathbf{I_3} = [\,2\ 2\ 1\ 2\ 1\,]$$

2. Which of the following are T-invariants? (explain)

$$\mathbf{J_1} = [\,1\ 2\ 2\ 1\,] \qquad \mathbf{J_2} = [\,1\ 1\ 1\ 0\,] \qquad \mathbf{J_3} = [\,0\ 1\ 0\ 1\,]$$

MPB 2012/13 – Towards the Exam of Nov 7, 2012

(a)   (b)
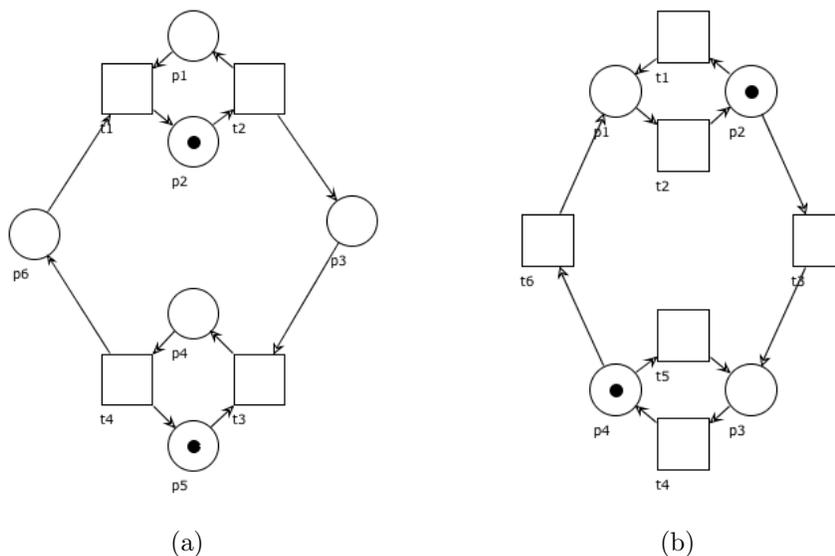
Figura 1: Two systems

[Ex. 1 (6 pt)]

1. What is a Business Process?

2. What are the Levels of the Business Process Methodology?

[Ex. 2 (6 pt)]
Give the formal definitions for Petri net, pre- and post-set, marking, enabling, firing. Then, illustrate them over an example.

[Ex. 3 (6 pt)]
Consider the net system in Figure 1(a). Say if it is live, deadlock-free, bounded, safe, cyclic.

[Ex. 4 (6 pt)]
Define the matrix and the vector that corresponds to the net in Figure 1(b) and its initial marking.

[Ex. 5 (6 pt)]
Exploit the Marking Equation Lemma to find the marking reached in Figure 1(b) after firing the sequences of transitions $t_6 t_2 t_1 t_3 t_4 t_5$ and $t_5 t_3 t_4 t_6 t_4 t_2 t_5 t_3 t_6$.

MPB 2012/13 – Nov 7, 2012
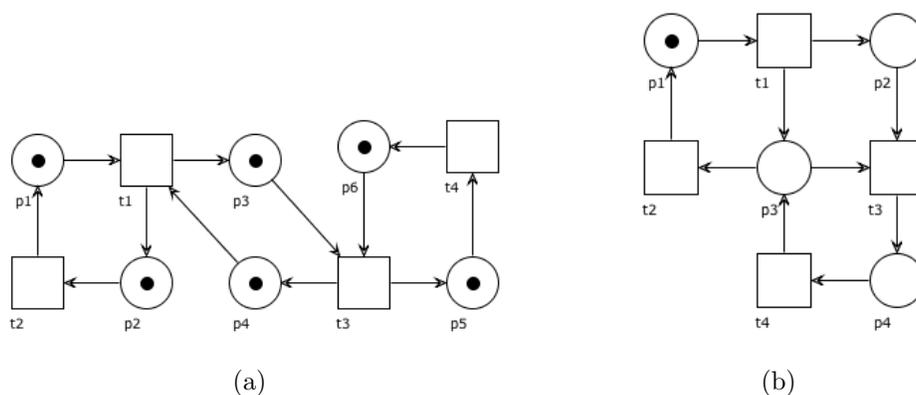
Figura 1: Two net systems

[Ex. 1 (6 pt)]

1. What is Business Process Management?

2. What are the phases of the Business Process Lifecycle?

[Ex. 2 (6 pt)]
Give the formal definitions of firing and firing sequence. Then, illustrate them over an example.

[Ex. 3 (6 pt)]
Consider the net system in Figure 1(a). Say if it is live, deadlock-free, bounded, safe, cyclic.

[Ex. 4 (6 pt)]
Define the matrix and the vector that corresponds to the net in Figure 1(b) and its initial marking.

[Ex. 5 (6 pt)]
Exploit the Marking Equation Lemma to find the marking reached in Figure 1(b) after firing the sequences of transitions $t_1 t_3 t_4 t_2 t_1 t_2 t_1$ and $t_1 t_2 t_1 t_2 t_1 t_2 t_1 t_3 t_4 t_3 t_4$.

MPB 2013/14 — Towards the Exam of Nov 6, 2013

(a)   (b)
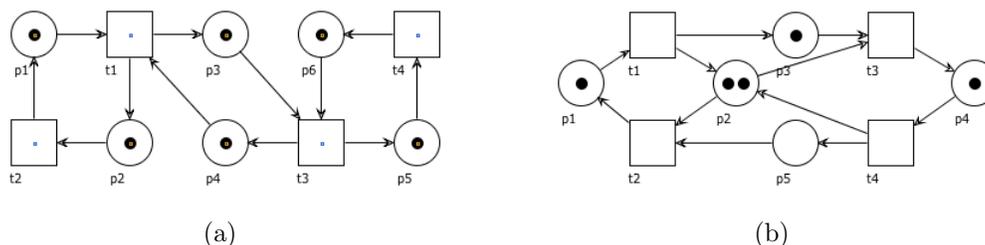
Figure 1: Two systems

[**Ex. 1**] Describe the difference between orchestration and choreography.

[**Ex. 1**] Describe the main stakeholders in the process domain.

[**Ex. 2**] Give the formal definition of bounded place, safe place and unbounded place. Then, show a single net system that contains a safe place, an unbounded place and a bounded place that is not safe.

[**Ex. 2**] Give the formal definition of deadlock-freedom and cyclicity. Then, illustrate some examples (with non-empty initial markings) that cover all the possible combinations of the two concepts.

[**Ex. 3**] Consider the net system in Figure 1(a). Say if it is live, deadlock-free, bounded, safe, cyclic.

[**Ex. 4**] Which of the following sentences is true? Exhibit a counterexample for any false sentence.

- boundedness implies safeness

- safeness implies boundedness

- safeness implies cyclicity

[**Ex. 5**] Define the net matrix and the initial marking vector that define the net system in Figure 1(b). Then, exploit the Marking Equation Lemma to compute the marking reached after firing the sequence of transitions $t_3t_1t_4t_2t_3t_1t_4t_3t_2t_4t_1t_3t_2t_4$, and find a suitable invariant to prove that the marking $2p_1 + p_2 + p_3 + p_4$ is not reachable.

[**Ex. 5**] Prove that the net system in Figure 1(b) is bounded. What is the minimal k for which it is k-bounded.

MPB 2013/14 – Nov 6, 2013
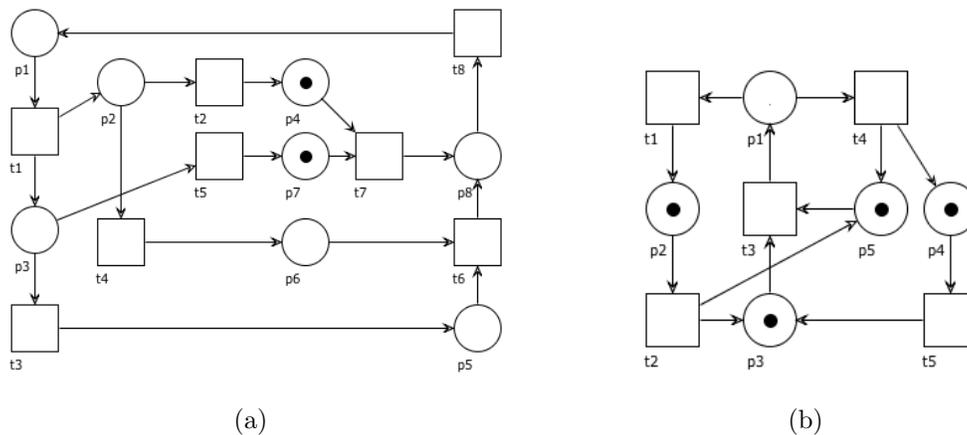
Figura 1: Two net systems

[Ex. 1]
Describe the hierachical, matrix and network organizational structures and explain their differences.

[Ex. 2]
Give the formal definitions of live transition, dead transition and live system. Then, illustrate them over positive (e.g. live transition, etc.) and negative (e.g. non-live transition, etc.) examples.
Can you define a net system with a non-live transition that is not dead?

[Ex. 3]
Consider the net system in Figure 1(a). Draw the complete reachability graph and then say if it is live, place-live, deadlock-free, bounded, safe, cyclic, motivating each answer.

[Ex. 4]
Exploit the Marking Equation Lemma to find the marking reached in Figure 1(a) after firing the sequence of transitions $t_7 t_8 t_1 t_4 t_3 t_6 t_8 t_1 t_3$.

[Ex. 5]
Consider the net system in Figure 1(b). Prove that the marking $p_1 + p_2 + p_3 + p_4$ is not reachable without computing the reachability graph.

MPB 2014/15 – Nov 7, 2014

(a) $M_0 = p_1$

(b) $M_0 = p_1 + p_2 + p_6$
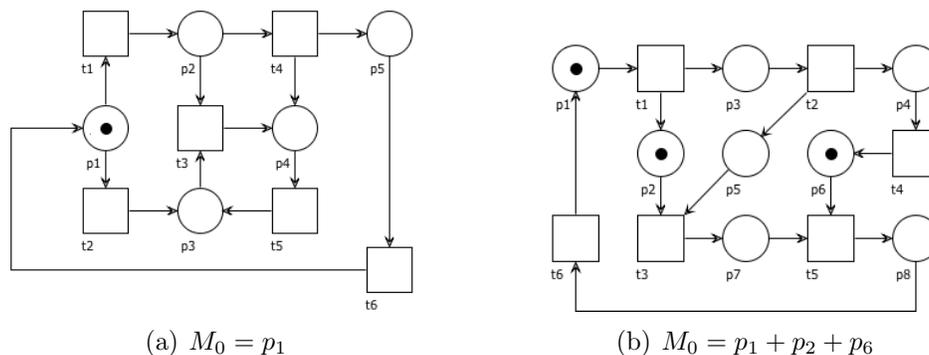
Figura 1: Two net systems

[Ex. 1]
Explain the meaning of the following terms in the context of business process management: "task", "resource", "activity", "principal", "contractor".

[Ex. 2] Consider a net system (P, T, F, M_0).
Give a formal definition of each of the following three statements: "a deadlock state is reachable"; "the place p is dead"; "the transition t is not live".

[Ex. 3] Consider the net system in Figure 1(a).
Prove that the system is not deadlock-free.
Is the system live (explain)?
Is the system free-choice (explain)?
Prove that the place p_3 is unbounded by exploiting the Monotonicity Lemma (hint: find two suitable reachable markings $M \subset M'$ such that $M' \in [M\rangle)$.

[Ex. 4] Consider the net system in Figure 1(a).
Exploit the Marking Equation Lemma to find the marking reached after firing the sequence $\sigma = t_1 t_4 t_6 t_1 t_5 t_4 t_5 t_6 t_1 t_4 t_6 t_2$.
Exploit the Marking Equation Lemma to justify the fact that the firing sequence $\sigma' = t_1 t_4 t_6 t_1 t_5 t_3 t_5 t_4 t_6 t_1 t_3 t_4$ is not enabled.

[Ex. 5] Consider the net system in Figure 1(b).
Prove that the system is bounded by exhibiting a suitable S-invariant.
Exploit the fundamental property of S-invariants to prove that the marking $M = p_2 + p_4 + p_6 + p_8$ is not reachable.

[Ex. 6, Optional]
Describe the "Design & Analysis" phase of the business process lifecycle.

(a) $M_0 = p_1 + p_2 + p_3 + p_4$ (b) $M_0 = 3p_1 + p_2 + 3p_3 + 3p_4 + p_5$
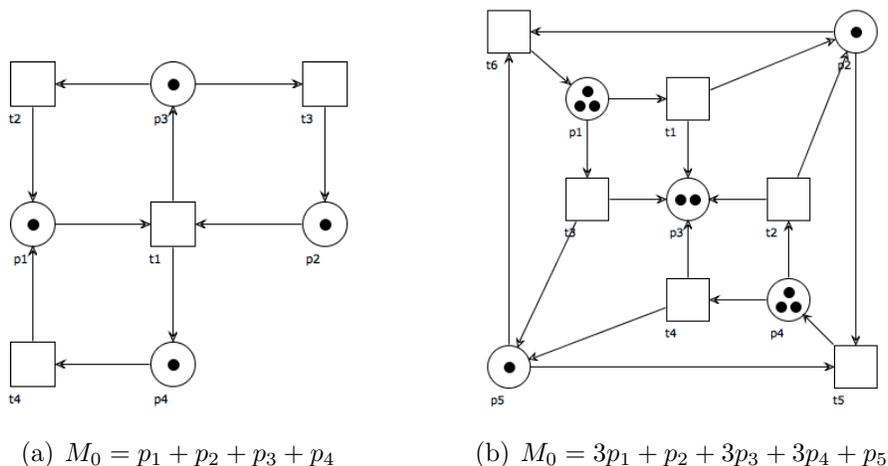
Figura 1: Two net systems

[**Ex. 1**] (i) Explain the difference between the terms "principal" and "contractor" in the context of Business Process Management.
(ii) Explain the difference between "point-to-point" and "hub-and-spoke" integration architectures in the context of Enterprise Application Integration

[**Ex. 2**] Consider a net system (P, T, F, M_0).
Give a formal account of each of the following sentences:
(i) "there is a reachable marking M such that (P, T, F, M) is live";
(ii) "the place p will always contain at most two tokens";
(iii) "the place p is not live".

[**Ex. 3**] Consider the net system in Figure 1(a).
(i) Is it a T-system (explain)?
(ii) Is it bounded (explain)?
(iii) Can you find a positive T-invariant (explain)?
(iv) Is it live (explain)?

[**Ex. 4**] Consider the net system in Figure 1(a).
(i) Exploit the Marking Equation Lemma to find the marking reached after firing the sequence $\sigma = t_1 t_2 t_3 t_4 t_1 t_4 t_3 t_1 t_3 t_4 t_4 t_1 t_2$.
(ii) Exploit the Fundamental Property of S-invariants to justify the fact that the marking $M = 2p_1 + 2p_2 + p_3$ is not reachable.

[**Ex. 5**] Consider the weakly connected net system in Figure 1(b).
(i) Is it free-choice (explain)?
(ii) Is it a workflow net (explain)?
(iii) Is it strongly connected (explain)?
(iv) Find a positive S-invariant.
(v) Is it live (explain)?
(Note: do not attempt to build the reachability graph: it has 371 nodes)

[**Ex. 6, Optional**] Describe the three different kinds of abstraction for modelling business processes: "Horizontal" , "Aggregation" and "Vertical".

(a) $M_0 = p_1 + p_4$ (b) $M_0 = p_1 + p_4$
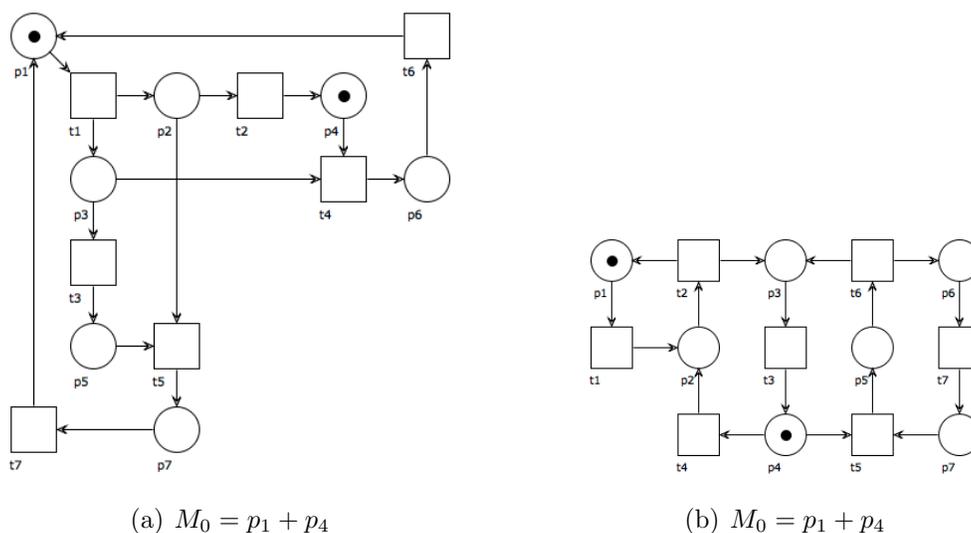
Figura 1: Two net systems

[Ex. 1] Describe the aim and role of the **Validation** activity inside the *Design & Analysis* phase of the Business Process Lifecycle.

[Ex. 2] Describe the communication protocol between service requestor, service registry and service provider in the Service-Oriented Architecture.

[Ex. 3] Give an example of business strategy.

[Ex. 4] Consider the net system in Figure 1(a).
(i) Is it a free-choice system? (explain)
(ii) Exhibit an S-invariant that proves the system is bounded. (explain)
(iii) Prove that the marking $M = p_6 + p_7$ is not reachable. (explain)
(iv) Give a firing sequence that starts in M_0 and reaches a deadlock marking.
(v) Is the system live? (explain)

[Ex. 5] Consider the net system in Figure 1(b).
(i) Exhibit a firing sequence that proves the system is unbounded. (explain)
(ii) Exhibit an S-invariant that proves the system is not live. (explain)
(iii) Exploit the Marking Equation Lemma to prove that the sequence $\sigma = t_1 \ t_4 \ t_2 \ t_3 \ t_2 \ t_1 \ t_3 \ t_4 \ t_2 \ t_4 \ t_4 \ t_3 \ t_4$ is not fireable.

[Ex. 6, Optional] Draw the complete reachability graph for the net system in Figure 1(a) (12 nodes, 20 arcs) and check the findings of Ex. 4 (ii-v).

(a) $M_0 = p_1 + p_4 + p_5$ (b) $M_0 = p_1$
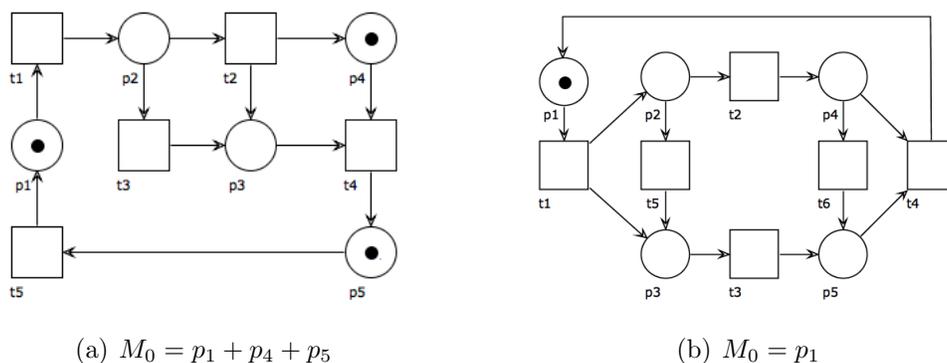
Figura 1: Two net systems

[**Ex. 1**] What is the goal of EAI middleware? Give some examples of EAI middleware solutions.

[**Ex. 2**] Explain the difference between primary and secondary processes.

[**Ex. 3**] Consider a net system (P, T, F, M_0). Formalize the statement "*there is a dead transition and it is attached to a safe place*".

[**Ex. 4**] Consider the system in Figure 1(a).
(i) Is it a T-system? (explain)
(ii) Show that the system is not deadlock-free.
(iii) Is the system live? (explain)
(iv) Show that no positive S-invariant exists.
(v) Does (iv) imply that there is an unbounded place?

[**Ex. 5**] Consider the system in Figure 1(a). Exploit the Marking Eq. Lemma:
(i) to find the marking reached after having fired the sequence
$$\sigma = t_1\ t_3\ t_5\ t_4\ t_1\ t_2\ t_5\ t_1\ t_3\ t_4;$$
(ii) to prove that the sequence $\sigma' = t_1\ t_3\ t_5\ t_4\ t_1\ t_2\ t_3$ is not fireable from M_0.

[**Ex. 6**] Consider the system in Figure 1(b).
(i) Find a positive S-invariant.
(ii) Use (i) and the Fundamental prop. of S-invariants to show that p_1 is safe.
(iii) Show that no positive T-invariant exists.
(iv) Can we conclude from (i) and (iii) that the system is not live?

[**Ex. 6, Optional**] Draw the complete reachability graph for the net system in Figure 1(b) (8 nodes, 12 arcs).

MPB 2018/19 – Oct 31, 2018

(a) $M_0 = p_1$

(b) $M_0 = p_1 + p_2 + p_4 + p_5$
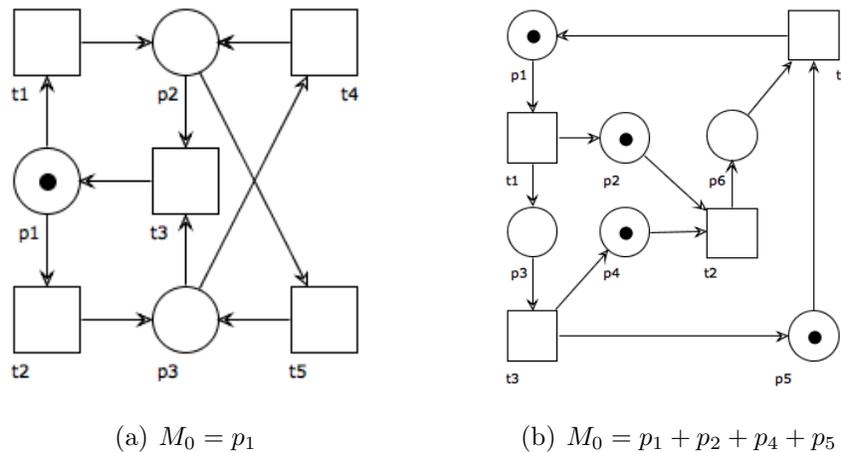
Figura 1: Two net systems

[**Ex. 1**] Define the roles of a principal and a contractor. Can a principal be also a contractor?

[**Ex. 2**] What is the difference between a business process and a business process instance?

[**Ex. 3**] Consider a net system (P, T, F, M_0). Formalize the statement "*the place p_1 is not safe*".

[**Ex. 4**] Consider the system in Figure 1(a).
(i) Draw the reachability graph G.
(ii) By looking at G, is the system live? (explain)
(iii) By looking at G, is the system deadlock free? (explain)
(iv) By looking at G, is the system bounded? (explain)
(v) By looking at G, is the system safe? (explain)
(vi) By looking at G, is the system cyclic? (explain)

[**Ex. 5**] Consider the system in Fig. 1(b). Exploit the Marking Eq. Lemma:
(i) to find the marking reached after having fired the sequence
$$\sigma = t_2\ t_1\ t_4\ t_1\ t_3\ t_2\ t_4\ t_3\ t_1\ t_3;$$
(ii) to prove that the sequence

$$\sigma' = t_1\ t_2\ t_4\ t_1\ t_3\ t_2\ t_3\ t_2\ t_1$$

is not fireable from M_0.

[**Ex. 6**] Consider the system in Figure 1(b).
(i) Is it a T-system?
(ii) Find a positive S-invariant.
(iii) How many tokens can be found at most in place p_1 at any time?