Information Technology Strategic Planning: Modeling, Analysis and Verification of Business Processes

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EXTENDED ABSTRACT: Research interest in the business process modeling area has increased dramatically over the past decade. The most critical point in the development of a business model depends largely on the ability to choose a conceptual model to represent the problem domain in a coherent and natural fashion.

This paper introduces a modeling paradigm for developing business process representation. It is supported by an information technology strategic planning (ITSP) model and methodology, which integrates the business/organizational strategic visions and the information technology (IT) strategic vision in a resulting unified way. The method is based in business strategy decomposition. High-level business strategies are refined up to the point when they reach a tactical business strategy level, described only in terms of goals and strategies. Activities are considered as operationalizations of goals and are applied in accordance with the strategies needed to achieve these goals. Thus, the decomposition process results in a set of primitive actions such as "order a product". Strategies are expressions that define valid state transitions in the business process. In fact, strategies specify the event occurrences and they represent either integrity rules or control operations. Since the business strategy decomposition determines actions sequence applications, a process can be ordered introducing a partial ordered relation.

The ITSP model considers a dynamic application environment. Its conceptualization is based in three fundamental concepts: interaction, adaptation and evolution. The ITSP methodology is organized in fifteen modules one of them being the business process.

Partially ordered Petri nets are used for business process representation, taking advantage of the well-know properties of the Petri net approach namely, formal semantic, graphical display and wide acceptance by practitioners. A partially ordered Petri net model of a business process gives a specific and unambiguous description of the behavior of the process. Its solid mathematical foundation has resulted in different analysis methods and verification tools. Despite of the formal background, Petri net models are easy to understand.

1 Introduction

Research interest in the business process modeling area has increased dramatically over the past decade. The most critical point in the development of a business model depends largely on the ability to choose a conceptual model to represent the problem domain in a coherent and natural fashion.

This paper introduces a modeling paradigm for developing business process representation. It is supported by an ITSP model and methodology, which integrates the business/organizational strategic visions and the information technology (IT) strategic vision in a resulting unified vision, (for related works in ITSP modeling see [5] and [3]).

The method is based in business strategy decomposition (see [2]). High-level business strategies are refined up to the point when they reach a tactical business strategy level, described only in terms of goals and strategies. The notion of business strategy decomposition is adopted to represent the process of business strategy refinement. Activities are considered as operationalizations of goals and are applied in accordance with the strategies needed to achieve these goals. Thus, the decomposition process results in a set of primitive actions such as "order a product". Strategies are expressions that define valid state transitions in the business process. In fact, strategies specify the event occurrences and they represent either integrity rules or control operations. Since the business strategy decomposition determines actions sequence applications, a process can be ordered introducing a partial ordered relation. The method considers a dynamic application domain, since the organizational model is able to modify its structure and respond appropriately to the changes in the business strategy.

The ITSP model considers a dynamic application environment, which integrates the business/organizational strategic visions and the IT strategic vision in a resulting unified vision. Its conceptualization is based in three fundamental

concepts: interaction, adaptation and evolution (for related works in evolution see [4] and [8]) . The ITSP methodology is organized in fifteen modules one of them being the business process.
Partially ordered Petri nets are used for business process representation, taking advantage of the well-know properties of the Petri net approach namely, formal semantic, graphical display and wide acceptance by practitioners. A Petri net model of a business process gives a specific and unambiguous description of the behavior of the process. Its solid mathematical foundation has resulted in different analysis methods and verification tools. Despite of the formal background, Petri net models are easy to understand (a different modeling and analysis approach, to the one provided here, of business processes using Petri nets is given in [1]).
The rest of the paper is structured in the following manner. The next section presents the necessary mathematical background and terminology needed to understand the rest of the paper (see [7]). Section 3, describes the basic formalism of the ITSP model and the methodology. Section 4, discusses the issues associated to the business process model method. Section 5, presents a modeling application example where the analysis/verification of the stability and non-blocking properties of it are made. Finally, section 6 concludes the paper.

2 Preliminaries

This section presents some well-established definitions and properties which will be used later.
NOTATION: $N = \{0, 1, 2, ...\}$, $\mathbb{R}_+ = [0, \infty)$, $N_{n_0}^+ = \{n_0, n_0+1, ..., n_0+k, ...\}, n_0 \geq 0$. Given $x, y \in \mathbb{R}^d$, we usually denote the relation "$\leq$" to mean componentwise inequalities with the same relation, i.e., $x \leq y$ is equivalent to $x_i \leq y_i, \forall i$. A function $f(n, x)$, $f : N_{n_0}^+ \times \mathbb{R}^d \to \mathbb{R}^d$ is called nondecreasing in x if given $x, y \in \mathbb{R}^d$ such that $x \geq y$ and $n \in N_{n_0}^+$ then, $f(n, x) \geq f(n, y)$.
Consider systems of first order ordinary difference equations given by

$$x(n+1) = f[n, x(n)],\ x(n_o) = x_0,\ n \in N_{n_0}^+ \quad (1)$$

where $n \in N_{n_0}^+$, $x(n) \in \mathbb{R}^d$ and $f : N_{n_0}^+ \times \mathbb{R}^d \to \mathbb{R}^d$ is continuous in $x(n)$.

Definition 1 *The n vector valued function $\Phi(n, n_0, x_0)$ is said to be a solution of (1) if $\Phi(n_0, n_0, x_0) = x_0$ and $\Phi(n+1, n_0, x_0) = f(n, \Phi(n, n_0, x_0))$ for all $n \in N_{n_0}^+$.*

Definition 2 *The system (1) is said to be*
i). Practically stable, if given (λ, A) with $0 < \lambda < A$, then

$$|x_0| < \lambda \Rightarrow |x(n, n_0, x_0)| < A,\ \forall n \in N_{n_0}^+,\ n_0 \geq 0;$$

ii). Uniformly practically stable, if it is practically stable for every $n_0 \geq 0$.

Definition 3 *A continuous function $\alpha : [0, \infty) \to [0, \infty)$ is said to belong to class $\mathcal{K}$ if $\alpha(0) = 0$ and it is strictly increasing.*

2.1 Lyapunov Methods for Practical stability

Consider the vector function $v(n, x(n))$, $v : N_{n_0}^+ \times \mathbb{R}^d \to \mathbb{R}_+^p$ and define the variation of v relative to (1) by

$$\Delta v = v(n+1, x(n+1)) - v(n, x(n)) \quad (2)$$

Then, the following result concerns the practical stability of (1).

Theorem 4 *Let $v : N_{n_0}^+ \times \mathbb{R}^d \to \mathbb{R}_+^p$ be a continuous function in x, define the function $v_0(n, x(n)) = \sum_{i=1}^p v_i(n, x(n))$ such that satisfies the estimates.*

$$b(|x|) \leq v_0(n, x(n)) \leq a(|x|) \text{ for } a, b \in \mathcal{K} \text{ and}$$

$$\Delta v(n, x(n)) \leq w(n, v(n, x(n)))$$

for $n \in N_{n_0}^+$, $x(n) \in \mathbb{R}^d$, where $w : N_{n_0}^+ \times \mathbb{R}_+^p \to \mathbb{R}^p$ is a continuous function in the second argument.
Assume that : $g(n, e) \triangleq e + w(n, e)$ is nondecreasing in e, $0 < \lambda < A$ are given and finally that $a(\lambda) < b(A)$ is satisfied. Then, the practical stability properties of

$$e(n+1) = g(n, e(n)),\ e(n_0) = e_0 \geq 0. \quad (3)$$

imply the corresponding practical stability properties of system (1).

Corollary 5 *In theorem 4, if $w(n, e) \equiv 0$ we get uniform practical stability of (1) which implies structural stability.*

2.2 Petri Nets

Petri nets are a tool for the study of systems. Petri net theory allows a system to be modeled by a Petri net, a mathematical representation of the system. Analysis of the Petri net then, can hopefully, reveal important information about the structure and dynamic behavior of the modeled system. This information can then be used to evaluate the modeled system and suggest improvements or changes.
A place-transition Petri net is a 5-tuple, $PN = \{P, Q, F, W, M_0\}$ where: $P = \{p_1, p_2, ..., p_m\}$ is a finite set of places, $Q = \{q_1, q_2, ..., q_n\}$ is a finite set of transitions, $F \subset (P \times Q) \cup (Q \times P)$ is a set of arcs, $W : F \to N_1^+$ is a weight function, M_0:

$P \to N$ is the initial marking, $P \cap Q = \varnothing$ and $P \cup Q \neq \varnothing$. A Petri net structure without any specific initial marking is denoted by PN.
Let $M_k(p_i)$ denote the marking (i.e., the number of tokens) at place $p_i \in P$ at time k and let $M_k = [M_k(p_1), ..., M_k(p_m)]^T$ denote the marking (state) of PN at time k. A transition $q_j \in Q$ is said to be enabled at time k if $M_k(p_i) \geq W(p_i, q_j)$ for all $p_i \in P$ such that $(p_i, q_j) \in F$. It is assumed that at each time k there exists at least one transition to fire. If a transition is enabled then, it can fire. If an enabled transition $q_j \in Q$ fires at time k then, the next marking for $p_i \in P$ is given by

$$M_{k+1}(p_i) = M_k(p_i) + W(q_j, p_i) - W(p_i, q_j).$$

Let $A = [a_{ij}]$ denote an $n \times m$ matrix of integers (the incidence matrix) where $a_{ij} = a_{ij}^+ - a_{ij}^-$ with $a_{ij}^+ = W(q_i, p_j)$ and $a_{ij}^- = W(p_j, q_i)$. Let $u_k \in \{0,1\}^n$ denote a firing vector where if $q_j \in Q$ is fired then, its corresponding firing vector is $u_k = [0, ..., 0, 1, 0, ..., 0]^T$ with the one in the j^{th} position in the vector and zeros everywhere else. The matrix equation (nonlinear difference equation) describing the dynamical behavior represented by a Petri net is:

$$M_{k+1} = M_k + A^T u_k \tag{4}$$

where if at step k, $a_{ij}^- < M_k(p_j)$ for all $p_j \in P$ then, $q_i \in Q$ is enabled and if this $q_i \in Q$ fires then, its corresponding firing vector u_k is utilized in the difference equation (4) to generate the next step. Notice that if M' can be reached from some other marking M and, if we fire some sequence of d transitions with corresponding firing vectors $u_0, u_1, ..., u_{d-1}$, we obtain that

$$M' = M + A^T u, \; u = \sum_{k=0}^{d-1} u_k. \tag{5}$$

Definition 6 *The set of all the markings (states) reachable from some starting marking M is called the reachability set, and is denoted by $R(M)$.*

Let (N^m, d) be a metric space where $d : N^m \times N^m \to \mathbb{R}_+$ is defined by

$$d(M_1, M_2) = \sum_{i=1}^{m} \zeta_i \mid M_1(p_i) - M_2(p_i) \mid ; \zeta_i > 0,$$
$$i = 1, ..., m.$$

and consider the matrix difference equation which describes the dynamical behavior of the discrete event system modeled by a Petri net (5) then we have.

Proposition 7 *Let PN be a place-transitions Petri net. PN is uniform practical stable if there exists a Φ strictly positive m vector such that*

$$\Delta v = u^T A \Phi \leq 0 \Leftrightarrow A\Phi \leq 0 \tag{6}$$

Next, we are interested in finding a firing sequence vector, control law, such that system (5) remains bounded.

Definition 8 *Let PN be a Petri net. PN is said to be stabilizable if there exists a firing transition sequence with transition count vector u such that system (5) remains bounded.*

Proposition 9 *Let PN be a Petri net. PN is stabilizable if there exists a firing transition sequence with transition count vector u such that the following equation holds*

$$\Delta v = A^T u \leq 0. \tag{7}$$

Remark 10 *It is important to underline that by fixing a particular u, which satisfies (7), we restrict the coverability tree to those markings (states) that are finite. The technique can be utilized to get some type of regulation and/or eliminate some undesirable events (transitions). Notice that in general (6)$\not\Rightarrow$(7) and that (7)$\not\Rightarrow$* (6).

Given a Petri net PN, the performance achievement problem consists in finding a firing transition sequence u such that:
1). A target state M_t will be attained, where the target state is restricted to belong to the reachability set $R(M_0)$ and must satisfy one and only one of the next two conditions:
a). The target state M_t is such that it is always possible to return to the initial state M_0 through it.
b). The target state M_t is the last and final task processed by the system with some fixed starting state.
or
2). A set of reachable states, which define a loop starting from the initial state, will be visited some finite number of times, with the possibility of existing or not loops between the intermediate states.
In addition stability must be guaranteed for all the states which play a role in the problem.

Theorem 11 *The performance achievement problem is solvable.*

3 ITSP Conceptual Model and Methodology

In the model (fig. 1), the real world is composed by entities representing physical things (persons, government, enterprises, etc.). Entities are related in terms of goals, beliefs, etc., and under

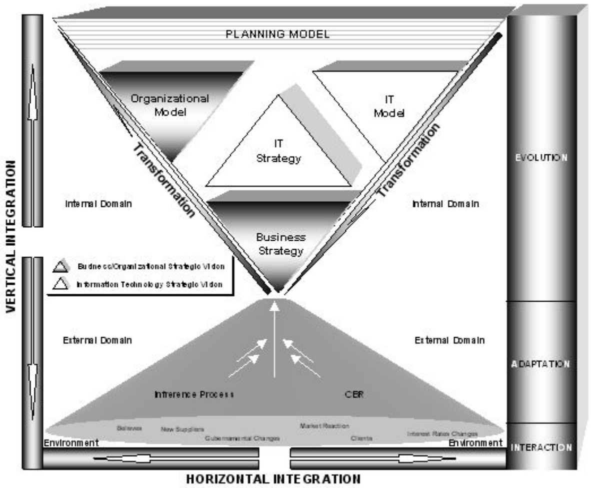

Figure 1: ITSP model

events generation change the environmental conditions. They take particular strategic positions through the network of relationships with other entities, playing different roles. The model is based in three fundamental concepts: interaction, adaptation and evolution.

The interaction concept represents the dynamic behavior of the environment, leading to incorporation or rejection of beliefs and facts related with environmental conditions. Interactions are established by the relationships between the roles that each entity plays in the application domain. The environmental behavior is induced by entities interaction.

An incident happening (beliefs, market reactions, etc.) which changes the environmental conditions is called an event. Each entity has the option to consider an event occurrence and incorporate or reject facts related to the environment´s conditions changes. Acceptance or rejection depend on entities interest. Examples of conditions that can be accepted are: economic plans changes, political beliefs, new technological tendencies, interest rate grow, etc.

Adaptation incorporates business strategies using a logic inference method, which uses beliefs and facts in order to generate new business strategies. This is a dynamic process where old business strategies are replaced by those corresponding with the actual environmental state.

In the real world, there are always assumptions that, if proven to be unfounded, are easily corrected. The environmental changes always take place in the curse of events that invalidate previous states. Non-monotonic reasoning is a way around this problem. It simply allows the retraction of 'truth' whenever contradictions arise forcing the incorporation of new beliefs.

Evolution is a process during which the business strategy is transformed into operative and IT components (IT strategy, organizational model, IT model and planning model). It considers a dynamic application domain which integrates the business/organizational strategic visions and the IT strategic vision in a resulting unified vision.

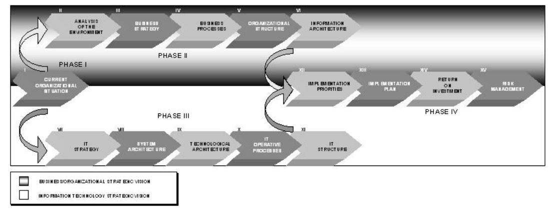

Figure 2: ITSP methodology

The evolution process is represented by an inverse pyramid where business strategy represents the " axioms" of the organization's archetype. Axioms are considered as true i.e., fundamental principles, in virtue that they are congruent with the reality of the environment. In every case, the ITSP tries to be in contact with the real world to give, to its construction, the most possible logic coherence.

The organizational propositions (IT strategy, organizational model, IT model and planning model) are deduced from the axioms through an inference logic method. Thus, every proposition is true if it can be deduced form the axioms.

This definition is in agreement with the fact that enterprise efficiency and IT effective use depend on the concordance that exists with the business strategy. If the business strategy is incompatible with the enterprise physical structure and IT configuration then, the organizational areas functionality will be inefficient. It is important to note that the organizational axioms are not necessarily absolute, but they evolve according to the internal and external changes in the environment[1].

The ITSP methodology (fig. 2) is organized in fifteen modules divided in four phases, conceiving two visions. On the one hand, it is concerned with creating a business\organizational vision, which provides the critical information inputs and, forms the foundations for later stages of planning. On the other hand creates an IT vision, which exploits new technological solutions which improve the enterprise situation. This paradigm is in concordance with the conceptual model.

4 Business Process Modeling

In the proposed method, high-level business strategies are refined up to the point when they

[1]Note that changes in the organization are limited by the core competencies, i.e. an enterprise that sells computational equipment can be transformed in to an enterprise that sells telecommunication equipment, but would be very difficult to transform it into a financial institution.

reach a tactical business strategy level, described only in terms of goals and strategies[2].

Notice that the business strategy formulation is derived from the interaction and adaptation phases in the ITSP model (see section, 3).

Business strategy decomposition represents a hierarchy of objective/decision-points, varying from the high-level business strategy with the maximum long-term impact to the more refined operational business strategy (goal, strategy) with relative short-term impact.

The business strategy refinement process concludes when a resulting business strategy can be transformed in to an executable action. In this sense, the nodes found in the lowest levels of the business strategy decomposition tree are usually mapped into actions.

A business process is regarded as a set of activities. Activities are considered as operationalizations of goals and are applied in accordance with the strategies to achieve the goals. Strategies determine the legal sequentially movements that can be made from any activity to another. The structure of each node in the business strategy decomposition is a complex object, defined by the ordered pair goal-strategy.

Since the business strategy decomposition determines actions sequence applications, a process can be ordered as follows.

Let X be a process and $x, y \in X$ two activities.

Definition 12 *We say that the activity y "depends on" the activity x, and we denoted it by $x \precsim y$, if the corresponding decomposed node of x is lower than that of y in the business strategy decomposition tree.*

Clearly, "$\preceq$ " establishes a partial ordering.

The partial order concept guarantees that the nodes found in the lowest levels of the business strategy decomposition tree, are already partially ordered and ready to be mapped into what next, is defined to be a partially ordered Petri net.

Definition 13 *A partially ordered Petri net is a duple $(PN, \preceq)$ where PN is a Petri net and $\preceq$ is the partial order previously defined and in addition the following conditions hold:*

- every place has at least one input and one output transition
- every transition has at least one input and one output place
- there are no possible cycles in the activities

[2]For simplification, we decompose the business strategy in goals and strategies, which we consider is adequate from an operational point of view

Events are actions which take place in a process. The occurrence of these events is controlled in part by the state of the process. The state of a process can be described as a set of conditions. Each condition represents the existence of a marking tuple on a particular place of the Petri net. The minimal elements of the net are those conditions associated to the initial marking.

Since events are actions, they may occur. For an event to occur, it may be necessary that certain preconditions hold. Each transition has associated a strategy that determines the preconditions to hold or not and may cause postconditions to become true.

For the sake of completeness, let us recall some basic notations of ordering. Given a poset $(X, \sqsubseteq)$ a successor of an element $x \in X$ is an element y such that $x \sqsubseteq y$, but $x \neq y$ and there is no third element u between x and y. x is a precessor of y if y is a successor of x. In symbols, , for any $x \in X$

Successors of x**:** $y \in suc(x)$ iff $x \neq y, x \preceq y$ and $\forall u : x \preceq u \preceq y \Longrightarrow (u = x) \vee (u = y)$

Precessors of x**:** $y \in pre(x)$ iff $y \neq x, y \preceq x$ and $\forall u : y \preceq u \preceq x \Longrightarrow (u = y) \vee (u = x)$

The graph of the ordering is the graph whose vertices are the points in X and each pair (x, y) where y is a successor of x determines an edge. The graph corresponding to the ordering "$\preceq$ " defined is a directed acyclic graph (DAG).

The minimal elements are those with no precessors, i.e. nodes with null inner degree in the DAG. The maximal element*s* are those with no successor, i.e. nodes with null outer degree in the DAG. In this ordering the conditions with no input transitions correspond to the minimal elements, and the conditions with no output transitions correspond to the maximal elements.

5 Example

Let us consider an insurance broker agency formed by ten employees. As a broker, the agency sells policies for different companies. The main products are life and automobile policies.

For selling and advertising the insurance company obtains detailed information from potential customers (C), and from private and governmental agencies (A). This information is distributed between the company's agents (AG) which contact potential clients via phone and try to set up a conference call; however, they also have their own sources of information. At the interview, the agent examines the client's current insurance coverage and tries to find an opportunity for a policy that will best fit the customer's needs. Before obtaining an insurance policy, the new client suffers an identity investigation. In the case of a life insurance, the client has, in addition, to approve a physical examination test in an accredited hospi-

Objectives	Goals	Strategies	CSFs
O1 Achieve Market Leadership position (M)	G1 Reduce Operation Costs 5% (O1, O2)	S1 Improvements in Marketing Practices (O3, O4, M, A)	C1 Improve Cash Flow Management (O1, G3)
			C7 Growth Through Acquisition (O1, S2)
O2 Improve Service Quality (A, C, AG, H, M, B, AD)	G2 Achieve 30% Market Participation (O1, O4, M)		
		S2 Penetration into New Markets (O1, O2, G3)	C3 Improve Human Resources Training (O4)
O3 Gain Competitive Advantage (M)	G3 Improve Stockholders Gains 15% (O1, O5, M)		C5 Improve Client Service (O2, G4, S3)
O4 Enhance Company Image (M)	G4 Introduce IS/IT Solutions within two year (O2, O3)	S3 Improvements in New Product Generation (O2, O3)	C4 Introduce Strategic Distinction (O1, O3, S1)

tal (H). In the case that the investigation is positive both parts sign a policy and keep a copy of the contract. If during the investigation irregularities are found, the agent is informed who meets with the client in order to find new options.

The insurance policy is in effect when the client makes the first insurance premium payment. Every policy carries with a schedule of premiums, which varies with the type and coverage. Each policy provides a commission for the agency. The commission varies with the insurance company, policy type and coverage. The insurance company management (M) defines the commissions politic, which varies from agency to agency. The agency splits the commission received for each policy with the agent who sold it; the rate depends on the seniority of the agent. Once a policy has been sold, the agency submits premium bills to the client, collects payment and sends the payment, minus it commission, to the insurance company. If a client fails to pay premiums, the agent who sold the policy is informed, so that he can contact the client.

Claims can be made on insurance policies as specified in the policy itself. Clients or beneficiaries (B) contact the agent to file such claims. For an automobile insurance policy, claims are made when the car is involved in an accident, damaged or stolen. Life insurance claims may be made by the beneficiaries on the death of the insured. In both cases, the insurance company sends an adjuster (AD) to legitimate the claim and arrange the final insurance details.

For simplification, we will consider just the organizational strategy of the insurance company. Let us construct the organizational strategy like in [6]. In the business strategy decomposition tree each node has a complex structure as follows: objective, goal, strategy, critical success factors (CSF) (fig. 3).

Remark 14 *The complete business strategy decomposition is out of the scope of this article. However, we are following the decomposition process presented in [2].*

The decomposition is as follows:

(Achieve Market Leadership position, Reduce Operation Costs 5%, Penetration into New Markets, Growth Through Acquisition)

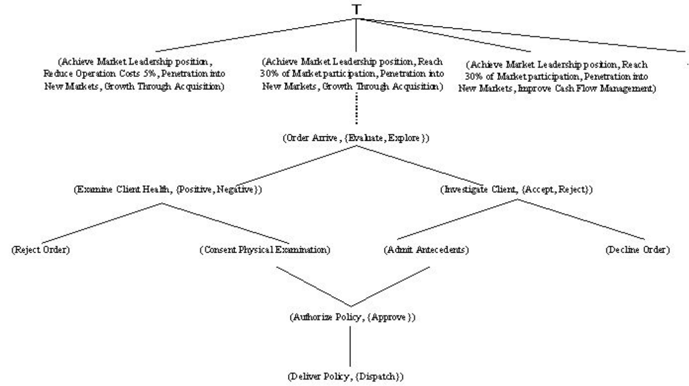

Figure 3: Business strategy decomposition tree

(Achieve Market Leadership position, Reach 30% of Market participation, Penetration into New Markets, Growth Through Acquisition)

(Achieve Market Leadership position, Reach 30% of Market participation, Penetration into New Markets, Improve Cash Flow Management)

$$\Downarrow$$

...

The business strategy decomposition tree is shown in fig. 3.

Next, the partially ordered Petri net model $(PN, \preceq)$ is constructed by mapping the activities in the business strategy decomposition tree (fig. 3). Notice that the goals are represented by the places while the transitions represent the activities. The partially ordered Petri net (fig. 4) has the following specifications:

Places:

P_1: order arrive, P_2: examine client health, P_3: investigate client, P_4: reject order, P_5: decline order, P_6: consent physical examination and admit antecedents, P_7: artificial place, P_8: artificial place, P_9: artificial place, P_{10}: artificial place, P_{11}: authorize policy,P_{12}: deliver policy.

Transitions:

t_1: request life policy and review physical condition, t_2: deny physical examination, t_3: accept order, t_4: refuse antecedents, t_5: sign contract, t_6: send life policy, t_7: artificial transition, t_8: artificial transition, t_9: artificial transition, t_{10}: artificial transition.

5.1 Stability and non-blocking analysis/verification

Now, since the reachability set of a Petri net without inhibitor arcs contains the reachability set of the same Petri net with inhibitor arcs from the incidence matrix of the partially ordered Petri net

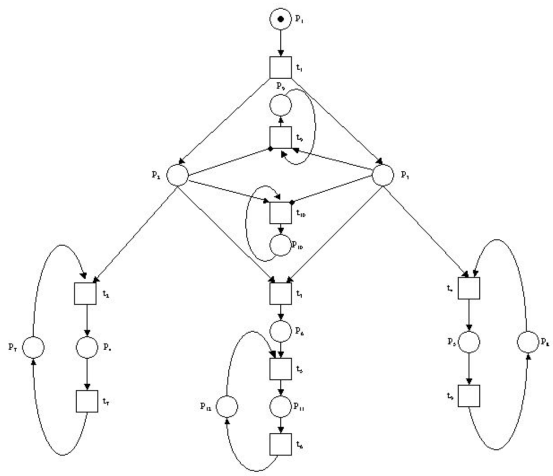

Figure 4: Petri net model

shown in fig. 5, (without inhibitor arcs), given by

$$A = \begin{array}{c} t_1 \\ t_2 \\ t_3 \\ t_4 \\ t_5 \\ t_6 \\ t_7 \\ t_8 \\ t_9 \\ t_{10} \end{array} \left[\begin{array}{cccccccccccc} -1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & -1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & -1 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 \\ 0 & 0 & 0 & -1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{array} \right] \quad (8)$$

picking $\Phi = [1,1,1,1,1,1,1,1,1,1,1,1]$, $\Phi > 0$ we obtain that $A\Phi \leq 0$ concluding stability.
Next, since stability has already been verified, the non-blocking property of the model follows straightforward by applying the results presented in section 2.4 for the case when the target state M_t = [acceptance $\oplus$ {rejection by physical examination + rejection by antecedents}] is the last and final task processed by the system with some fixed starting state.

Remark 15 *We would like to point out that in order to apply theorem 5 of section 2.4 for the case when the target state M_t is such that both, rejection by physical examination and rejection by antecedents, are true a slight modification in the Petri net model has to be made in order to reduce this two tokens to one. However, the resulting Petri net model continues to be stable. The details are omitted.*

6 Conclusions

A formal framework for business process modeling and verification using partially ordered place-transitions Petri nets has been presented. The business process model was supported by an information technology strategic planning (ITSP) model and methodology. The modeling methodology was based in business strategy transformation. An illustrative example where stability and non-blocking properties were shown to hold was addressed.

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