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PETRI NETS FOR MODELING A SUPPLY CHAIN MANAGEMENT PROCESS

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Abstract. We chose Petri Nets to use for modeling a manufacturing enterprise, in fact the supply chain management process (SCM) that is subject to unexpected events for which reactions are required. Usually Petri Nets are used for describing and studying systems that are characterized as being concurrent, asynchronous, distributed, parallel, nondeterministic, and/or stochastic. We described also a classic software for Enterprise Resource Planning (ERP) offered by SAP, which has also a module (software division) for SCM called mySAP SCM. We will try to offer a modest alternative solution for a SCM using Petri Nets.

1. What is a Supply Chain Management Process (SCM)

Since its inception in the early 1990's, the field of supply chain management has become tremendously important to companies in an increasingly competitive global marketplace. The term supply chain refers to the entire network of companies that work together to design, produce, deliver, and service products. In the past, companies focused primarily on manufacturing and quality improvements within their four walls; now their efforts extend beyond those walls to encompass the entire supply chain.

There is more to supply chain management than just material flows; information flows and financial flows are also important. Consider the figure below, which lists examples of material, information, and financial flows in each pull-down menu.

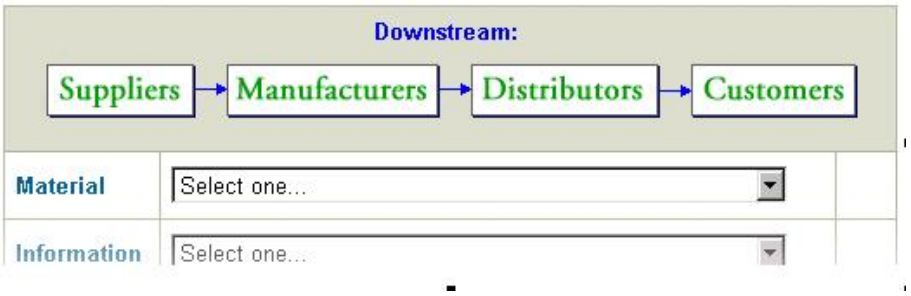


Figure 1: Three Flows: Materials, Information, and Financial

2. Supply Chain Management Tools offered by SAP - mySAP SCM

Who is SAP? Founded in 1972, SAP is the recognized leader in providing collaborative business solutions for all types of industries and for every major market. With 12 million users, 96,400 installations, and more than 1,500 partners, SAP is the world's largest inter-enterprise software company and the world's third-largest independent software supplier overall. They have a rich history of innovation and growth that has made us a true industry leader. Today, SAP employs more than 32,000 people in more than 50 countries.

What is SCM for SAP? As most chores within the supply chain today cannot do without the use of computer software, the SCM designed by SAP shows concrete examples using SAP within different industry areas. Since SAP is emphasizing recent developments in operations management in its SCM initiative, it describes the methodological background from the viewpoint of a company using SAP systems, order processing both in an intra and inter organizational perspective, as well as describing future developments and system enhancements. In an age of intense competition, supply chain efficiency and adaptability are not just requirements for success. They are necessities for survival.

About mySAP. mySAP Supply Chain Management (mySAP SCM) can help your organization transform a linear supply chain into an adaptive supply chain network, in which communities of customer-centric, demand-driven companies share knowledge, intelligently adapt to changing market conditions, and proactively respond to shorter, less predictable life cycles.

Many companies across the globe have used mySAP SCM to improve their business and operations processes. In fact, mySAP SCM is the only supply

chain solution that integrates collaboration, planning, execution, and coordination of the entire supply chain network (SAP opinion) - empowering with:

- Synchronize supply to demand – Balance push and pull network planning processes. Replenish inventory and execute production based on actual demand.

- Sense and respond with an adaptive supply chain network – Drive distribution, transportation, and logistics processes that are integrated with real-time planning processes.

- Provide network wide visibility, collaboration, and analytics – Monitor and analyze your extended supply chain.

3. The Petri Nets as a modeling tool

A Petri net is a mathematical representation of discrete distributed systems. Petri nets were defined in the 1960s by Carl Adam Petri. Because of their ability to express concurrent events, they generalize automata theory. The concept of Petri nets has its origin in Carl Adam Petri's dissertation Kommunikation mit Automaten, submitted in 1962 to the faculty of Mathematics and Physics at the Technische Universität Darmstadt, Germany.

A Petri net is a graphical and mathematical modeling tool. It consists of places, transitions, and arcs that connect them. Input arcs connect places with transitions, while output arcs start at a transition and end at a place. There are other types of arcs, e.g. inhibitor arcs. Places can contain tokens; the current state of the modeled system (the marking) is given by the number (and type if the tokens are distinguishable) of tokens in each place. Transitions are active components. They model activities which can occur (the transition fires), thus changing the state of the system (the marking of the Petri net). Transitions are only allowed to fire if they are enabled, which means that all the preconditions for the activity must be fulfilled (there are enough tokens available in the input places). When the transition fires, it removes tokens from its input places and adds some at all of its output places. The number of tokens removed / added depends on the cardinality of each arc. The interactive firing of transitions in subsequent markings is called token game.

Petri nets are a promising tool for describing and studying systems that are characterized as being concurrent, asynchronous, distributed, parallel, nondeterministic, and/or stochastic. As a graphical tool, Petri nets can be used as a visual-communication aid similar to flow charts, block diagrams, and networks. In addition, tokens are used in these nets to simulate the dynamic and concurrent activities of systems. As a mathematical tool, it is possible to set up state equations, algebraic equations, and other mathematical models governing the behavior of systems.

DEFINITION 1. *A Petri Net is a bipartite directed graph represented by a quadruple*

$$PN = (P, T, I, O)$$

where:

$P = \{p1, ..., pn\}$ *is a finite set of places.*

$T = \{t1, ..., tm\}$ *is a finite set of transitions.*

$I(p, t)$ *is a mapping* $PT\{0, 1\}$ *corresponding to the set of directed arcs from places to transitions.*

$O(t, p)$ *is a mapping* $TP\{0, 1\}$ *corresponding to the set of directed arcs from transitions to places.*

The nets under consideration, where I *and* O *take the values of 0 or 1, are called ordinary Petri Nets.*

4. Modeling a supply chain process using Petri Nets

We shall use Petri Nets for modeling a very simple (scholastic) supply chain process. We have a very simple supply chain process.

To design a simulation we shall use a new transition called **consuming** placed at the end of the chain. This will create a deadlock (blocking state), so we have to consider that the client will consume the buying product.

Now we have a continuous process for **providing** – **selling** – **consuming**.

The utility of the Petri Net in modeling a process is revealed when we have two clients.

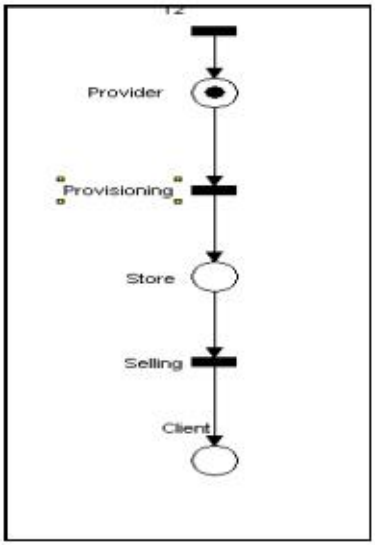


Figure 2: Simple supply chain process

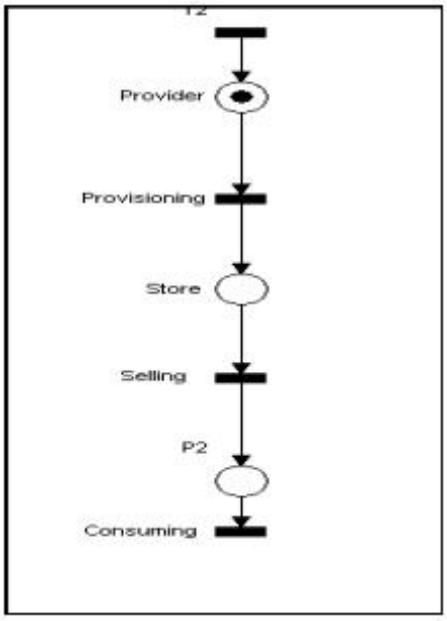


Figure 3: Continuous supply chain process: providing – selling – consuming

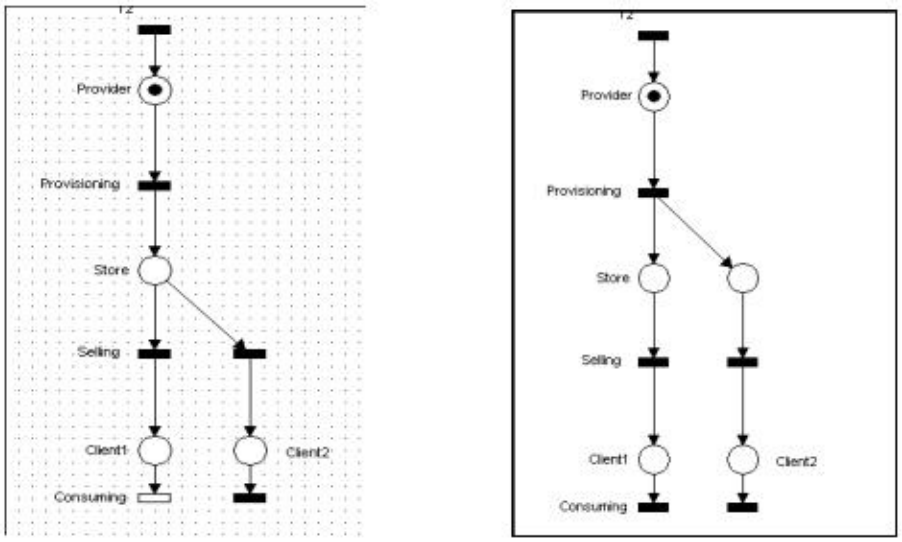
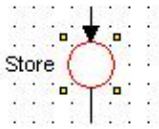


Figure 4: Two client supply chain process

Property	Value
Name	Store
Size	Normal
Show Name	TRUE
Show Capacity	FALSE
Initial Tokens	0
Current Tokens	0
Capacity	1
Tokens Count	0



Property	Value
Name	P4
Size	Normal
Show Name	FALSE
Show Capacity	FALSE
Initial Tokens	0
Current Tokens	0
Capacity	1
Tokens Count	0

Figure 5: The two store left right nodes

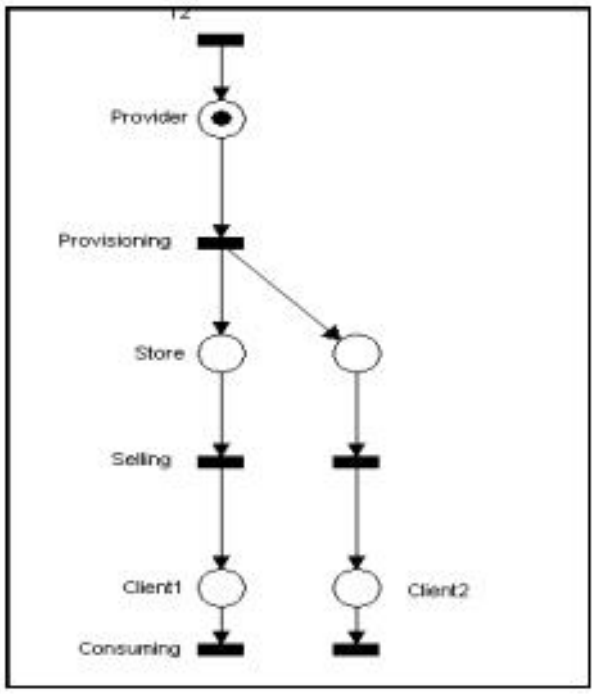


Figure 6: Two client supply chain process hawing two store nodes

In this case (figure 4) we have a conflict – confusing situation. When one of the two store nodes is marked in "Store" (figure 5), we can not predict which of the two clients will be satisfied, so it is a random situation.

For solving this situation we can use two methods:

1. Introducing a new node on the Store level, so we shall insert a new resource which will bring us to the following situation:

2. Using a special transition category called temporized transition. These transitions are not executed on each execution step, but only at a defined number of steps. This will mean that it will exists an agreement between the clients, so a new demand of supply will be made not instantly after the use of previous supply, but with a specified delay.

This modifying will affect the consuming level transitions, using an additional arc, which will confirm that one of the clients have received the merchandise, and the next client will follow.

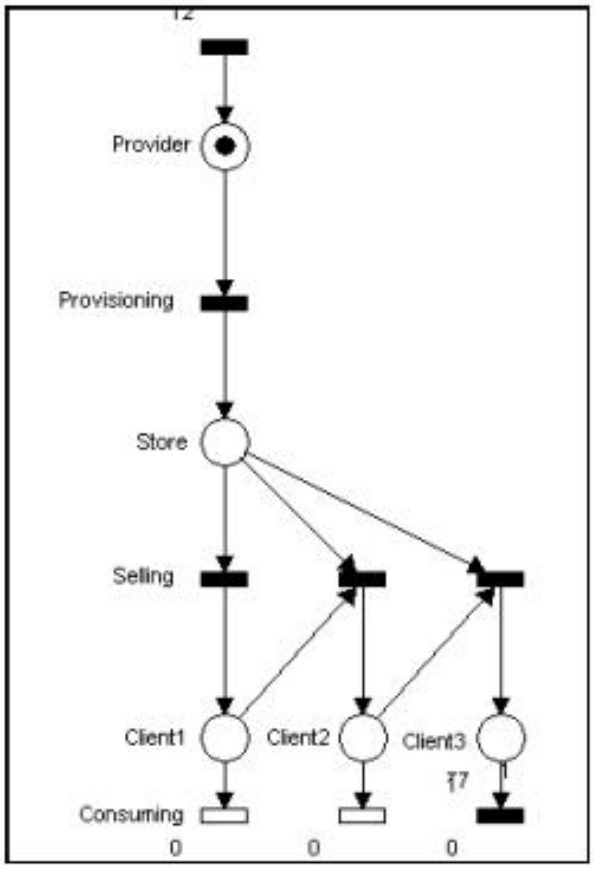


Figure 7: Multi client supply chain process

This regulation of the clients create a FIFO list , which will apply for 1 to n clients. The next figure will show 3 clients, which will be satisfied in a temporized order.

5. Conclusions

We have used HPetriSym software for modeling the supply chain process. We can conclude that the system which used the simple supply chain process modeled by Petri Nets can be generalized for n clients, being an alternative for resource multiplication, depending on the number of clients.

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