

## A PETRI NETS APPLICATION IN THE MOBILE TELEPHONY

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**Abstract** Petri nets are used to describe graphically the structure of the distribute systems that need some representations of the concurrent or parallel activities. It represents a modelling language that is applicable to a wide variety of systems thanks to their generality and permissiveness. There are many types of Petri nets; more studied in this paper are CEN(Condition Event Nets), PTN(Place Transition Nets) and CPN (Coloured Petri Nets).

This paper aims to reveal the differences between these three types of Petri nets using an application on a mobile phone. From the several processes that the mobile phone can be used for, it is presented the action of sending the data using infrared or bluetooth system.

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### 1. INTRODUCTION

A Petri network is a mathematical representation for the discrete distribute systems. As a modelling language, it can describe graphically the structure of a distribute system using a direct graph with labels. This network contains nodes which can determine the places, nodes that can determine the transitions and direct arcs that are connecting the places with the transitions.

A Petri network is a 5-tuple  $PN=(P, T, F, W, M_0)$ , where

$P = \{p_1, p_2, \dots, p_m\}$  is a finite set of places,

$T = \{t_1, t_2, \dots, t_m\}$  is a finite set of transitions,

$F \subseteq (P \times T) \cup (T \times P)$  is a set of arcs,

$W : F \rightarrow \{1, 2, 3, \dots\}$  is the weight function,

$M_0 : P \rightarrow \{0, 1, 2, 3, \dots\}$  is the initial marking,

$$P \cap T = \emptyset \text{ and } P \cup T \neq \emptyset.$$

The Petri networks are using graphical symbols to represent states (usually represented by circles), transitions (usually represented by squares) and arrows from the states to the transitions and from the transitions to the states.  $\bigcirc \rightarrow \square \rightarrow \bigcirc$ . The states can be called places or conditions, and the transitions are also referred like events.

The condition event networks (CEN) represent the base type for the Petri nets. A CEN is formed through *conditions* (states), *events* (transitions) and *connections* (arrows) from the conditions to the events and from the events to the conditions.

A simple extension of the condition event network is to allow a marking to have more than one token for the conditions. These networks are known as place transition network (PTN). The conditions are now called *places* and the events *transitions*. In a PTN the places are labelled with a positive number that represents the capacity. This means the maximum number of tokens that can be in one place. The arrows can be labelled with a positive number representing the weight.

In the colored Petri nets (CPN) there is a difference between the tokens. The term colored is referring to the fact that the tokens are distinct through the value, that is called color. In a CPN to any place it is associated a colored set that is specifying the set of the colors for that place. A transition may have a sequence of guard expressions that will be evaluated to a Boolean value. The arrows from the places to the transitions and from the transitions to the places are called arcs.

## 2. SENDING THE DATA USING INFRARED AND BLUETOOTH SYSTEM

Sending the data using infrared or bluetooth system needs to proceed the following steps:

- 1 select the file that have to be sent;
- 2 select the type of the sending (infrared or bluetooth);
- 3 - bluetooth

- looking for the available mobile phones;
- selecting the mobile phone for sending;
- infrared
  - connecting using infrared system to the other mobile phone;
- 4 sending the file to the mobile phone;
- 5 receiving the file from the first mobile phone;
- 6 receiving the message about the successful sending.

The special cases of this process are of interest. Such is the moment when it is possible to send a file through infrared or the moment when it is possible to send through bluetooth, and all the settings that are included.

We suppose that it is not possible to send from a mobile phone one file through infrared and bluetooth system at the same time. Thus, the first rule is that for sending one file through infrared it is necessary that the phone not to send files using bluetooth. Similarly for the bluetooth not sending the file through infrared. In the same time it is not possible to send more than one file using any of the two systems. For sending the second file it means waiting for the finishing process of sending the first file.

The preconditions for the event *sending through infrared* are:

- *system for sending through infrared free;*
- *system for sending through bluetooth free;*
- *ready for sending through infrared.*

The postcondition for this event is *ready to receive through infrared*.

In the same time for occurring bluetooth event *sending through bluetooth* there are preconditions:

- *system for sending through infrared free;*
- *system for sending through bluetooth free;*
- *ready for sending through bluetooth.*

The postcondition for this event is *ready to receive through bluetooth*.

For a PTN we suppose that for sending the data through infrared we need the same resources as for sending the data through the bluetooth system. The number of the available resources is three. One process that doesn't get the necessary number of resources for running will wait until the resources will become free. The place *Keys* will show through a token each resource that is in use. When one process of sending the data is finished, the used resources are being returned in the place *Keys* and proceed to the other actions which don't need the critical resources. For representing using CPN the number of places

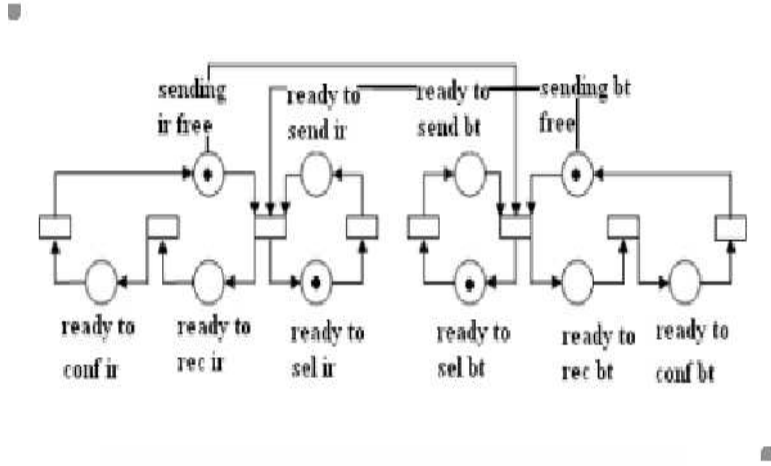


Fig. 1. CEN for Sending the File

will be reduced. It is not necessary to have representation for sending the file through the infrared and a separate one for sending through the bluetooth. Previously there were three preconditions for each case, now there is just one place, and the marking with colors will make the difference between the two cases. The function  $S(x)$  is making the connection between the case of sending the data using one system and the possibility of realizing this process.

Further we study the properties of this system. For this we use just the PTN diagrams. The networks above are bounded, because there are no places in which the number of the tokens become infinity. As noted from above the

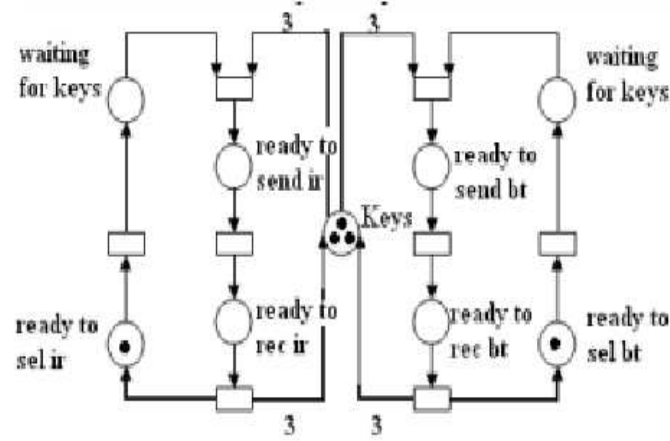


Fig. 2. PTN for Sending the File

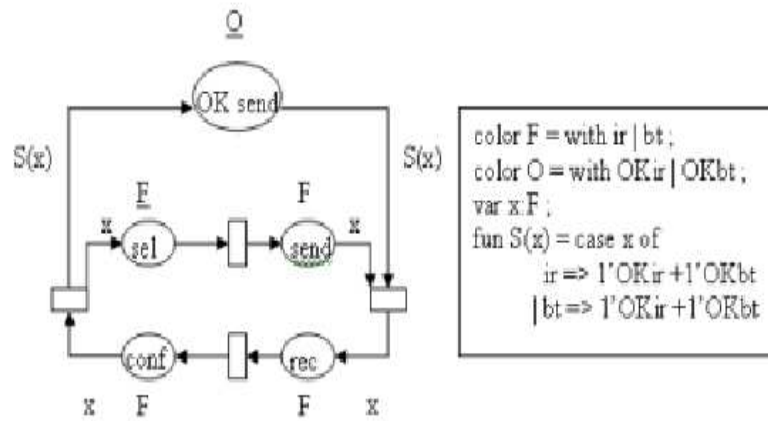


Fig. 3. CPN for Sending the File

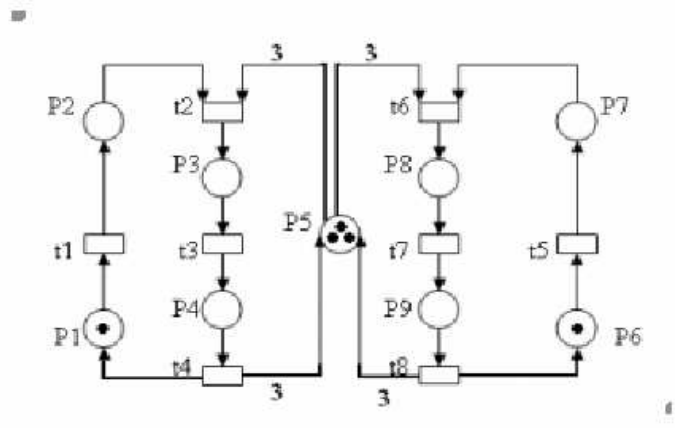


Fig. 4. Figure 2 with the Places and the Transitions Numbered

liveness property, we can say there are no dead transition, so the networks are 3-live. In the same time the networks above are reversible, coverable and persistent.

For getting the coverability tree for fig. 2, we numbered the places and the transitions. Thus the initial marking will be  $M_0=(1,0,0,0,3,1,0,0,0)$ . Here two transitions  $t_1$  and  $t_5$  occur.

If  $t_1$  will fire we get the marking  $M_1=(0,1,0,0,3,1,0,0,0)$ , then two transitions  $t_2$  and  $t_5$  can occur.

If  $t_2$  will fire we get the marking  $M_2(0,0,4,0,0,1,0,0,0)$ . For  $M_3$  there are two transition that can occur,  $t_3$  and  $t_5$ .

If  $t_3$  will fire we get  $M_3(0,0,0,4,0,1,0,0,0)$  then can occur  $t_4$  and  $t_5$ .

If  $t_4$  will fire we get  $M_4(1,0,0,0,3,1,0,0,0)=M_0$ , so the node  $M_4$  will become "old".

If  $t_5$  will fire in  $M_3$  we get the marking  $M_5(0,0,0,4,0,0,1,0,0)$  then it can occur the transition  $t_4$ . If  $t_4$  will fire we get  $M_6(1,0,0,0,3,0,1,0,0)$  then  $t_1$  and  $t_6$  can occur.

If  $t_1$  will fire, then we get  $M_7(0,1,0,0,3,0,1,0,0)$  and  $t_2$  and  $t_6$  can occur.

If  $t_2$  will fire, we get the marking  $M_8(0,0,4,0,0,0,1,0,0)$ , then the transition  $t_3$  can occur. After firing the transition  $t_3$  we

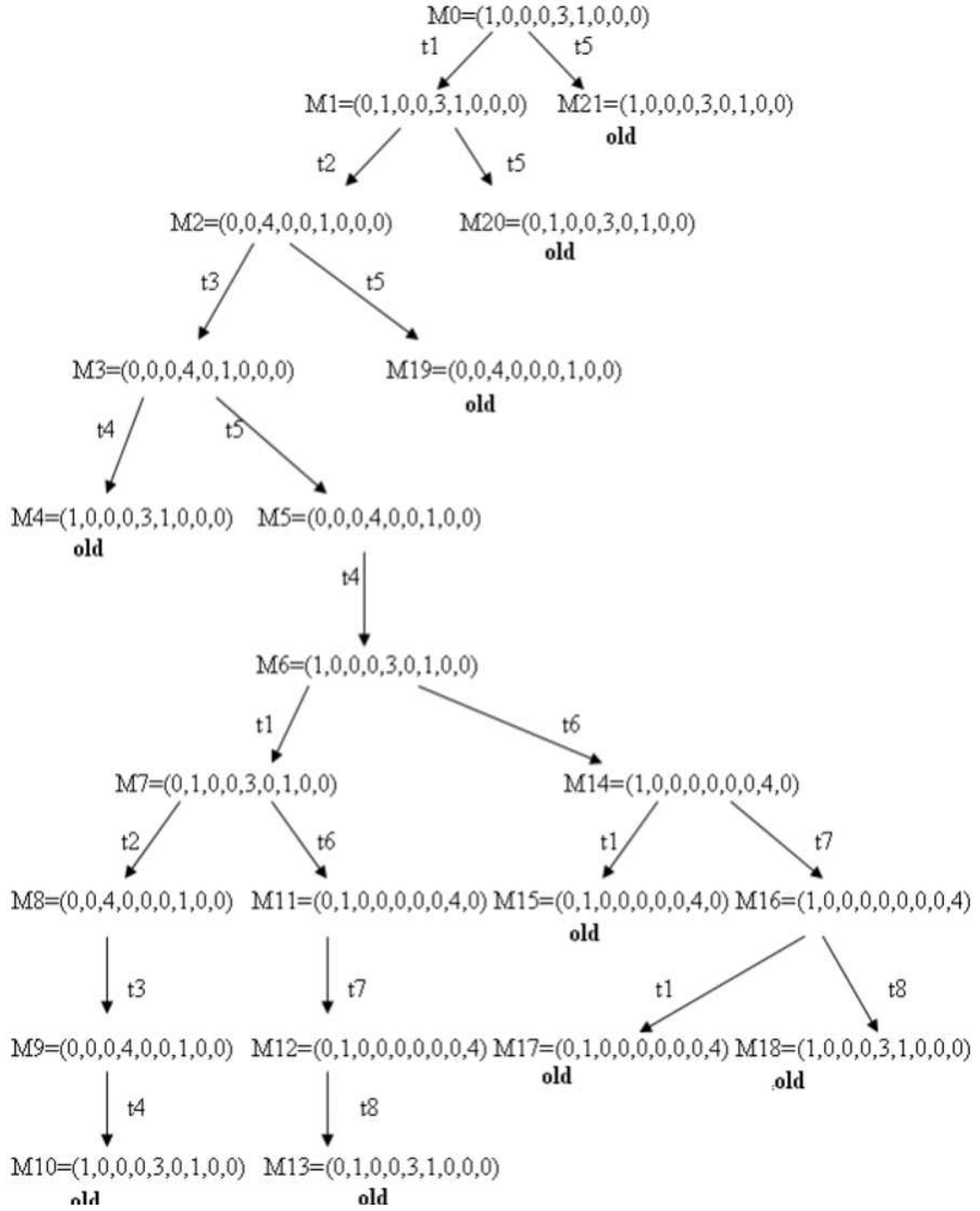


Fig. 5. The Coverability Tree for the Figure 2

get  $M9(0,0,0,4,0,0,1,0,0)$ . For this marking it can occur  $t4$ .

After firing  $t4$  we'll get  $M10=(1,0,0,0,3,0,1,0,0)=M6$ ,

so the node  $M10$  is "old".

If for  $M7$  will fire  $t6$  we get the marking  $M11=(0,1,0,0,0,0,0,4,0)$

for which it can occur  $t7$ .

The firing of  $t7$  is getting the marking  $M12=(0,1,0,0,0,0,0,4,0)$ .

For this marking the transaction  $t8$  can occur. After firing

this transition we get the marking  $M13=(0,1,0,0,3,1,0,0,0)=M1$ ,

so the node will be labeled "old".

If for  $M6$  will fire  $t6$  we get the marking  $M14=(1,0,0,0,0,0,0,4,0)$

then it can occur  $t1$  and  $t7$ .

If  $t1$  will fire we get the marking  $M15=(0,1,0,0,0,0,0,4,0) =$

$M11$  so the node will be "old".

If for  $M14$  will fire  $t7$  we get the marking  $M16=(1,0,0,0,0,0,0,4,0)$

then it can occur  $t1$  and  $t8$ .

If  $t1$  will fire we get  $M17=(0,1,0,0,0,0,0,4,0) = M12$ , so the

node  $M17$  will be labeled "old".

If for  $M16$  the transaction  $t8$  will fire we get the marking

$M18=(1,0,0,0,3,1,0,0,0)=M0$ , so the node will be "old".

If for  $M2$  will fire  $t5$  we get the marking  $M19=(0,0,4,0,0,0,1,0,0)=M8$ , so

the node  $M19$  will be "old".

If for  $M1$  will fire  $t5$  we get the marking  $M20=(0,1,0,0,3,0,1,0,0)=M7$ , so  $M20$

will become "old".

If for  $M0$  will fire  $t5$  we get the marking  $M21=(1,0,0,0,3,0,1,0,0)=M6$ , so the

node  $M21$  become "old".

The coverability tree that result is in Figure 5.

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