

Development of Effective Urban Road Traffic Management Using Workflow Techniques for Upcoming Metrocities like Lucknow (India)

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Abstract

This paper discusses the application of Petrinet as the workflow tool to model urban Traffic system. The paper is divided into phase : the first phase deals with orthogonal extension into phase : the first phase deals with orthogonal extension of Petrinet to enhance the permutation of control and traffic flow simulation. The second phase discusses application of continuous pertinent with intelligent agents to the model the UTS in continuous format with single central control agent.

1. Introduction

The fast rate of urban growth has always posed a serious challenge to road capacity of a growing city like Lucknow. Unless attention is immediately directed for designing and implementing an optimal system and efforts are made on a continuous basis to build up adequate carrying capacity, we will never be able to remove congestion, Lucknow is eight most upcoming cities in India which has witnessed sudden rise in population during last five years. According to the projected survey. The population of Lucknow will be doubled 2013. The core areas of the city going or coming in are characterized by insufficient with which do not permit smooth flow of traffic. The absence of rail based transport system and inadequate city buses has led to frequent use of private vehicles leading to congestion.

The rapid increase in vehicular trips without corresponding increasing in road space is causing heavy congestion in many parts of the city.

There were various traffic studies being conducted on Lucknow and the traffic volume survey reveals that : - traffic volumes are high in Hazrat Ganj, because of the shops and offices, Nakahindola and Sadar because of bulk trading activities during early morning hours and this concentration shifts itself to residential areas like Gomti Nagar, Indira Nagar and Aliganj during evening till 8 p.m.

Direction wise analysis also explains that nearly 50% of the locations the traffic volume is almost double the capacity.

The average passenger car occupancy is about $1.7 \cong 2$ which is quite low leading to unnecessary congestion.

From the above findings anyone can conclude the simplest solution could be to wider the existing road Network. Widening road network probably is not the only solution, there are other factors too which we have to take into consideration before reaching to a conclusion. In this paper we have used patients as the workflows Tool to model and analyze the complex traffic control system. This paper is divided into two sections, the first part deals with application of petrinet in orthogonal n- array structure for modeling complex condition. The second part deals with making the pertinent flow Intelligent in deriving its own solution when required.

2. Petrinet : A Brief Overview :

Petrinet are a well founded process modeling technique. It was invented by Carl Adam Petri in the sixties since then petrinets have been used to model and analyze all kinds of processes. In nineties petrinet has been extended with color, time and hierarchy. Although there are other workflow technique available but petrinet has certain edge over then like :

- Formal semantics
- Graphical Nature
- Expressiveness
- Vendor Independent.

2.1 The Basic Model :

To consider our model let us first deal with a simple graphical model with Hazratganj as the Nodal point from this point traffic converges and diverges.

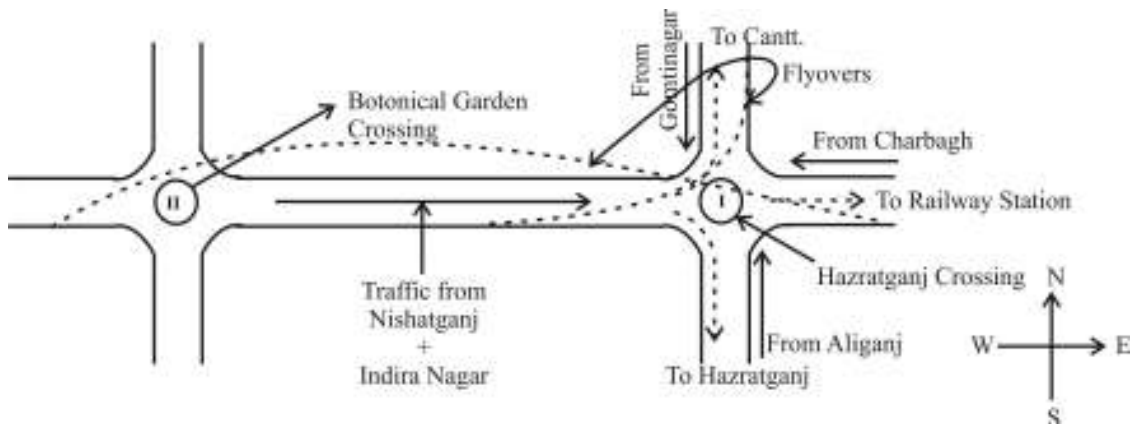


Figure 1. Main Hazratganj Crossing at its interconnectivity. Traffic flow is from Crossing-II to Crossing-I.

In the first instance we consider all the traffic powering into crossing (I) i.e. Hazratganj Crossing from other localities like Indira Nagar, Aliganj, and Gomti Nagar and Charbagh.

The basic model is being derived from stochastic Petrinet Modeling by Yi Deng . It consists of flow of vehicle from one location to another in the direction of east to west or to south along with petinet representation of Traffic light control. In order to avoid congestion at

Hazratganj Crossing (i.e. crossing -I) if we introduce two flyover one of the flyover starting just before crossing II and ending after crossing -I for the commuters whose destination is Charbagh. We can have the following general diagram for four 4-phase intersection as adopted from Jin and Deng (2006) in Fig. 2. Similarly the general control model will be complex petrinet network as shown in Fig. 3.

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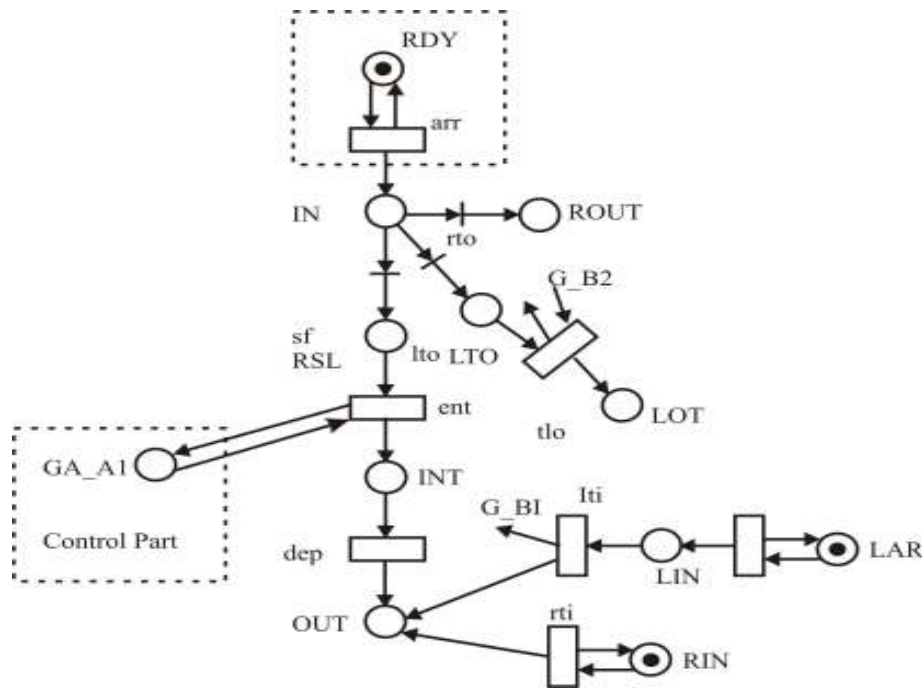


Figure 2. The Traffic flow model of 4-phase intersection

Similarly the general control model will be complex petrinet network as shown in Fig. 3.

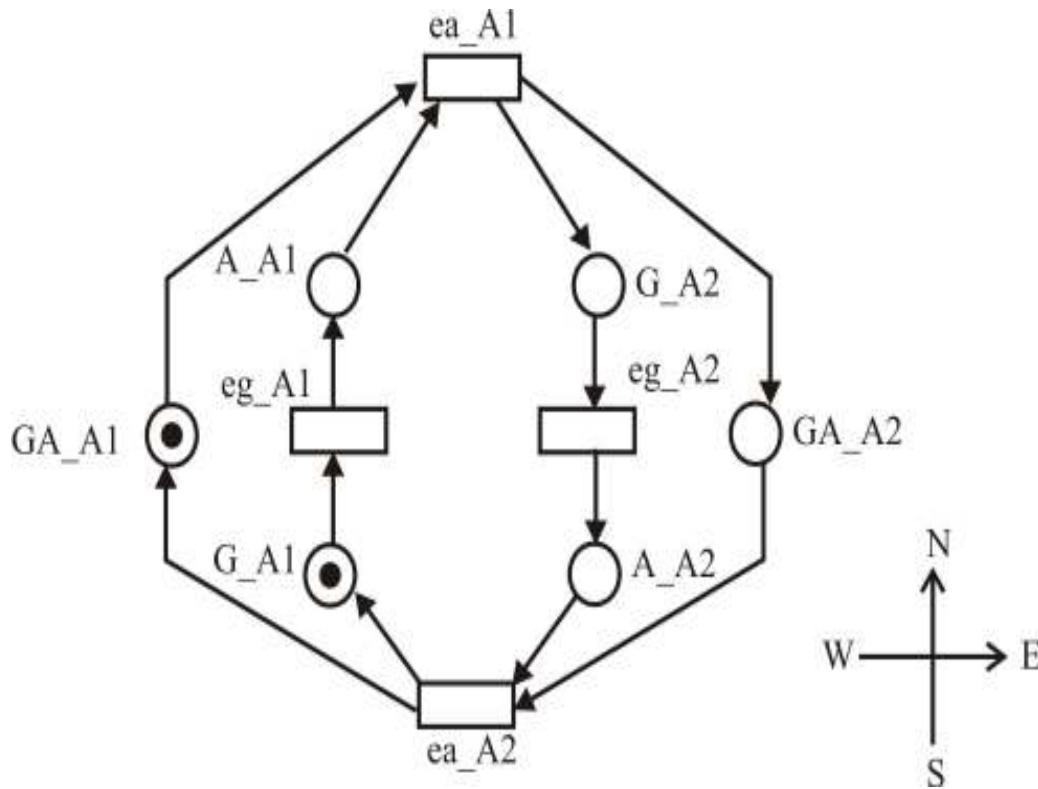


Figure 3. The control model of 2-phase intersection

3. Orthogonal Extension

In order to link signals and flow of traffic moving from west to east or vice versa across the flyover similarly for west to North we extend pertinent in orthogonal representation.

There are many applications in which the input parameters is small and the values of each of the parameters may take are clearly bounded. When these numbers are very small it is possible to consider every situational input permutation and exhaustively test process it.

When orthogonal arrangement of pertinent is done the Black Dots are dispersed uniformly throughout the domain.

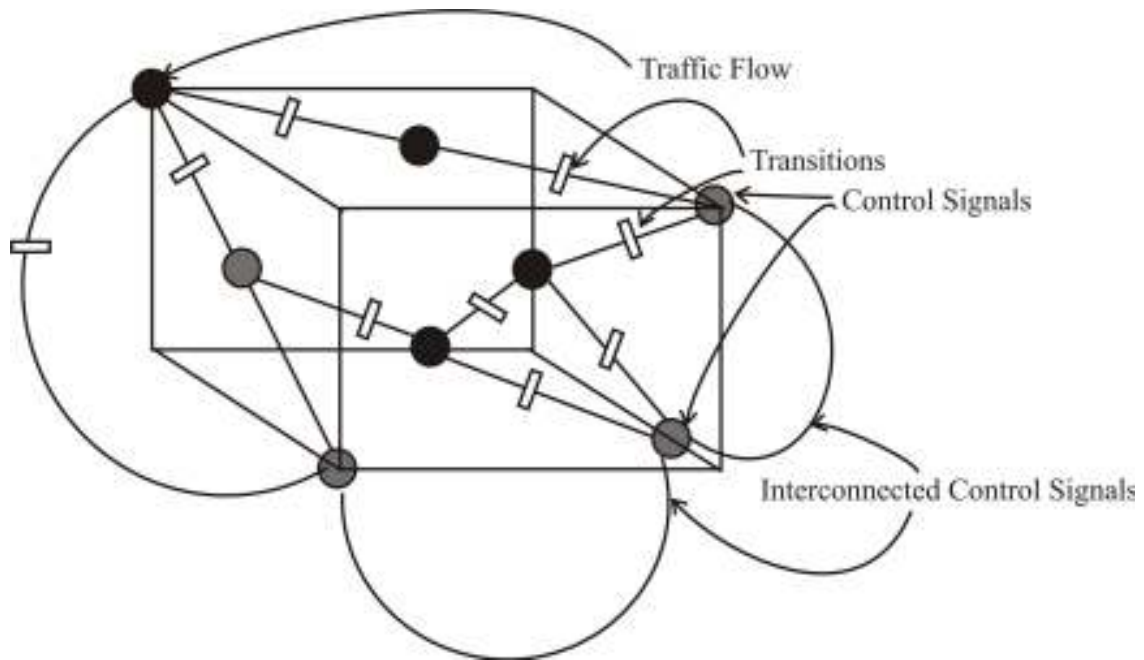


Figure 4 : Orthogonal Petrinet Case Testing

The above mentioned Traffic situation is not only linked to one crossing i.e. Botanical Garden but also to all preceding Traffic coming in the way of Indira Nagar to Hazratganj route. To illustrate the use of orthogonal array we assume all the control signal functions on the above mentioned route are having the same message i.e. Traffic " Jam at Hazrat Ganj crossing". So this Jam function is passed with four stochastic parameters. Each taking three discrete values.

- x1 = 1; Increase the Red Light Duration
- x2 = 2; Divert the traffic to Right sublane
- x3 = 3; Display NO GO on VMS.

Similarly x2, x3 and x4 will also take on values 1,2 and 3. If we choose one input at a time then we can have nine permutations of combining traffic flow and crossings. This means that chances of controlling the traffic will be much more higher and efficient. The orthogonal array testing approach enables us to provide good coverage.

3.1. Intelligent Continuous Multi Agent Petrinet Model (ICMPM)

To further extend the above problem we plan to make the stochastic parameter passing more intelligent by introducing Intelligent Agent which will coordinate and communicate between Petrinet Traffic flow and Control Network. The basic structure is shown in figure 5:

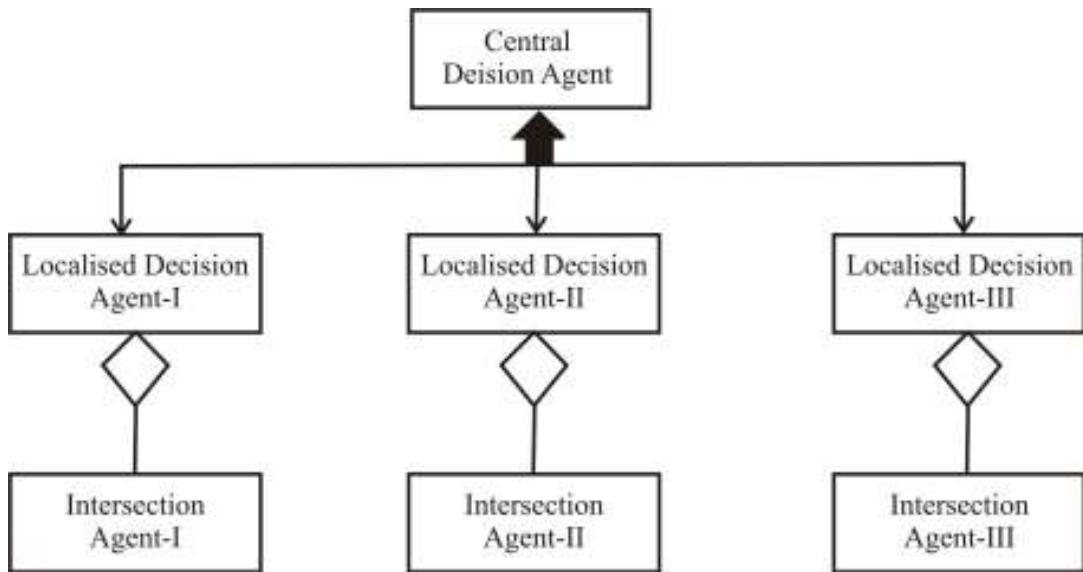


Figure 5. Model of Agent oriented Traffic Control

In order to represent the above agent model in Petrinet Dynamics we have to deal with multi level Architecture of the control Model.

The petinet flow model of control Agent will receive and send signals from localised Decision Agent. The intersection Agents are functioning in two aspects like information gathering from real time situation and subsequently receiving the necessary instructions from the superior agents. The generalised layerical structure can be shown by the figure 6.

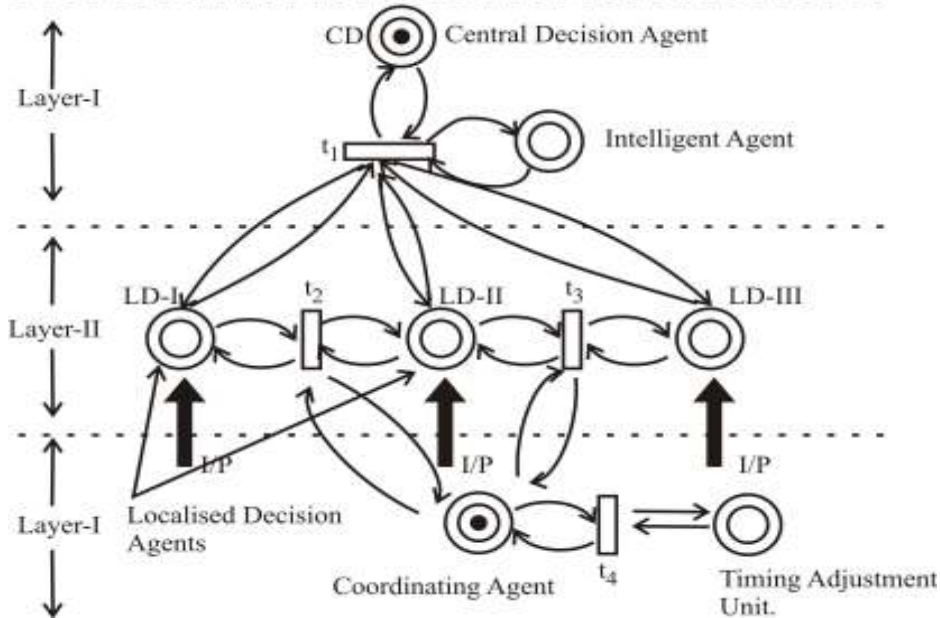


Figure 6. A continuous Petrinet representation of Control Section with Intelligent Agents and Timing Adjustment Unit.

The “ Double Circle ” represents the continuous Petri nets adopted from Jorge and Bod Model (2005). The central agent and other localized decision agents LD-I to LD-III are also in continuous working mode, the two way arrows show the flow of action and information in both the directions. The local agents receives the information from the various sensors and CCTV located at all the three functions any diversions or unusual conditions will be passed on to local decision center from where this information then moves upward to central decision agent for necessary action. The central decision agent takes the help of intelligent agent for firing of any new activity. The intelligent agent consists of necessary subroutines and set of algorithm which are also activated in a dynamic mode. The working of Intelligent Agent decision making can be understood in a simple way by considering Agent to have a short memory associated with it. It operates by keeping in memory its store percept sequence and using, it to index into table, which contains the appropriate action for all possible percept sequences shown in Table-I.

Table I : An Agent based Algorithm of look up table.

Function TABLE DRIVEN AGENT (percepts) returns action
Static : percepts, a sequence, initially empty table, a table, indexed by percept sequences append percept to the end of percepts.
Action ← Look up (percepts, tables) return action.

Now let us how the intelligent agent draws the table and in what factors it is to be categorised. The controlling agent task is extremely open ended there is absolutely no limit to the combinations of the circumstances the can arise. The Percepts, Actions, Goals and Environment can be summarised in Table-II.

Table-II : Agent Generated Table.

Agent Type	Percepts	Actions	Goals	Environments
Decision Center	Cameras, GPS, Wireless Communication	Divert Traffic, No. Go, Flyover only, Signal Timings	Safe, Fast smooth flow of Traffic	Road, Flyover, Crossing signals, Traffic

The decision signals flows from decision center to the localised agents. The localised agent then pass this information to second part of Layer-I (control and Decision Layer) Here the coordinating agents further freezes the current situation at all the three agents and sets the priority accordingly regarding diversions or traffic flow diversion from and to the flyovers. The main focus of showing continuous petinet is to make the model more real time representation of the Traffic situation, by integrating it with orthogonal Model and placing entire set of continuous controlling structure as one single block, we can easily enhance the discrete time internal permutations into more continuous format as shown in Figure 7.

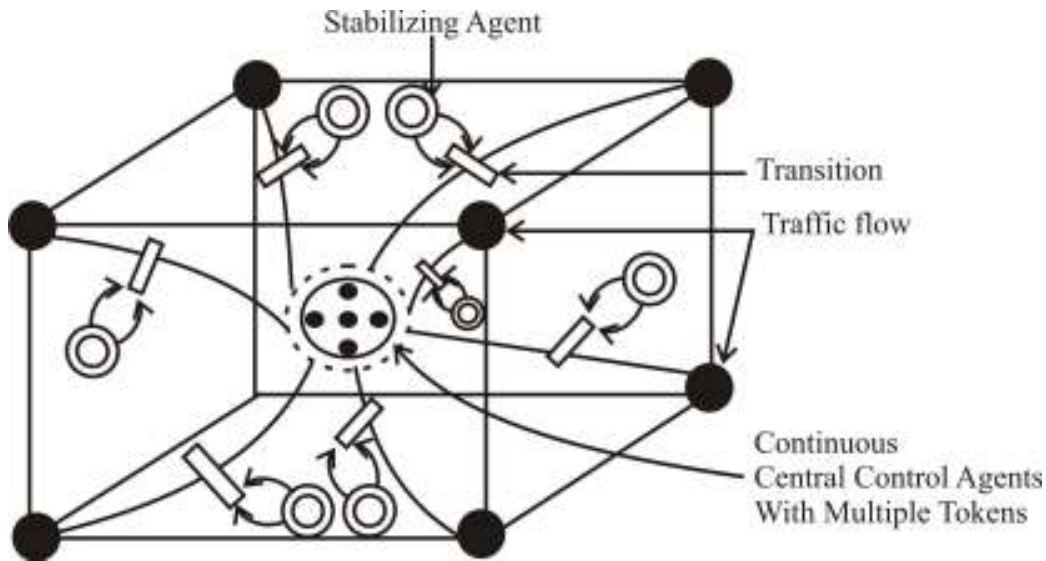


Figure 7. Modified Orthogonal Petinet Model of Urban Traffic System

The Modified central Agent has as many tokens as many traffic flow points. The main modification is at the transitions where stabilizing agents are being used in order capture and compare the decision made by the central agent and then apply it on to the current traffic flow at various points.

4. Conclusion

The growing complexity of urban Traffic requires the use of advanced tools and various types of analysis which could simulate the traffic in real time.

Although there are sufficient tools to analyze the results but on the other hand they have great limitations related to their graphical interface. In this paper we have tried to demonstrate the compositional method for modeling and performance evaluation of complex traffic situations. By using the orthogonal approach we have increased the permutation of various test cases in state space dimensions. To make the model more real life we have introduced the concept of Multi Agent System, by the help of continuous petinet system we have derived a more collaborative model of Multi Agent System.

Future extension of one work deals with software realisation and testing of Intelligent Continuous Multiagent Petinet Model. (ICMPM).

5. References

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