Simulation of Random Waypoint Mobility Model Using Coloured Petri Nets

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Abstract

Due to dynamic nature of ad-hoc network and in order to simulate a network protocol, it is essential to use a mobility model that represents how the mobile node utilizes the given protocol. Selection of mobility model can determine whether the proposed protocol will be useful or not. This paper introduces random waypoint mobility model for describing simulation of mobile nodes distribution within then network. Before simulation, UML (Unified modeling language) modeling is done to describe the structural view of a model and also for error correction. The simulation process has been done with the help of hierarchical coloured petri net which is extension of normal coloured petri nets.

Keywords

Random Waypoint Mobility Model (RWP MM), Mobile Ad-hoc Network (MANET), Coloured Petri Nets (CPN),Unified Modelling Language (UML).

1. Introduction

Mobile ad-hoc network is infrastructure less network where nodes can move freely in the network. So the node mobility is major issue in mobile ad-hoc networks. There are several Mobility models, which are used to describe node movement within the network and are needed in the evaluation of protocols for medium access, power management, leader election, routing, and so on. Therefore, the choice of mobility model can significantly affect the simulation result [1].Simulation of ad-hoc network uses two types of mobility model: 1) Traces and 2) Synthetic model [2]. The mobility pattern in real time systems is observed by traces. Synthetic model provide realistic behavior of mobile nodes without use of traces [3].Random Waypoint mobility model is a synthetic model. RWP mobility model is one of the mobility model, which is the basic building block of most of the routing protocols. In RWP mobility model, node movement is concentrated in the middle of a simulation area (border effect) [4,5,6], because node bounce back, when it reaches to the network boundary.

Ad-hoc networks protocol has ability to behave correctly in dynamic environment. Main key issue is that the nodes may change their position continuously, and therefore modeling of user's movement is required in such dynamic network[15]. This include several considerations like allocation of nodes at the start up, dynamic nature of nodes, total number of nodes present and the selection of mobility models[7].

In this paper, nodes are spread in a two dimensional area using random waypoint mobility model. This is the most popular mobility model because of its simplicity. Every node chooses a random direction, destination and speed for its mobility pattern and after reaching to its destination it pauses for some time (called pause time) and again it chooses random direction and destination until the simulation stops. This pause time is independent of direction and speed (vary from [1,v_{max}]).So there are three major factor in RWP mobility model: speed (s),direction (d) and pause time (p) .In RWP mobility model ,node distribution is done randomly although mobility parameters and direction are independent variable.

The rest of this paper is organized as follows. Section 2 describes Related work on CPN and RWP mobility model in ad-hoc network .Section 3 contains UML diagram of RWP mobility model. Section 4 presents implementation of Random waypoint mobility model using CPN tool. Section 5 describes the Simulation parameters and results .We make the conclusion of the paper in the last section.

2. Related Work

2.1 Work done in Ad-hoc networks Using CPN tool

Coloured Petri Nets have been used by some of the researchers for validating and modeling some of the features of the mobile ad hoc networks. Chinara et al. [8] have proposed the validation of neighbor detection protocol for ad-hoc network by using the CPN tools.

Erbas et al. [9] proposed a two designed position based routing approach based model on Colored Petri Nets for mobile ad-hoc network. Here the author shows that the multicast routing protocol delivers better result than the basic ODMRP (On Demand Multicast Routing Protocol). This model (CPN model) developed reliable unicast and multicast routing method based on geographical position of a node.

Kodikara et al. [10] proposed the simulation model of context exchange based on hierarchical coloured petri nets. Simulation of vertical communication model has done which is cross layer info exchange module of context exchange (conEX).State space used for verification of Petri nets dynamic behavioral properties like liveness, home property, boundedness and fairness.

To improve quality of route selection for MANET routing protocol, Nakhaee et al. [11] presented new route selection criteria instead of hop count. This scheme adds two parameter to route request packet: number q_{mean} and number max_q, shows the average queue length and maximum queue length of the nodes in the path respectively. Nakhaee et al. [12], presented an approach to improve AODV protocol routing reliability. The approaches of both the papers ([11] and [12]) are almost same.

It has been studied that much work has not been done on the mobility pattern of the ad hoc networks by using CPN tools. This provides a motivation for the current work where CPN tools have been used for the modeling of the Random Way Point mobility for MANET.

2.2 Random Waypoint Mobility Model

Random waypoint mobility model is most common choice of researchers and its already implemented in NS2, GLOMOSIM and also used in implementation of many network protocols and algorithms. In the previous papers, simulation of random waypoint as a mobility model begins with the nodes distribution informally in the simulation area. Uniform distribution of mobility parameter in the random waypoint mobility model is quite different from the stationary distribution. In stationary distribution [13][14][1],nodes are concentrated around the center of the network. So the point chosen by node while travelling spend more time at center.

For initialization problem [3], there are three approaches. The first approach save the location as position file after that simulation has executed. For every simulation it has to make position file, so that each simulation starts with the stationary distribution. The Second approach suggests discarding starting 1,000 seconds of the simulation time to prevent the initialization problem. The difficulties of these two approaches are that, how long we have to discard. In third approach position and speed of a node are chosen by stationary distribution.

3. UML diagram of Random Waypoint Mobility Model

UML is graphical oriented language. It provides structural and behavioral diagrams. In structural diagram, it consists of class, collaboration and use case diagram. It provides static view of a model. In behavioral diagram, it consists of state machine and other diagrams.

Fig. 1 shows the use case diagram of RWP mobility model. Use case define relationship between actor and use cases [16].In this diagram, NETWORK ANALYST act as an actor .Each ellipse or circle define the use cases (velocity of point, analysis mobility scheme, calculate distance, select route etc).Use cases are set of operation to represent a set of action in order to achieve a goal.

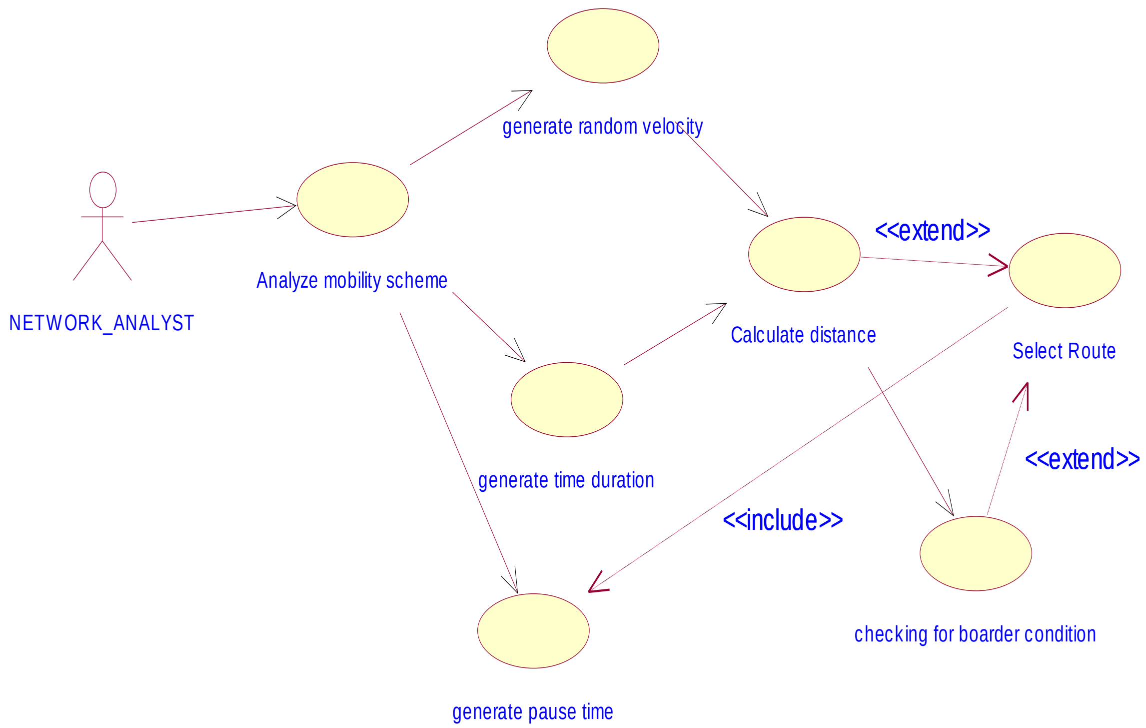


Figure 1. Use case diagram

Fig. 2 shows the class diagram of RWP mobility model. A class diagram consist of a set of classes which is divided into three parts: Class name (MobileNode, Module, MobilityModel etc.), attributes (Speed: sp, time: tm etc.) and operation (finish (), next () etc.). A class consists of set of objects which perform similar operation.

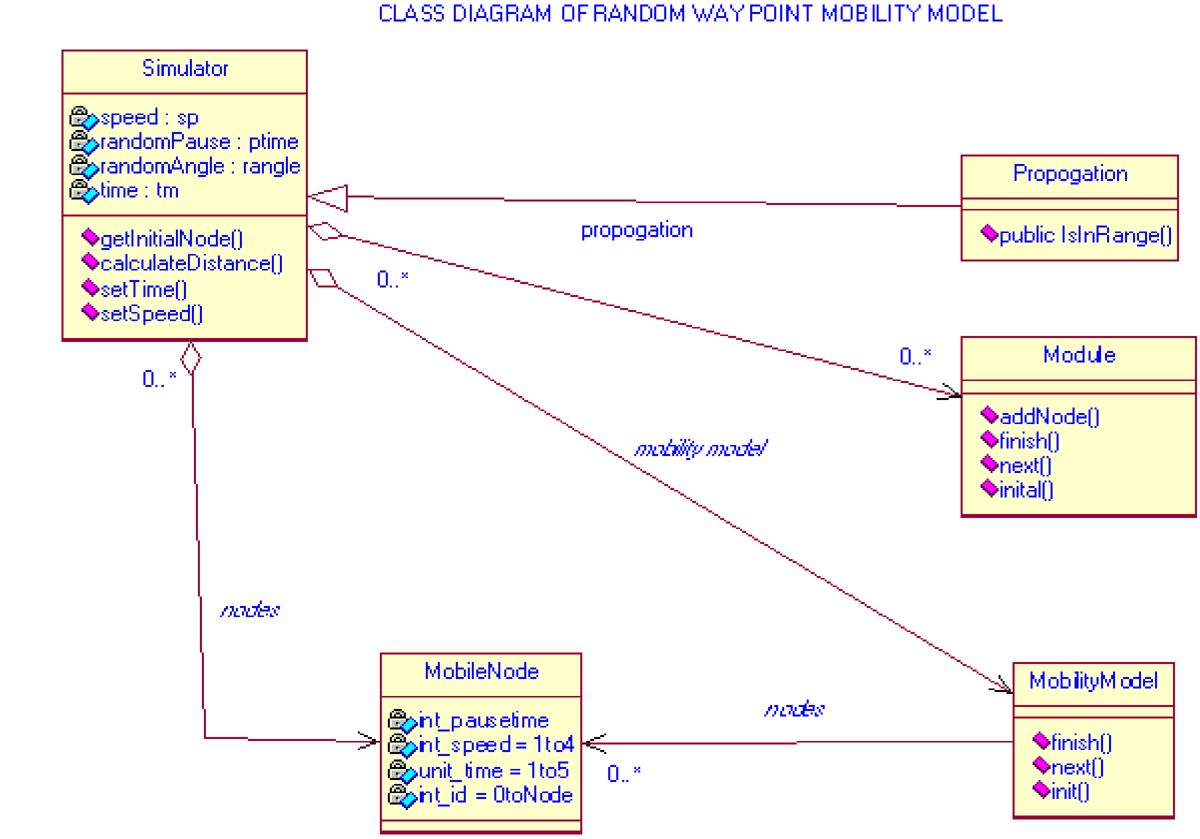


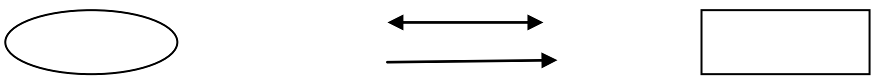
Figure 2.Class Diagram of Random Waypoint Mobility Model

4. Implementation of RWP Mobility Model Using Coloured Petri Nets

4.1 Colored Petri Nets and its Component

Coloured petri nets are used for modeling and validation of a system. It provides communication, concurrency and synchronization.CPN has three basic elements places, arcs and transition. We can write inscriptions by using CPN ML programming language.
Component of CPN [17]:

1. Places: Places drawn as ellipses or circles. Places contain token and each token is attached to data value.

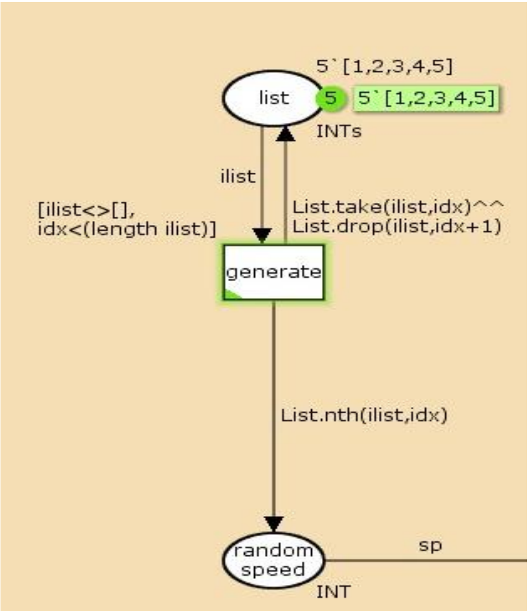


Places Arc Transition

2. Arc: Arcs can be unidirectional or bidirectional.
3. Transition: Transitions drawn as rectangular boxes.

4.2 Implementation

For implementation of any network protocol or algorithm, selection of mobility model is necessary. Synthetic mobility model are well suited for realistic behavior of a network. Random waypoint mobility model is one of the synthetic mobility models [3]. To avoid the initialization problem, speed and direction choose randomly. Pause time is taken same for all the movement to provide stability to the network.



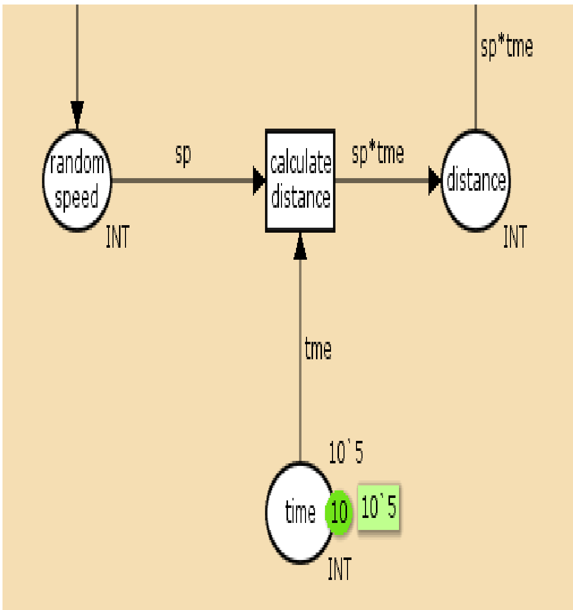


Figure 3. Random speed generation Figure 4. Direction calculation

In fig. 3, there is a random generator function which selects random speed varying from [1, 5]. Each time it generate random speed and by taking constant time, module calculate the distance (by using Speed x Time) (fig. 4).

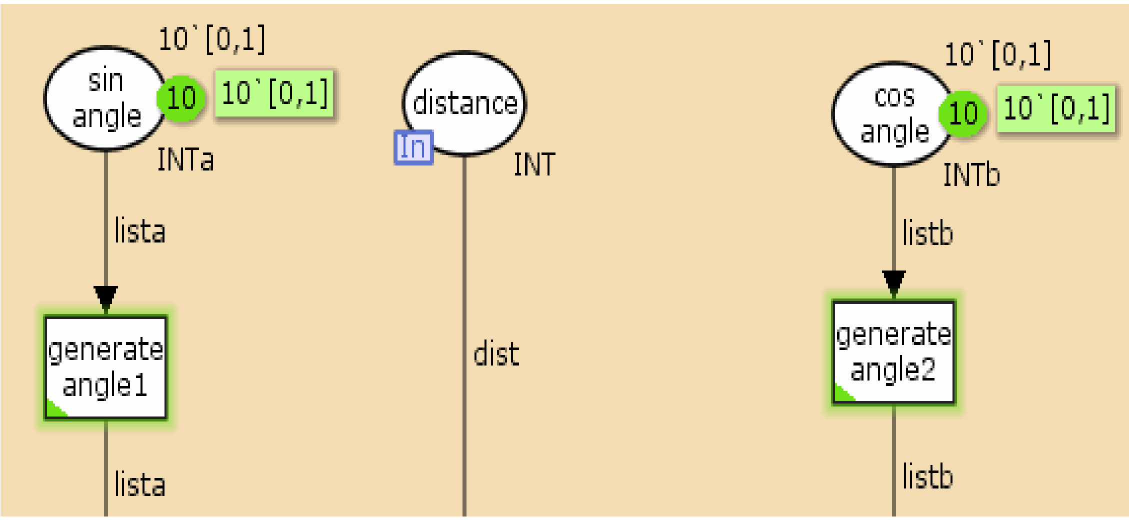


Figure 5. Angle selection

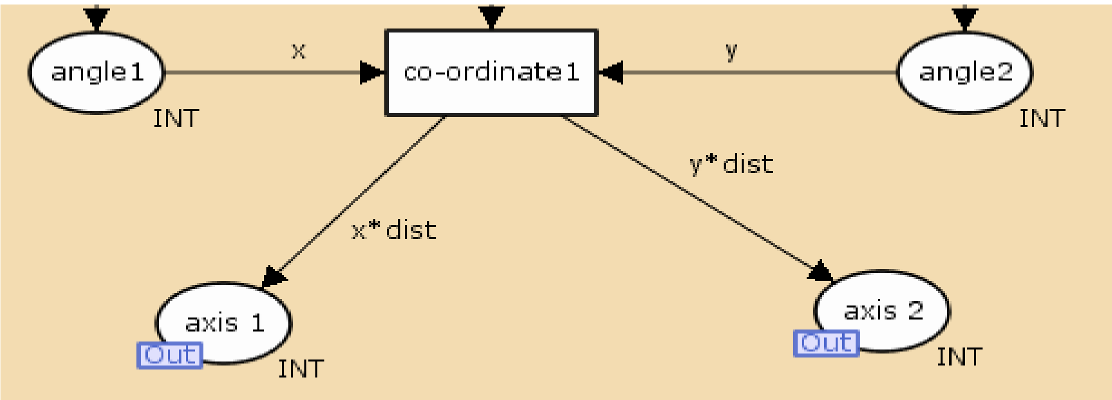


Figure 6.Co-ordinate selection

Meanwhile the second module selects angle by which it has to move as shown in fig. 5. In CPN tool, we cannot take any decimal or negative value so the simulation has limited angle movement. After selecting the angle, it calculates the X and Y co- ordinates.

Suppose we have initial point (x1, y1) and we have to find the next point (x2, y2) .The known parameter are distance (d) and angle (a). By applying a trigonometric formula, we can find the co-ordinates of the next point which is (x2, y2) and this process will continue till the simulation ends (fig 6). The formula is given below:

For finding x co-ordinate: X=r sin a

For finding y co-ordinate: Y=r cos a

Where, r is radial distance.

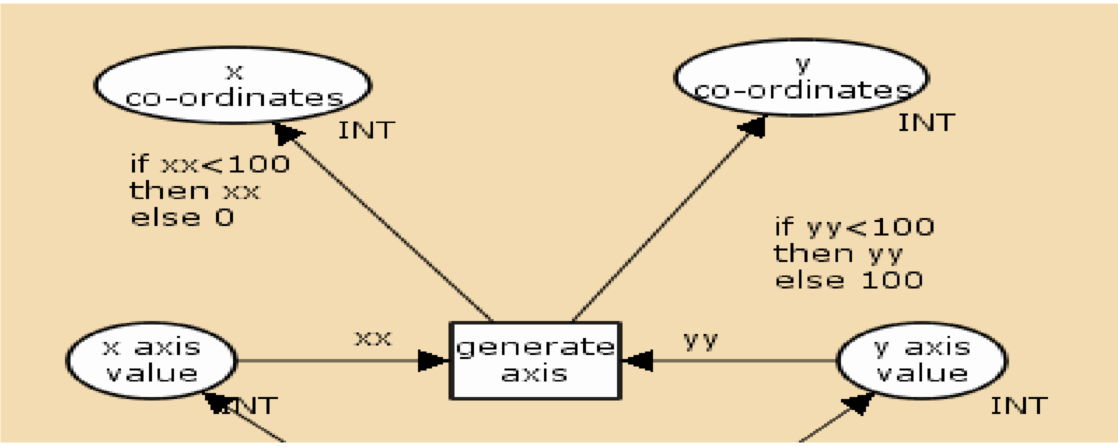


Figure 7. Border checking

The simulation has done within the 100 m x 100 m area. So we have to check border (Figure 7) condition each time. If the distance is greater than 100m then sets the co-ordinate value equal to zero.

The simulation is done in square area which is 100 m x 100 m and its divided into two pages or module. First page (fig. 8) generates random speed and calculates distance between individual moves.

The second page (fig. 9) generates angle from which it calculate the next location co-ordinate value. Pause time taken is 2ms.

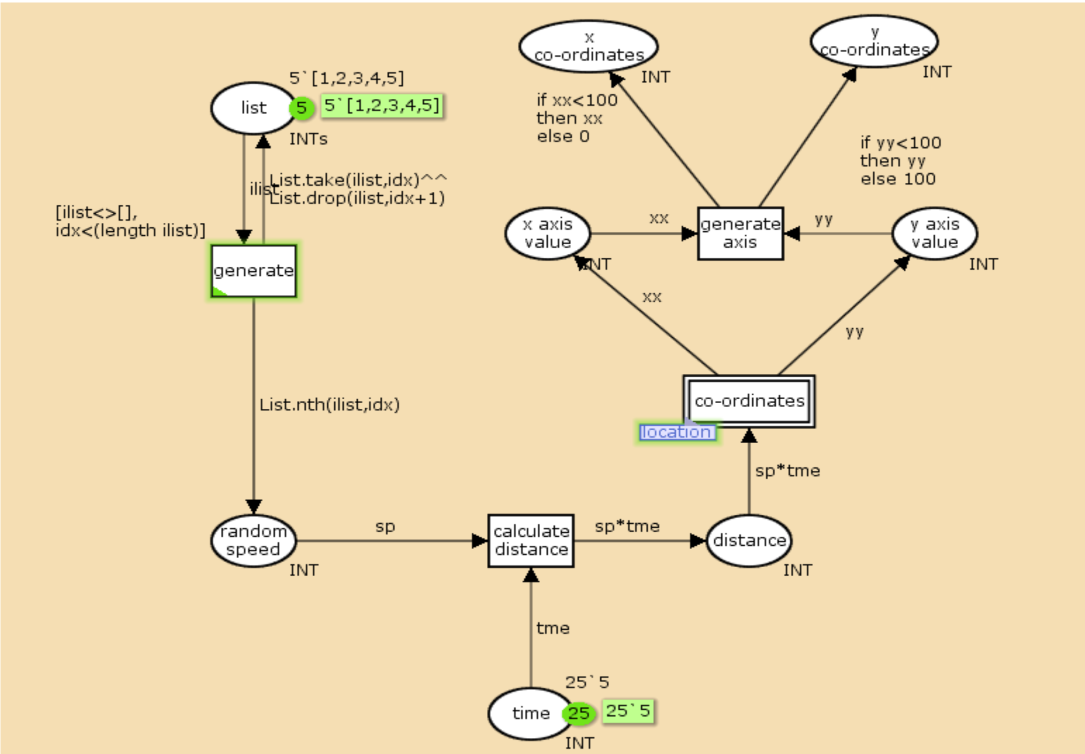


Figure 8 . model of RWP MM in CPN

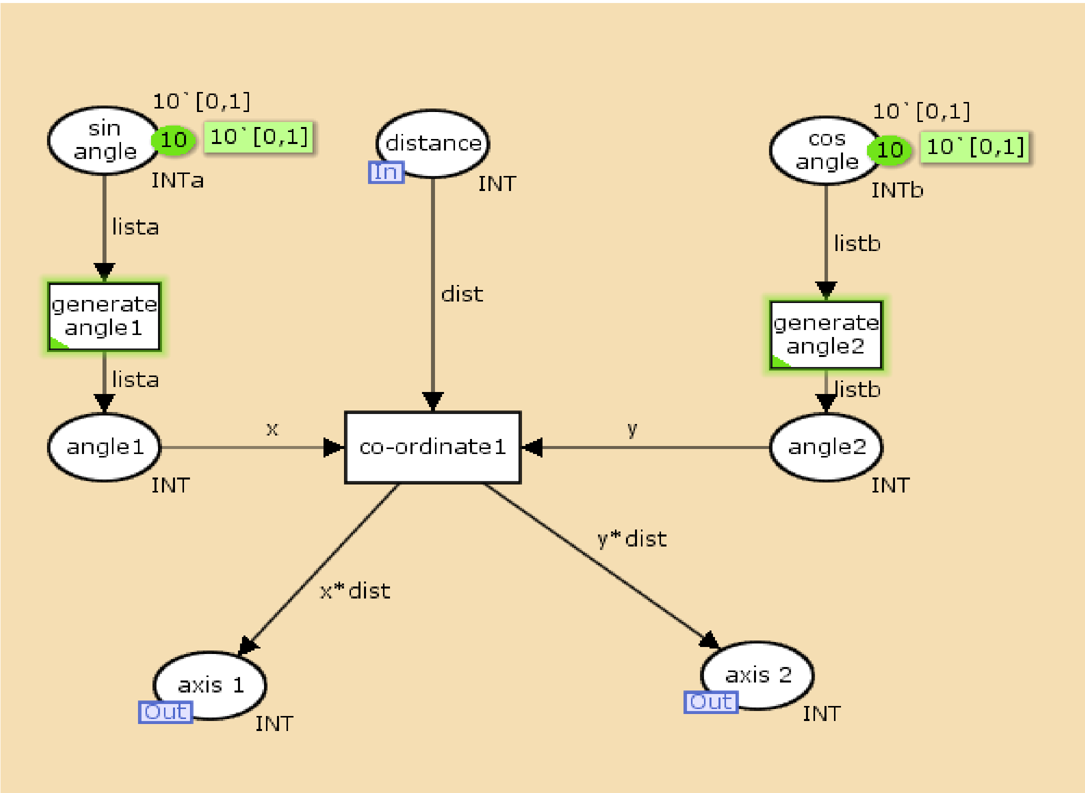


Figure 9 . Running model (module 2) of RWP MM in CPN

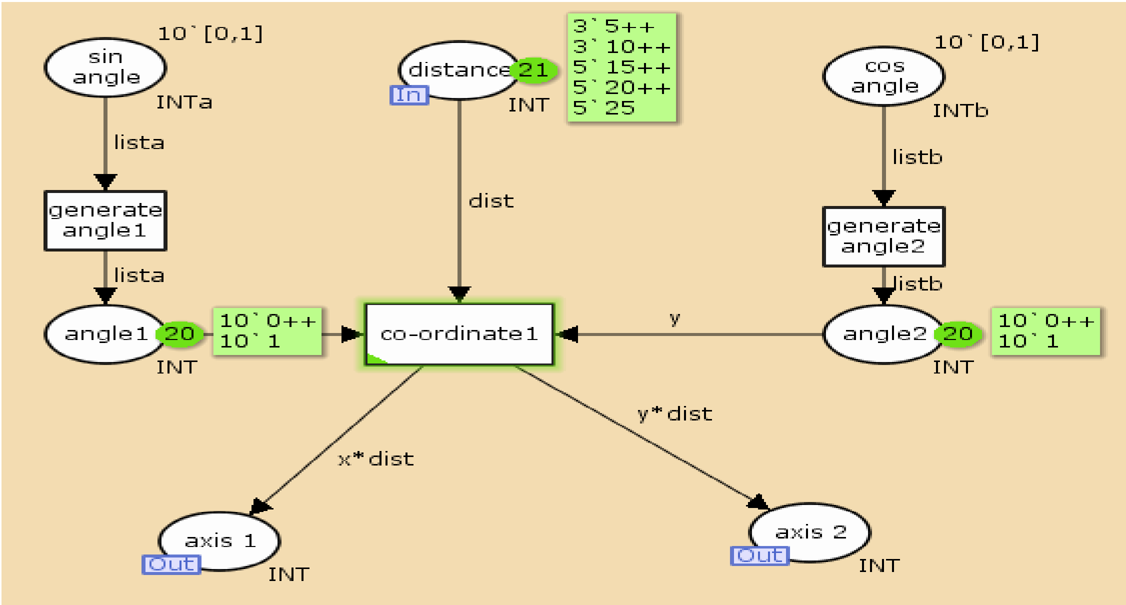


Figure 10. Token passing

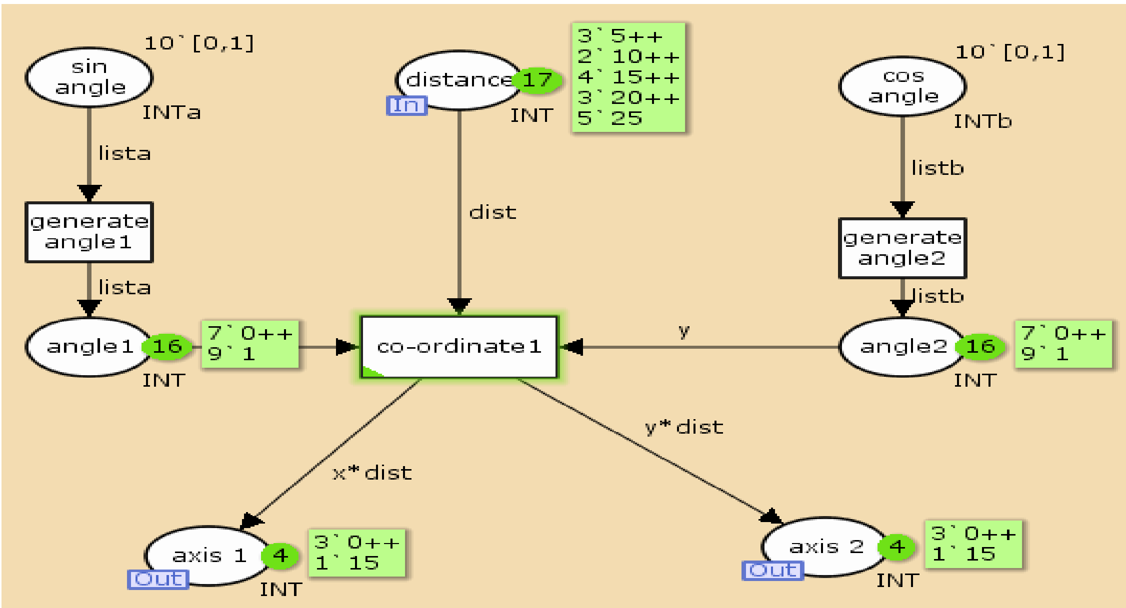


Figure 11. Co-ordinate generation by enabling Transition

In fig.10 number around small green circle represent, due to availability of tokens transition enables. After that token reaches to the next place which is shown in fig.11.

This simulation uses some declarations which are described below:

```
Declarations
  Standard declarations
  colset INTs = list INT;
  var ilist : INTs;
  val maxLen = 10;
  colset ListLength = int with 0..maxLen;
  var idx : ListLength;
  var sp:INT;
  colset DATAs = INT;
  var tme:INT;
  colset INTa = list INT;
  colset INTb = list INT;
  var lista:INTa;
  var listb:INTb;
  var dist:INT;
  var x,xx:INT;
  var y,yy:INT;
```

5. Simulation Result

After simulation, it will generate co-ordinate value. The Figure 12 shows how the node moves around the network.

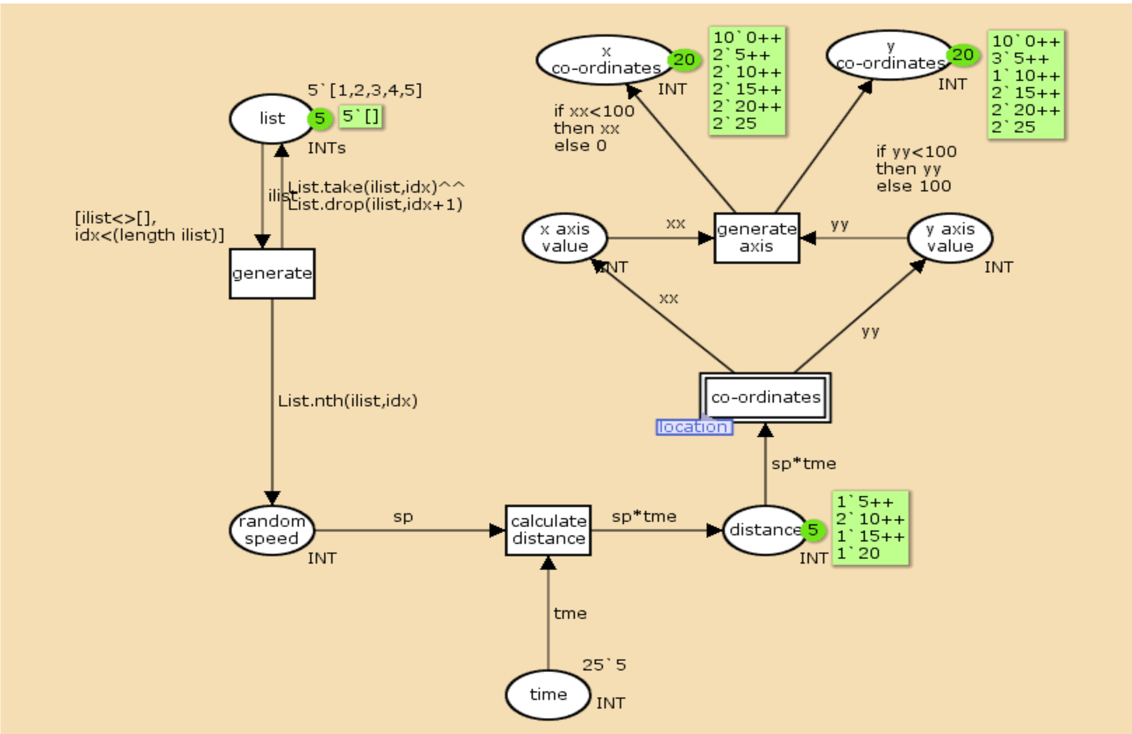


Figure 12.Simulation and result

6. Conclusion

Modeling of a system helps to analyses the flow of data and control within it. Random waypoint mobility model depicts the dynamic nature of the network by allowing the nodes to move in the network. Initially it decides a random speed, direction to move in the network. After reaching the destination it pauses for a short period after which it takes the next movement. This synthetic mobility model has been modeled by using the colored petri nets tools. The model helps to trace the flow of control while studying the mobility pattern. Unlike the previous method ,it does not require to discard some initial steps and no need to save a location in position file .Further research on the ad hoc networks where this mobility pattern is of major concern could be possible by studying the above designed model.

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