COLOURED PETRINET FOR MODELLING AND VALIDATION OF DYNAMIC TRANSMISSION RANGE ADJUSTMENT PROTOCOL FOR AD-HOC NETWORK

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

in

Computer Science and Engineering

By

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CERTIFICATE

This is to certify that the thesis entitled **'Coloured Petrinet for Modelling and Validation of Dynamic Transmission Range Adjustment Protocol for Ad Hoc Network "** submitted by Debansu Panda and Lopamudra Mohapatra, in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Computer Science and Engineering at the National Institute of Technology, Rourkela is an authentic work carried out by them under my supervision and guidance. To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other university / institute for the award of any Degree or Diploma.

DATE:

Dr. S. K. Rath

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Abstract

The IEEE 802.11 standard defines two operational modes for WLANs: infrastructure-based and infrastructureless or ad hoc. A wireless ad hoc network comprises of nodes that communicate with each other without the help of any centralized control. Ad hoc implies that the network does not rely on a pre-existing infrastructure but rather each node participates in routing by forwarding data for other nodes. The decentralized nature improves the scalability of wireless ad hoc network as compared to wireless managed networks. Each node acts as either a host or router. A node that is within the transmission range of any other node can establish a link with the later and becomes its immediate neighbour. However, the nodes in the ad hoc networks are constrained with limited resources and computation capability. So it may not be possible for a node to serve more number of neighbours at some instant of time. This enforces a node to remain connected or disconnected with few of its existing neighbours supporting the dynamic restructuring of the network. The presence of dynamic and adaptive routing protocol enables ad hoc networks to be formed quickly.

The Dynamic Transmission Range Adjustment Protocol (DTRAP) provides a mechanism for adjusting transmission range of the ad hoc nodes. They maintain a threshold number of registered neighbours based on their available resources. The node protects its neighbourhood relationship during data communication by controlling its transmission range. It registers or de-registers a communicating node as its neighbour by dynamically varying the transmission range. However a node has a maximum limit on its transmission range. If the distance between the node and its neighbour is less than the transmission range and;

1)if the number of neighbours of a node falls short of threshold value, the node dynamically increases its transmission range in steps until it is ensured of an optimal number of neighbours

2)if the number of neighbours of a node exceeds the threshold value, the node dynamically decreases its transmission range in steps until it is ensured of an optimal number of neighbours.

Coloured Petri nets (CP-nets) is the modelling language tool used for systems having

communication, synchronisation and resource sharing as significant aspects. It provides a framework for the design, specification, validation, and verification of systems. It describes the states in which the system may be in and the transition between these states. The CPN combines Petri nets and programming languages. Petri nets amalgamate the use of graphical notation and the semantical foundation for modelling in systems. The functional programming language standard ML provides the primitives for the definition of data types and manipulation of data values. Besides providing the strength of a graphical modelling language, CP-nets are theoretically well-founded and versatile enough to be used in practice for systems of the size and complexity of industrial projects.

ABBREVIATIONS

IEEE- Institute of Electrical and Electronics Engineers

LAN - Local Area Network

MAC - Medium Access Control

NIC - Netwok Inteface Controller

CPN - Coloured Petrinet

QoS - Quality of Service

MANET - Mobile Ad hoc Networks

TT - Time to Live

OSI - Open Systems Interconnections

TCP/IP - Transmission Control Protocol/Internetworking Protocol

DTRAP - Dynamic Transmission Range Adjustment Protocol

ML - Modelling Language

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INTRODUCTION

Chapter 1

1 INTRODUCTION

The IEEE 802.11 standard defines two basic modes of operation for wireless LANs- infrastructure-based and infrastructure-less or ad-hoc. In an infrastructure-based wireless network, the nodes communicate through an access point that serves as a bridge to a wired-network infrastructure. However, we can have peer-to-peer communication in an infrastructure-less network. Ad-hoc is a Latin word, which means "for this or for this only."

1.1 AD HOC NETWORKS

An ad-hoc network is a decentralized type of wireless network which does not depend on any pre-existing infrastructure for its operation

In an ad-hoc network, the computers (nodes) communicate to forward packets for one another over a multi-hop network. The nodes may be mobile in an ad-hoc network .Due to this, the radio propagation conditions constantly vary, thereby creating a dynamic scenario. Ad-hoc networks find wide applications in cases where there is no infrastructure in the environment, or where the infrastructure cannot be established due to cost and security issues, or it has been destroyed or damaged.

With the significant advances achieved in the field of wireless communication in the past decade, the ad-hoc networks concept has attained a broader scope, referring to a wide diversity of wireless autonomous networks designed and deployed for various purposes like wireless sensor networks, vehicular networks, home networks and so on. Such networks are subject to fragile multi-hop relay paths, dynamically changing sporadic connections, distributed autonomous operations and communication that is highly prone to errors.

The IEEE 802.11 defines similar modes of operation for both infrastructure-based and ad-hoc networks. The use of the ad-hoc mode has an impact on the protocols implemented, and there is no effect on the physical layers (i.e., 802.11a and 802.11b).In the MAC layer, the handling of frames and the carrier-sensing responsibilities are quite the same in the modes. However, due to the absence of access-points in the ad-hoc mode, more of the MAC layer tasks must be taken up by the ad-hoc wireless LAN. Some of the factors that favour the use of ad-hoc network include:

1)**Cost savings:** cost-saving is a major concern. It is economical as it avoids the need to purchase or install access points.

2)**Rapid setup time:** Only the installation of radio NICs is needed in the user devices for communication. Thus, the set-up time required is much less as compared to an infrastructure wireless LAN.

However, some factors that must be considered while opting for ad-hoc mode include:-

3)**Performance:** The performance of an ad-hoc network is quite debatable. Performance can be considered to be better since there is no need for packets to travel through an access point. However, it is true for a moderate number of users. For a network involving large number of users, contention for the channel may arise and a large number of collisions may occur [6].

4) **Network Access:**Absence of a distributed system does not enable users to have effective access to the Internet and other wired network services. Even though a system can be setup with a radio NIC and configured with a connection to the internet, this would not cater to a large number of users. Thus, ad-hoc mode might be unsuitable for large enterprise systems where there is a frequent need to access applications and servers on a wired network.

5) **Network Management:** This is a onerous task in case of an ad-hoc network due to the varying network topology and its decentralized structure. Monitoring performance or security audits can be applied at the access points, which are absent. Network management has to be done at the user device level, which involves a significant overhead and is not feasible in case of large enterprise applications.

1.2 COLOURED PETRINETS

Various dynamic and adaptive routing algorithms are needed for an ad-hoc network. To validate such protocols, Coloured Petrinets serves are as an efficient modeling and validation tool. It is a discrete event-modeling language combining Petrinets and Standard ML. CPN models of a system can be built to represent the various states the system is in and the transitions that cause a change of state. Using CPN tools, simulations are run to investigate the behavior and verify its properties. A license for this tool can be obtained free of charge for individual as well as for commercial uses. The CPN modeling language is regarded as a general purpose modeling language, that is aimed towards modelling various classes of systems in different application domains like communication protocols, data networks, distributed algorithms and embedded systems. The simulations aid in investigating different scenarios validating them. These simulations can also be interactively run. CPN models can be applied to a wide variety of systems and are found suitable for systems of various size and complexity.

1.3 ORGANIZATION

This thesis is organised into various chapters. The Chapter 2 gives a brief overview of Mobile Ad Hoc Networks (MANETs) and highlights their salient features. The second part of this chapter describes about some of the features of the Coloured Petrinet Tool. In Chapter 3, the topology control in MANETs is explained and the Dynamic Transmission Range Adjustment Protocol is presented. In Chapter 4, validation of the current routing protocol is done using CPN and the simulation results are presented. Chapter 5 concludes the thesis.

Chapter 2

LITERATURE REVIEW

Chapter 2

2 LITERATURE REVIEW

2.1 MOBILE AD HOC NETWORK

2.1.1 INTRODUCTION

A Mobile Ad hoc network (MANET) is a wireless network where the mobile nodes communicate over radio frequencies. The network has a decentralized architecture and does not rely on any previous infrastructure. With the advent of MANETs, a new art in the field of network management was discovered which enabled a network to be designed without being heavily dependent of the infrastructure establishment, as was the case in case of traditional network designs.

Mobile wireless networks vary from fixed networks over numerous operational factors like:

- Nominally lower capacity is available in mobile wireless networks as compared to the wired network.

-Dynamic changes in the network topology.

-Potentially higher delays and jitter.

-Greater chances of channel interference and congestion detection problems.

-Higher loss rates

-The lack of physical control leads to lack of physical security over media [1].

The nodes in a mobile ad hoc network are constantly in motion thereby leading to variations in the network topology. As a result, the Quality of Service (QoS) of the network is likely to be affected unless specialized schemes are developed to handle such dynamic networks. The nodes are the transmitting stations and are limited by a transmission range, so in most cases a direct communication between the source and receiver is not facilitated. To solve this issue, the nodes communicate in a multi-hop fashion to relay packets from the source to the destination. Therefore, the nodes function as both hosts and routers. This enables communication between nodes even when they are not in the transmission range of one another. Due to the decentralized nature of the network, it is not possible for a node to know the entire state of the network. So, the nodes frequently transmit messages to get updated about the network. Moreover, the motion of the nodes results in disruption of the links as they may frequently go out of the transmission range, thereby hampering routing in MANETs.

The MANET network interfaces differ from conventional wired network interfaces based on various scenario-dependent factors like:-

-Relative motion of the neighbours resulting in environmental and distance effects

-Dynamic local noise and interference caused by the nodes itself

-Links established between the nodes are often asymmetric in nature

-Time varying communication channels

-Lower layer wireless protocol behaviours

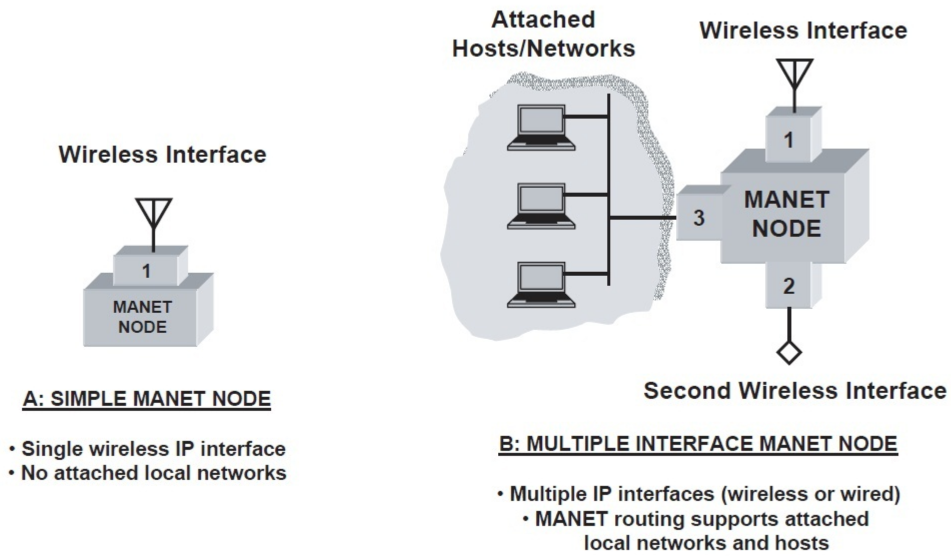

Figure 1: Types of MANET configurations

2.1.2 ROUTING APPROACHES IN MANET

Since the MANET neighbour interfaces behave quite differently from the conventional wired network interfaces. Therefore, the conventional routing protocols are insufficient to handling routing decisions in case of MANETs and new protocols that cater to the requirements while simultaneously considering the node-constraints have been developed. Routing in MANETs is a dynamic optimization task aimed at providing an optimal path in terms of some criterion and also satisfying some constraints like limited power, transmission range, etc. Therefore, based on when the routing tables are built MANET routing algorithms are categorised as:-

1)Proactive algorithms: Each node in the network maintains a route to every other node at all times, even if they are not needed.They are useful when there are a large number of data sessions in the network [1].

2)Reactive algorithms: These are also called as on-demand routing techniques. Routes to destinations are discovered only when they are actually needed.

3) Hybrid algorithms: They exhibit reactive and proactive behaviour depending on the circumstances. They maintain routes to nearby nodes even if they are not needed and maintain routes to far away nodes only when needed [2].

Since the nodes are characterized by limited resources and channel bandwidth, high error rates and frequently varying network topology, certain considerations must be taken before designing routing protocols for such networks.

The typical design goals for routing protocols in MANETs include:-

-Minimal control overhead- the number of control messages transmitted between the devices should be restricted to a minimum threshold since both transmission and reception consume battery power.

-Minimal processing overhead- protocols should be so designed to incur minimal overhead for processing cycles and rather preserve the battery power and other resources for user-oriented tasks.

-Multihop routing-Due to limited transmission range of devices, the sender and receiver are not in direct link often. In such cases, the packet relay is done in a multi-hop manner.

-Dynamically changing topology-The constant motion of the nodes leads to breakage of the links between the nodes which must be handled quickly with minimum overheads.

-Prevention of occurrence of loops- Presence of loops in the network consumes unnecessary resources and the packets are transmitted multiple times within it until the time to live(TTL) of the packets reaches zero or the path is eliminated.

Hence, presence of loops are detrimental to the network and must be avoided.

2.1.3 THE PROTOCOL STACK

This section describes about the protocol stack in case of MANETs. It also depicts the protocol stack of various other models like the OSI and the TCP/IP model.

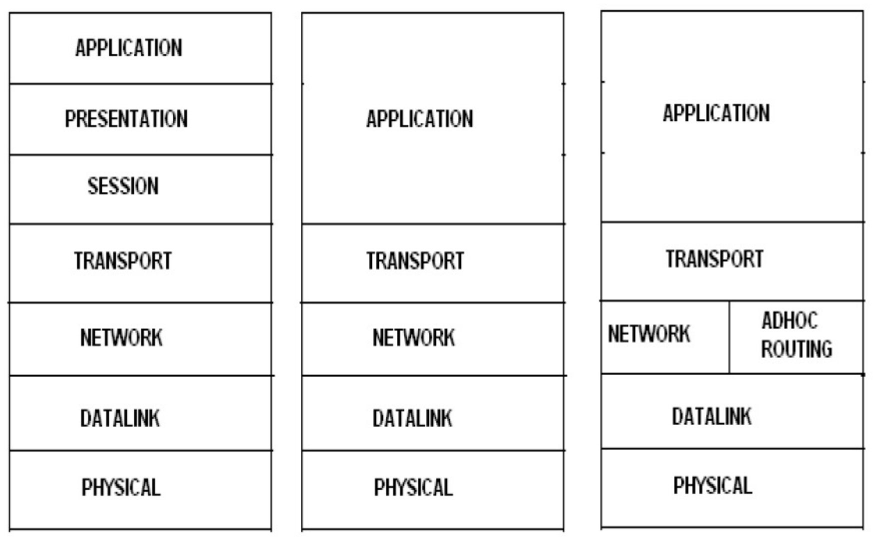

Figure 2: Network Models

The OSI model has 7 layers with a defined functionality for each layer to facilitate communication between all types of systems. The OSI model is diagrammatically depicted in Fig 2.The TCP/IP model is basically a protocol-oriented model. It has 5 layers. The application, presentation and the session layers of the OSI model are merged to form the application layer in this model. However, the rest of the layers are similar in both the models.

The MANET protocol stack is quite similar to the TCP/IP protocol stack except for the network layer. The network layer is divided into two parts- network and ad hoc routing. Since the nodes in a MANET can act as both hosts and routers, the implement an ad-hoc routing protocol to relay packets. The network part uses the IP protocol where the ad hoc part uses various other protocols specifically designed for ad hoc networks. The lower layers, the datalink and the physical layer implement protocol designed for wireless communication.

2.1.4 APPLICATIONS

MANETs find enormous applications in case of emergency rescue operations, disaster relief efforts, low enforcements and military operations. MANET technology is also widely used to provide a wireless routing region at the *edge* of the Internet. This helps to extend the range of the network and provide robust adaptation to infrastructure dynamics.

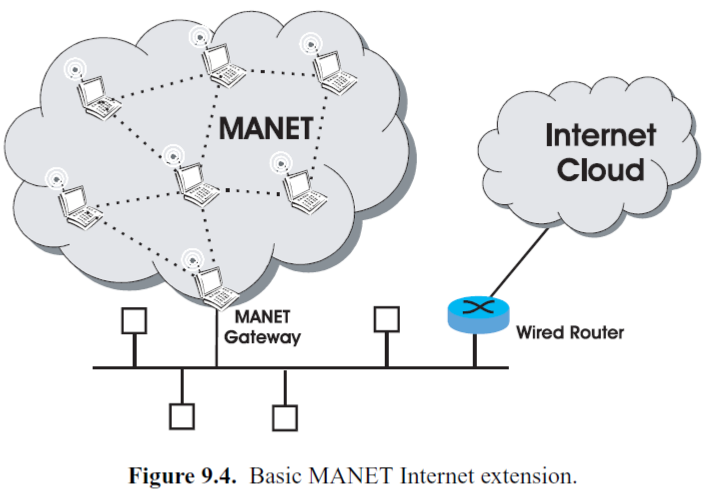

Figure 3: Basic MANET Internet extension

2.2 COLOURED PETRINET

2.2.1 INTRODUCTION

Coloured Petri nets (CP-nets or CPNs) is a language used for modelling and validation of systems having concurrency, communication and synchronization as vital aspects [4]. They provide a framework for the design, specification, validation and verification of systems [5]. CP-nets is used to model discrete-event systems.CPN is a combination of Petri nets and Standard ML. Standard ML is a functional programming language that provides primitives for defining data types and for their manipulation, describing how data can be manipulated and for the creation of compact and parameterisable models [4].

A CPN model describes the various states the system is in at different points of time. It also specifies the events (transitions) that cause the system to change its state. By making simulations, the system design can be investigated, the different scenarios it can possibly be explored and the behaviour of the model can be tested therein. Also, it is possible to verify the properties of the system by state-space methods and a simulation-based performance analysis can be generated. The users can interact with the CPN tool by direct manipulation of the graphical representation using user-interaction techniques like the tool palette and marking menus [6].

CPN models are structured into a set of modules for handling large specifications.As in programming languages, here too the modules can interact with one another with the help of well-designed interfaces. The modular concept of CP-nets, based on a hierarchical structuring mechanism, allows a module to have sub modules and allowing a set of modules to be composed to form a new module.The time concept adds vitality to the modelled systems by indicating the timeelapsed in execution of events.

The CPN models are formal in nature. This means that the modelling language has a well-specified mathematical definition of its syntax and semantics. Therefore, such models can be constructed to verify the system properties, to check if the system meets the desired properties, and certain undesired functionality have not been mistakably introduced into the system. This verification of the system properties is facilitated by state-space methods. The basis underlying this technique of validation lies in computing all the reachable states of the system and the corresponding state changes. The details of these are represented as a directed graph with the nodes depicting the states, and the occurring events are indicated by arcs. State spaces can be constructed fully automatically. The results at each step of simulation can be observed directly in the graphical representation of the model [4].

2.2.2 MODELLING OF STATES

Unlike most specification languages, CPN models are both state and action oriented at the same time and thereby provide an explicit explanation of both. This enables the modeller to determine on which to focus at a given point of time, the states or the actions.

The basic constructs of the CPN model are:

1)Places: These are ellipses or circles and indicate the states of the system

2)Types: Each place is associated with a type, also called as a colour-set. These indicate the type of data a place can hold, very similar to that in programming languages. These colour-sets can be combined in any fashion to form arbitrarily complex patterns.

3)Transitions: These are represented by rectangles. The names of transitions are written inside these rectangles. The actions of the system are represented by means of transitions. An action of a CP-net consists of one or more transitions occurring concurrently.

4)Markings: They indicate the state of the system. Marking refers to the tokens positioned over the individual places. Tokens refers to the data value(colour) present at the place. The colour-sets are synonymous to the data-types and the colours are synonymous to the data-values. The token values belong to the type of the place on which the token resides. The marking can be a multi-set of token values, which are several appearances of the same element.

5)Initial Marking: A CP-net has a distinguished marking called the initial marking, which is used to describe the initial state of the system. The initial marking of a place is, by convention, written on the upper left or right of the place.

4)Arcs and Arc Expressions: Arcs are used to connect transitions and places. The actions are basically firing of transitions. An occurrence of a transition transfers the tokens from input places(places connected to incoming arcs) to the output places (places connected to outgoing arcs). Thus, the marking of the CP-net changes. This is known as the token game. The number of tokens added and removed by the transition, and their corresponding changes in the data-values are decided by the expressions, which are positioned next to the arcs.

A transition can be enabled only when the two criteria are satisfied:-

1)All the arc expressions must evaluate to the tokens which are present on the corresponding places connected to the incoming arc.

2)The guard conditions must be satisfied, if any.

The values of the token that removed from the input places of an enabled transition depends on the input arc expressions and similarly, the values of the tokens transferred to the output places depends on the output arc expressions.

Places and transitions are referred to as nodes. Nodes along with the directed arcs constitute the net structure. An arc always connects a place to a transition or a transition to a place. However, two transitions or two places cannot be connected directly by arcs. A number of tokens along with the token colours on the individual places are representative of the state of the system and is called a marking of the CPN model. On the other hand, the tokens on a specific place form the marking of that place [5].

2.2.3 CONSTRUCTION OF HIERARCHICAL MODELS

The concept of hierarchical CP-nets allows the modeller to construct a large model by an aggregation of a number of small CP-nets. These small CP-nets are called pages and they are related to each other in a well-defined manner. It is possible to relate a transition along with its connected input places and arcs on a page to a more precise and explicated version of the intended activity on a separate page.

Substitution transitions are used to implement the hierarchy concept. They are replaced by subpages which contain the detailed description of the activity represented by the corresponding substitution transition. The subpages have a number of places marked with an In-tag, Out-tag, or I/O-tag. These places are called port places. They provide an interface through which the subpage communicates with its surroundings. The input port enables a place to receive a token from its surroundings. It is marked with an In-tag. The Out-tag represents the output port through which data values are sent from the place to the surroundings. Places marked with an I/O-tag can act as both input as well as output places. The port places of the subpage must be assigned to the socket places in the main page in-order to specify the relationship between a substitution transition and the subpage. This is referred to as the port-socket assignment [4]. The Hierarchy palette provided by the GUI helps in the construction of hierarchical models. The steps to construct a hierarchical model are:-

1) Move a transition or group to a new submodule.

2) Replace a substitution transition with its submodule.

3) Assign a submodule to a substitution transition.

4) Assign a port to a socket.

5) Set port type to input.

6) Set port type to output.

7) Set port type to input/output.

8) Assign a place to a fusion set [4].

There are two methods for implementing hierarchy in CPN models:

1) top-down construction

2) bottom-up construction

Top-Down Approach:- The Move to Submodule tool finds its application here. A substitution transition is first created in the original module with the appropriate arcs. The port places are specified in the subpages and they are linked to the substitution transition page by means of the corresponding socket assignment.

Bottom-Up Approach:- The Assign Submodule tool supports a bottom-up approach. In this case, existing modules are first created and then, they are assigned as submodules to a substitution transition. Port-socket assignment is done automatically wherever possible.

Apart from these, the Clone tool helps to clone hierarchy elements including the substitution transitions, port-types, tags, and even all the sub-modules.

2.2.4 SYNTAX CHECK AND CODE GENERATION

CPN Tools performs syntax and type checking, and simulation code generation. Error messages are easy to interpret and are indicated to the user in a contextual manner near the object causing the error [4]. The processes of syntax checking and code generation are incremental in nature. They aare parallel performed with editing. This makes it possible to execute separate parts of a CPN model even though the entire model is not yet constructed. It also facilitates in unit testing, that is when individual parts of a CPN model are modified, the syntax check and code generation can be only performed on the elements that are interdependent with the modified parts. Also, the checking of some elements is postponed until they have enough information to be checked if they are syntactically correct or not. For example, a place without its colour set inscription is not checked, or a transition is not checked until all of its surrounding places are checked, and all its surrounding arcs have the corresponding arc inscriptions [4].
When a simulation is run, the following is the simulation feedback shown:
1) Current markings of places are indicated near the individual places.
2) The number of tokens currently present at a place is given by a green circle.
3)The corresponding token values at the places are shown in green boxes.
4)Green auras are present around enabled transitions.
5) Green underlines are shown on the pages with enabled transitions.
6) The step count and time taken is shown in the index for the net under simulation. [7] The main outcome of the code generation phase is the generation of the simulation code. The simulation code contains the functions for inferring the set of enabled binding elements in a given marking of the CPN model, and for computing the marking reached after an enabled binding element occurs [4].

Chapter 3

TOPOLOGY CONTROL IN MANETS

Chapter 3

3 TOPOLOGY CONTROL IN MANETS

3.1 INTRODUCTION

The network topology is determined by the links between the nodes that is used by the routing mechanism. MANETs are indeterministic in nature and the topology of the network is dependent on a number of factors like mobility of the nodes, their battery power , the traffic patterns in the network, noise, interference and transmission power of nodes. However, these factors are subject to changes depending on the current state of the network and its present demands.

The network size, referring to the number of nodes in the network and their distribution has an effect on the performance of the network. A sparse network may have numerous network partitions and the entire network may be divided into disconnected portions. Thereby, the connectivity is hampered and it may result in lack of routes for packet transmission. On the other hand, dense networks may have problems like congestion and contention for bandwidth leading to a low packet delivery ratio. More number of collisions are also caused and thereby more energy is expended in overcoming these.

However, the network size and density are invariable parameters and hence cannot be changed. Moreover, the nodes are constantly in motion, making it all the more difficult to predict the distribution patterns. The focus is to implement adequate routing protocols to minimize the overheads incurred due to the variability in MANET topology. This is essential as the topology has a huge impact on the performance of the network and in making routing decisions. Hence, the network topology must be controlled adequately.

Topology control includes maintaining network connectivity, increasing throughput, reducing interference, **ameliorating energy efficiency**. This is basically done by manipulating the parameters of the node so as to attain a particular network topology. This process of parameter adjustment is a controlled loop, **involving a dynamic system**, failing which, may lead to the instability of the network. Topology control is done to improve the performance of the routing protocol [7].

One such adjustable parameter of nodes is its transmission range. If the transmission range of a node is very high, it is likely to have many neighbors (nodes within its transmission range), hence a higher degree. This leads to lower average hop-length but, more contention for bandwidth. On the contrary, if the transmission range is very low, the nodes will more likely have a lower degree (less neighbors). This could be similar to the case of having a spatial network where the entire network is divided into disconnected portions, leading to a scarcity of routes. In such a case, an optimal number of neighbors must be kept by a node so as to ensure a desired performance is delivered by the network. Thus, the transmission range could be adequately varied to satisfy this criterion of maintaining and optimal neighbor count for the nodes in an ad-hoc network. Studies have shown that the optimal number of neighbours for each node in a stationary network, is six and the transmission radius should be adjusted accordingly to allow each node to maintain this node degree [7].

3.2 DYNAMIC TRANSMISSION RANGE ADJUSTMENT PROTOCOL

The basic assumption in an ad-hoc network is, two nodes willing to communicate may be outside the wireless transmission range of each other but can communicate in multiple hops, provided other nodes in the network are willing to forward packets. However, there may be a disruption in the working of an ad-hoc network, if an intermediate node, participating in a communication moves out of the fixed transmission range. So the nodes must be capable of dynamic reconfiguration by self-adjusting the variable transmission range. A low transmission range may result in a sparse network and the connectivity among nodes may not be effective. On the contrary, a high transmission range will ensure connectivity but collision and congestion of control packets will increase, which may significantly increase the end-to-end delay.In an operating area, when there are fixed number of nodes distributed uniformly, the optimality in transmission range is essential. Thus, a variable transmission range protocol like the Dynamic Transmission Range Adjustment Protocol (DTRAP) would be highly effective in such a dynamic environment [5].

The Dynamic Transmission Range Adjustment Protocol provides a mechanism for adjusting the transmission range of the ad hoc nodes. The nodes are configured to maintain a threshold number of neighbours based on their available resources. The nodes protect their neighbourhood relationship during data communication by controlling their transmission range. It can register or de-register a node as its neighbour by dynamically varying its transmission range in steps. However, there is a maximum limit of the transmission range. It can register or de-register a node as its neighbour by dynamically varying its transmission range in steps. However, there is a maximum limit of the transmission range beyond which it cannot be increased. If the separating distance between the nodes is less than the maximum transmission range and;

1)if the number of neighbours of a node is less than the threshold value, the node dynamically increases its transmission range in steps until it is ensured of an optimal number of neighbours.

2)if the number of neighbours of a node exceeds the threshold value, the node dynamically decreases its transmission range in steps until it is ensured of an optimal number of neighbour [5].

Chapter 4

DESIGN AND VALIDATION

Chapter 4

4 DESIGN AND VALIDATION

4.1 INTRODUCTION

In the field of multi-hop wireless network, it is almost inevitable for any design to overcome the disturbance in communication process and also a design which allows us to control the packet congestion in a dynamic field, which in turn reduces delay in end-to-end communication. The self adjustable transmission protocol, which forms a part of DTRAP is an efficient protocol with regards to the ad hoc network.

Our work is based on two significant phases:

1)Design and modelling the ad hoc network using CPN.

2)Validate the above model for the Dynamic Transmission Range Adjustment Protocol using CPN.

4.2 INSTALLATION

The CPN tool software was downloaded from the Aarhus University site which provides license for the use of this tool. On downloading the set up file, it was successfully installed alongwith its component files.

As a start up the help page is referred to get used to the different options and components of of this tool.

4.3 DESIGN AND MODELLING

4.3.1 INITIAL MODELS

To get used to the know-how of this tool, first a preliminary task was taken up to validate a scenario where a node sends its coordinate values and it gets updated on firing a transition.

Thereafter another subsequent model was designed wherein the two nodes were taken in the scenario and the square of their geometrical distance was calculated.

To get acquainted with the hierarchy, an hierarchical model was also designed.

4.3.2 ESTABLISHING LINK BY FINDING NEIGHBOURS

This forms the core part of our project where in we have taken five static nodes in an ad hoc network. These five nodes share a common message store **MsgStore**. The page **MsgStore** shows the five nodes and their messages being sent to the **MsgStore**.

The nodes in the main page **MsgStore** then form a hierarchy being replaced by a subpage

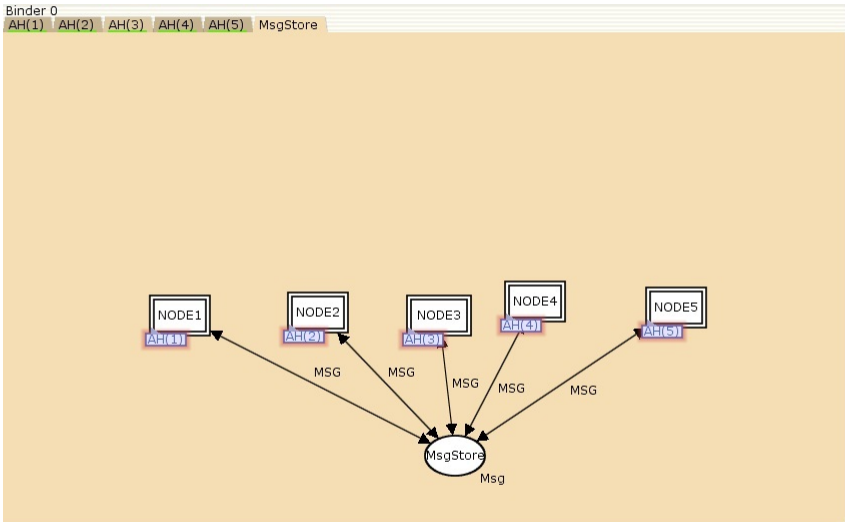

Figure 4: Model of five nodes communicating

which portrays the establishing of link of each node with its neighbours.

The subpage **AH(3)** demonstrates the neighbour node determination. Here the parameters of the node such as its co-ordinates, battery power, mobility and counter (which keeps a note of its number neighbour, initialized as zero) is broadcast to the **MsgStore**.

The appropriate or intended node retrieves the **MSG** from the **MsgStore**.

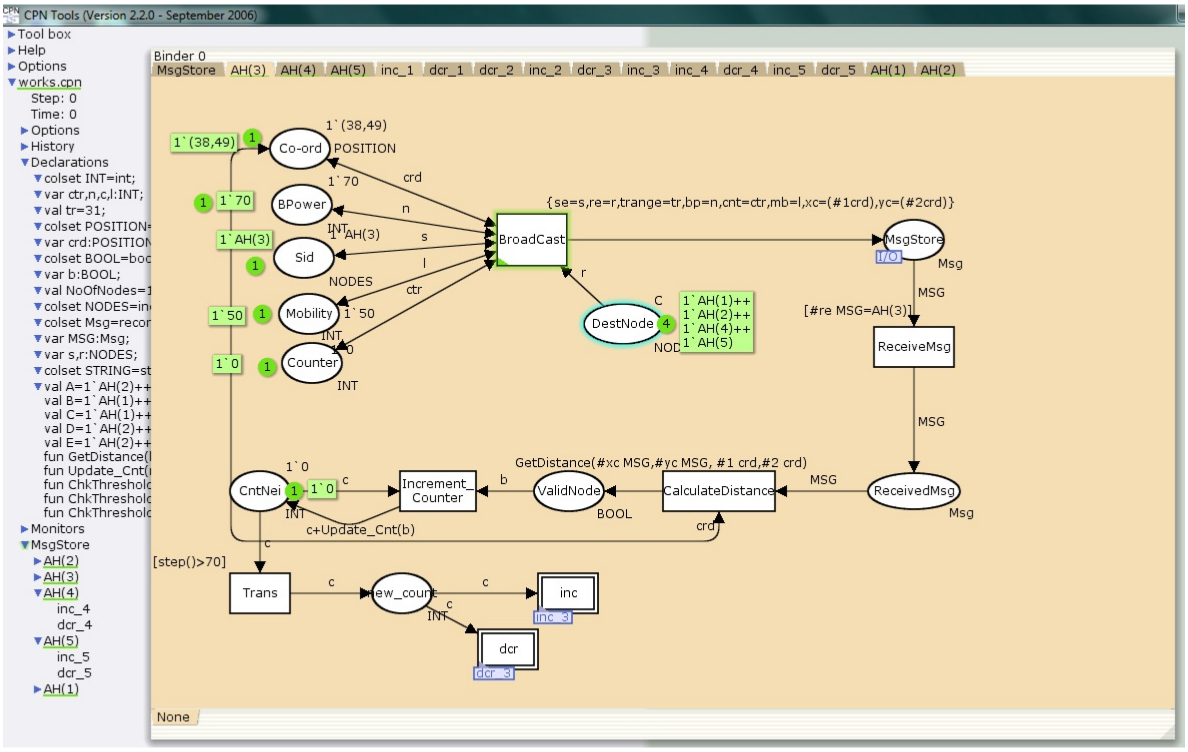

Figure 5: Extensive view of node 3

DISTANCE CALCULATION: CalculateDistance transition is fed with the senders and the receivers co-ordinates. On firing this transition it calculates the distance between them. If the distance is within a specified transmission range then it returns a Boolean yes else no.

fun GetDistance(k:INT,l:INT,p:INT,q:INT)=if (((k-p)*(k-p)+(l-q)*(l-q))<961) then yes else no;

COUNTER INCREMENT: IncrememntCounter is fed with the previous step counter value and the boolean returned by **CalculateDistance**. So initially it is fed with zero. Whenever is the boolean is yes, the counter gets incremented by1.

fun Update_Cnt(m:BOOL)=if(m=yes) then 1 else 0;

c+Update_Cnt(b);

The place **CntNei** keeps a track of the counter value for each and every node.

4.4 VALIDATION OF DTRAP USING CPN

TRANS: We use a transition **Trans** which is fed with updated final counter value. This transition is fired only when the no. of steps is greater than the no. of steps taken so that no token value is left behind at any place. Here we use the **control flow** concept. We only take the counter value when it has reached to the end of execution leading to no leaving behind of tokens in any of the places in the model. The advantage of using such control flow mechanism is: The place **CountNei** acts as a store and the value stored in this place can be used subsequently in the DTRAP validation.

4.4.1 TRANSMISSION RANGE ADJUSTMENT

The output of the **Trans** is fed to a place, **new_count** which is the node parameter as specified earlier. This dynamic counter keeps the updated value of the count of number of nodes. This updated **c** is passed to two substitution transitions:

1)inc

2)dcr

Here we use the hierarchy concept of CPN tools. inc and dcr are substitution transitions and when fired, they invoke two subpages , **inc_#** and **dcr_#**respectively.

Subpages are used to replace the substitution transition **inc** in order to increment the transmission range whenever the number of neighbours falls short of the threshold value. The increment is done in steps of 5. The updated transmission range is stored in a place,**newrng**.

Subpages are used to replace the substitution transition **dcr** in order to decrement the transmission range whenever the number of neighbours falls short the threshold value. The increment is done in steps of 5. The updated transmission range is stored in a place,**newrng**.

fun ChkThreshold(c:INT)=if(c>=2)then tr-5 else tr+5;

The steps to construct a hierarchical model are:-

1) Move a transition or group to a new submodule.

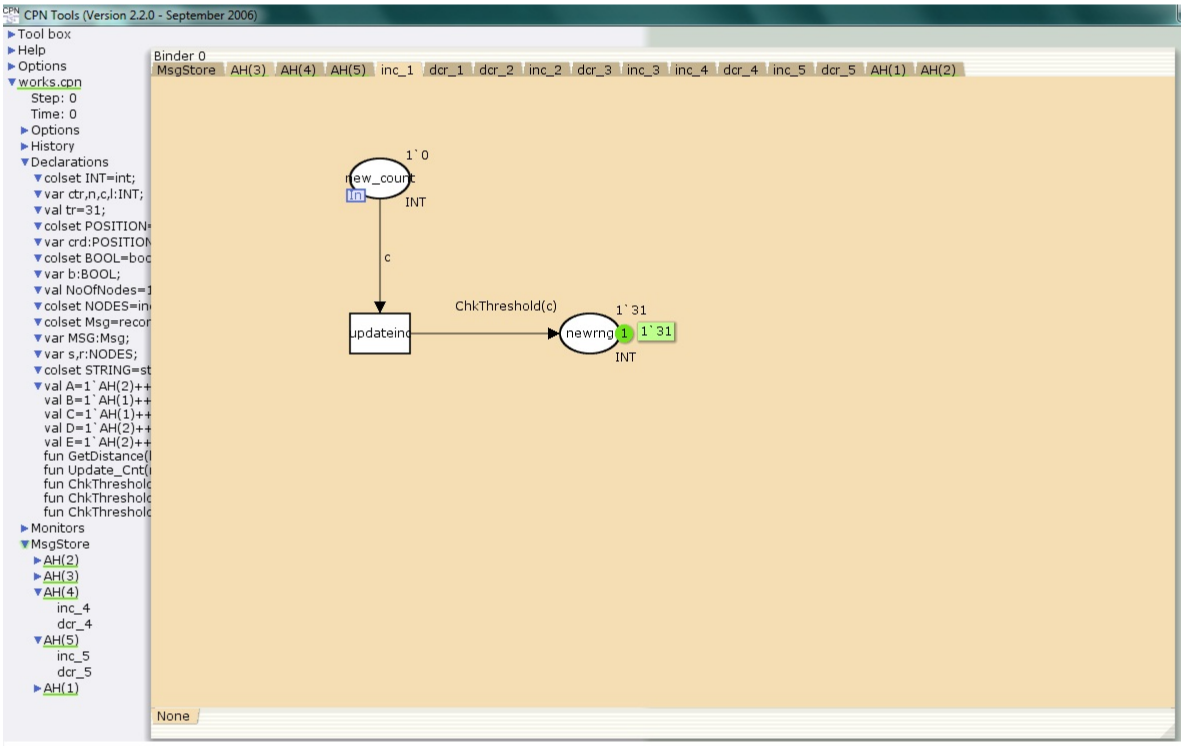

Figure 6: Subpage showing transmission range adjustment

2) Replace a substitution transition with its submodule.

3) Assign a submodule to a substitution transition.

4) Assign a port to a socket.

5) Set port type to input.

6) Set port type to output.

7) Set port type to input/output.

8) Assign a place to a fusion set. [4]

For example; if we take node 3: the no. of neighbours=3. Initial transmission range was 31. So now since 3>2 (as used in the simulation , the threshold no. of nodes are 2), hence new range is 31-5= 26.

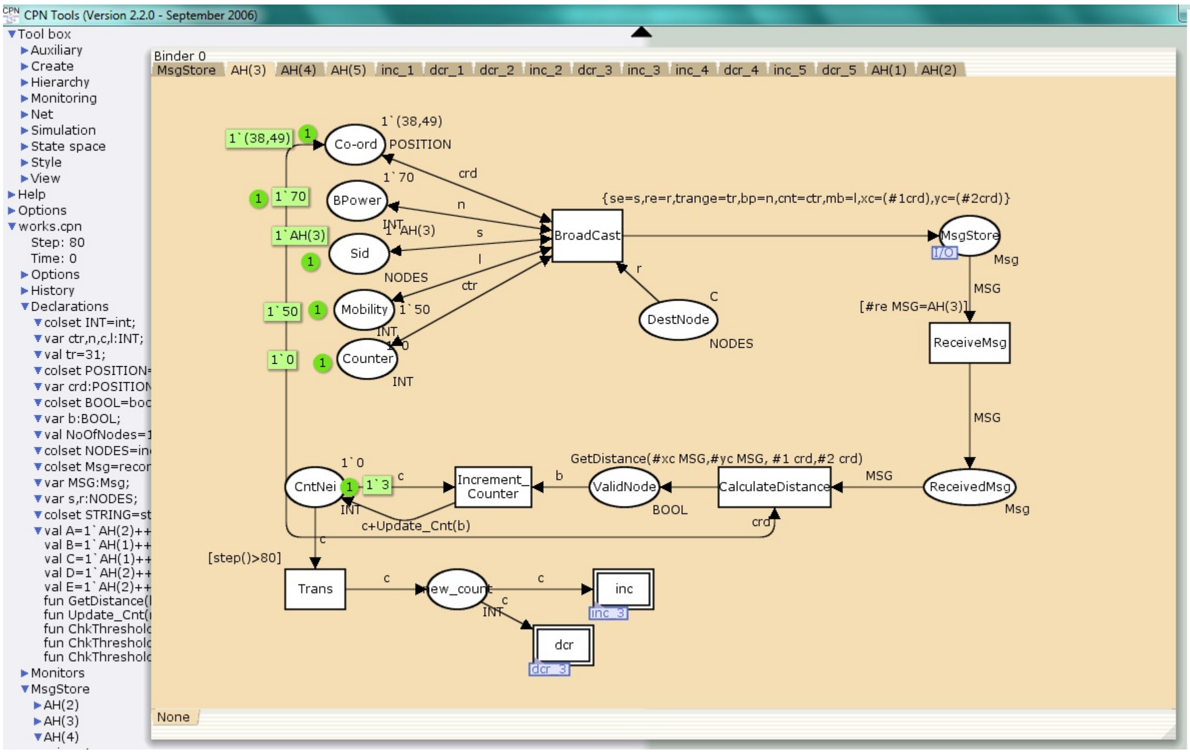

Figure 7: Counter value of node 3 after simulation is run

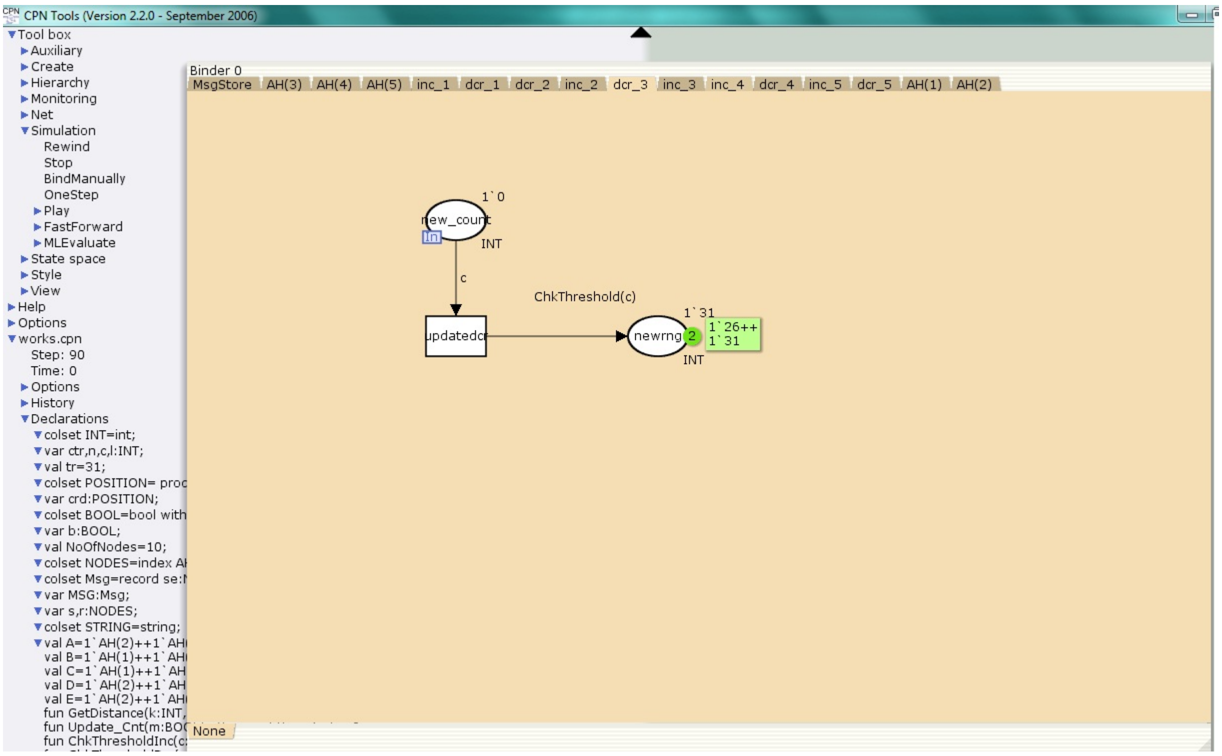

Figure 8: Subpage of node 3 showing new transmission range

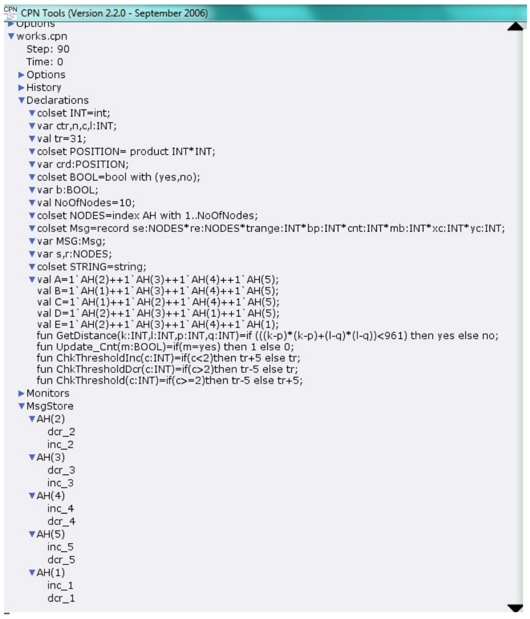

Figure 9: Codes for declaration of variables and functions used

The Dynamic Transmission Range Adjustment protocol is implemented here using five nodes. The situation of incrementing the transmission range has been successfully achieved. The next task towards the validation of the Dynamic Transmission Range Adjustment protocol is by validation of the decrementing the transmission range for the same, using Coloured Petrinet Tool.

Chapter 5

CONCLUSION

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5 CONCLUSION

Our work is based on ad hoc network which works on static nodes. This can be further extended to mobile nodes. Validation of this protocol ensures that the self adjusting transmission range protocol can be implemented in ad hoc network for bringing optimality in the resource utilization of nodes. It has got variety of application in the field of sensor network as well and also in emergency situations like natural disasters or military conflicts. The presence of a dynamic and adaptive routing protocol will enable ad hoc networks to be formed quickly.

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