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**Stochastic Routing Algorithm for Ad-Hoc
Networks**

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Dedication

To our great parents who provided us with their encouragement ,love ,and understanding,

To our beloved sisters and brothers for their love and support,

To our families the symbols of love and giving,

To all the people in our life who touch our hearts

we dedicate this research

khawla & Loubna

To my great parents who provided me with their encouragement ,love ,and understanding,

To my beloved sisters Hadjer,Asia ,Amina and brothers Abdo,Zino And Mimo for their love and support,

To my families especially my uncle Nasro, Abdel Moumen, Abdel Razzaq, my aunt Maryam, Warda, Zeina, and my uncle Radhia's wife,

To my dear husband Elmekki,

To Pr. Saudi.A

To my friends Loubna, Khawla, Zahra ,Souhila ,Fati and Aicha.

To all university classmates,

To all the people in my life who touch my heart.

Khawla

I dedicate the fruit of my effort to the most dear in existence to the spring of tenderness to you, my beloved mother,

To the dearest and most precious thing in existence to you, my dear father,

To my support in life, my dear husband,

To the chicks of the house, my children: Ratil and AnasAbdulRahman,

To my brothers and sisters: Haitham Nada AbdulLatif Wafa,

To my second family:noura othman djamal kholoud Ikram Abdlkader lamya,

To my best girlfriend ever khawla dahman.

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Abstract

The need for communication services is rapidly increasing, because the mobile communication service is synonymous with an ideal communication style realizing communication anytime, anywhere and with anyone.

Mobile ad hoc networks (MANET) is a collection of mobile nodes connected by wireless links that form a temporary network topology that works without a base station and centralized administration.

We investigate a network routing problem in this dissertation studies online shortest path routing over multi-hop networks.

Link costs or delays are time-varying and modeled by independent and identically distributed random processes, whose parameters are initially unknown. The parameters, and hence the optimal path, can only be estimated by routing packets through the network and observing the realized delays. Our aim is to find a routing policy that minimizes the regret (the cumulative difference of expected delay) between the path chosen by the policy and the unknown optimal path.

We formulate the problem as a combinatorial bandit optimization problem. We present results showing that an policy KL-SR (KLBASED SOURCE-ROUTING) is optimal for the routing problem by NS2 ,TCL.

Keywords: MANETS , Protocoles de routage ,The regret , KL-SR (KLBASED SOURCE-ROUTING) , NS2, TC

Résumé

Le besoin de services de communication augmente rapidement, car le service de communication mobile est synonyme d'un style de communication idéal permettant de communiquer à tout moment, n'importe où et avec n'importe qui.

Les réseaux mobiles ad hoc (MANET) sont un ensemble de nœuds mobiles connectés par des liaisons sans fil qui forment une topologie de réseau temporaire qui fonctionne sans station de base et administration centralisée.

Nous étudions un problème de routage de réseau dans cette thèse étudie le routage de chemin le plus court en ligne sur des réseaux à sauts multiples.

Les coûts ou délais de liaison varient dans le temps et sont modélisés par des processus aléatoires indépendants et répartis de manière identique, dont les paramètres sont initialement inconnus. Les paramètres, et donc le chemin optimal, ne peuvent être estimés qu'en acheminant les paquets à travers le réseau et en observant les retards réalisés. Notre objectif est de trouver une politique de routage qui minimise le regret (la différence cumulée de retard attendu) entre le chemin choisi par la politique et le chemin optimal inconnu.

Nous formulons le problème comme un problème d'optimisation combinatoire des bandits. Nous présentons des résultats montrant qu'une politique KL-SR (KLbased Source-Routin) est optimale pour le problème de routage par NS2, TCL.

Mots clés: MANETS, Protocoles de routage, Le regret, KL-SR (KLBASED SOURCE-ROUTING), NS2, TCL

الملخص

تتزايد الحاجة إلى خدمات الاتصالات السريعة، حيث أن خدمة الاتصالات المتنقلة مرادفة لأسلوب اتصال مثالي للتواصل في أي وقت وفي أي مكان ومع أي شخص.

شبكة الأقران (MANETs) عبارة عن مجموعة من العقد المحمولة المتصلة بواسطة ارتباطات لاسلكية تشكل هيكل شبكة المتنقلة

مؤقت يعمل بدون محطة أساسية وإدارة مركزية.

ندرس مشكلة توجيه الشبكة في هذه الرسالة ندرس أقصر مسار في الخط على شبكات متعددة القفزات .

تختلف تكاليف أو حالات التأخير في الارتباط بمرور الوقت ويتم تصميمها بواسطة عمليات عشوائية مستقلة وموزعة بشكل متماثل والتي تكون معلماتها غير معروفة في البداية. لا يمكن تقدير المعلمات ، وبالتالي المسار الأمثل ، إلا من خلال توجيه الحزم عبر الشبكة ومراقبة التأخيرات التي تم إجراؤها.

هدفنا هو إيجاد سياسة توجيه تقلل من الندم (الاختلاف التراكمي في التأخير المتوقع). (بين المسار المختار من قبل السياسة والمسار الأمثل غير المعروف.

نصوغ المشكلة كمسألة تحسين قطاع الطرق الاندماجية. نقدم نتائج KL-SR (KL based Source-Routing) بواسطة توضيح أن

NS2 وTCL

الكلمات NS2 ، TCL ، Regret ، KL-SR (KLbased Source-Routing) ، بروتوكولات التوجيه ، MANETS الرئيسية:

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1-General Introduction

1- Introduction

The rise of wireless technologies now offers interesting prospects in the telecommunications field. Recent developments in wireless means of communication have allowed the manipulation of information through portable computing units with characteristics specific items (low storage capacity, energy source, autonomy, limited power, etc.) who access the network through a wireless communication interface [1]

Mobile wireless networks can be classified into two categories: networks with infrastructure that generally use the model of cellular communication, and networks without infrastructure or ad hoc networks. Several systems already use the cellular model and are experiencing a very strong expansion at the moment (GSM networks for example) but require a significant fixed logistical and material infrastructure.[2]

The other type of wireless network, in infrastructure less networks, is known as Mobile Ad-hoc Networks (MANET).

These networks have no fixed routers, every node could be router. All nodes are capable of movement and can be connected dynamically in arbitrary manner.

The responsibilities for organizing and controlling the network are distributed among the terminals themselves. The entire network is mobile, and the individual terminals are allowed to move freely. In this type of networks, some pairs of terminals may not be able to communicate directly with each other and have to relay on some terminals so that the messages are redelivered to their destinations. Such networks are often referred to as multi-hop or store-and forward networks. The nodes of these networks act as routers, which discover and maintain routes to the destination nodes in the networks. The nodes may be located in or on airplanes, ships, trucks, cars, perhaps even on people or very small devices.

Mobile Ad-hoc Networks are supposed to be used for disaster recovery, battlefield communications, and rescue operations when the wired network cannot work there.[3]

The protocols in MANET can be classified into three different groups:

proactive, on demand or reactive, and hybrid. In proactive routing protocols, the routes to all the destinations are determined at the start-up and maintained by using a periodic route update process. In reactive protocols, routes are determined when they are required by the source using a route discovery process. Hybrid routing protocols combine the basic properties of two proactive and reactive protocols into one.[4]

Our study mainly offers a synthetic study of the research that has been done, and which are being done at present, in order to solve the problem of routing data between mobile hosts in the ad hoc network. As we will see the problem of routing is very complicated, this is mainly due to the property that characterizes ad networks hoc and which is the absence of fixed infrastructure and any centralized administration. [5]

Chapter 1

Mobile Ad Hoc Network (MaNet)

1-Introduction

The rapid development of wireless telecommunications technology has enabled the manipulation of information through portable computing units.

These units have specific characteristics (low storage capacity, an autonomous energy source, etc.) and access the network through a wireless communication interface.

The mobile ad hoc network is a self-configuring network of mobile hosts connected by wireless links, whose union forms the topology of the network [1]. The advantages of ad hoc networks are convenience (no central administration), mobility, productivity, deployment and extensibility. As the network nodes are mobile, the network topology changes unpredictably. It is therefore difficult to generate a path between two nodes.

The phenomenal success of ad hoc networks is mainly due to the continuous development of wireless technologies which are becoming more popular and less expensive. Mobile devices are therefore becoming increasingly small and powerful in terms of processing capacity and data storage. And, they come with a host of features that can support different types of applications and services.

2-History Of Mobile Ad Hoc Network:

In the early 1970s, the Mobile Ad Hoc Network (MANET) was called the Packet Radio Network which was sponsored by DARPA (Defense Advance Research Projects Agency). The latter founded the project called PRNets (Packet Radio Networks), packet radio, which consists of several wireless terminals communicating on battlefields.

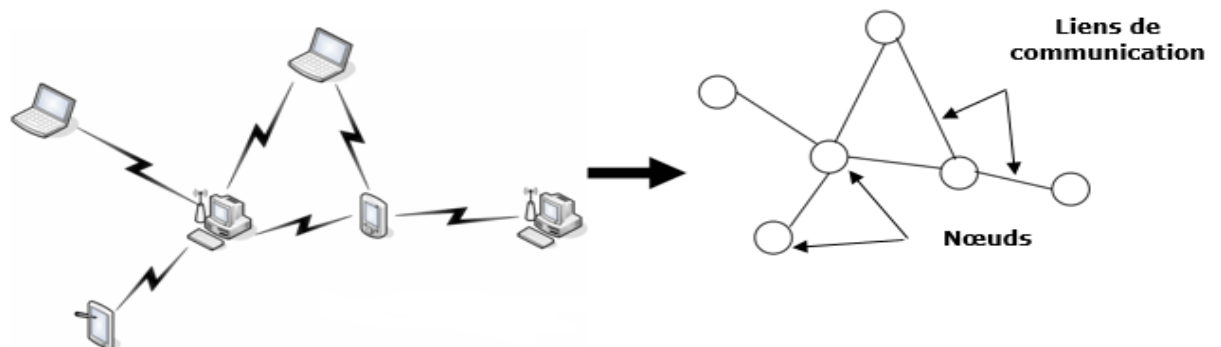
These networks have a distributed system architecture, and share the broadcast channel through a combination of Aloha and CSMA protocols. Subsequently, in 1983, SURAN (Survivable Radio Networks) was developed by DARPA. The goal was to overcome the main limitations of PRNet (in particular, allowing the transition to networks with a large number of nodes, managing security, managing energy, and offering sufficient computational capacity to support advanced protocols). Research on these types of networks remained exclusively military. Civilian or generalized applications of these so-called ad hoc networks did not appear until much later, in the late 1990s[6,7]

3-Definition Of Mobile Ad Hoc Network:

The ad hoc networks we are interested in are those described and studied by the MANET (Mobile Ad hoc Networks) working group of the IETF (the Internet Engineering Task Force). A definition of these networks is formally given in RFC 2501. [8]

A mobile ad hoc network, commonly referred to as Mobile Ad hoc Network (MANET), is a collection of mobile nodes that move around any territory in an autonomous and cooperative manner, without the use of any pre-existing infrastructure or network. centralized administration. The “radio waves” which propagate between the various mobile nodes are the only means of communication. As soon as a set of mobile nodes are within radio range of each other, then the network forms spontaneously but temporarily. There are two modes of communication between two mobile nodes which depend on the distance between them. In the event that the two nodes are within radio range and can communicate directly, this mode is called ad hoc transmission. On the other hand, in the event that the two nodes are not in range,

they have to use other mobile nodes as relays in order to ensure communication and route the packets to the destination, this mode is called multi-hop transmission. [9]

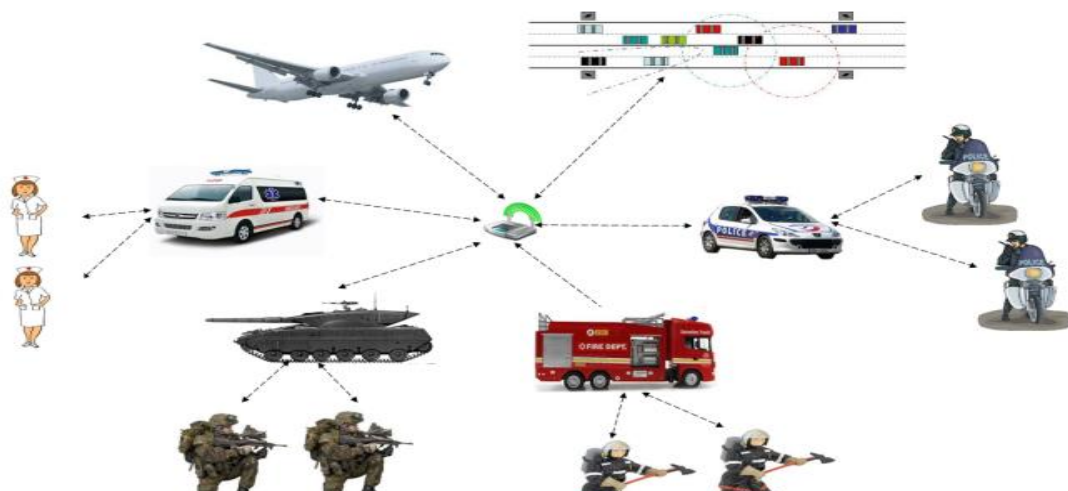


– **Figure 2.1 : shows an example of an ad hoc mobile network and its communication topology.**

4-Applications Of Mobile Ad Hoc Network:

The fields of application of mobile ad hoc networks are numerous and very rich, and we can cite the following applications:

- Military environments or battlefields remain the very first applications of ad hoc networks. The mobile nodes of this type of network can be soldiers, tanks, fighter planes, etc. For military applications, MANETs can be used to monitor enemy movement in a given geographic area, or to collect data in a dangerous area where sending humans would be risky.
- Personal use used for sharing applications of mobile equipment and household objects such as smartphones, laptops, printers, etc. But, MANETs are also being deployed to contribute to home comfort by transforming personal homes into smart environments that automatically adapt to user behavior and avoid wiring at home.
- Emergency interventions, search operations, first aid and emergency rescue during natural disasters such as earthquakes, fires, floods, etc.
- Civilian environments deployed to enable collaborative work and communications within a boardroom, college campus, stadiums, ships, etc.
- Commercial applications used for remote electronic payment (taxi, shops) or for mobile Internet access, etc.
- Sensor networks generally used for environmental applications (weather, land activity, animal monitoring, etc.). [10]



5-The Characteristics

Figure 2.2 : MANET application examples.

Ad hoc networks are distinguished from cellular networks by several characteristics. These should be taken into consideration in any protocol design process. They are fully specified in RFC 2501 [11] and summarized in the following paragraphs:

1. Lack of centralized infrastructure: Ad hoc networks are distinguished from other mobile networks by the lack of pre-existing infrastructure and any kind of centralized administration. Mobile hosts are responsible for establishing and maintaining network connectivity on an ongoing basis. [12]
2. A dynamic topology: The mobile units of the network move freely and arbitrarily. As a result, the topology of the network can change, at unpredictable times, in a rapid and random manner. The links of the topology can be unidirectional or bidirectional.
3. The energy constraint: Mobile hosts are powered by stand-alone energy sources such as batteries or other consumable sources. The energy parameter must be taken into account in any control made by the system.
4. Limited bandwidth: One of the essential characteristics of networks based on wireless communication is the use of a shared communication medium (radio waves). This sharing makes the bandwidth reserved for a host modest.
5. Limited physical security: Mobile ad hoc networks are more vulnerable compared to other wired and cellular networks. This vulnerability is due primarily to the nature of the wireless propagation medium which makes possible certain malicious attacks ranging from passive eavesdropping to active interference. Other formidable attacks, due to the topology of the network, can also be considered, for example the Worm Hole attack. [13]

6-Advantage Of Mobile Ad Hoc Network:

The advantages of ad hoc mobile networks are: [14]

- No cabling: One of the characteristics of Ad Hoc networks is the absence of cabling, eliminating all wired connections which are replaced by radio connections.
- Easy deployment: the absence of cabling gives more flexibility, and allows you to deploy an Ad Hoc network quickly and easily. This ease can be justified by the absence of a pre-existing infrastructure allowing, thus, to save all the time of deployment and installation of the necessary hardware.
- Energy consumption: A mobile sends more messages in Ad Hoc mode than in infrastructure mode, since it must both transmit its own packets but also the packets of other mobiles for which it acts as a router. We could therefore think that this mode is more energy intensive. Nevertheless, the communication ranges can be greatly reduced in Ad Hoc mode. This reduction in communication range saves a lot of energy, since the energy consumption varies less in proportion to the square of the communication distance. So, even if we transmit ten times more messages in Ad Hoc mode, dividing the transmission range by ten only consumes

one tenth of the energy required in base station mode.

- Allows mobility: Ad Hoc mobile networks allow some mobility to their nodes. As a result, they can move around freely as long as they do not move too far from each other to maintain their connectivity.
- Scalable: One of the most important properties of an Ad Hoc network is the ability to expand, and increase its size very easily and without requiring too much money. To explain this aspect, one only needs to imagine the arrival of a new mobile node to an Ad Hoc network already installed and set up. In order for this node to function within the network, it is sufficient to make a few configurations at the node itself.
- Cost: the deployment of an Ad Hoc network does not require installing base stations, mobiles are the only physical entities necessary to deploy such a network. Which leads to a significant reduction in its cost.

7-Disadvantages Mobile Ad Hoc Network:

There are many Disadvantages of MANET (Mobile Ad hoc Network) these are[15]

Energy Consumption: Energy management is process of managing the sources and consumers of energy in node or in the network as a whole for enhancing the lifetime of the network.

Security in MANET: Security in Mobile Ad hoc Network is very important especially in military applications. Lack of central coordination and shared wireless medium makes them more vulnerable to attacks than wired network.

Deployment Consideration: During deployment of Ad hoc wireless network involves actions different from the wired network. It needs good amount of planning and estimation of future traffic growth

8-Routing Protocols In Ad Hoc Networks

1-Routing Definition

Routing is a method of routing information to the correct destination through a given connection network. The routing problem consists in determining an optimal routing of the packets through the network within the meaning of a certain performance criterion. The problem is to find the least cost investment in nominal and reserve capacity that ensures the routing of nominal traffic and guarantees its survivability in the event of any arc or node failure. [16]

2-Routing Problem In Ad Hoc Networks

Routing must provide a strategy for routing data, at all times, between a pair of nodes (source and destination) across a network. The routing issue is one of the main issues raised by multi-hop radio communications. In MANETs, mobiles are forced to perform the data routing by themselves, due to the lack of infrastructure in this type of network. When the destination is outside the radio range of the source, each mobile in the network acts as a relay by retransmitting the data to another mobile until it reaches the destination. The frequent instability of paths due to mobility and the constraints of radio resources (variable rate, limited bandwidth, etc.) present major challenges for this type of routing. Routing protocols ensure the transfer of data from one mobile to another through multi-hop routes. Radio links change dynamically and frequently: links are created and destroyed by the free movement of mobiles. Routing protocols adapt to these changes in routes. In addition, they must take into consideration the limited resource constraints that characterize MANETs. The routing protocol must ensure routing of data through routes that have the necessary resources despite

the frequent change of routes. The Internet Engineering Task Force (IETF) MANET working group has standardized a number of routing protocols which will be described below. [17]

9-Classification Of Routing Protocols In MANETs:

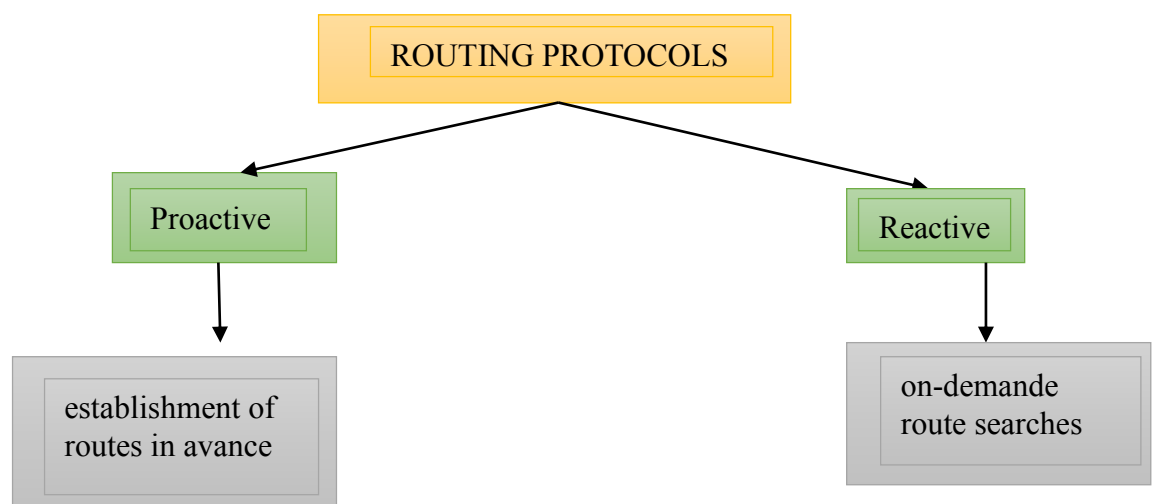
routing in ad hoc networks has become a popular topic of research.

In the early 1980s, a large number of routing protocols were designed and proposed for ad hoc networks. These protocols cover a range of choices and design approaches, from simple modifications of Internet protocols to more complex hierarchical multi-level protocols.

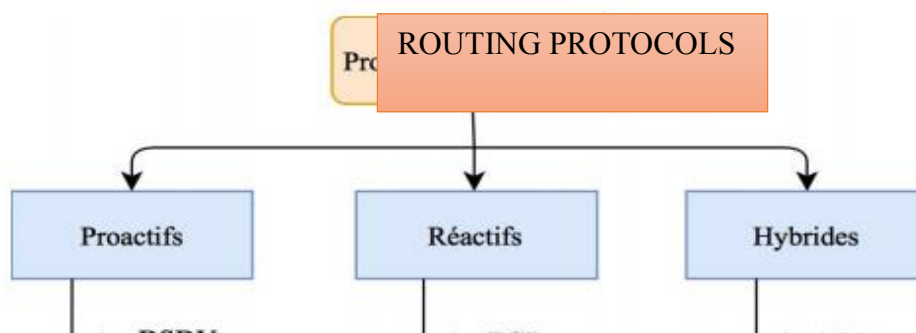
The routing protocols that have been designed are based on similar sets of assumptions. For example, most routing protocols assume that all nodes have homogeneous resources and possibilities. This includes node transmission ranges and bidirectional links that are often assumed. In the latter case, the protocols then eliminate unidirectional links from consideration. Out of the box other protocols have mechanisms to determine these unidirectional links.

This chapter describes the classifications of the most popular routing approaches and their characteristics. The routing protocols mentioned as example classes are chosen for a number of reasons. They can be popular choices for research among the ad hoc community. They may, at the time of this writing, be under consideration by the IETF's Mobile Ad Hoc Networks (MANET) Standardization Working Group, or they may simply be good examples of standardization protocols. illustration of their classes.

In the classifications cited below, the protocol classes do not have a tree structure, although certain characteristics are generally common among the classes. Some classes are of an oppositional nature for example: reactive and proactive. Others will not have counterparts with interesting characteristics to specify (such as hierarchical routing, since non-hierarchical protocols do not share distinguished characteristics, except that they are not hierarchical).[18,19,20,21]



– Figure 2.3 : routing protocols can be separated into: Proactive, Reactive and Hybrid.



Reactive

– Figure 2.4 : classification of some routing protocols.

9-1-Proactive Routing Protocols:

Proactive routing approaches, designed for ad hoc networks, are derived from traditional state vector and distance vector protocols developed for use in wired networks. The primary characteristic of proactive approaches is that each node in the network maintains a route to all other nodes in the network at all times. Route creation and maintenance is accomplished by a combination of periodic updates and triggering of events:

Periodic updates are done by exchanging routing information between nodes at predefined time intervals, regardless of mobility characteristics and network traffic.

Updates by triggering events are done by exchanging routing information whenever a certain event occurs, such as an addition of links or a displacement of a node. In this case, the mobility rate directly affects the frequency of updates because the link changes occur as mobility increases.

Proactive approaches have the advantage that routes are available at all times. However, the major drawback of these protocols is that the control overheads can be significant especially in large networks or in networks with high mobility. Additionally, the amount of routing state maintained in each node is $O(n)$, where n is the number of nodes in the network. Proactive protocols tend to perform well in networks where there are a significant number of active data sessions. In the latter, the overhead is justified because the majority of these paths are used.

Example of protocols that update their tables by triggering events:

CBRP, DSDV, TORA ...

Example of protocols that update their table periodically:

OLSR, TBRPF[22,23,24,].

9-1-1-The DSDV Protocol:

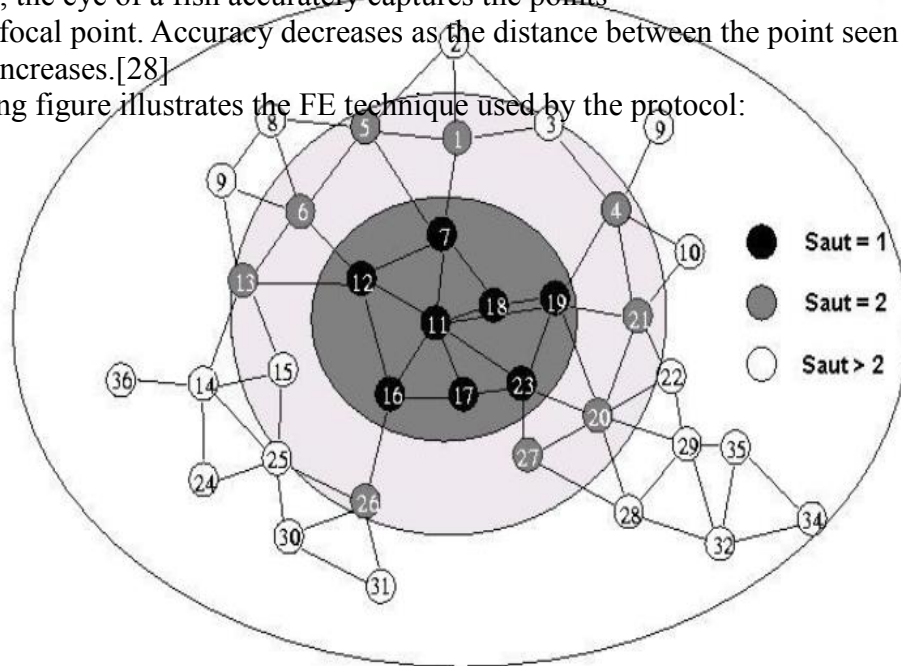
- Based on the classic idea of the Bellman-Ford distributed algorithm with some improvements.
- Each mobile station maintains a routing table which contains:
 - All possible destinations.
 - The number of nodes (or hops) required to reach the destination.
 - The sequence number (SN: sequence number) which corresponds to a destination node.
 - NS is used to distinguish between old and new routes, which prevents the formation of routing loops.
- The update therefore depends on two parameters: The time, that is to say the transmission period, and The events

- An update package contains:
 - 1- The new incremented sequence number of the sending node. And for each new route:
 - 2- The address of the destination.
 - 3- The number of nodes (or jumps) separating the node from the destination.
 - 4- The sequence number (of the data received from the destination) as it was stamped by the destination.
- The DSDV eliminates the two routing loop problems, and that of the "counting to infinity". However:
 - In this protocol, a mobile unit must wait until it receives the next update initiated by the destination, in order to update the entry associated with that destination, in the distance table. So the DSDV is slow.
 - The DSDV uses periodic and event-based updating, which causes excessive control in communication. [25,26,27,].

9-1-2-The FSR Protocol:

- The FSR protocol is based on the use of the "fish eye" (fisheye) technique, proposed by Kleinrock and Stevens, who used it in order to reduce the amount of information needed to represent graphical data.
- In practice, the eye of a fish accurately captures the points close to the focal point. Accuracy decreases as the distance between the point seen and the focal point increases.[28]

The following figure illustrates the FE technique used by the protocol:



– **Figure 2.5 : the FE technique used by the FSR protocol.**

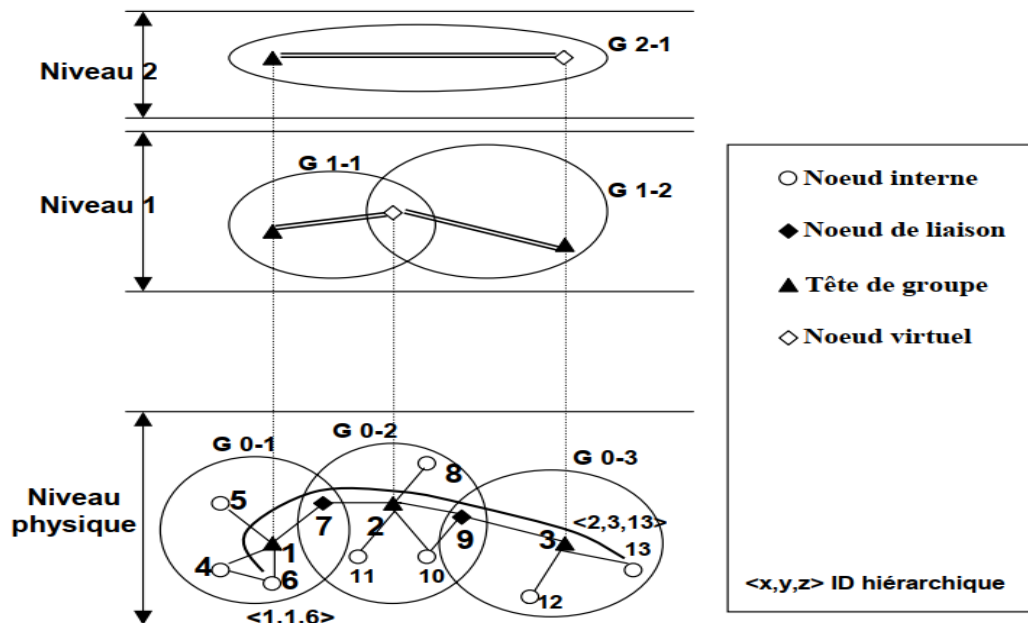
- In the context of routing, the "fisheye" approach materializes, for a node, the maintenance of data concerning the precision of the distance and the quality of the path of a direct neighbor, with a gradual decrease in detail and precision, as the distance increases.
- The frequency reduction is ensured by changing the update frequencies, and this by using different exchange periods for the different entries of the routing table. The entries which correspond to the closest nodes, are sent to the neighbors with a high frequency (therefore with a relatively small exchange period). [28]

9-1-3-The HSR Protocol:

- The HSR protocol combines the notions of dynamic groups, hierarchical levels with efficient location management.
- In the HSR, the image of the network topology is saved in hierarchical form. The network is

partitioned into a set of groups:

- In a group, one node must be elected to represent the rest of the members. The representatives of the groups in a level l , become members in the level $l + 1$. These new members, organize themselves in a set of groups in the same way of the low level, and so on for the rest of the levels. .[29,30]



- The hierarchical location of the location of

Figure 2.6 : the application of the hierarchical partitioning mechanism.

9-1-4-The OLSR Protocol:

is an optimization of the link state algorithm. This protocol also uses the shortest path algorithm for route selection. In the link-state algorithm, each node in the network declares its neighborhood to the entire network. In contrast, in OLSR, nodes only declare a subset of their neighborhood using the technique of multipoint relays. In the section, we describe how OLSR works, and we explain the choice of this protocol for our study. .[31,32]

9-2-Advantages And Disadvantages Of Proactive Protocols:

With a proactive protocol, routes are immediately available when needed. Thus the advantage of such a protocol is the saving of time when requesting a route. The problem is, the route changes can be more frequent than the demand of the route. In this case, the traffic induced by the routing table control and update messages may be significant and partially unnecessary. Because only certain roads will be used.

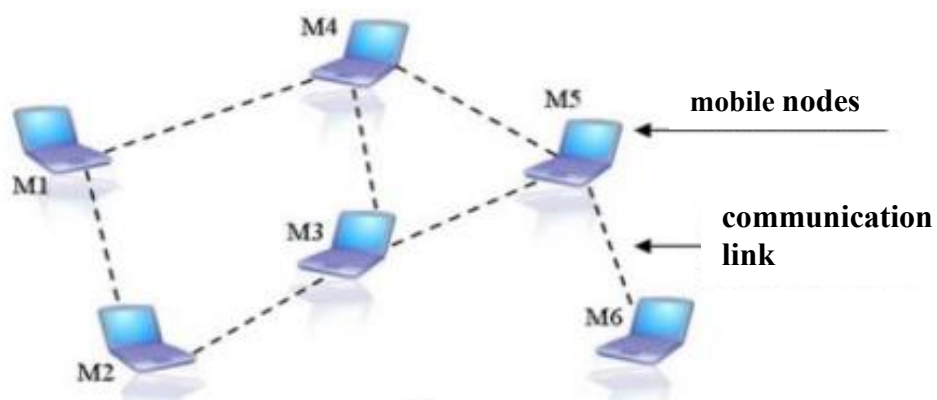


Figure 2.7 : example of an ad hoc network.

Destination	number of hop	next node	sequence number
M1	0	M1	NS1
M2	1	M2	NS2
M3	2	M2	NS3
M4	1	M4	NS4
M5	2	M4	NS5
M6	3	M4	NS6

Table 2.1 :Node routing table M1 in figure 2.7.

by applications in general. This wastes the capacity of the wireless network in terms of bandwidth. As a result, a new type of protocol has appeared, and it is reactive routing protocols. [33,34,35,36]

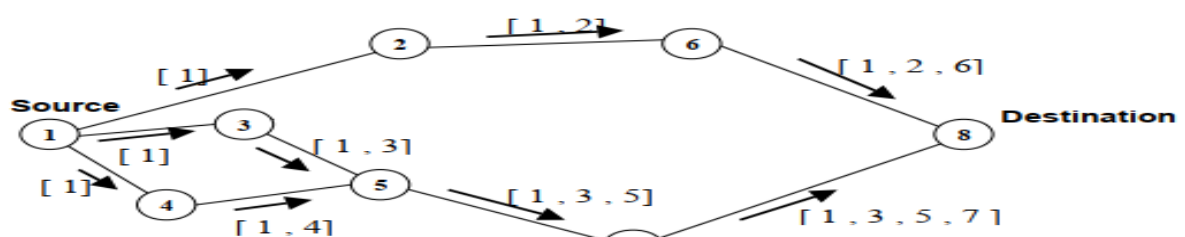
9-3-Responsive Routing Protocols:

As we mentioned in the previous paragraph, proactive routing protocols try to maintain the best paths to all network destinations by periodically exchanging update control messages. The routes are saved even if they are not used, which induces excessive control, especially in the case of dense networks.

Responsive routing protocols create and maintain routes according to the needs of transmitters and their applications. In this case, a global route discovery procedure is launched which provides very specific information but unknown beforehand. The protocols based on this principle, also called on demand, are among others: DSR, AODV CBRP, LMR, TORA, ABR, SSR, LAR, etc.

9-3-1-The DSR Protocol:

- The "Dynamic Source Routing" (DSR) protocol is based on the use of the "source routing" technique. In this technique: the data source determines the complete sequence of nodes through which the data packets will be sent.
- A site initiating the "discovery of routes" operation broadcasts a route request packet. If the discovery operation is successful, the initiator receives a route response packet that lists the sequence of nodes through which the destination can be reached. The route request packet therefore contains a route record field, in which the sequence of the nodes visited during the propagation of the request in the network will be accumulated, as shown in the following figure:



– **Figure 2.8 : discovery of paths in the DSR.**

- In order to ensure the validity of the paths used, the DSR performs a route maintenance procedure:

- When a node detects a fatal transmission problem, using its link layer, a route error message is sent to the original sender of the packet.

The error message contains the address of the node that detected the error and that of the node following it in the path.

- When the source host receives the route error packet, the node affected by the error is deleted from the saved path, and all paths that contain that node are truncated at that point.

Subsequently, a new route discovery operation to the destination is initiated by the transmitter.

- The use of the "source routing" technique eliminates the need for transit nodes to maintain up-to-date information to send data packets, since the packets contain all routing decisions.

- In this protocol, there is a total absence of a routing loop, because the source-destination path is part of the data packets sent. [37,38]

9-3-2-The AODV Protocol:

- The AODV protocol essentially represents an improvement in

the DSDV algorithm discussed already, in the reactive context. The protocol

AODV, reduces the number of message broadcasts, and this by creating routes when needed, unlike DSDV, which maintains all routes.

- The AODV uses the principles of sequence numbers to maintain the consistency of routing information.

- Due to the mobility of nodes in ad hoc networks, routes change frequently, causing routes maintained by some nodes to become invalid. The sequence numbers allow the use of the newer routes (fresh routes).

- Similar to DSR, AODV uses a route request in order to create a route to a certain destination. However, the AODV maintains the paths in a distributed manner by keeping a routing table, at the level of each transit node belonging to the searched path.

- A node broadcasts a route request in the event that it needs to know a route to a certain

destination and such a route is not available. It can happen :

→ if the destination is not known in advance, or

→ if the existing path to the destination has expired its lifetime or has become faulty

- The destination sequence number field of the RREQ packet contains the last known value of the sequence number associated with the destination node.

This value is copied from the routing table. If the sequence number is not known, the value zero will be taken by default. The source sequence number of the RREQ packet contains the value of the sequence number of the source node.

- In order to maintain consistent routes, a periodic transmission of the "HELLO" message is performed. If three "HELLO" messages are not received consecutively from a neighboring node, the link in question is considered faulty.

- The AODV protocol does not have a routing loop, moreover it avoids the Bellman-Ford "counting to infinity" problem, which offers rapid convergence when the topology of the ad hoc network changes. .[39,40,41]

9-3-3-The TORA Protocol:

uses a routing technique called "Link Reversal". This protocol is based on Directed Acyclic Graph (DAG) for the creation of a route to a destination. The source broadcasts a QUERY (QRY) message specifying the destination identifier, and the receiver responds by sending an UPDATE (UPD) message. TORA was designed primarily with the goal of minimizing frequent topology (mobility) changes in ad hoc networks. This protocol saves multiple paths to a single destination, so frequent topology changes do not affect data routing unless all paths to the destination are broken. Therefore, the number of control messages used is reduced in the network. .[42,43,44,45,46]

9-3-4-The ABR Protocol:

is based on a new approach to routing that uses a new metric known as the degree of association stability. In this protocol, the selection of routes is based on the associativity states of the nodes. The selected routes will thus have a long lifespan. Network nodes signal their existence by exchanging periodic control messages called beacons. When receiving a beacon, the node updates its associativity table: it increments its associativity value corresponding to the sending node.

Association stability is defined as the connection stability between two nodes.

A high associativity value with a node means low mobility. On the other hand, a small associativity value indicates high mobility. Thus, finding paths with a long lifespan is ABR's main objective.

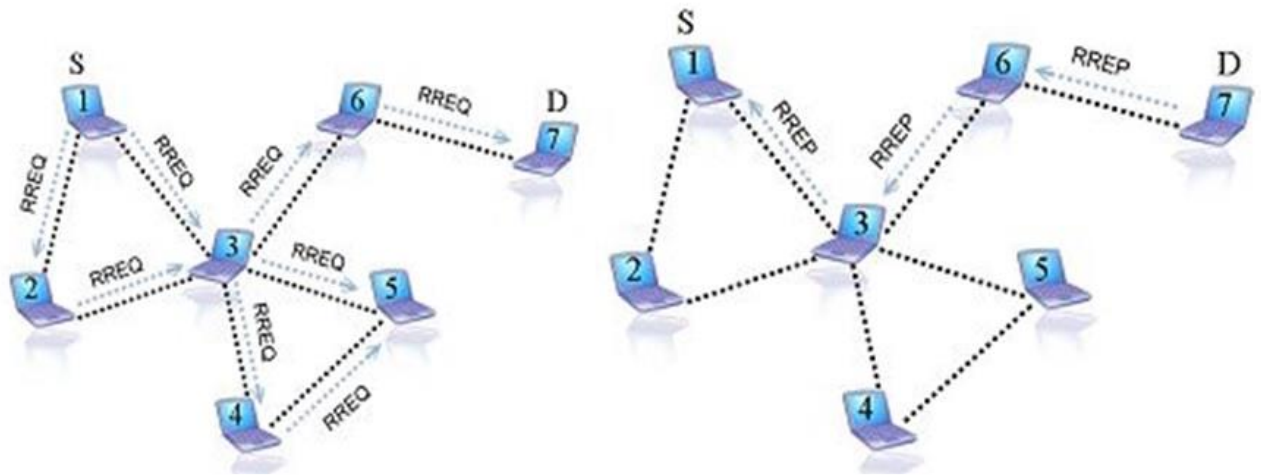
During the route discovery phase to a destination, a source broadcasts a Broadcast Query (BQ) message. A node forwards the received BQ by appending its address and its associativity intervals to the request packet. Once this request is received by the destination, the latter chooses the path with the best degree of associativity. It sends a response packet called REPLY to the source node using the chosen path.

In addition to the two categories of routing protocols, proactive and reactive, there is another category called hybrid which combines the previous ones. This category will be the subject of the next paragraph. .[47,48]

9-4-Advantages And Disadvantages Of Reactive Protocols:

Unlike proactive protocols, in the case of a reactive protocol, no control message loads the

network for unused routes. This saves network resources from wasting (this saves bandwidth and energy).



– Figure 2.9 : The two RREQ and RREP requests used in the AODV protocol

But building a flood road can be costly and cause significant delays before the road opens. .[49;50]

9-5-Hybrid Routing Protocols:

These protocols use the proactive approach to determine the two-hop or three-hop neighborhood. In this way, the roads in the neighborhood are defined. Beyond this pre-defined area, hybrid protocols use the reactive approach for route search. As a result, the network is divided into several zones. Upon receipt of a reactive route search request, the node can signal whether the destination is in its vicinity or not to resend the request to other areas. Zone Routing Protocol (ZRP) is an example of this category.

Hybrid protocols adapt well to large networks, however, they also have the disadvantages of reactive protocols such as: periodic control messages, plus the cost of finding a new route.

.[51]

9-5-1-The ZRP protocol:

The ZRP routing protocol divides the network into zones. Each zone of the network includes a set of nodes whose number of hops does not exceed a certain predefined number also called the radius of the zone. Update messages are exchanged locally in each zone in order to allow the nodes to know locally the topology of the network. .[52,53]

Table 2.2 : Description of the criteria adapted in the classification of MANET routing protocols .

Type	Description
Uniform	All nodes in the node act the same for the routing function: no hierarchy in the network
Not uniform	Some nodes participate in the routing function: hierarchical structure of the network
Topology oriented protocols	Each node collects information on the state of its connections with its neighbors and transmits it to other nodes to guarantee

	them precise knowledge of the topology of the network
Destination oriented protocols	Each node exchanges its distance estimates with each of its direct neighbors for all network nodes
Partitioned protocols	The network is divided into zones in which routing is provided by a single master node
Protocols with selection of neighbors	Each node processes the routing function to a subset of its direct neighbors

In one area, a proactive routing protocol such as DSDV is used to learn about the topology. To determine a path to a node in an outside zone, a reactive routing protocol such as DSR is employed.

When discovering a route in ZRP, the source first checks that the destination is outside its zone. It then sends a request packet to all the nodes on the edge of its area. Each of the nodes that receives the request packet adds its address to it and forwards it to its edge nodes, in case the destination is not in their routing area. Otherwise, where a node identifies the destination as a member of its zone, the leader of that zone sends a response packet that includes the complete route to the destination.

9-5-6-Advantages and disadvantages of hybrid protocols:

The hybrid protocol is a protocol which is intended as a solution bringing together the advantages of the two preceding approaches by using a notion of division of the network. However, it still brings together some drawbacks of both proactive and reactive approaches.
.[54]

– Table 2.3: Comparison of routing protocols.

Protocols	Type	Structure	Routes	Operations	Control Msg
DSDV	proactive	dish	simple	distributed	No
CGSR	proactive	hierarchical	simple	distributed	No
FSR	proactive	dish	simple	distributed	No
OLSR	proactive	dish	simple	distributed	Yes
TBRPF	proactive	dish	simple	distributed	Yes
WRP	proactive	dish	simple	distributed	Yes
GSR	proactive	dish	simple	distributed	No
SSR	reactive	dish	simple	distributed	Yes

ABR	reactive	dish	simple	distributed	Yes
LMR	reactive	dish	multiple	distributed	Yes
RDMAR	reactive	dish	simple	distributed	No
AODV	reactive	dish	simple	distributed	Yes
DSR	reactive	dish	multiple	distributed	No
CEDAR	reactive	hierarchical	simple	distributed	Yes
TORA	reactive	dish	multiple	distributed	Yes
ZRP	hybrid	dish	multiple	global in terzone	Yes
ZHLS	hybrid	hierarchical	simple	distributed	No
HSR	hybrid	hierarchical	simple	distributed	No

2-10-Conclusion:

In this chapter, we have presented the mobile ad hoc networks, their main characteristics, Advantages, disadvantages and their applications. We have highlighted the problem of routing due to mobility. A group of routing protocols is discussed in order to deduce a classification of these protocols.

In the next chapter, we will describe a set of Algorithms most used by routing protocols in ad hoc networks. The definitions of these Algorithms will lead us subsequently to make a classification, in order to refine our choice in the Algorithms to be studied in our approach.

Chapter 2

State of the art

1_Intreduction:

In most real-world networks, link delays vary stochastically due to unreliable links and random access protocols , mobility , randomness of demand , etc. In many cases, the associated parameters to links, e.g. the packet transmission success probabilities in wireless sensor networks, are initially unknown and must be estimated by transmitting packets and observing the outcomes.

When designing routing policies, we therefore need to address a challenging trade-off between exploration and exploitation: on the one hand, it is important to route packets on new or poorly known links to explore the network and ensure that the optimal path is eventually

found; on the other hand, it is critical that the accumulated knowledge on link parameters is exploited so that paths with low expected delays are preferred.

When designing practical routing schemes, one is mostly concerned about the finite-time behaviour of the system and it is crucial to design algorithms that quickly learn link parameters so as to efficiently track the optimal path.

Many algorithms, with a trade-off between computational complexity and performance, are proposed. We mention some of them:

2_Termite Algorithm:

A biologically inspired algorithm is presented to route messages in mobile wireless ad-hoc networks. The principles of swarm intelligence are used to define a probabilistic algorithm for which routing through paths of maximum throughput is an emergent property. This adaptive algorithm, dubbed termite, uses stigmergy to reduce the amount of control traffic needed to maintain a high data goodput. Stigmergy is a process by which information is indirectly communicated between individuals through their environment. The termite environment is the contents of all routing tables. The movement of packets is influenced at each node, and communicating nodes observe this influence to update their own tables. Strong routing robustness is achieved through the use of multiple paths; each packet is routed randomly and independently.[55]

Termite is a swarm intelligent routing algorithm for mobile wireless ad-hoc networks. Based on previous work in the field and the termite hill building analogy, Termite is designed to remedy many of problems commonly associated with MANET routing algorithms. Primarily, Termite aims to reduce the amount of control traffic necessary to maintain acceptable performance in the network. The total number of transmissions necessary to deliver a data packet should be minimized. One way in which this is done is to institute a local route repair scheme where packets are simply forwarded to another neighbor if the current communications link fails. If a node is entirely unaware of a destination, then a route discovery process is initiated. Unlike the traditional approach of flooding the network to search for a route, Termite takes advantage of the broadcast communications environment and uses a random walk to find routes. This approach manages to find routes to most destinations while avoiding the cost of many packet transmissions. There are many considerations when using a swarm intelligent algorithm such as Termite for network routing. Termite's probabilistic approach departs from standard routing practice, which is based on deterministic algorithms on graphs.

Instead, Termite depends on a global routing solution as an emergent behavior, the result of the interactions of many packets. Each of these packets collects and distributes information about the network, known as pheromone, as it moves through the network; exploring while traveling. A disadvantage of this approach is that packets may lose themselves while exploring and die in the network. Termite can only be considered a best-effort routing service and requires a reliable transport layer implemented on top of it.

Termite is shown to be an effective routing algorithm based on simple rules following the principles of swarm intelligence. The pheromone update strategies are controlled by positive and negative feedback, and the behavior of individual packets is random and dependant on multiple interactions. .[56]

3_Random Walk Algorithm:

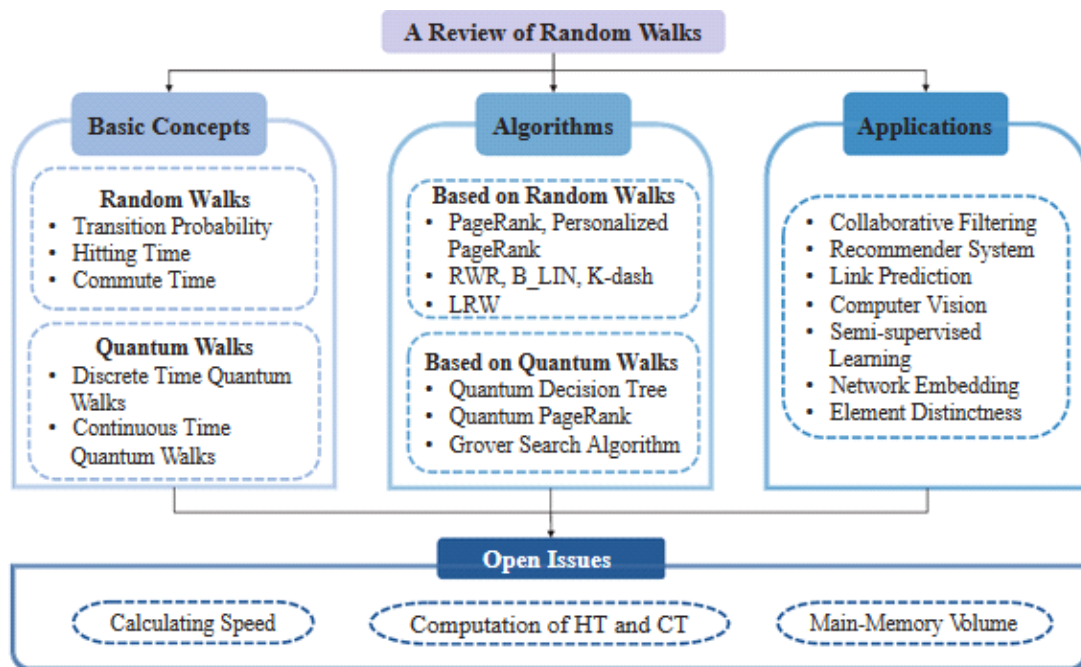
A random walk, sometimes denoted RW, is a mathematical formalization of a trajectory that consists of taking successive random steps. The results of random walk analysis have been applied to computer science, physics, ecology, economics and a number of other fields as a fundamental model for random processes in time. For example, the path traced by a molecule as it travels in a liquid or a gas, the search path of a foraging animal, the price of a fluctuating stock and the financial status of a gambler can all be modeled as random walks. Specific cases

or limits of random walks include the drunkard's walk and Lévy flight. Random walks are related to the diffusion models and are a fundamental topic in discussions of Markov processes. Several properties of random walks, including dispersal distributions, first-passage times and encounter rates, have been extensively studied.

Various different types of random walks are of interest. Often, random walks are assumed to be Markov, but other, more complicated walks are also of interest. Some random walks are on graphs, others on the line, in the plane, or in higher dimensions, while some random walks are on groups.

Random walks also vary with regard to the time parameter. Often, the walk is indexed by the natural numbers, as in. [57]

Random walks can be used to calculate the proximity between two nodes and extract the network topology. It has been proved that random walks play an important role in many scenarios. We explore the applications of random walks in the field of computer science including collaborative filtering, computer vision, network embedding, and so on. Many problems with existing random walk based algorithms are caused by giant networks, such as slow convergence speed, insufficient storage capacity. Further research in this field would be of great help in theoretical and practical application of random walks.[58]



– Figure 3.1 : The framework of random walks

4 The Emergent Ad Hoc Routing Algorithm (EARA):

EARA is an on-demand multipath routing algorithm. Inspired by the ant foraging intelligence, this algorithm uses positive feedback originated from destination nodes to reinforce the existing pheromone on good paths. Ant-like packets, analogous to the ant foragers, are used to locally find new paths. Artificial pheromone is laid on the communication links between nodes and data packets are biased towards strong pheromone but the next hop is chosen probabilistically. To prevent old routing solutions from remaining in the current network status, exponential pheromone decay is adopted as the negative feedback.

Each node using this algorithm maintains a probabilistic routing table. This routing table serves in a probabilistic fashion. Each route entry for the destination d is associated with a list of neighbor nodes j . A probability value $P_{i;j,d}$ in the list expresses the goodness of node j as

the next hop to the destination d. For each neighbor, the shortest hop distance to the destination and the largest sequence number seen so far are also recorded. .[59]

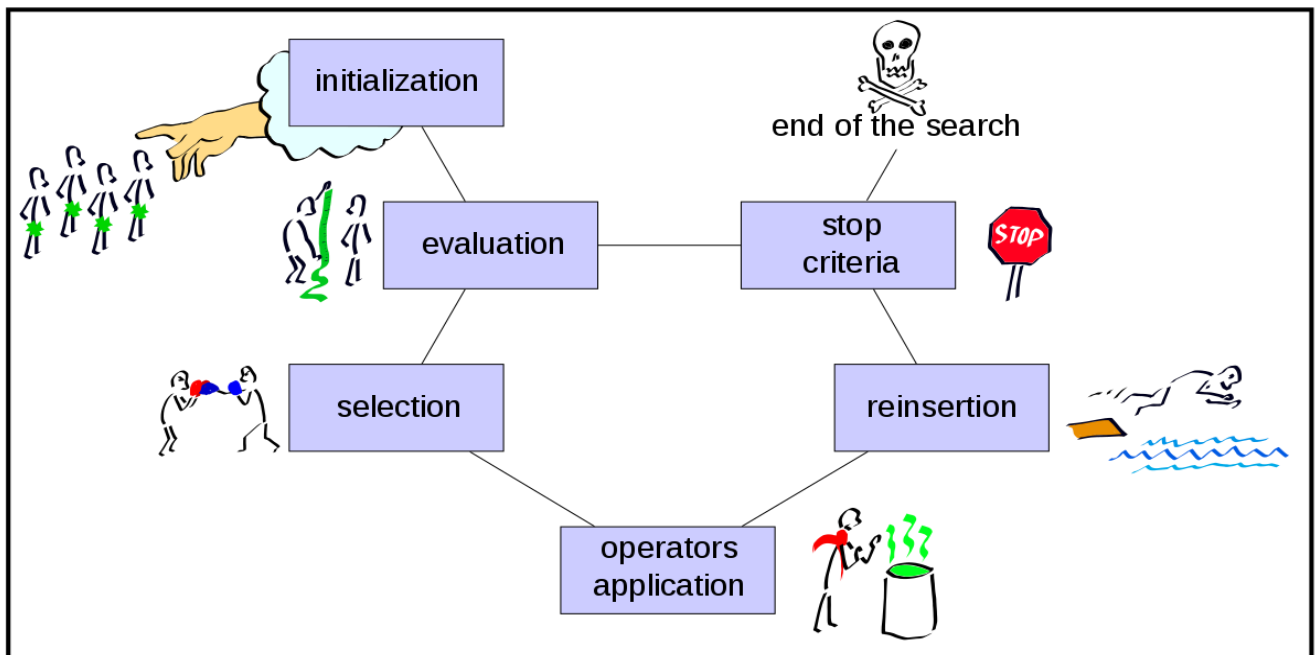
The EARA algorithm consists of several elements. Multiple routes are found with the route discovery procedure, good quality routes are reinforced and maintained with positive and negative feedback, and route failures are handled with the local connectivity management[60]

5_ Evolutionary Algorithms:

In Evolutionary computation, a evolutionary algorithm is a subset of developmental reckoning, a bland populace based metaheuristic streamlining calculation. An evolutionary algorithm utilizes systems roused by organic development, for example, propagation, change, recombination, and determination. .[61]

Evolutionary algorithms are research techniques inspired by the biological evolution of species. They draw inspiration from the evolution of living things (Darwin's theory of natural selection of species) to solve optimization problems.

The idea here is that, individuals who have inherited traits well adapted to their environment tend to live long enough to reproduce, while the weaker ones tend to disappear. These include genetic algorithms, genetic programming, evolutionary strategies and differential evolution. .[62]



– Figure 3.2 :General Schema of an Evolutionary Algorithm(EA)

The main classes of EA in contemporary usage are (in order of popularity) genetic algorithms (GAs), evolution strategies (ESs), differential evolution (DE) and estimation of distribution algorithms (EDAs). Multi-objective evolutionary algorithms (MOEAs), which generalise EAs to the multiple objective case, and memetic algorithms (MAs), which hybridise EAs with local search, are also popular, particularly within applied work. Special-purpose EAs, such as genetic programming (GP) and learning classifier systems (LCS) are also widely used. .[63]

Figure 3.3 :Code Of Evolutionary Algorithm(EA)

Algorithm 1: Evolutionary programming algorithm

```

1 population = InitializePopulation(populationSize, problemDimension);
2 evaluatePopulation(population);
3 bestSolution = getBestSolution(population);
4 while testForTermination == false do
5     offspring = {};
6     for parenti ∈ population do
7         offspringi = mutate(parenti);
8         offspring = {offspring} ∪ offspringi;
9     evaluatePopulation(offspring);
10    bestSolution = getBestSolution(offspring,bestSolution);
11    population = {population} ∪ {offspring};
12    population = environmentalSelection(population);
13 Return(bestSolution);

```

6_ Swarm Based Algorithms:

An optimization algorithm is an iterative procedure, starting from an initial guess. After a certain (sufficiently large) number of iterations, it may converge towards to a stable solution, ideally the optimal solution to the problem of interest. This is essentially a self organizing system with solutions as states, and the converged solutions as attractors. Such an iterative, self-organizing system can evolve, according to a set of rules or mathematical equations. As a result, such a complex system can interact and self-organize into certain converged states, showing some emergent characteristics of self-organization[64]

Swarm-based algorithms are optimization techniques inspired by collective behavior in social species such as ants, bees, wasps, termites (white ants), fish and birds. Who are extremely simple populations of agents, interacting and communicating indirectly through their environment, constitute distributed algorithms to solve difficult real problems. Among the most successful swarm intelligence-inspired optimization algorithms are ant colonies and particle swarm optimization, bee colony optimization and recently cuckoo research. [65] Optimization algorithms based on swarm intelligence can have some distinct advantages over traditional methods. By using theories of dynamical systems and self-organization as well as the framework of Markov chains, we have provided a critical analysis of some recent SI-based algorithms. The analysis has focus on the way of achieving exploration and exploitation, and the basic components of evolutionary operators such as crossover, mutation and selection of the fittest[66]

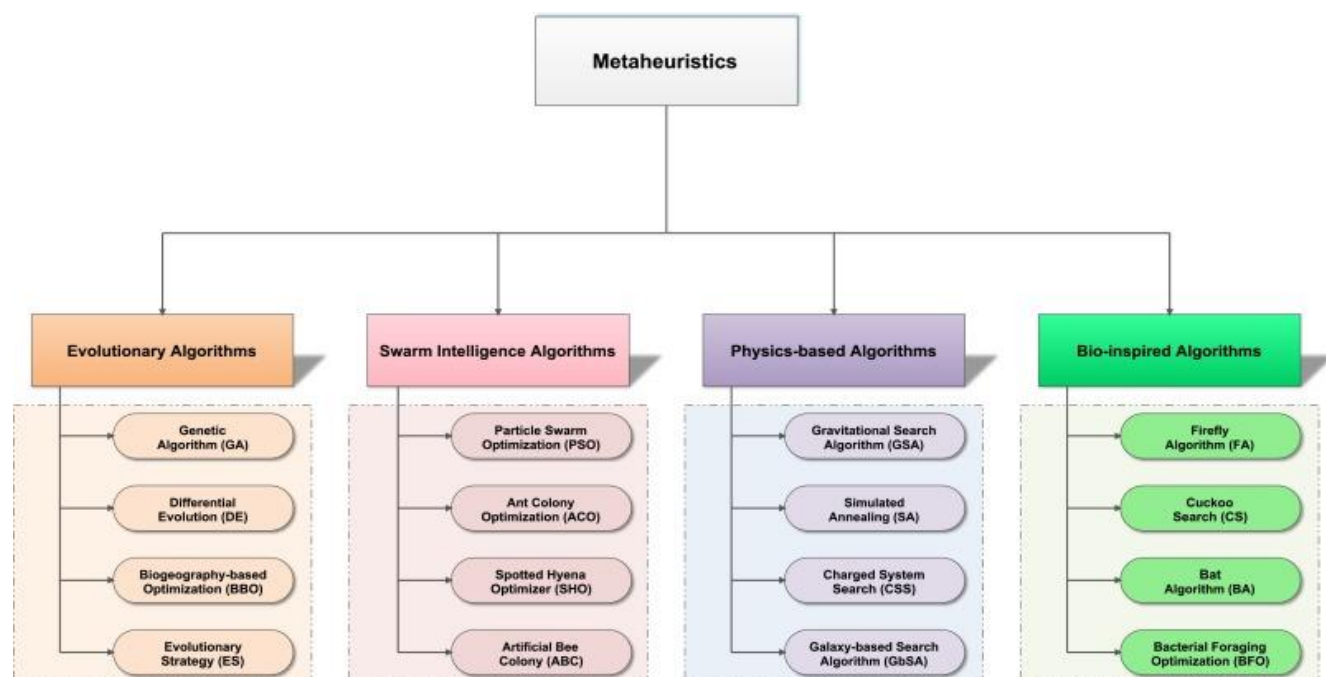


Figure 3.13 : Bio-inspired algorithm

Algorithm KL-SR:

KL-SR (KLbased Source-Routing) we improve the regret upper bound of KL-SR to $O(\frac{dm}{\Delta_{\min} \theta_{\min}^3} \min \log(N))$, where m denotes the length (number of links) of the longest path in the network from the source to the destination, $\theta_{\min}$ is the success transmission probability of the link with the worst quality, and $\Delta_{\min}$ is the minimal gap between the average end-to-end delays of the optimal and of a sub-optimal . [60]

We now present an improved regret upper bound for the KL-SR algorithm. KL-SR, initially proposed in [1] relies on an index attached to links. More precisely, for each link $i \in E$, KL-SR maintains index ω_i defined for the n -th packet as:

$$\omega_i(n) = \min \left\{ \frac{1}{q} : q \in [\hat{\theta}_i(n), 1], t_i(n) \text{kl}(\hat{\theta}_i(n), q) \leq f_2(n) \right\},$$

Algorithm KL-SR:

for $n \geq 1$ do Select path $M(n) \in \argmin_{M \in \mathcal{M}} M > \omega(n)$ (ties are broken arbitrarily).
Collect feedbacks on links $i \in M(n)$, and update $\hat{\theta}_i(n)$ for $i \in M(n)$.
end for

where $f_2(n) = \log(n) + 3 \log(\log(n))$. For the transmission of the n -th packet, KL-SR selects the path $M(n) \in \argmin_{M \in \mathcal{M}} M > \omega(n)$, where $\omega(n) = (\omega_i(n))_{i \in E}$. The pseudo-code of KL-SR is presented in Algorithm 5.2. In the following theorem, we provide an improved finite-time analysis of the KL-SR algorithm. Theorem 5.6. There exists a constant $K_0 \geq 0$ such that for every $\delta \in (0, 1)$, the regret under policy $\pi = \text{KL-SR}$ satisfies for any N :

$$R^\pi(N) \leq \frac{45(1+\delta)^2}{(1-\delta)^5} \cdot \frac{mdf_2(N)}{\Delta_{\min} \theta_{\min}^3} + m\theta_{\min}^{-1} \left(K'' + \frac{2}{\delta^2 \min(\frac{\Delta_{\min}}{M^{\frac{1}{1-\delta}}}, 1)^2} \sum_{i \in E} \theta_i^{-2} \right).$$

$$\text{Hence, } R^\pi(N) = \mathcal{O} \left(\frac{md}{\Delta_{\min} \theta_{\min}^3} \log(N) \right) \text{ when } N \rightarrow \infty.$$

Algorithm	Regret	Complexity
KL-SR (Theorem 4.6)	$\mathcal{O} \left(\frac{dm}{\Delta_{\min} \theta_{\min}^2} \log(N) \right)$	$\mathcal{O}(d V)$

Index	Type	Computation	Algorithm
ω_i	Edge	Line search	KL-SR

7Conclusion

Mobile Ad Hoc Network (MANET) is a collection of wireless mobile nodes that are able to dynamically form a temporary network without any fixed infrastructure or centralized administration. In this chapter, a brief survey on Types of algorithms has been introduced. Different researchers discussed various solutions and each researcher used a different parameter for the shortest path for routing.

Routing in MANETs has become a very important problem in terms of quality of service, which is why many researchers are thinking of solving this problem by using another type of very recent resolution algorithms.

In the next chapter, we propose algorithm source routing policy her name 2 KL-SR Here we improve its regret analysis.

Chapter 3

Stochastic Routing Algorithm for MANETs

1. Cygwin:

a large collection of GNU and Open Source tools which provide functionality similar to a Linux distribution on Windows.

Cygwin is an open source collection of tools that allows Unix or Linux applications to be compiled and run on a Windows operating system from within a Linux-like interface. This capability helps developers to migrate applications from Unix or Linux to Windows-based

systems, and makes it easier to support their applications running on the Windows platform. Cygwin includes a dynamic link library (DLL) and a collection of tools. The DLL serves as a Linux emulator, and the tool set provides the Linux-like development environment. Using Cygwin, developers can more easily provide remote support for applications running on Windows platforms. Because Unix and Linux are open to public input, administrators have contributed a great number of management scripts for these systems over the years, helping to assemble a large collection of available administrative tools. Cygwin makes it possible to use these scripts on computers running Windows, as well. An administrator can log in to a Windows-based computer and fix user problems within a Unix or Linux shell, and can also incorporate Windows command line interface tools into the shell script environment. [69]

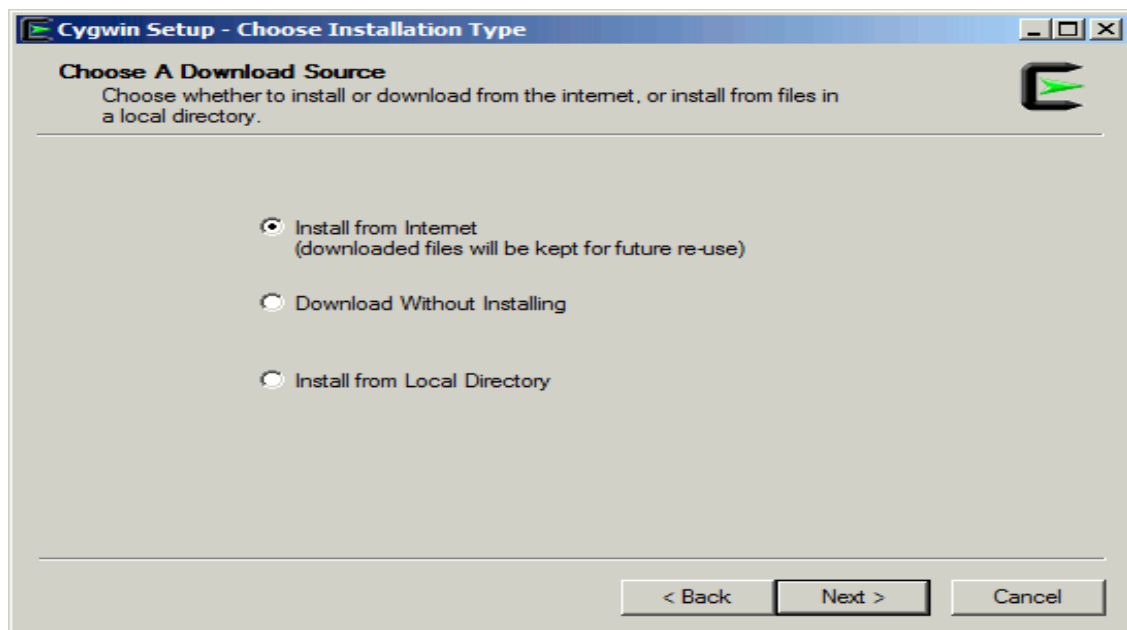
How To install Cygwin:

Cygwin is a Unix-like environment for windows.

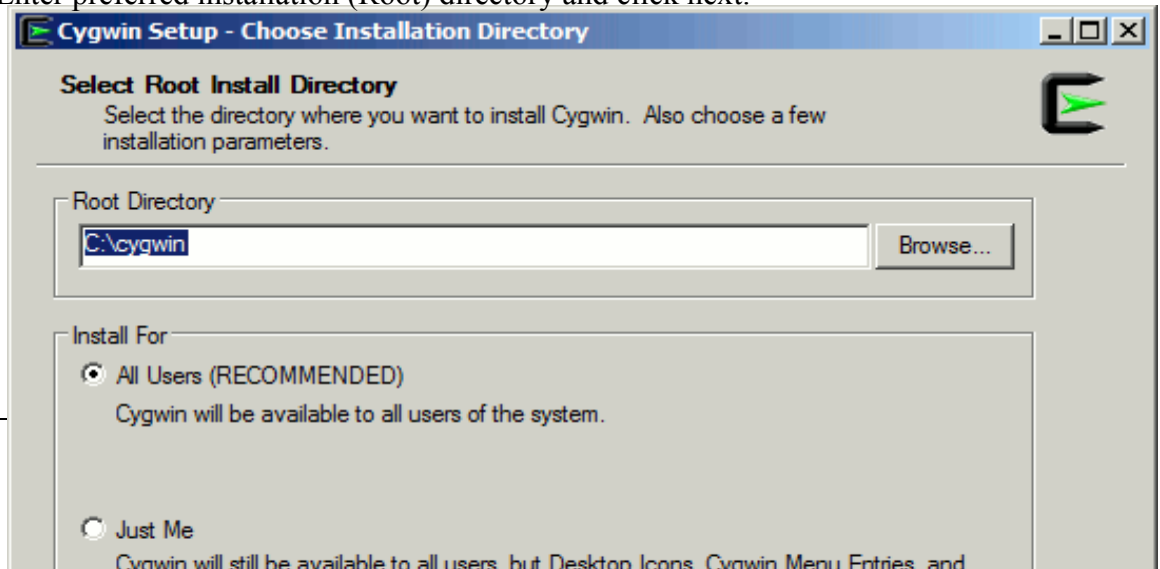
Below are notes on how to install and setup cygwin . [70]

Installation Notes:

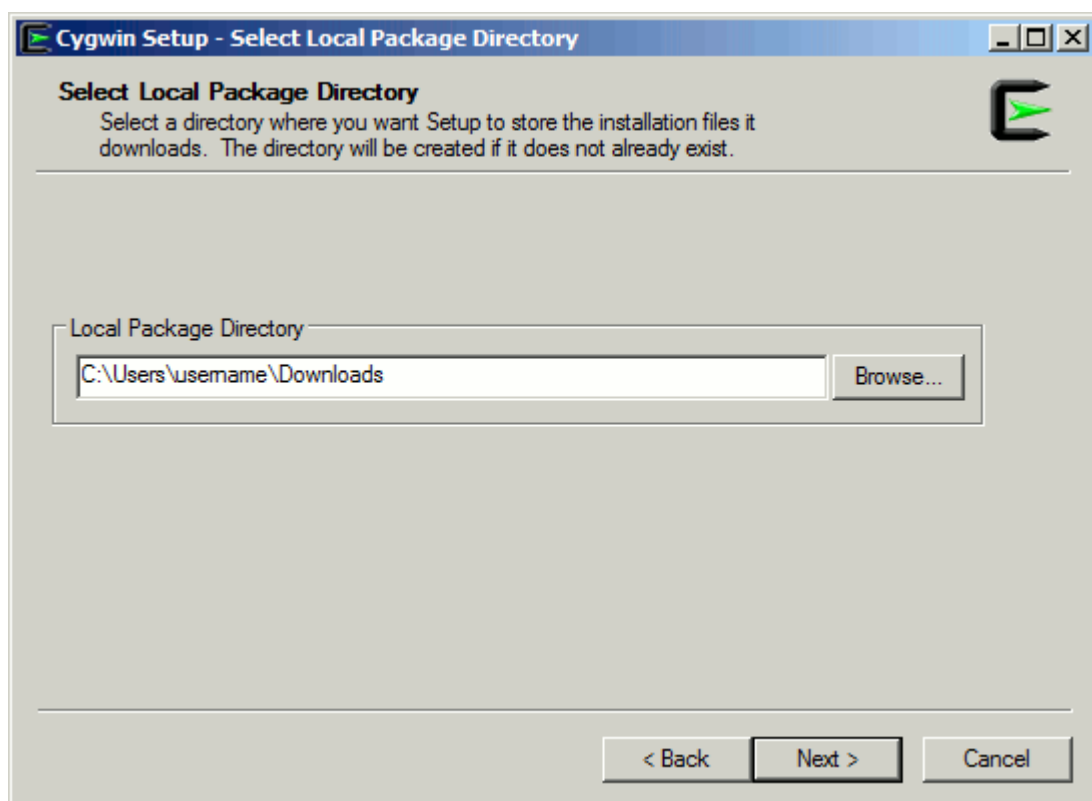
1. Download setup.exe  from www.cygwin.com.
2. Run application from your local harddrive.
3. Chose next on first screen.
4. Select "Install from Internet" and click next.



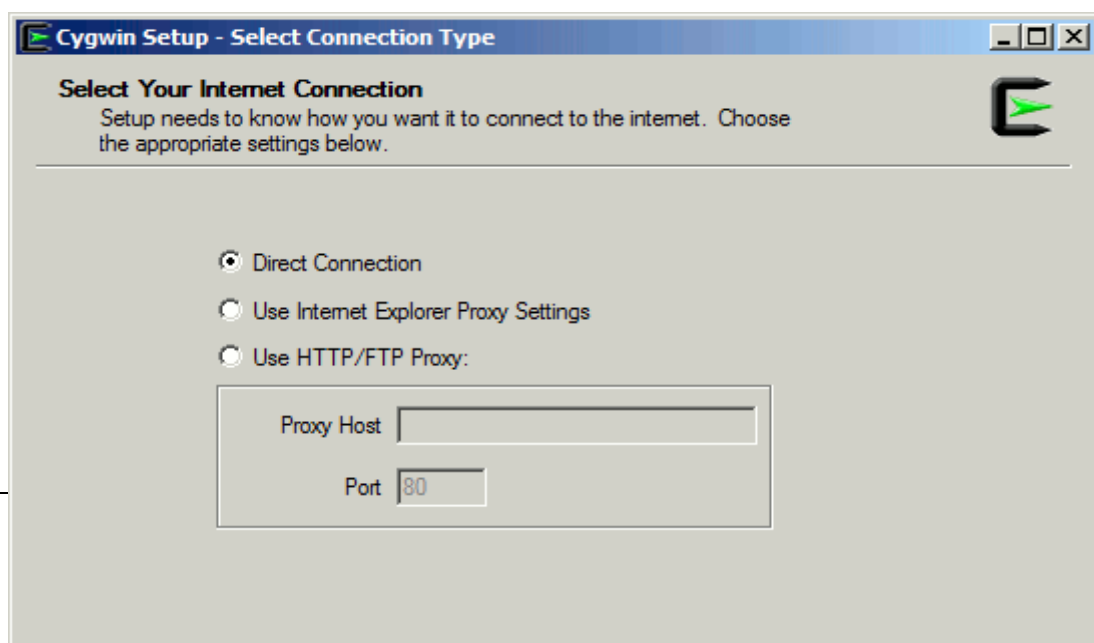
5. Enter preferred installation (Root) directory and click next.



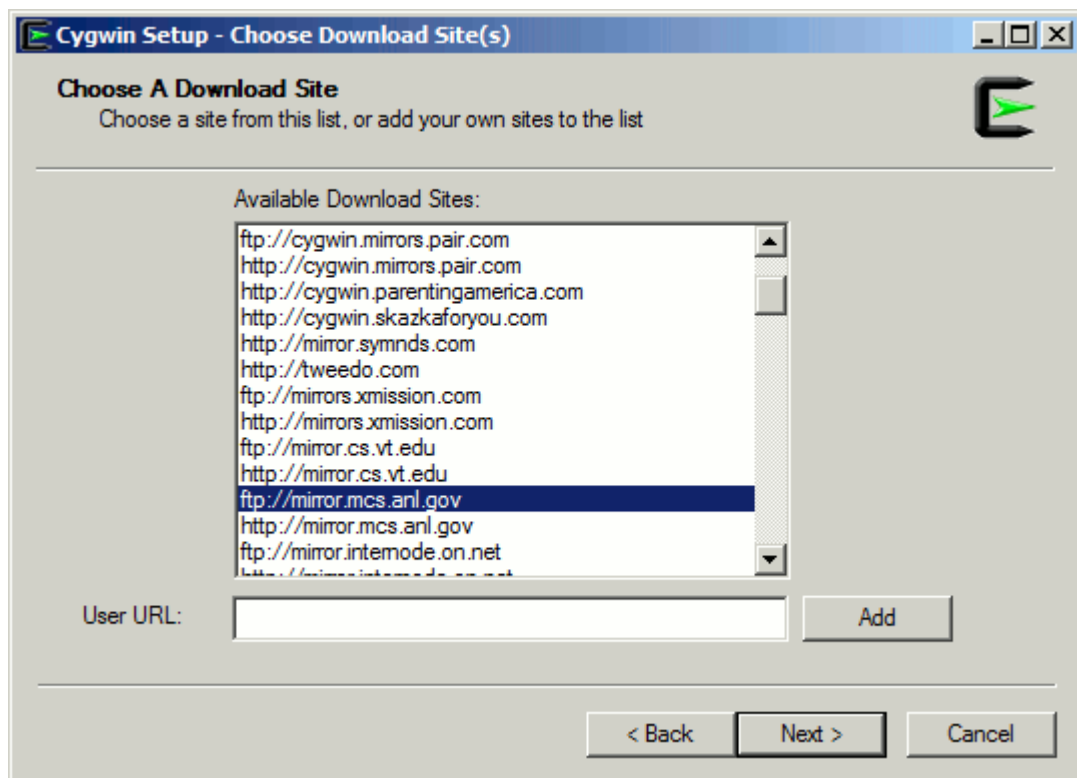
6. Enter a temporary installation directory and click next.



7. Select "Direct Connection" and click next.

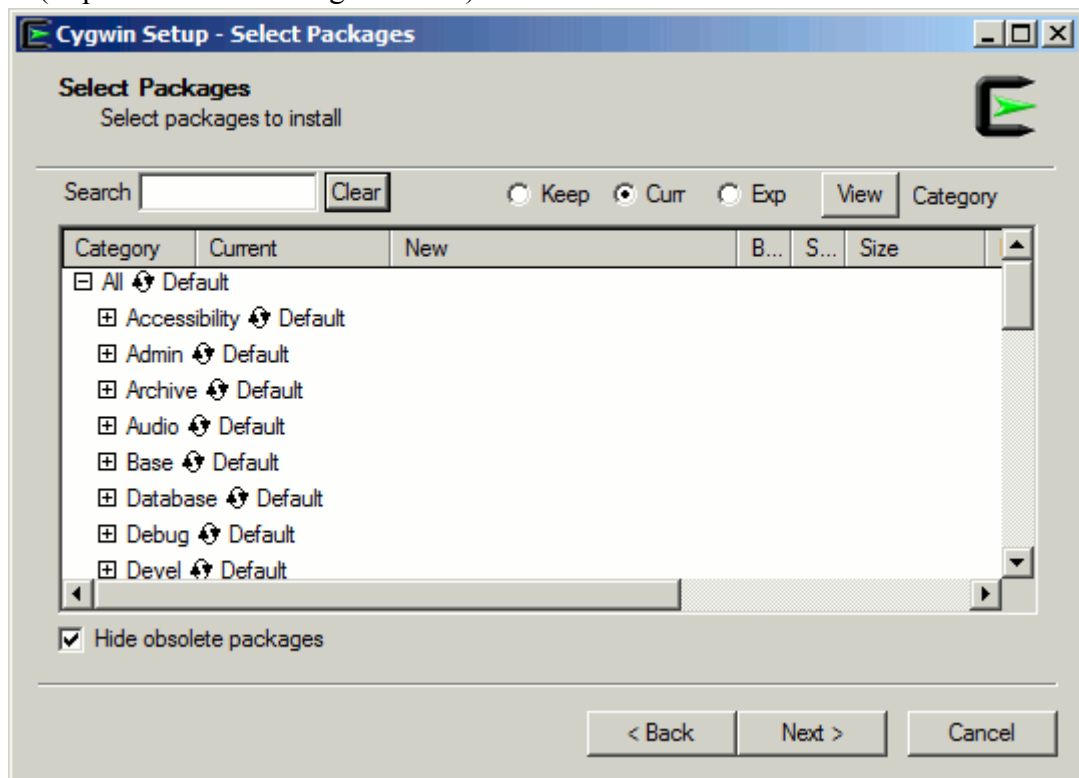


8. Select a download site and click next.
(Any site that you can connect to is fine. Some sites are more stable and/or faster than others. Try to pick one that works for you.)



9. Select the packages you want to install and click next.
Packages you may want to install include:
- ✓ opennssh
 - ✓ bc
 - ✓ python
 - ✓ keychain (for ssh key pairs)
 - ✓ gv
 - ✓ ghostscript
 - ✓ emacs
 - ✓ vi
 - ✓ grace
 - ✓ tcsh

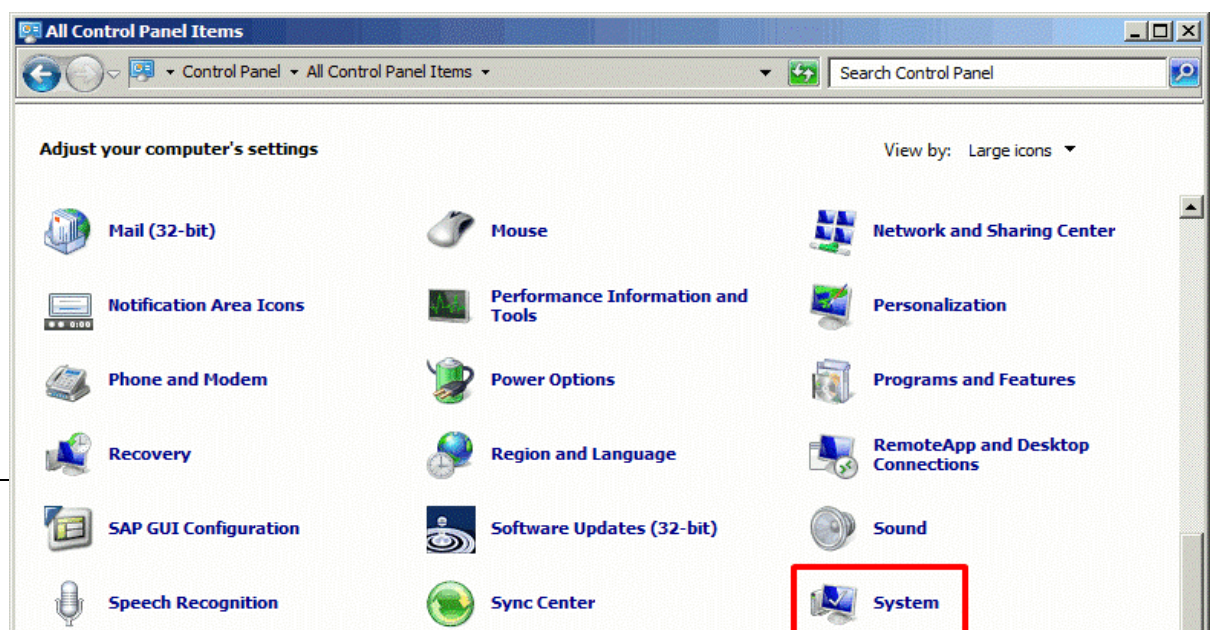
- ✓ gnu compilers
- ✓ tetex
- ✓ aspell
- ✓ xfig
- ✓ transfig
- ✓ ImageMagic
- ✓ gnuplot
- ✓ rsync
- ✓ xinit
- ✓ (important for installing X-server)



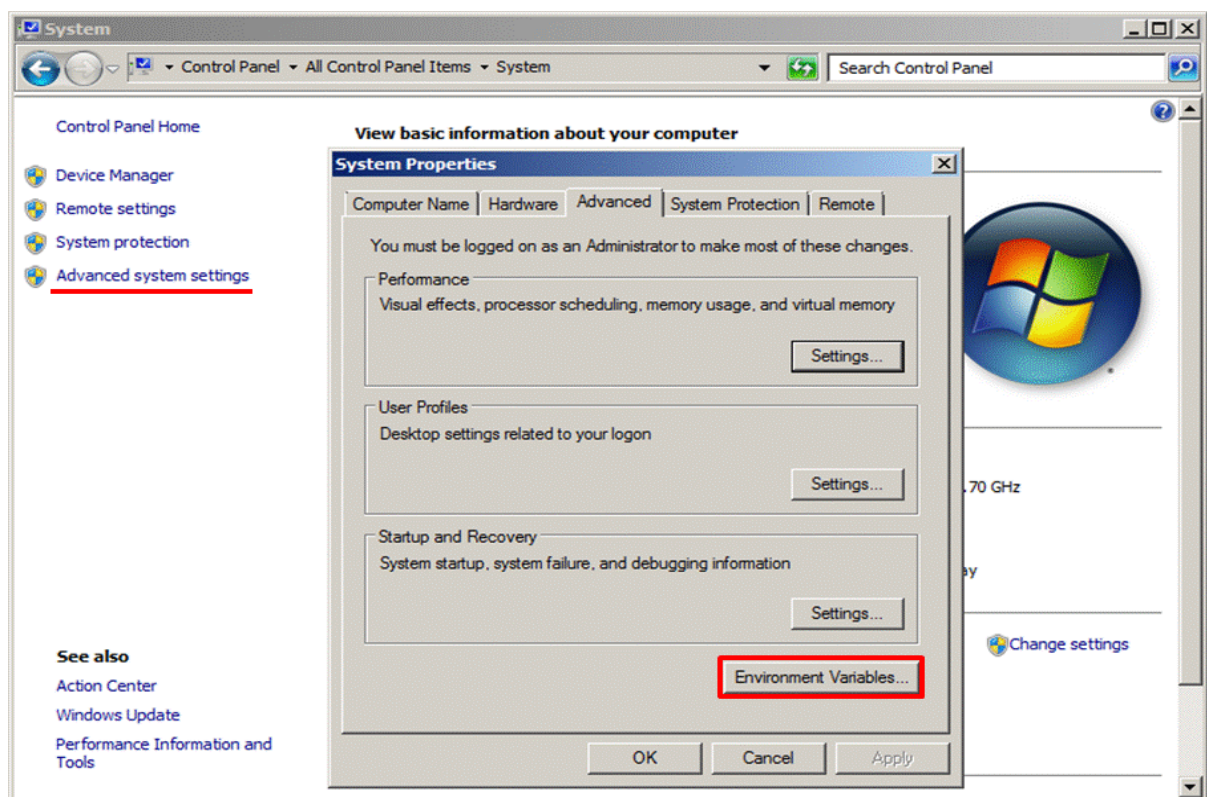
Once the installation is complete, click Finish and continue with the Setup section.

Setup Notes:

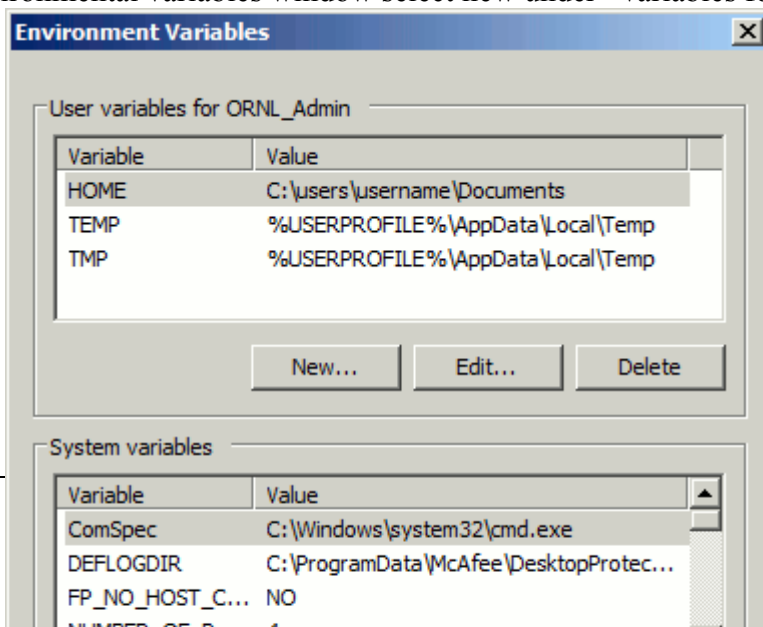
1. Setup Windows Environment Variables:
Open your System Control Panel:
Select [start]->Control Panel->System



Click on "Advanced System Settings", then select "Environmental Variables" under the "Advanced" tab of the "System Properties" Control Panel.



In the Environmental variables window select new under "Variables for User" window.

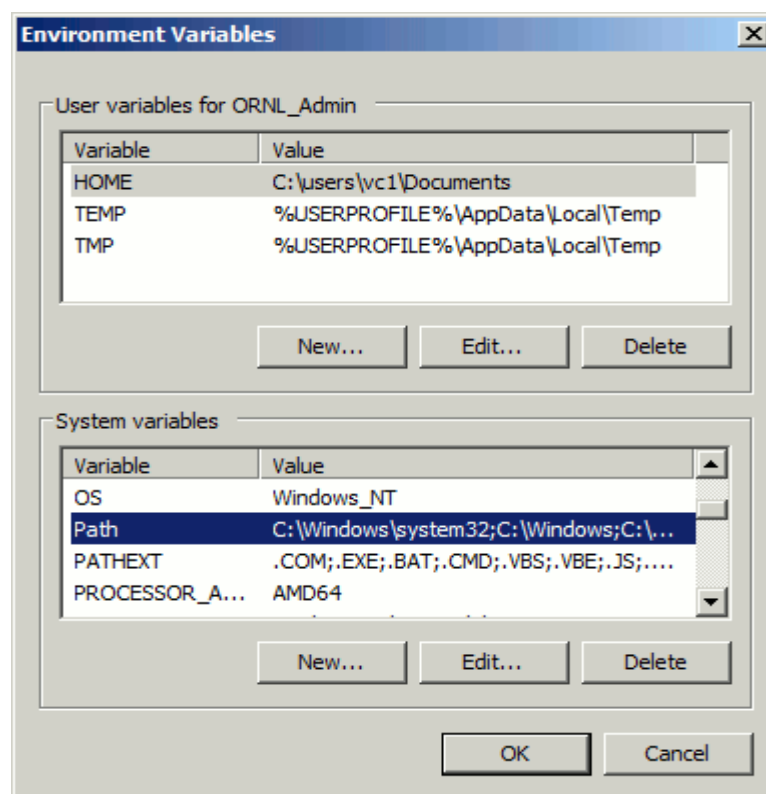


Edit "User Variable" as follows:

Variable name: HOME

Variable value: Path to where you want your home directory

In the Environmental variables window select Path under "System Variables".
Window.



Edit "System variable" as follows:

Append "; C:\cygwin\bin" to Variable value: (semicolon is very important)

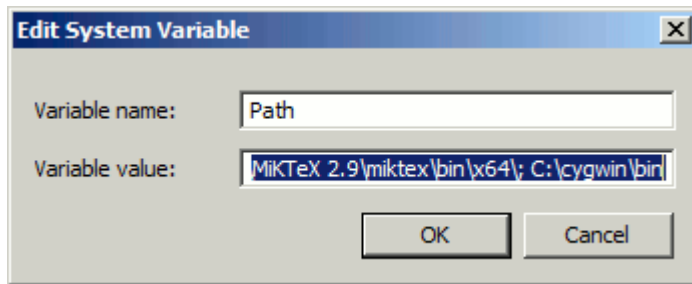
Select "Ok" to close both "Environmental Variables" and "System Properties" windows.

2. Creating link for starting X-windows:

Create a shortcut to C:\cygwin\bin\Run.exe (on your desktop is probably a good place to do this).

Right click on the shortcut and select properties.

Under Target in the Shortcut tab enter:



C:\cygwin\bin\run.exe /usr/bin/bash.exe -l -c /usr/bin/startxwin.exe

You may want to change the icon:

Select "Change Icon" and chose a preferred icon.

Select "Ok" to close the Properties dialog box.

To allow X-windows to start upon boot, place the your new shortcut in [Start]->[All Programs]->[Startup]<\ul>

Now is a good time to restart...

3. Setup and configuring cygwin files.

Create a new user and set a default user home directory other /home/username:

Using the terminal started by X-windows:

type: mkpasswd -c -p /cygdrive/c/Users/username/Documents >> /etc/passwd

edit /etc/passwd using your favorite editor. You will need to remove the extra username after Documents in the home path.

For easy use of the terminal create a startxterm.bat file in C:\cygwin\bin. A reasonable xterm file looks like:

```
@echo off
```

```
SET DISPLAY=127.0.0.1:0.0
```

```
REM Startup an xterm, using bash as the shell.
```

```
%RUN% xterm -geometry 120x40 -sb -rightbar -e /bin/bash -l
```

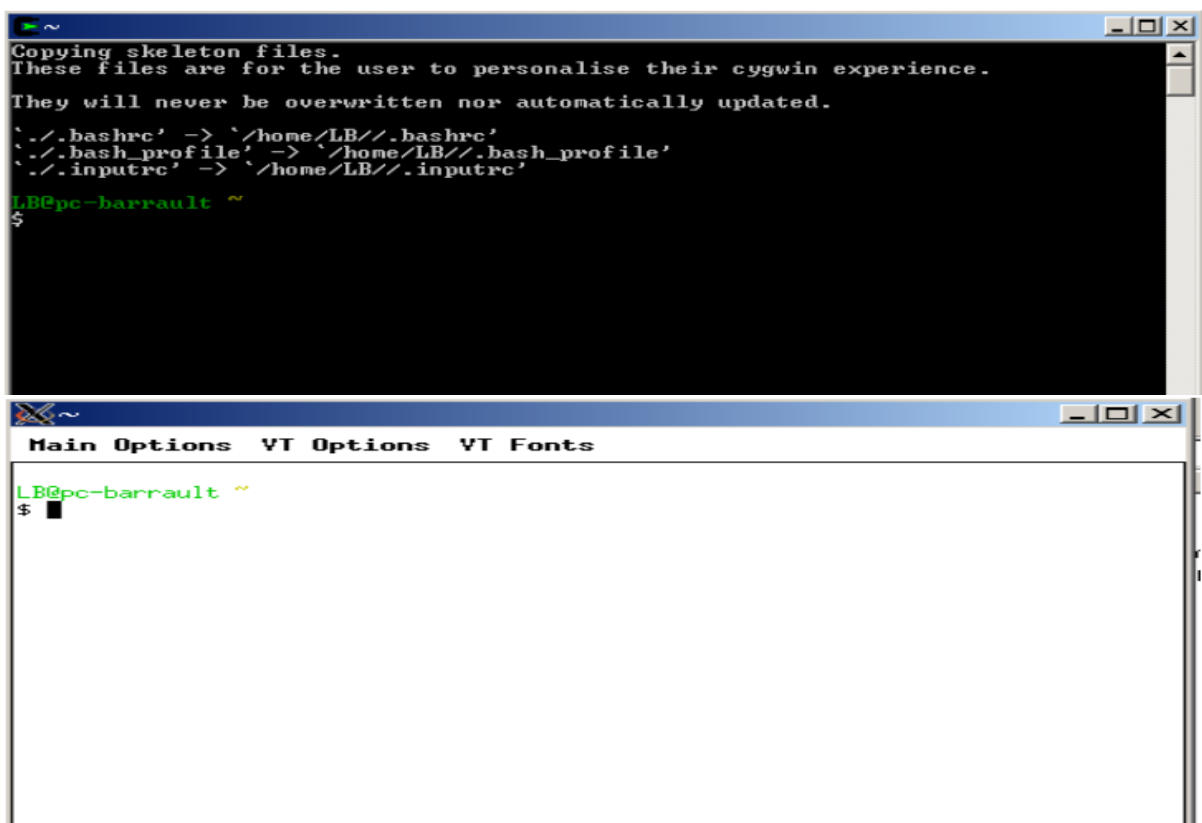
Save the file and you are done!

4. Start X-windows using the shortcut

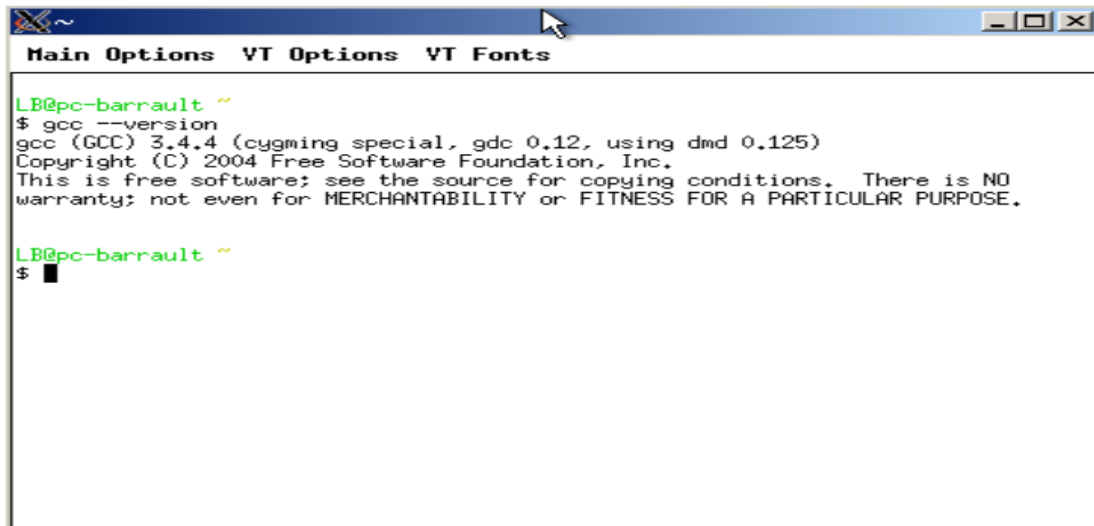
5. Use the startxterm.bat file to start a terminal.

USE:

Launch cygwin, you get this:



To verify that gcc is installed correctly, run: `gcc --version`, you are expected to get:



```
LB@pc-barrault ~  
$ gcc --version  
gcc (GCC) 3.4.4 (cygming special, gdc 0.12, using dmd 0.125)  
Copyright (C) 2004 Free Software Foundation, Inc.  
This is free software; see the source for copying conditions. There is NO  
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  
  
LB@pc-barrault ~  
$
```

2. NS2:

1. Definition of NS2

NS2 stands for Network Simulator Version 2.

NS2 is an open-source event-driven simulator designed specifically for research in computer communication networks.

Having been under constant investigation and enhancement for years, NS2 now contains modules for numerous network components such as routing, transport layer protocol, and application. To investigate network performance, researchers can simply use an easy-to-use scripting language to configure a network, and observe results generated by NS2.

Undoubtedly, NS2 has become the most widely used open source network simulator, and one of the most widely used network simulators. Unfortunately, most research needs simulation modules which are beyond the scope of the built-in NS2 modules. Incorporating these modules into NS2 requires profound understanding of NS2 architecture. Currently, most NS2 beginners rely on online tutorials. Most of the available information mainly explains how to configure a network and collect results, but does not include sufficient information for building additional modules in NS2. Despite its details about NS2 modules, the formal documentation of NS2 is mainly written as a reference book, and does not provide much information for beginners. The lack of guidelines for extending NS2 is perhaps the greatest obstacle, which discourages numerous researchers from using NS2. .[70]

NS2 is primarily Unix based.

NS2 provides substantial support to simulate bunch of protocols like TCP, FTP, UDP, HTTP and DSR.

NS2 Uses TCL as its scripting language

2. components of NS2:

Among the principal components of NS2 that are listed by category:

application: Web, ftp, telnet, traffic generator (CBR, ...);
transport: TCP, UDP, RTP, SRM;
unicast routing: Static, dynamic (distance vector);
multicast routing: DVMRP, PIM;
queue management: RED, DropTail, Token bucket.
Service discipline: CBQ, SFQ, DRR, Fair Queueing.
Transmission system: CSMA / CD, CSMA / CA, point to point link.

3. Advantages and Disadvantages of Simulation in NS2:

Advantages:

- Multilayer simulation software.
- A completely free tool for several platforms
- Ability to add components on demand.
- Object oriented development.
- Due to its popularity, many protocols are a priori available for NS-2

Disadvantages

- the modeling in NS-2 remains a complex task: there is no graphical interface.
- Strong technical skills are required to use this simulator.

4. How To install NS2 on windows 7:

Here i show you how to install NS2 on windows 7 (32-bit | 64-bit)

Important: Your User Name Shouldn't Contain any SPACE.[71]

Step 1:

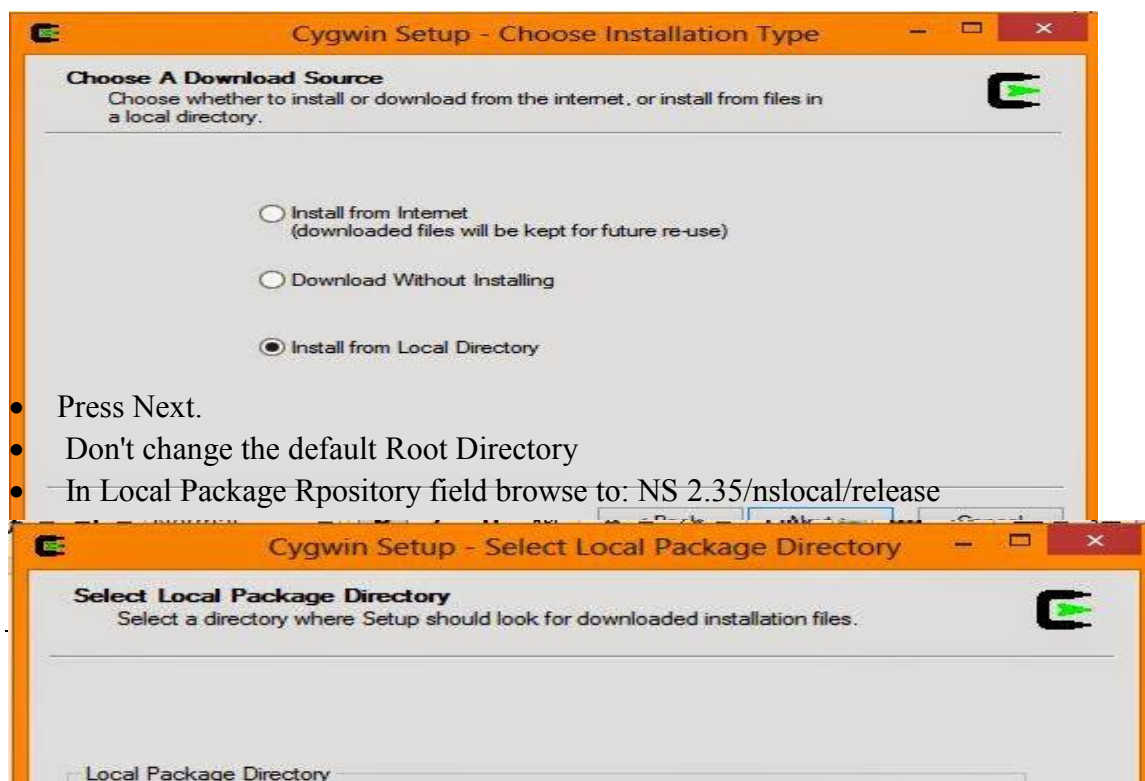
- Go to these link and download the three .rar files and place them in a single folder.
- Link for part 1(100Mb):NS 2.35-Part1
- Link for part 2(100Mb):NS 2.35-Part2
- Link for part 3(19.49Mb):NS 2.35-Part3

Step 2:

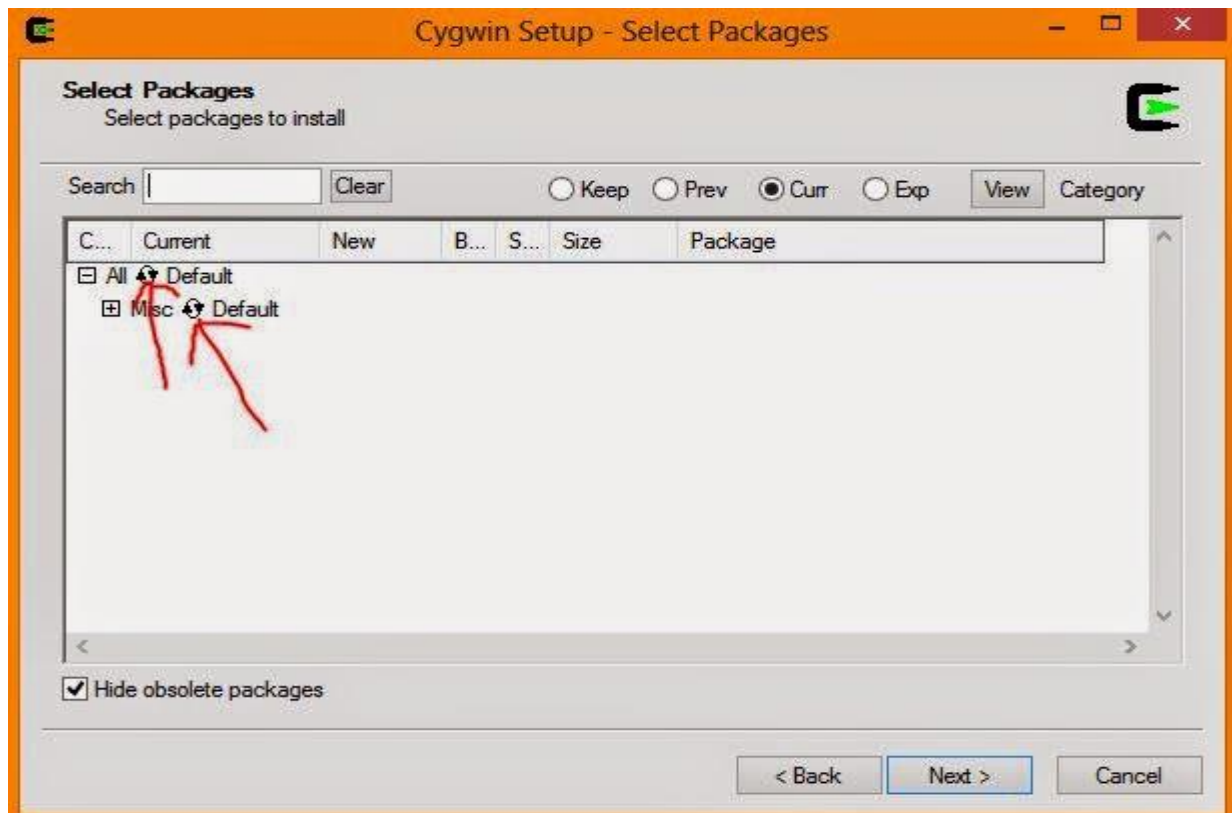
- Now Extract the NS 2.35.part1 only.It will extract the part2 an part3 automatically.

Step 3:

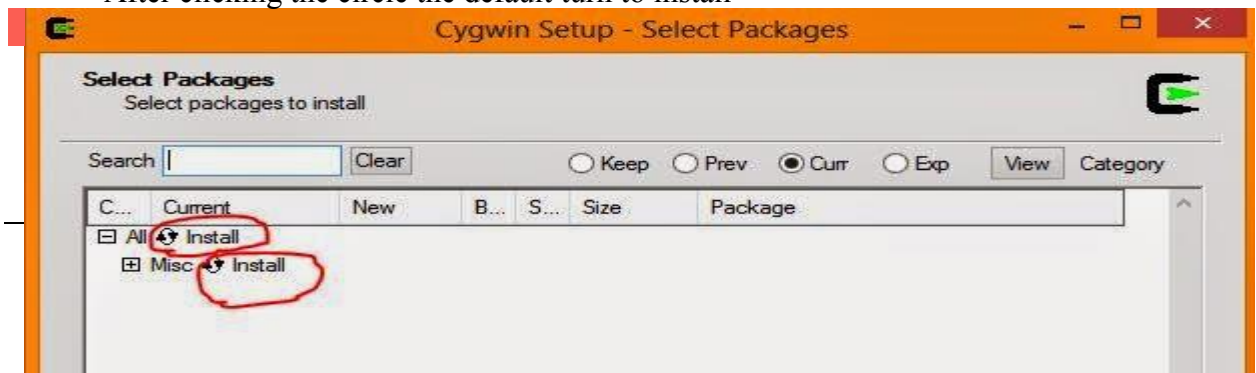
- After extraction you'll get a folder named NS 2.35
- Inside this folder you get cygwin setup , .bashrc etc..
- Now install the setup. Choose install from local directory



- Click Next
- Click on the Circle



- After clicking the circle the default turn to install



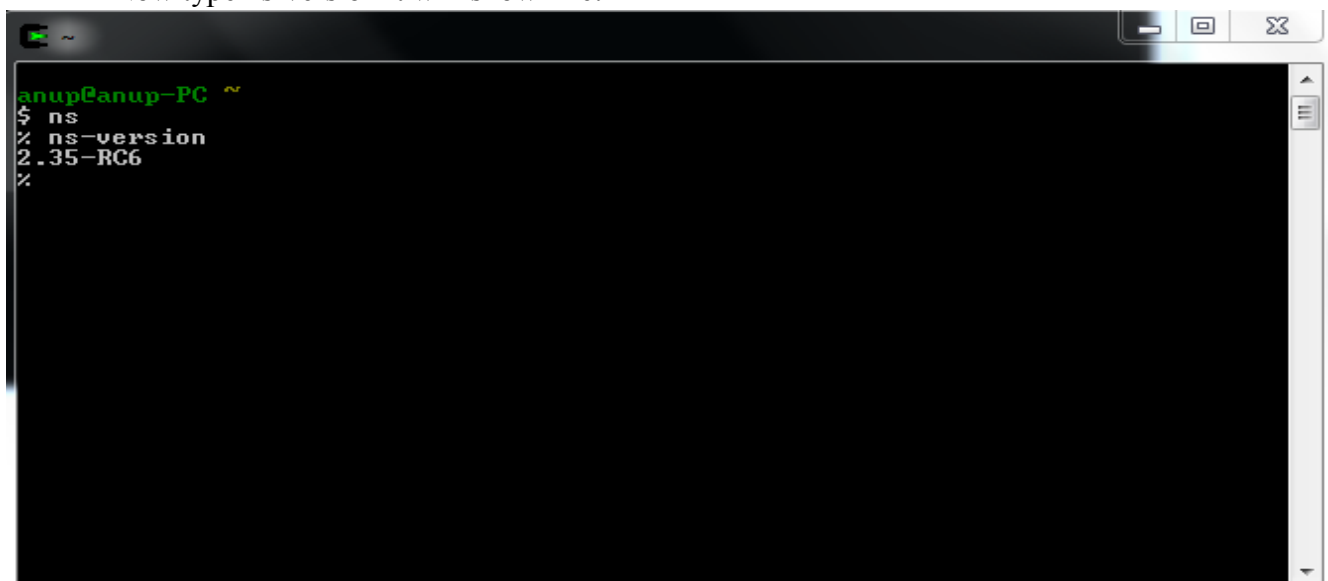
- After this press Next it will install the necessary packages for NS2
- check create a desktop shortcut and start menu shortcut
- Then installation finished.:)p
- Now you are halfway done !!!
- Now You'll get a screen like this:



- Now create a folder Named Nouredine in C:\cygwin\home
- Now copy the ns-allinone-2.35-RC7avecgraph.rar and Extract there. You'll get ns-allinone-2.35-RC7 folder.
- Now copy the .bashrc file from the downloaded Extract folder
- Now go to the "C:\cygwin\home\prittam" here "prittam" indicate my user name in your case it will be your user name.And replace(i.e paste) the .bashrc file that you copied.
- Now open the Cygwin command window which is on your desktop and type source .bashrc
- Now type ns "\$" change to "%"

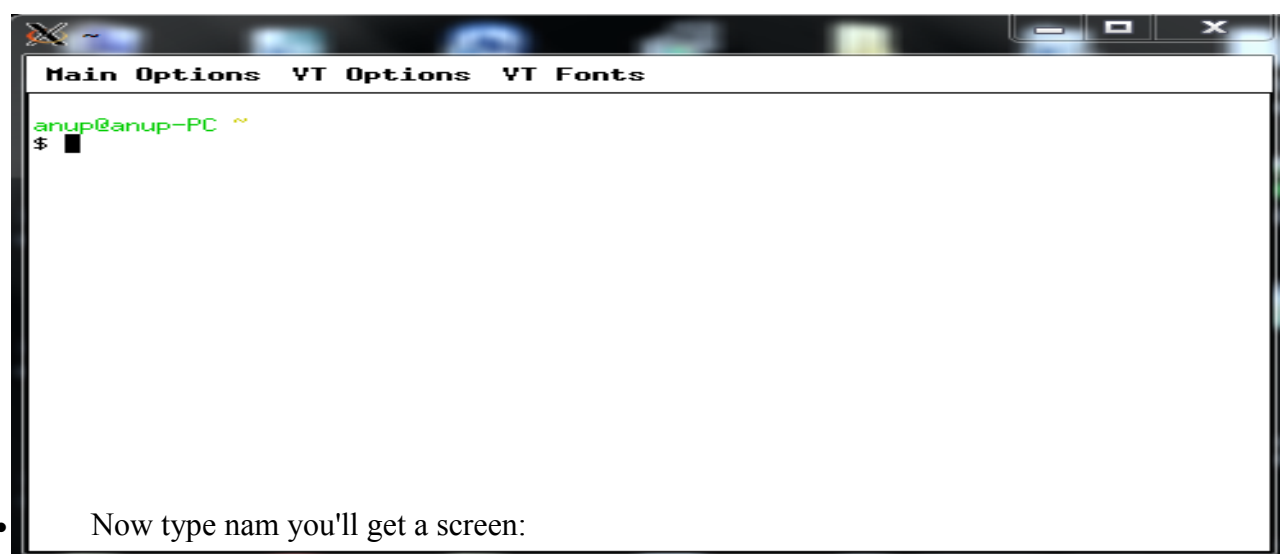


- Now type ns-version it will show like:

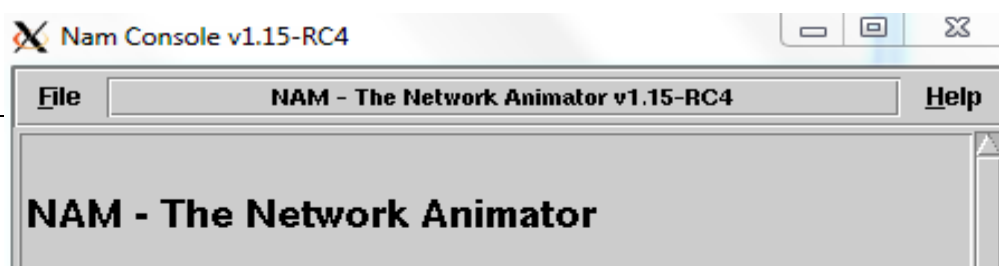


```
anup@anup-PC ~  
$ ns  
% ns-version  
2.35-RC6  
%
```

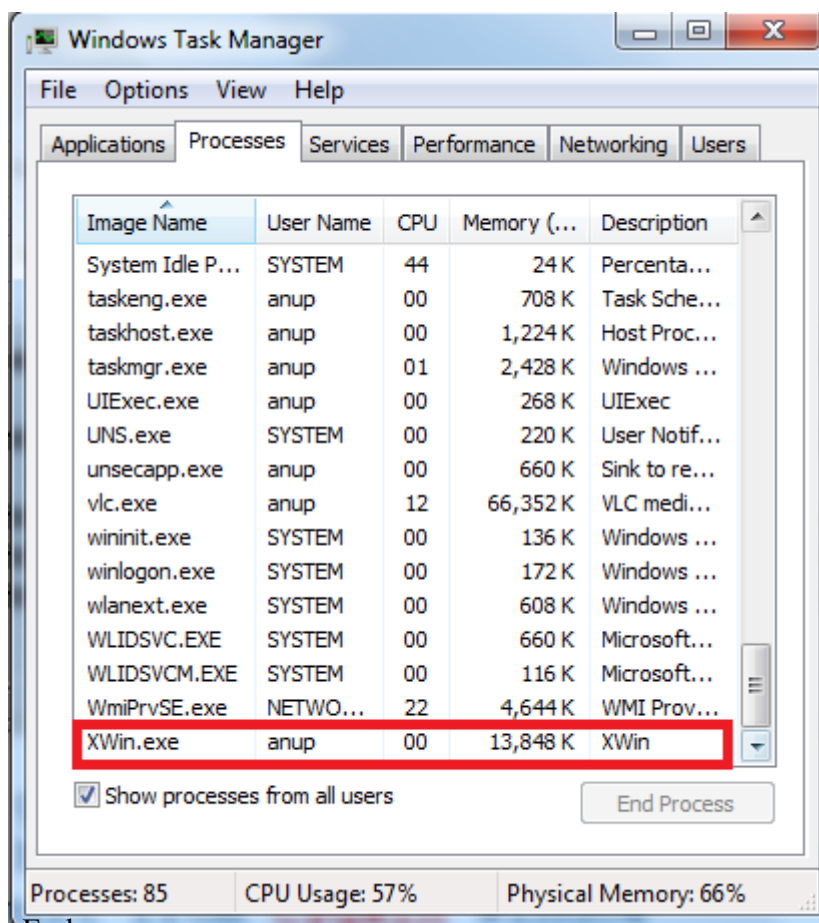
- Now press exit.
- Now type startxwin you'll get a window like this:



- Now type nam you'll get a screen:



- Now go to file and quit the nam window
- Now hold the main tab and drag your mouse to quit from Cygwin window(the white window)
- And exit from 'cygwin command' window (type exit)
- Important:
- go to Taskmanager(Alt+Ctrl+Del) and goto process tab and search for XWin.exe



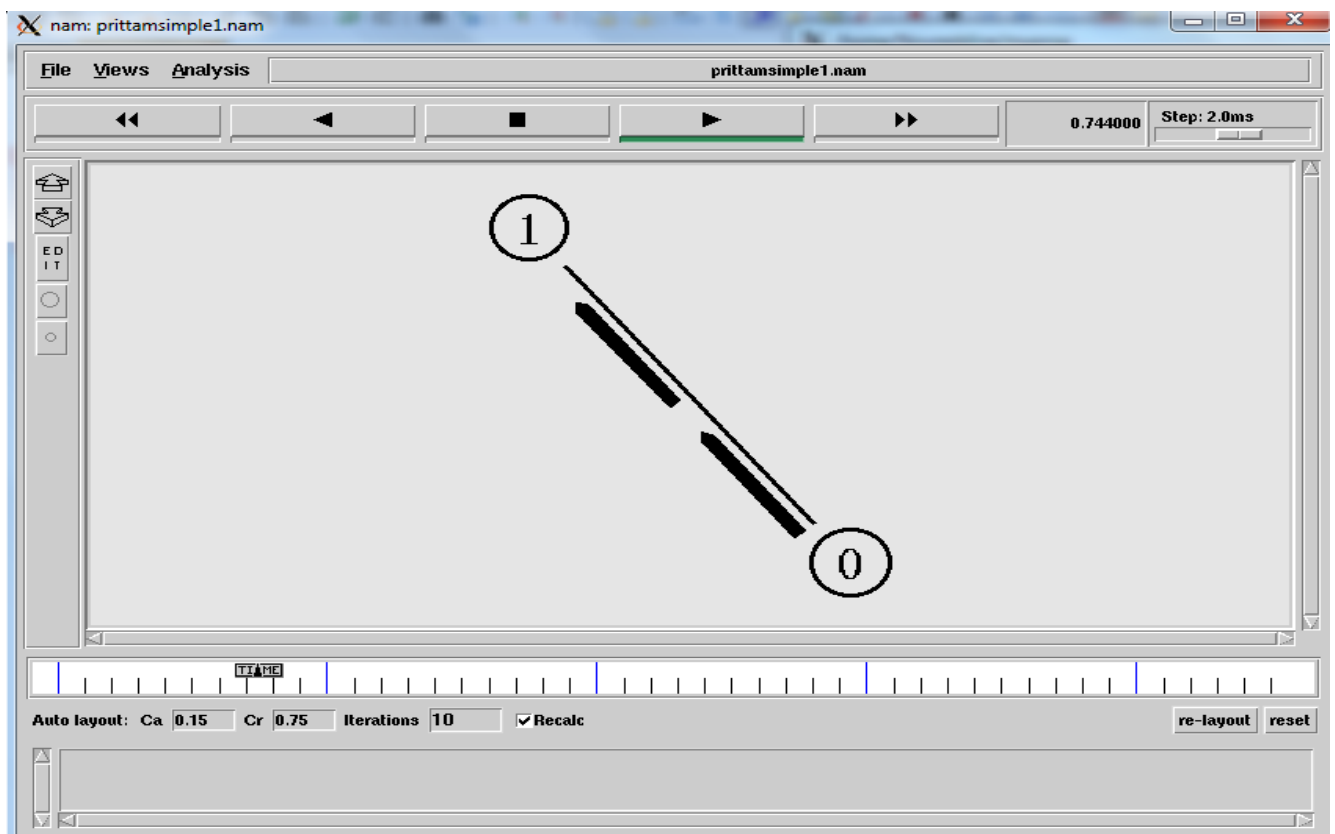
- End process
- If you not do this when you press startxwin in Cygwin command window for the second time then you get this:

```

anup@anup-PC ~
$ startxwin
startxwin: Resource temporarily unavailable (errno 11): Another X server instance is running on DISPLAY :0
anup@anup-PC ~
$

```

- Now open the cygwin command window startxwin and type ns yourfilename.tcl then nam file is generated and type nam yournamfile.nam.
- For my case:



- Write your code in notepad++ and save with .tcl extension.

3. TCL/TK:

1. Definition of TCL/TK:

Tcl is a general purpose multi-paradigm system programming language. It is a scripting

language that aims at providing the ability for applications to communicate with each other. On the other hand, Tk is a cross platform widget toolkit used for building GUI in many languages. This tutorial covers various topics ranging from the basics of the Tcl/Tk to its scope in various applications.

Tcl is shortened form of Tool Command Language. John Ousterhout of the University of California, Berkeley, designed it. It is a combination of a scripting language and its own interpreter that gets embedded to the application, we develop with it.

Tcl was developed initially for Unix. It was then ported to Windows, DOS, OS/2, and Mac OSX. Tcl is much similar to other unix shell languages

It aims at providing ability for programs to interact with other programs and also for acting as an embeddable interpreter.

Tk is a graphical user interface toolkit that takes developing desktop applications to a higher level than conventional approaches. Tk is the standard GUI not only for Tcl, but for many other dynamic languages, and can produce rich, native applications that run unchanged across Windows, Mac OS X, Linux and more. [72]

2. Features of Tcl

Reduced development time.

Powerful and simple user interface kit with integration of TK.

Write once, run anywhere.

Quite easy to get started for experienced programmers; since, the language is so simple that they can learn Tcl in a few hours or days.

You can easily extend existing applications with Tcl. Also, it is possible to include Tcl in C, C++, or Java to Tcl or vice versa.

Have a powerful set of networking functions.

Finally, it's an open source, free, and can be used for commercial applications without any limit.

3. Applications of TCL

Tcl is a general-purpose language and you can find Tcl everywhere. It includes,

Scalable websites that are often backed by databases.

High performance web servers build with TclHttpd.

Tcl with CGI based websites.

Desktop GUI applications.

4. Installation on Windows:

Download the latest version for windows installer from the list of Active Tcl binaries available.

Run the downloaded executable to install the Tcl, which can be done by following the on screen instructions.

Now, we can build and run a Tcl file say helloWorld.tcl by switching to folder containing the file using 'cd' command and then execute the program using the following steps

```
C:\Tcl> tclsh helloWorld.tcl
```

We can see the following output.

```
C:\Tcl> helloWorld
```

C:\Tcl is the folder, I am using to save my samples. You can change it to the folder in which you have saved Tcl programs.

Local Environment Setup

If you are willing to set up your environment for Tcl, you need the following two software applications available on your computer

- 1. Text Editor:** This will be used to type your program. Examples of a few text editors include Windows Notepad

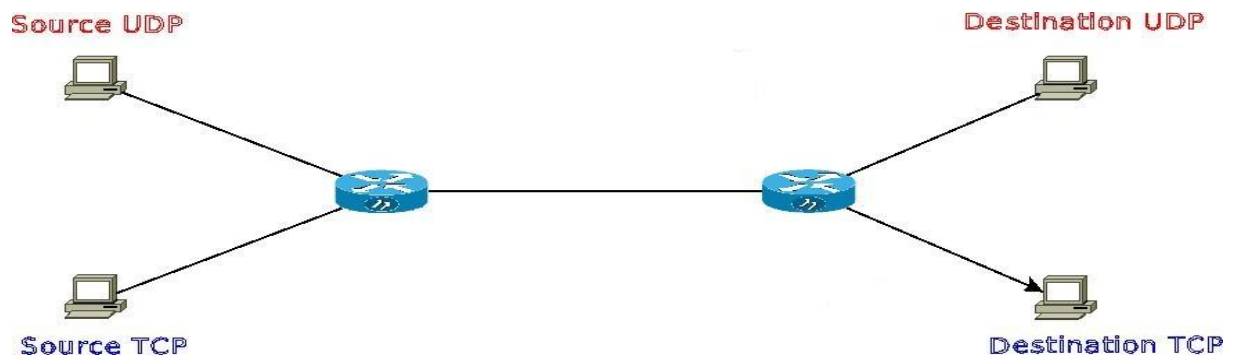
2. **Tcl Interpreter:** It is just a small program that enables you to type Tcl commands and have them executed line by line. It stops execution of a tcl file, in case, it encounters an error unlike a compiler that executes fully.

4. Sample code for shortest path routing:

```
int main()
{
Node N0(0);
Node N1(1);
Node N2(2);
Node N3(3);
Node N4(4);
RoutingVec_t NextHop;
RoutingVec_t Parent;
N0.AddAdj(1, 10);
N0.AddAdj(2, 5);
N1.AddAdj(3, 1);
N1.AddAdj(2, 2);
N2.AddAdj(4, 2);
N2.AddAdj(1, 3);
N2.AddAdj(3, 9);
N3.AddAdj(4, 4);
N4.AddAdj(0, 7);
N4.AddAdj(3, 6);
Nodes.push_back(&N0);
Nodes.push_back(&N1);
Nodes.push_back(&N2);
Nodes.push_back(&N3);
Nodes.push_back(&N4);
for (nodeid_t i = 0; i < Nodes.size(); i++)
{ // Get shortest path for each root node
printf("\nFrom root %ld\n", i);
Dijkstra(Nodes, i, NextHop, Parent);
PrintParents(Parent);
for (unsigned int k = 0; k < Nodes.size(); k++)
printf("Next hop for node %d is %ld\n", k, NextHop[k]);
printf("Printing paths\n");
for (nodeid_t j = 0; j < Nodes.size(); j++)
{
PrintRoute(i, j, Parent);
}
}
}
return(0);
}
```

5. Exemple de simulation avec NS2.[73]

To observe the operation of NS-2 and its NAM simulation tool, we simulated a simple network setup, corresponding to the following diagram:



For this, we have created six NS-2 nodes (node), connected by full duplex links (duplex-link) supporting different speeds, an access time to the medium of 10 ms, with a queue algorithm. DropTail2 for queue management.

Creation of the simulator

```
set ns [new Simulator]
```

Creation of the NS-2 trace file

```
set nf [open out.nam w]
```

```
$ns namtrace-all $nf
```

Definition of classes for coloring

```
$udp set class_ 1
```

```
$tcp set class_ 2
```

Class coloring: blue for udp (class 1) and red for tcp (class 2)

```
$ns color 1 Blue
```

```
$ns color 2 Red
```

End of simulation procedure, which writes the data to the file

and run NAM for viewing

```
proc finish {} {
```

```
global ns nf
```

```
$ns flush-trace
```

```
close $nf
```

```
exec nam out.nam &
```

```
exit 0
```

```
}
```

Creation of nodes

```
set n0 [$ns node]
```

```
$ n0 label "UDP source"
```

```
set n1 [$ns node]
```

```
$ n0 label "source TCP"
```

```
set n2 [$ns node]
```

```
set n3 [$ns node]
```

```
set n4 [$ns node]
```

```
$ n0 label "UDP destination"
```

```
set n5 [$ns node]
```

```
$ n0 label "TCP destination"
```

```

# Creation of links, all in 1Mbps / 10ms TR / DropTail queue
$ns duplex-link $ n0 $ n2 1Mb 10ms DropTail
$ns duplex-link $ n1 $ n2 1Mb 10ms DropTail
$ns duplex-link $ n2 $ n3 1Mb 10ms DropTail
$ns duplex-link $ n3 $ n4 1Mb 10ms DropTail
$ns duplex-link $ n3 $ n5 1Mb 10ms DropTail

# management of the topology layout
$ns duplex-link-op $ n0 $ n2 orient right-down
$ns duplex-link-op $ n1 $ n2 orient right-up
$ns duplex-link-op $ n2 $ n3 orient right
$ns duplex-link-op $ n3 $ n4 orient right-up
$ns duplex-link-op $ n3 $ n5 orient right-down

# Creation of two agents located in n0
set udp [new Agent / UDP]
$ns attach-agent $ n0 $ udp

set tcp [new Agent / TCP]
$ns attach-agent $ n1 $ tcp

# CBR traffic of 500 bytes every 5 ms for UDP0
set cbr0 [new Application / Traffic / CBR]
$ cbr0 set packetSize_ 500
$ cbr0 set interval_ 0.005
$ cbr0 attach-agent $ udp

# CBR traffic of 500 bytes every 10 ms for UDP1
set cbr1 [new Application / Traffic / CBR]
$ cbr1 set packetSize_ 500
$ cbr1 set interval_ 0.010
$ cbr1 attach-agent $ tcp

# Creation of an empty agent, intended to receive the packets implanted in n3
set null0 [new Agent / Null]
$ns attach-agent $ n4 $ null0

# Creation of an empty agent, intended to receive the packets implanted in n3
set tcpsink [new Agent / TCPSink]
$ns attach-agent $ n5 $ tcpsink

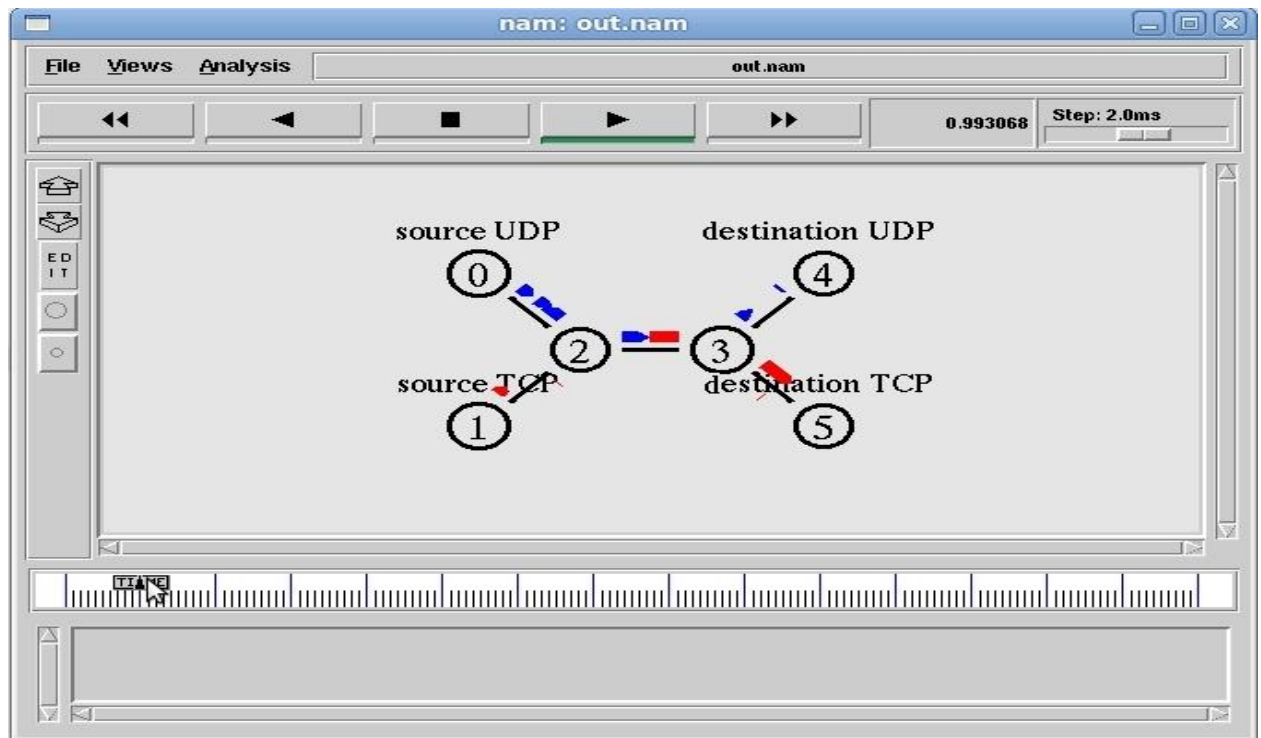
# Traffic from agents udp0 and udp1 is sent to null0
$ns connect $ udp $ null0
$ns connect $ tcp $ tcpsink

# Scenario of start and end of packet generation by cbr0
$ns at 0.5 "$ cbr0 start"
$ns at 0.5 "$ cbr1 start"
$ns at 14.5 "$ cbr0 stop"
$ns at 14.5 "$ cbr1 stop"

```

```
# The simulation will last 15 seconds and calls the finish procedure
$ns at 15.0 "finish"
# Start of simulation
$ns run
```

6. ANALYSIS AND RESULTS :



General conclusion

Computer networks based on wireless communication can be classified into two categories: networks with pre-existing fixed infrastructure, and networks without infrastructure. In the first category, the communication model used is generally the model of cellular communication. In this model the mobile units are covered by a set of base stations connected by a wired network, and which provide system connectivity. The second category tries to extend the notions of mobility to all the components of the environment, all the units of the network move freely and no centralized administration is available. Networks in this category are called: ad hoc networks.[74]

Through our study of the different routing protocols that exist, we have seen that these protocols use a variety of techniques in order to solve the routing problem in the environment of ad hoc networks. Among the techniques used: the principle of sequence, the concept of hierarchy, the "fisheye" technique, the concept of group, the concept of source routing, the link reversal principle, the localization principle, etc. This variety of techniques means that the use of existing routing solutions depends on the nature of the application, for example in an ad hoc network equipped with a GPS system it is preferable use a location-based routing protocol such as LAR or DREAM.[75]

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