Comparative Study of T-AODV and CI-AODV

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Abstract- **Routing is the main research issue in the development of wireless networks. Many of the routing approaches have been used but they are not optimal. Moreover all these approaches don't take into account the cognitive routing environment. In our work we have a comparison of Ad hoc On Demand Vector routing (AODV) with cognitive radio and normal AODV (without cognitive radio).AODV which is a reactive routing protocol, meaning that it establishes a route to a destination only on demand. In contrast, the most common routing protocols of the Internet are proactive, meaning they find routing paths independently of the usage of the paths. AODV is, as the name indicates, a distance-vector routing protocol. AODV avoids the counting-to-infinity problem of other distance-vector protocols by using sequence numbers on route updates.**

I. INTRODUCTION

Cognitive Radios (CR) technology is capable of sensing its surrounding environment and adapting its internal states by making corresponding changes in certain operating parameters. CR is envisaged to solve the problems of the limited available spectrum and the inefficiency in the spectrum usage. CR has been considered in Mobile Ad Hoc Networks (MANETs), which enable wireless devices to dynamically establish networks without necessarily using a fixed infrastructure. The changing spectrum environment and the importance of protecting the transmission of the licensed users of the spectrum mainly differentiate classical MANETs from CR-MANETs. The cognitive capability and re-configurability of CR-MANETs have opened up several areas of research which have been explored extensively and continue to attract research and development.

The Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol designed for ad hoc mobile networks. AODV is capable of both unicast and multicast routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers to ensure the freshness of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes. AODV builds routes using a route request / route reply query cycle.

II.COGNITIVE RADIO

A Cognitive Radio is a transceiver designed to use the best wireless channels in its vicinity. Such a radio automatically detects available channels in wireless spectrum. This process is a form of dynamic spectrum management. As defined by the researchers at Virginia Tech, a cognitive radio is "a software defined radio with a cognitive engine brain".

Recent technological advances have resulted in the development of wireless ad hoc networks composed of devices that are self-organizing and can be deployed without infrastructure support. These devices generally have small form factors, and have embedded storage, processing and communication ability. While ad hoc networks may support different wireless standards, the current state-of the-art has been mostly limited to their operations in the 900MHz and the 2.4 GHz industrial, scientific and medical(ISM) bands. With the growing proliferation of wireless devices, these bands are increasingly getting congested. At the same time, there are several frequency bands licensed to operators, such as in the 400–700 MHz range, that are used sporadically or under-utilized for transmission.

The licensing of the wireless spectrum is currently undertaken on a long-term basis over vast geographical regions. In order to address the critical problem of spectrum scarcity, the Federal Communications Commission (FCC) has recently approved the use of unlicensed devices in licensed bands. Consequently, Dynamic Spectrum Access (DSA) techniques are proposed to solve these current spectrum inefficiency problems. This new area of research foresees the development of Cognitive Radio (CR) networks to further improve spectrum efficiency. The basic idea of CR networks is that the unlicensed devices (also called cognitive radio users or secondary users) need to vacate the band once the licensed device (also known as a primary user) is detected. In response to the operator's commands, the cognitive engine is capable of configuring radio-system parameters. These parameters include "waveform, protocol, operating frequency, and networking". It functions as an autonomous unit in the communications environment, exchanging information about the environment with the networks it accesses and other cognitive radios (CRs).

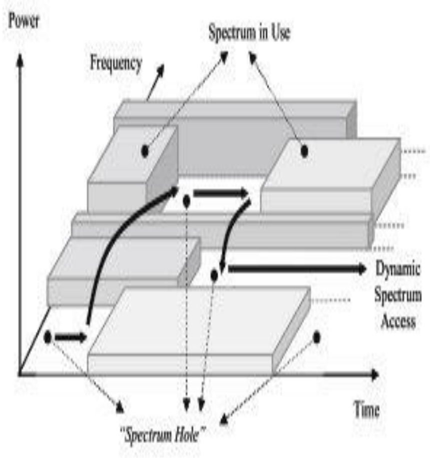

Fig 1. Spectrum Hole Concept

III. FUNCTIONS OF COGNITIVE RADIO

Main functions of cognitive radio are:

1) Spectrum sensing: Detecting unused spectrum and sharing it, without harmful interference to other users. Detecting primary users is the most efficient way to detect empty spectrum.

2) Transmitter detection: Cognitive radios must have the capability to determine if a signal from a primary transmitter is locally present in a certain spectrum. Cooperative detection: Refers to spectrum-sensing methods where information from multiple cognitive-radio users is incorporated for primary-user detection

3) Power Control: Power control is used for both opportunistic spectrum access and spectrum sharing CR systems for finding the cut-off level in SNR supporting the channel allocation and imposing interference power constraints for the primary user's protection respectively.

4) Spectrum management: Capturing the best available spectrum to meet user communication requirements, while not creating undue interference to other (primary) users. Cognitive radios should decide on the best spectrum band to meet quality of service requirements.

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IV. DESIGN OF ROUTING PROTOCOL

Ad hoc On-Demand Distance Vector (AODV) Routing is a routing protocol for mobile ad hoc networks (MANETs) and other wireless ad-hoc networks. It is a reactive routing protocol, meaning that it establishes a route to a destination only on demand.

1) Algorithm of AODV

The algorithm of AODV is as follows:

Step 1: When a node wishes to send a packet to some destination It checks its routing table to determine if it has a current route to the destination.

Step 2: If yes, forwards the packet to next hop node.

Step 3: If No, Goto step 4.

Step 4: Route discovery process begins with the creation of a Route Request (RREQ) packet -> source node creates it.

Step 5: The packet contains – source node's IP address, source node's current sequence number, destination IP address, destination sequence number.

Step 6: Once an intermediate node receives a RREQ, the node sets up a reverse route entry for the source node in its route table.

Step 7: Reverse route entry consists of <Source IP address, Source seq. number, number of hops to source node, IP address of node from which RREQ was received>

Step 8: Using the reverse route a node can send a RREP (Route Reply packet) to the source. Reverse route entry also contains – life time field

Step 9: RREQ reaches destination -> In order to respond to RREQ a node should have in its route table:

1. Unexpired entry for the destination

2. Seq. number of destination at least as great as in RREQ (for loop prevention)

Step 10: If above both conditions are met & the IP address of the destination matches with that in RREQ the node responds to RREQ by sending a RREP back using unicasting and not flooding to the source using reverse path else goto step 11

Step 11: If conditions are not satisfied, then node increments the hop count in RREQ and broadcasts to its neighbors.

Step 12: Ultimately the RREQ will make to the destination

2) CI-AODV Algorithm

Step 1: Each node maintains lists of locally available channels (channel Set As) that are not occupied by primary users

Step 2: The source node transmits the RREQ using the common control channel toward the downstream WP node, with its channel Set As

Step 3: As the WP node receives the RREQ, it first checks whether the destination is in the CMLT or not. If not, the WP node extracts the channel Set As, comparing with the channel Set of itself and the new channel Set which is the set of channels owned by both nodes, will be rewritten to the RREQ.

Step 4: Simultaneously, the channel Set As is compared with the channel Set of all normal nodes in the CMLT (Cluster Member List Table) and the Mt is calculated respectively defined as the number of identical frequency channels

Step 5: WP node transmits the RREQ to the normal nodes with the largest Mt

Step 6: The normal node receiving the RREQ is treated as source node and the operations are repeat until the RREQ reach the destination node.

Step 7: At the destination node, the channel Set As is compared with the sequence number of destination node, when the destination node has received the RREQ.

Step 8: Then one frequency channel is selected by destination node randomly from the available frequency channels and its sequence number is written to the RREP.

Step 9: The RREP return the source node with the sequence number of the frequency channel through the route indicated in RREQ and all the nodes in the route must locate in the frequency channel, so there is a route established in the cognitive mesh network which is referred as MRP.

Step 10: The MRP is considered as the most reliability path, because it contains the most available channels. While PUs appears suddenly, the network will have more frequency

V. NETWORK SIMULATOR- 2

NS (**network simulator**) is a name for series of discrete event network simulators, specifically **NS-1**, **NS-2** and **NS-3**. All of them are discrete-event network simulator, primarily used in research and teaching. NS-2 is free software, publicly available under the GNU GPLv2 license for research, development, and use.

The goal of the NS-2 project is to create an open simulation environment for networking research that will be preferred inside the research community; this mainly means two things:

- It should be aligned with the simulation needs of modern networking research and
- It should encourage community contribution, peer review, and validation of the software.

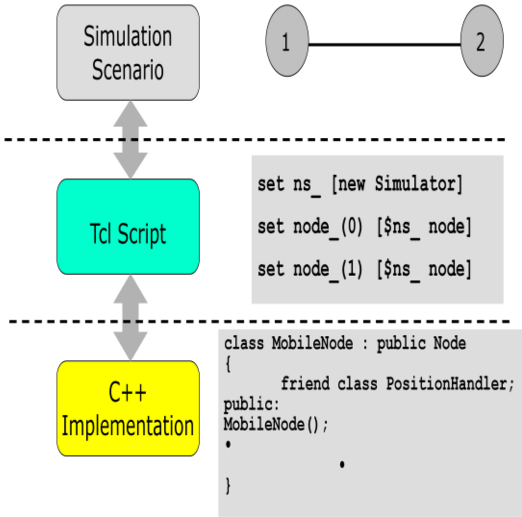


Fig 2: NS-2 Environment.

1) Components of NS-2

- NS-2, the simulator itself
  - Specify simulation, generate traces
  - Depends on TCL/Tk, OTCL, TCLCL
- nam, the network animator
  - Animate traces from simulation
  - GUI for constructing simple simulations
- Pre-processing
  - Traffic, topology generation
- Post-processing
  - Analyse trace output with awk, etc

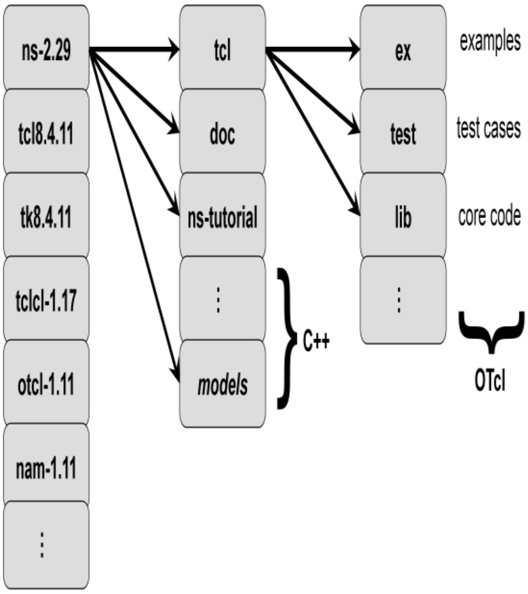


Fig 3: NS-2 components.

2) Working with NS-2

- Create simulation
  - Describe network, protocols, sources, sinks
  - Interface via OTCL which controls C++
- Execute simulation
  - Simulator maintains event list (packet list), executes next event (packet), repeats until done
  - Events happen instantly in *virtual time* but could take arbitrarily long real time
  - Single thread of control, no locking, races, etc
- Post-process results
  - Scripts (awk, perl, python) to process text output
  - No standard library but some available on web

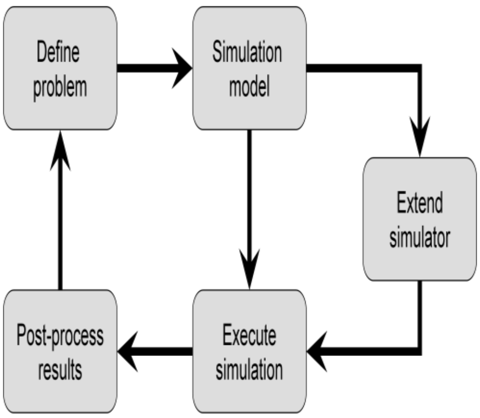


Fig 4: NS-2 outline.

VI. RESULTS AND SNAPSHOTS

Here 15 nodes have been considered for simulation using NS-2 2.31
The Fig 5 below shows the network animator where 15 nodes are considered and transmission among the nodes can be seen.

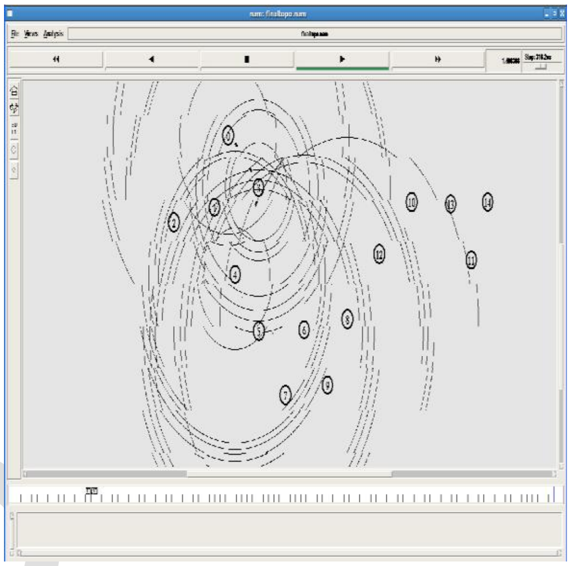
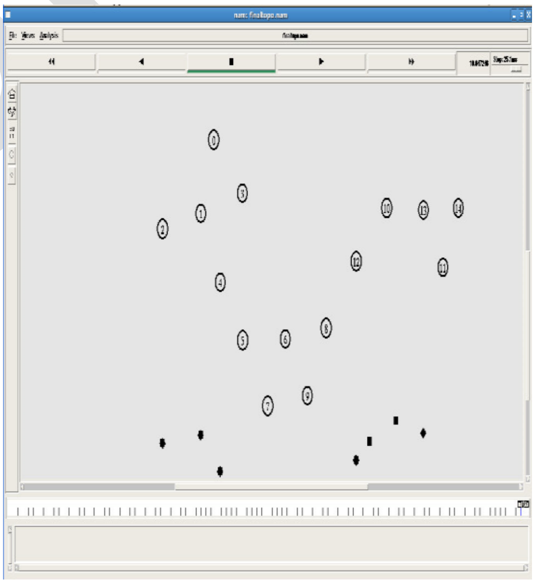


Fig 5: Data transmitted between nodes in AODV routing.



This Fig 6 shows the dropped packets among the various nodes that were involved in the transmission of the data packets at the end of the simulation.

Fig 6: Packets dropped after the end of simulation.

The Fig 7 below shows the end to end delay for various number of nodes.

We can see clearly that the end to end delay of Traditional AODV is more when compared to CI-AODV

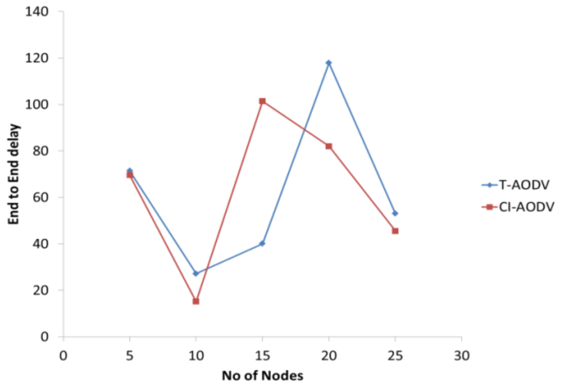


Fig 7: End to End Delay among T-AODV and CI-AODV

Table 1: comparison b/w T-AODV and CI-AODV based on end to end delay.

No of nodes	T-AODV	CI-AODV
5	71.4351	69.5972
10	27.1397	15.1913
15	40.0324	101.417
20	117.886	82.0453
25	53.0067	45.5972

The Fig 8 below shows the average number of packets dropped for various number of nodes.We can see clearly that the number of packets dropped is more in Traditional AODV when compared to CI-AODV

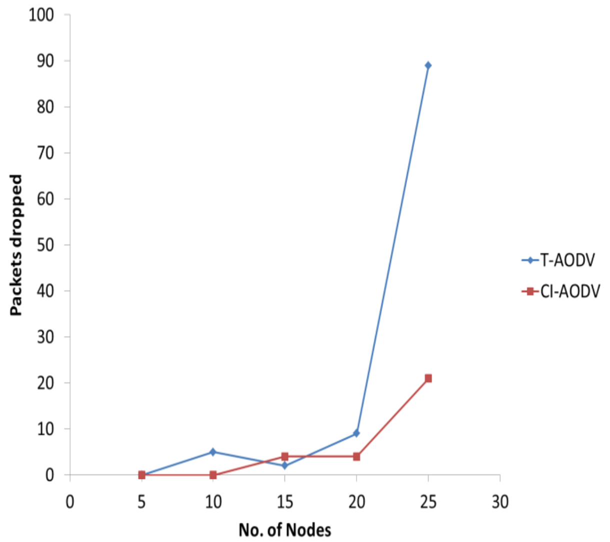


Fig 8: Average number of Packets Dropped

Table 2: comparison b/w T-AODV and CI-AODV based on packets dropped.

No of nodes	T-AODV	CI-AODV
5	0	0
10	5	0
15	2	4
20	9	4
25	89	21

The Fig 9 below shows the average number of packets dropped for various number of nodes.Here it can be noticed that the packet delivary ratio is more in CI-AODV when compared to T-AODV. Although the difference is considerably less we may observe it to be exponential when the number of nodes are larger.

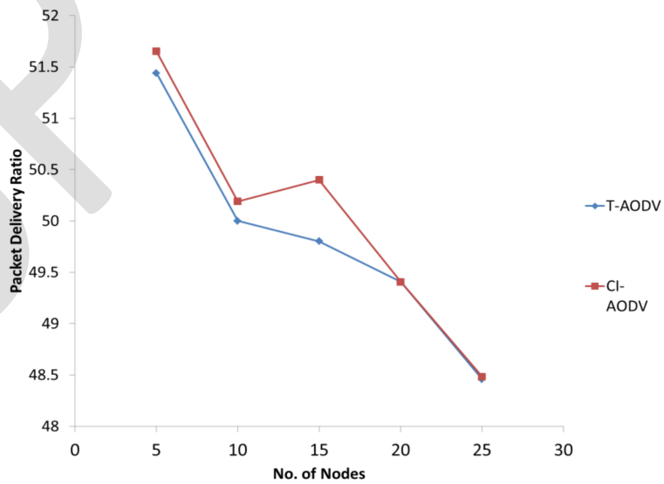


Fig 9: Packet Delivery Ratio

Table 3: comparison b/w T-AODV and CI-AODV based on packets delivery ratio.

No of nodes	T-AODV	CI-AODV
5	51.4403	51.6529
10	50	50.1916
15	49.8024	50.4
20	49.4071	49.4071
25	48.4587	48.4848

The Fig 10 below shows the throughput of Traditional AODV where time is plotted in the X-axis and average throughput is plotted in the Y-axis.

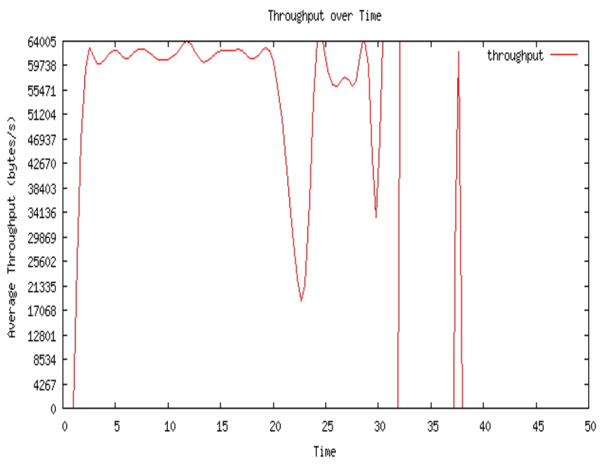


Fig 10: Graph depicting the throughput of Traditional AODV

The Fig 11 below shows the throughput of Cognitive Improved AODV where time is plotted in the X-axis and average throughput is plotted in the Y-axis

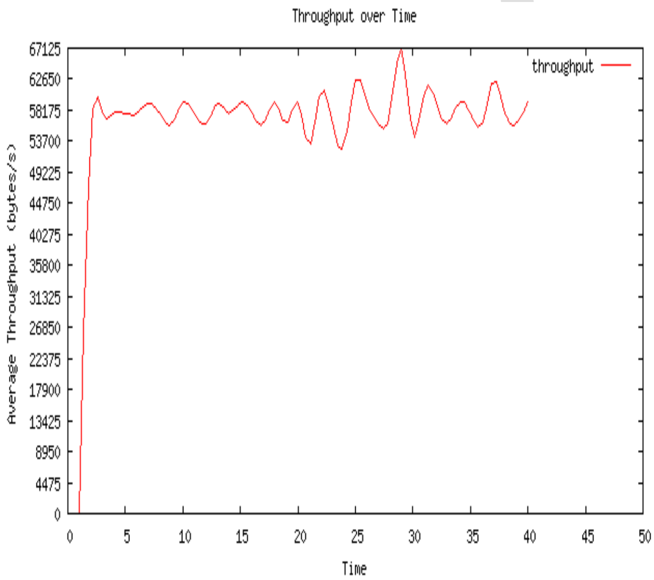


Fig 11: Graph depicting the throughput of Cognitive Radio attached AODV

CONCLUSION

In our work an introduction to a new concept of cognitive radio environment along with AODV routing has been taken into consideration there by making a comparison between traditional AODV and Cognitive Radio attached AODV. Simulation results shows that the throughput of traditional AODV is not constant and the throughput of cognitive radio attached AODV is constant. By simulation results it is clear that the cognitive radio attached AODV provides better packet delivery rate and better results in End to End Delay and packets dropped than traditional AODV. The results confirm that our scheme achieves significant improvement on keeping the merits of traditional AODV and improvising them upon integrating a Cognitive Radio environment.

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