Enhancing video transmission in MANETs utilizing multiple interfaces and multiple channels per node

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Abstract. Mobile Ad hoc NETworks (MANETs) are becoming more essential to wireless communications due to growing popularity of mobile devices. MANETs are also essential in Emergency Response situation where network information flow between deployed units is vital. In such cases voice and video transmission is essential to form a global view of the situation and decide on action. However, MANETs do not seem to effectively support multimedia applications and especially video transmission. In this work we propose a simple and efficient channel selection mechanism for enhancing Video Transmission in MANETS that have nodes with multiple interfaces, and can utilize multiple channels at the same time. The mechanism is implemented and tested in the ns-2 network simulator. Simulation results indicate that the mechanism improves the networks capacity for video transmission and reduces the video streams' packet delay.

Keywords. MANETs, Multi-interfaces and Multi-channels, Video transmission.

1 Introduction

Disaster management and direct response in emergency situations are currently one of the most important fields of Mobile Ad-hoc Network (MANET) technology and has been under study for the last few years ([1], [2]). This technology has increasingly drawn the attention of communications research communities over the past years and encouraged the attempts of applying it to real time situations.

MANETs have significant advantages over traditional telecommunication networks. They are decentralized, self-organized, and capable of restoring communications without depending on any infrastructure. Big catastrophes, over the past few years, have shown that wired telecommunications and common static wireless infrastructures are vulnerable and not efficient for usage when disasters take place. With MANETs, each device equipped with wireless modules can act as a node that may communicate with any other node in the network area over wireless channels supporting multi-hop connections and covering great distances. In addition, compared to traditional telecommunication networks, they are cheaper, because they do not require any infrastructure and more robust, because of their non-hierarchical structure and network management mechanisms. The most important attributes of MANETs are mobility and flexibility as they can be organized and dispersed in very short time.

However, MANETs are still facing a number of open issues that are under consideration by the research community. These include mostly efficient routing, quality of service (QoS), energy consumption, and security. Various solutions have been proposed in the past so as to ensure that MANETs successfully provide services with the desired QoS and effectiveness in emergency situations. Routing protocols such as Ad hoc On-Demand Distance Vector (AODV) [3], Dynamic Source Routing Protocol (DSR)[4] and Optimized Link State Routing Protocol (OLSR) [5] are the most commonly used in MANETs. In [6] emergency eMANETs are presented as the networks consisted mostly from intelligent devices such as smart phones and PDAs, using an adaptive routing protocol called ChaMeLeon (CML). The CML defines the size of the network Critical Area (CA) and based on this information it routes using AODV in small topologies and OLSR in larger. Although this approach tries to exploit the characteristics of reactive routing (AODV), which are suited better in small areas and the reactive ones (OLSR) in large areas, in cases of moving nodes inside and out of the network, the CML is not that effective. In [7] a Hybrid Adhoc Network (HANET) is proposed which is a combination of Static Adhoc Network (SANET) and Mobile Adhoc Network (MANET). This mesh network model can be easily built in situations where communications, power and roads get disrupted. This model includes a MAC protocol based on the directional smart antenna and the results have shown better throughput and end-to-end performance than the legacy MANETs with IEEE 802.11-MAC. Another type of solution in [8] is a framework for disaster management. According to this solution, depending on the disaster grade of the alertness (DGA) three phases of management are analyzed (Most Critical Phase, Optimal Power Phase, Average Reliable and Power Phase). The simulations showed that MCP is the most reliable model in data transmission with the fewer hops but with the most energy consumption.

Until now, an efficient and promising solution in emergency ad-hoc networks seems to be the use of Multi-Interfaces and Multi-Channels (MIMC). The rapid growth of IEEE 802.11 technology has eased the sharp decrease of multi-interface enabled devices' prices and therefore, their presence is each day more and more common. Several efforts have been made in the last years in order to implement and attach the technology of MIMC on the mobile nodes. As far as NS-2 (Network Simulator) is concerned, TeNs (The Enhanced Network Simulator, http://www.cse.iitk.ac.in/users/braman/tens/), [9], and [10] are the most complete previous works for MIMC technology. An older project, MITF (which was discontinued, and is no longer available) was carried out at the University of Rio de Janeiro and its goal was to adapt MIMC technology to the AODV routing protocol in ns-2.28 (see, [10]). TeNs was implemented at the Indian Institute of Technology of Kanpur-India, and its main goal was to add multi-interface support for ns-2.1b9a and improve its implementation of the IEEE 802.11 protocol. The project Hyacinth was conducted at the University of New York for ns-2.29a and could be extended for use at ns-2.29. These three projects add many capabilities concerning the implementation of MIMC in NS-2, but do have several drawbacks. Static configuration, low flexibility in routing protocol and inability to develop various tcl scripts are such drawbacks. However, the model of [10] about the MIMC implementation in NS-2 is much more flexible and complete as it is based on the combination of all the previous projects referred above. In [10] a detailed set of changes that need to be performed on the simulation framework is presented, in order to use a flexible number of interfaces and channels per node.

Making use of multiple channels is applicable in emergency response situations (e.g. a fire in the woods) as it is expected that in the area there will not be any other devices making use of the available wireless channels.

In our solution, by following the model of [10], we design a cross-layer mechanism for effective channel assignment and routing based on specific metrics used in Cognitive Radio Networks (CRN) [11] in order to improve the spectrum utilization. Cognitive Radio (CR) technology provides a new and promising solution to equipartition of channel utility and discovery of optimal paths. This is due to channels being dynamic and diverse from one user to others and not statically configured. Routing metrics in CRNs considerably affect the performance of channel assignment and routing algorithms, meaning that selecting the right combination of them is crucial. Hop Count is the base metric used in most MANET protocols and is a simple measure of the number of hops between the source and destination of a path. This metric has high stability allowing minimum weight paths to be found efficiently and under scenarios of high mobility, it can outperform other load-dependent metrics [12]. However hop count, not taking into consideration metrics for each link such as link quality, capacity or interference, leads to reduced link and path reliability and fails to satisfy the requirements of an emergency response scenario.

In contrast, Expected Transmission Count (ETX) ([12], [13]), is a measure of link and path quality which finds paths with fewest expected transmissions and retransmissions required to deliver a packet to its destination. Its main goal is to discover paths with high throughput, after taking into consideration interference, link loss ratios and acknowledgement in the reverse direction. Although ETX is considerably a more effective metric than the Hop Count, it still lucks effectiveness in multi radio - multi channel environments ([12], [14]) as it does not gather knowledge about co-channel interference and link sensitivity to different rates and capabilities. In many occasions, this lack of knowledge, leads ETX to select paths with lower rate and lower channel diversity. The Expected Transmission Time (ETT) metric ([12], [14], [15]) overcomes the limitations of ETX by considering the different link rates or capacities. It retains many of the properties of ETX but can considerably improve the overall network performance.

However, the ETT is still not the desired effective routing metric in multi-radio topologies, because it was not designed to assign channels according to intra flow interference and channel diversity of the link. A new routing metric, the Weighted Cumulative ETT (WCETT) ([12], [14], [15], [16]), is a noticeable improvement of the previously mentioned routing metrics and is designed to fit in a multi-radio multi-channel environment. WCETT is a metric that reflects the effect of channel diversity on throughput and targets at choosing high throughput paths between the source and the destination. This metric is the weighted average of ETT with the additional feature of accounting intra-flow interference and thus augments the performance of ETT at MIMC environments. At this point, a drawback is that WCETT is not isotonic and there is no guarantee for optimal and loop free paths to destination.

2 Proposed Design

2.1 Node architecture

The proposed design is for MANETs, which have nodes with multiple interfaces and can utilise multiple channels at the same time. As such the networks nodes do not have the default mobile network architecture, but have an extended architecture to classify as being able to support MIMC. For clarity the default mobile node architecture and the mobile node architecture with MIMC support are briefly presented below.

Default mobile node architecture. For the purpose of this paper the node architecture is considered to be the pretty much default node architecture of a mobile node, shown in figure 1.
The node has only one network stack and thus can utilise only one channel at a time. If that channel is used by another node in the proximity the node’s attempt to transmit will result in a collision.

Mobile node architecture with MIMC support. The nodes that have multiple interfaces and can utilize multiple channels at the same time follow similar mobile node architecture, where the parts that relate to the multiple interfaces and the transmission in multiple channels are replicated as shown in figure 2.
The node has only multiple network stacks and thus can utilise more channels concurrently. If some channels are used by other nodes in the proximity the node may transmit using an unused channel. The same holds for the case that the node is transmitting another frame at the time. The node can transmit simultaneously another frame using a different interface and a different channel.

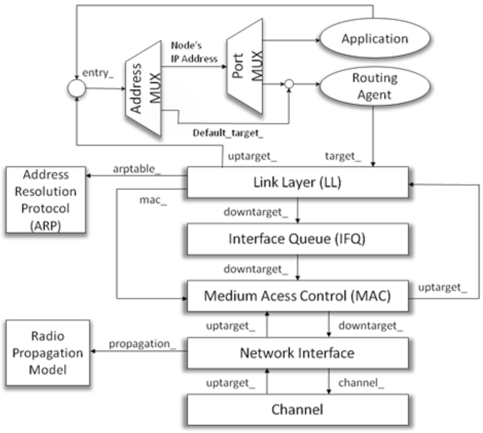

Fig. 1. Default mobile node architecture.

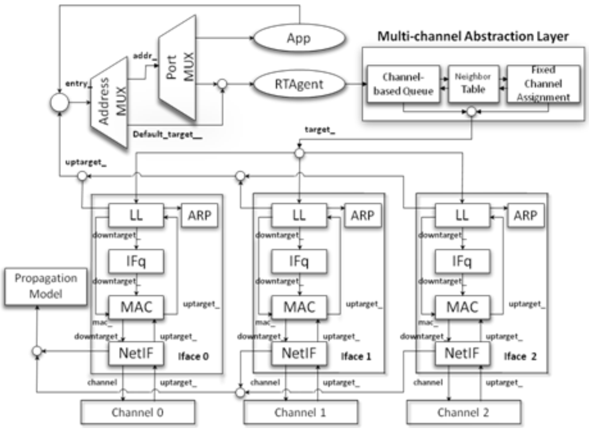

Fig. 2. MobileNode architecture, with multiple interface support.

2.2 Description of the mechanism

The proposed mechanism is based on tracking real time metrics during data packets transmission.

- Sound to Noise Ratio (SNR): Every node stores the value of the SNR for the channels attached to the interfaces used for transmissions. The stored value contains information for intra-flow and inter-flow signal strength and noise at the channels that are being used by the node. The intra-flow traffic is the traffic in the same path whereas the inter-flow traffic is the one performed by neighbors on different paths.
- Channel Collision: this metric contains the state of the MAC layer which has access to information about the channel at the physical layer. When the air is “busy” (collision at the currently fixed channel) the MAC state sends a signal to the routing layer at the corresponding node to check for switchable channels with better SNR value and less interference.

These metrics are utilized to select the best channel for transmitting the data frames on the currently created route between the senders and the receivers. When a collision takes place in a particular channel, the current state of the nodes forwarding or receiving is reevaluated and possibly another channel will be used to retransmit the frame. The basic aim is to offload busy channels.

In order to avoid packet collisions and the consequences of limited bandwidth, the topology nodes interact with as many available channels as possible. The number of channels used in a crisis management situation should depend on the number of nodes interacting in the field as well as the packet traffic.

The proposed approach will be based on the concept of usage of multiple channels for video transmission where each node is able to be aware of the best path and channel to send or forward packets. This means that according to current flows and packet traffic of the in-zone nodes, the sending node should correctly decide which channel to use. The model for usage of multiple channels and interfaces is described below:

Each node, has a routing table for each interface-channel, and is collecting information about all the possible paths to the destination. This means that the interfaces of the node keep data for the path to destination for the current channel they are attached to. The node then analyzes the routing table of each interface and according to specific parameters it sets as gateway one of them.

The usage of multiple channels-interfaces improves significantly the packet end-to-end delay and data delivery ratio. Every added channel greatly extends the current total bandwidth of each link and enhances the operation of tactical teams. However, as a wireless topology expands and its density increases, the bandwidth of each link is affected noticeably and the wireless communication gets more complicated.

The main problem with the bandwidth usage when a video is transmitted over a multi-hop route in the MANET is that every intermediate node cannot transmit when its previous and next nodes in the path are transmitting This means that just increasing the number of channels is not a complete solution. For this reason we insert in the current implementation an intelligent mechanism for interface management. With this mechanism, each node is able to choose the best routing path to the destination as well as the corresponding interface. This intelligence added in every node is based on the data collected during broadcast messages and route path discovery process from each interface. Alongside this addition, the mechanism is also collecting data about its surrounding traffic of neighbor nodes and channel usage that affects the bandwidth of the used link of the current node. In order to achieve this, the routing table of each interface is updated every time a better path or channel is discovered. This may require more energy, for the associate scanning, but this work doesn't touch this issue.

At last, the path from the sender to the destination may consist of different channels attached to different interfaces. In this way there is more flexibility as each node may have its interfaces and channels set in a different way from the other nodes. In our implementation, the paths are created based on the AODV routing protocol and every interface can connect to any other interface if set in the same channel and positioned in range.

Figure 3 shows cases where only one channel is used and thus the nodes are interfering with each other. In the displayed cases where the same channel is used by two links close in proximity the average link capacity is half the channel. The situation is worst if more links are using the same channel. Combined throughput can go up to the channel's capacity

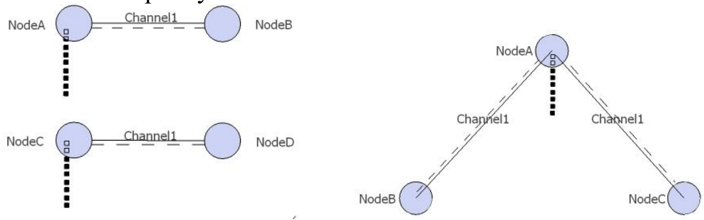

Fig. 3. Usage of the same channel by multiple links

Figure 4 shows cases where only multiple channels and multiple interfaces are used. In the displayed cases two channels are used and there is no interference. Each link's capacity is the corresponding channel's capacity; and the combined throughput can go up to the cumulative capacity of the used channels.

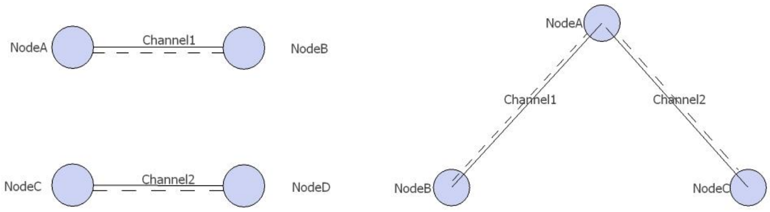

Fig. 4. Usage of multiple channels and multiple interfaces for different links

2.3 Interface Switching Mechanism

In the simulated multi-channel multi-interface ad-hoc wireless network, the topology nodes are configured with M interfaces available and 1 channel per interface. The number of interfaces can be dynamically set (not all the nodes should have the same number of interfaces) along with the simulation parameters. Every node has a fixed interface for a routing path and according to the number of interfaces, one or more switchable ones.

Fixed Interface. The interface a node uses to send packets in the network. The corresponding channel of this interface is regarded as the fixed channel. Fixed interfaces are initially set to iface0, but during the transmission and according to the needs for throughput, they can be automatically switched to one of the switchable interfaces. The fixed interface of a node can be different for different paths crossing it, which means it can divide the channel utility in packet flow junctions.

Switchable Interface. The remaining M-1 interfaces in idle state are referred as the switchable interfaces. The corresponding channels are designated as switchable channels. When a channel switch is needed, the node should set a new interface from the switchable interfaces as its fixed one. A switchable interface enables node X to transmit to node Y in its neighborhood by assigning it as the fixed interface which has the same channel assigned as of the receive channel used by Y. Figure 5 shows two communicating nodes and their fixed and switchable interfaces. The second node has a different fixed interface to be able to transmit to another node while receiving from the first node.
In order for node A to communicate with node B the fixed interface of node A should be set in same channel with the receive interface of node B.

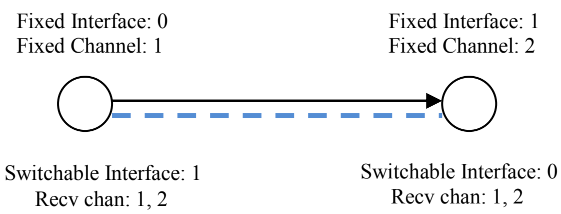

Fig. 5. Fixed and switchable interfaces

For our implementation we define a struct which stores real time data for the topology in the following arrays:

- NeighbourTable [Nodes]: Contains a list with the neighbors of each node in the topology and it is updated when hello messages are sent. The interval is set by the AODV routing protocol,
- ChannelUtilityArray [Nodes][Ifaces]: Keeps information about the utility of each channel for every node in the topology,
- TotalChannelUtility[Ifaces]: Keeps information about the total utility of each channel per neighborhood,
- FixedInterface[Nodes]: Contains the interface(channel) that each node uses for data sending,
- SwitchableInterface[Nodes]: Keeps the switchable interface(channel) for each node when a channel switch is needed,
- ReceiveChannel[Nodes]: Keeps the channels set to receive packets for each node.

The rules for assigning the switchable interface of a node proposed in [17] are:

1. The Mac layer stores at each mac address (interface) per node the Mac state and the SNR for the corresponding channel being used. This information is sent directly to the routing layer at the index node forwarding data packets.
2. When the route is up and forwarding data packers:
   a. The index node checks the information sent by the mac layer concerning the channel SNR, the mac state of the index node and the mac state of the mac addresses in the zone of the index node that use the same channel. After this information analysis, it decides whether a channel switch should occur and if so which channel should be set as the switchable channel.
   b. For broadcasting the packet, the node copies it to each channel's queue. The packet will be sent out when that channel is scheduled for transmission.
3. The fixed interface changes channels if there are packets queued for another channel.

The algorithm's pseudocode follows:

```
Procedure sendHello()
  if nifaces
    for (iface i=0 to nifaces)
      Broadcast Hello_msg on iface[i]
    endfor
  else
    Broadcast Hello_msg on iface[0]
  endif
Endprocedure

Procedure recvHello()
 NeighborList[index] <- add source node
replyHello();
Endprocedure

Procedure forward()
  fixedIface[index] <- rt->rt_interface
  channel_in_use[index] = channel[index][fixedIface[index]]
  if RREQ.packet_type == data
    macList <- getMac_collision_addrs(channel_in_use[index])
    snrList <- getSnr_channelList(channel_in_use[index])
    ChannelUtility[index][channel_in_use[index]] ++
    weaknode <- getWeaknode( neighborhood( index ) )
    switchableChannel[index] <- getSwitchableChannel([index]]
```

```
    for ( neighbor i=macList.begin() to macList.end() ++neighbor )
      if ( is_neighbor( index, neighbor ) )
        collisionState[channel_in_use[index]] = true
      endif
    endfor
    if ( collisionState[channel_in_use[index]] == true )
      collisionState[channel_in_use[index]] = false
      channel_in_use[weaknode] <- switchableChannel[index]
      for ( iface i=0 to nifaces)
        if ( channel_in_use[weaknode] == channel[weaknode][iface]
          fixedIface[weaknode] = iface
        endif
      endfor
      if(weaknode == index ) rt->rt_interface = fixedIface[index]
    endif
  if ( !broadcast )
    schedule packet at fixedIface[index]
  endif
Endprocedure
```

Every node is aware of the channels being used by its neighbors (ChannelUtilityArray) and it updates the NeighbourTable and ChannelUtilityArray every time it receives a request (broadcast, hello, rrep, rreq message) or sends (forward, sendrequest, sendreply, etc.) a packet. The interface switching mechanism is based mainly on the channel utility stored in the ChannelUtilityArray and the packet collision flags. When a channel with less utility is discovered, and the packets flowing in the current channel being used start to report collision messages, the routing agent sets the outgoing interface of the node with the already discovered channel. In this way, every node has always its switchable interfaces ready and is able to make the best channel setting decision when collision starts to occur.

The source code implementing the mechanism is available from the web site of Research Unit 6 / Computer Technology Institute and Press "Diophantus", at the address: http://ru6.cti.gr/ru6/research_tools.php#MIMC (Network Simulations, Simulations in MANETS using Multiple Interfaces and Multiple Channels per node).

Another proposed mechanism, which can be implemented simultaneously with the previously described one, is a more efficient video data rate adaptation mechanism. When more than one video is sent from the source to destination, the used bandwidth of the wireless links between the nodes tends to reach or pass the limit. In such scenarios, a degradation of the videos quality leads to better results as more video packets are allowed to pass throw the link and reach the destination in time. Our proposed design can adapt the rate of the video sent and drops its quality efficiently so as maximum quality and minimum delay is achieved in the same time. However, a rate adaptation mechanism has not been implemented in the work described in this paper, and remains as future work.

3 Performance Evaluation

3.1 Reference Scenario

In this work, we performed simulations with a variety of topologies using the random topology creator BonnMotion (BonnMotion: A mobility scenario generation and analysis tool, http://sys.cs.uos.de/bonnmotion/). The topology dimensions are set to 1000m x 1000m and the number of wireless nodes to 20. The bandwidth of data channels is set to 2Mb and the two-ray ground propagation model is selected. Nodes have radio range set to 250m and top speed set to 20. For the Mac protocol, multi-radio and multi-channel is selected and each node has 3 interfaces and 3 channels. The simulations were implemented with data traffic set to Constant Bit Rate (CBR) for common flows and TCP Friendly rate Control (TFRC) [18] for video flows. Topology types are categorized based on the nodes density and speed. For the most cases, when low movements and density was applied to the topology, the AODV with MIMC and the proposed mechanism performed in a quite similar way, with the last one showing slightly better performance in throughput and delay. However, when higher density and more intense mobility of the nodes was chosen for the simulated scenario, the proposed design performed noticeably more effectively. The results are more intense and noticeable when video flows and TFRC is selected. In order to simulate a realist topology, with greater demands, we have implemented a topology with quite intense node density and mobility for 5 video flows with minimum number of hops set to 2 and maximum set to 5. All 5 video flows are causing great interference to each other as at many points of the network they are meeting and sharing the same paths. Also, the nodes mobility creates extra interference and need to set the suitable channels to avoid collisions. Video flows 1 to 5 start respectively at 10, 11, 12, 13, 14 sec and should end at 90, 91, 92, 93, 94 sec of the simulation. The starting and final positions of the nodes are shown in figure 6. The total simulation time is 120 sec.

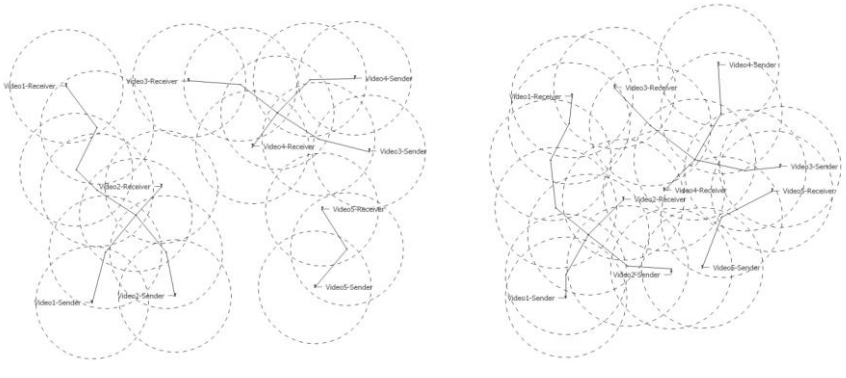

Fig. 6. Starting and final positions

3.2 Ns-2 Based Simulations

In this section we present the simulation results for the previously described topology and evaluate the performance of the proposed mechanism for channel assignment compared to the AODV with MIMC but no additional channels selection mechanism.

Figure 7 shows the throughput for the 5 video flows in the case of using AODV with MIMC. In this case, 3 video flows out of 5 manage to reach the destination node within the desired stream time. The other two flows, video 2 and 3, are delivered with some noticeable delay that does not satisfy the end user requirements. Video flows 2 and 3 have some instability in the throughput due to the interference caused by the nodes that were initially outside the interference zone of these 2 flow paths and after a period of time they approach the interference zone of these 2 flows. The AODV with MIMC fails to see this interference change and does not switch to non interfering channels.

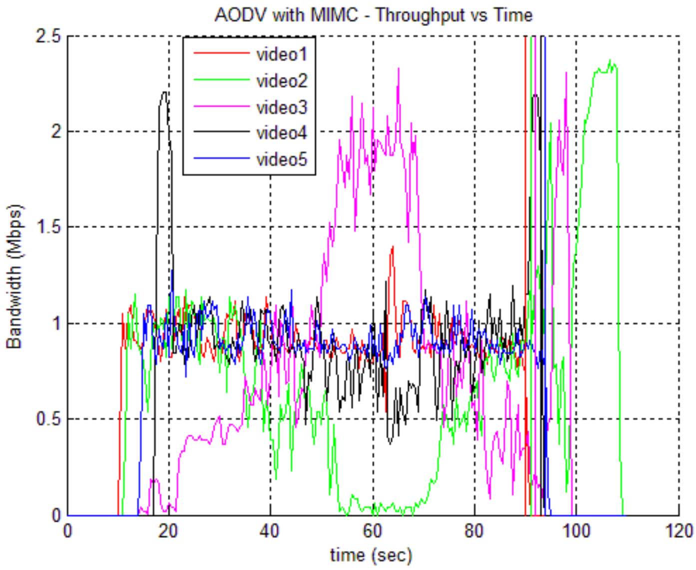

Fig. 7. Throughput of the video streams in the case of AODV with MIMC

Figure 8 shows the throughput per packet in the case of using AODV with the proposed design. It is noticeable that the video flows' throughput is more stabilized and only one video is delivered with unpleasant delay, which in this case, could be in the limits of not being discarded in an emergency situation. The stable video flow is important factor for multimedia transmission quality. The proposed design monitors the changes of the interference caused by nodes with interfering channels that move towards the index flow and makes the decision to switch channels. The switchable channel is set based on the signal to rate of the channels in the flow neighborhood and as a result the delay is maintained at desirable levels.

The proposed mechanism largely improves the situation for video 3, which otherwise experiences a very slow start and a delayed delivery. With the proposed mechanism, video 3 transmits more normally, and finishes almost on time. It should be noted that there is large improvement also for video 2, which unfortunately is not delivered on time even with the proposed mechanism. However, video 2 also gets some more bandwidth and the final delay is less than when the proposed mechanism is missing.

Figure 9 demonstrates the cumulative throughput for the two protocols. The cumulative throughput is better for the proposed mechanism for most of the period, and therefore transmission of the videos finishes earlier and with only one video delayed. This obviously is due to the proposed mechanism that makes good choices when selecting the transmission channels and thus avoids causing much interference (i.e. cause less collisions).

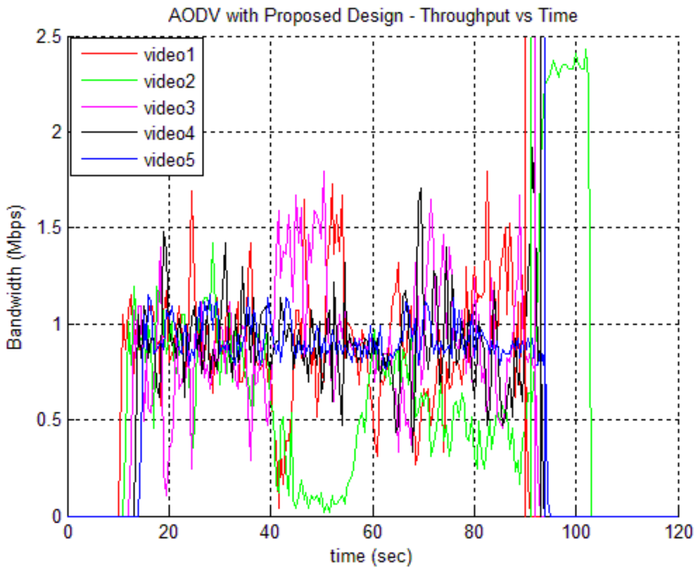

Fig. 8. Throughput of the video streams in the case of AODV with the proposed mechanism

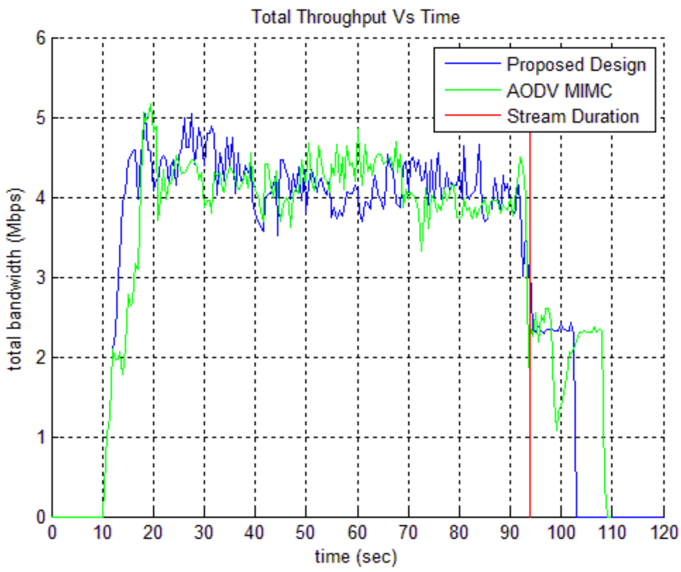

Fig. 9. Cumulative throughput comparison with and without the proposed mechanism

Figure 10 shows the delay of each packet in the case of selecting AODV with MIMC protocol. It is obvious that the delay for two video streams is noticeable and that these streams have a large delay for their final packets. This means that these streams cannot be played back without interruptions.

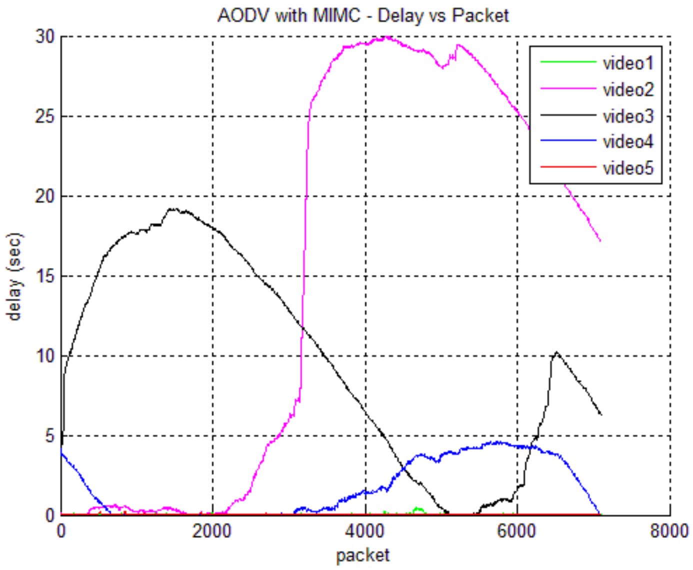

Fig. 10. Packet delay of the video streams in the case of AODV with MIMC

Figure 11 shows the delay per packet in the case of selecting AODV protocol with the proposed design. The delay is much better, and only one stream faces problems. This means that the proposed mechanism improves the video transmission. It should be noted that the proposed mechanism seems to keep the delays of the transmitted videos at an acceptable level, when possible. In the presented case the delays for videos 3 and 4 are kept quite low at acceptable levels, even this means that the delay for video 1 has to increase at some periods (but still remaining at acceptable levels. Without the proposed mechanism videos 3 and 4 experience large delays (although video 4 catches up at the end), while video 1 experiences almost no delay. In all cases video 2 experiences large delays and while the proposed mechanism cannot lower it down to an acceptable level it nonetheless improves it. However it seems that video 2 faces high interference from more than one neighboring links and cannot be transmitted on time in this case of using up to three channels. In order to solve this problem it seems that up to four channels must be used.

Figure 12 shows the average delay for the two cases. The results demonstrate that the proposed mechanism distributes the available capacity more efficiently leading to more smooth transmission of the videos and much less delays. It is obvious that the positive effect of the proposed mechanism in the delays of the video packets is substantial.

Figure 13 shows the PSNR of each frame for each video flow for the proposed design. The results concerning the PSNR are exactly the same for both the AODV with MIMC and are not presented. This however is to be expected, as the quality of the videos transmitted is not altered, and as packets are not dropped and finally arrive at their destinations (even with a considerable delay).

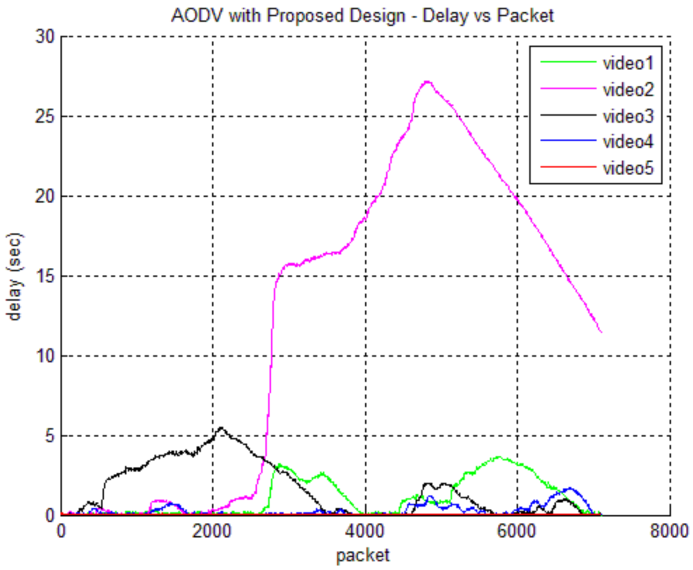

Fig. 11. Packet delay of the video streams in the case of AODV with the proposed mechanism

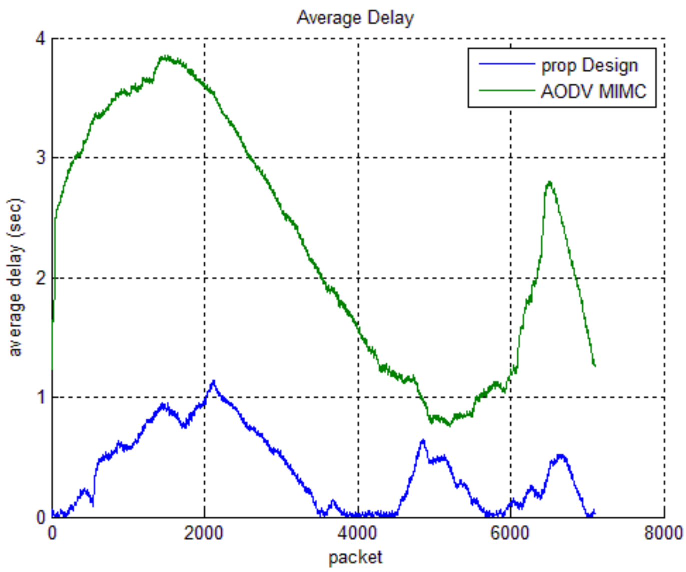

Fig. 12. Average delay comparison with and without the proposed mechanism

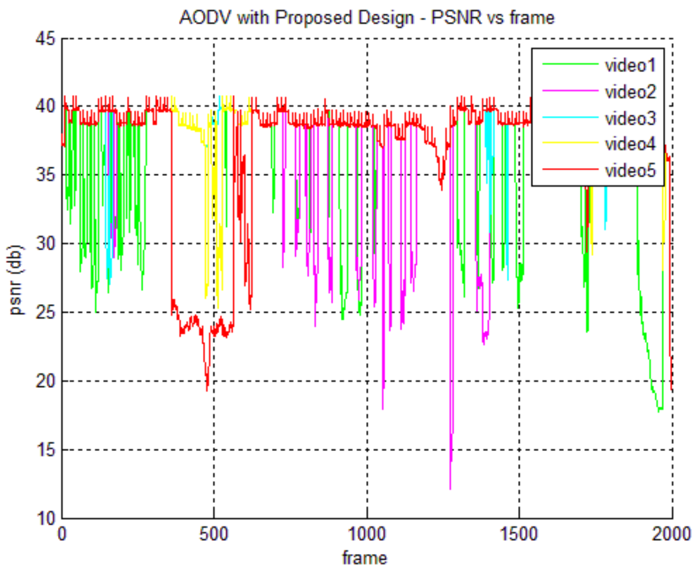

Fig. 13. PSNR for the video streams in both cases (with and without the proposed mechanism)

From the above evaluation is obvious that the proposed mechanism has a positive affect in the video transmission and leads to better end user experience. Without the proposed mechanism the video transmission rates are lower than the video playback rates and this obviously leads to interruptions. With the proposed mechanisms the transmission rates match the playback rates and reproduction smooth.

4 Conclusions and Future Work

In this paper we propose a simple channel selection mechanism that can be used in MANETs that have node with multiple interfaces and can utilise multiple channels at the same time. This mechanism is implemented in the ns-2 network simulator, and simulations have been performed with and without this additional mechanism. The proposed mechanism is shown to be beneficial for transmitting video streams and enhances the networks ability to accommodate more streams as well as reduces the delay that is experienced by the video streams' packets.

In the future we plan to introduce also path selection (in addition to the channel selection the mechanism performs) and combine this mechanism with other mechanism such as rate adaptation mechanisms, to further improve video transmission in this kind of MANETs.

In addition we plan to extensively compare our simple mechanism to more complicated one proposed in the literature, in order to estimate if the additional implementation complexity of these solution is justified, or if a simple solution can lead to adequate improvements.

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