

The Network Simulator NS-2

NIST add-on

Mac 802.11

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2 Overview

This document contains the modification made to the Mac 802.11 implementation available in NS-2 version 2.29. Many problems were identified in the version released with NS-2, and many features were missing in order to support mobility.

3 Design

3.1 Backoff and Defer timers

The Defer timer implemented in NS-2 2.29 represented a defer (such as SIFS, DIFS, or EIFS) plus a backoff time. The problem is that only the backoff timer was configured to pause when the Mac was not idle. In this case, the first backoff was never paused even if the medium was not idle. The modification made include the separation of the defer time and the backoff time. Now the defer timer only contains SIFS, DIFS or EIFS, and when it expires, it is followed by a backoff time implemented in the backoff timer.

Another modification is that after receiving an ACK, a backoff is triggered only if there is no beacon to be sent.

3.2 Management Frames

Management frames were a missing part of the current implementation. It only contains RTS, CTS, ACK, and data. To support mobility, beacon and association messages needed to be added. With the beacon, an MN is capable of detecting an AP and using that information for movement detection. With the Association Request/Response, an AP has the possibility to reject an MN.

3.2.1 Beacon

The beacon messages have been added to the implementation. They can be used by an AP to inform the MN about its presence, and are sent a specific interval (typically every 100ms).

According to the 802.11 standard, the beacon has priority of Data and Management frames. Also it does not require a backoff before being sent but only a defer time. This is because the beacon must be sent at regular intervals to synchronize the MNs.

3.2.2 Association Request and Response

The Association Request and Response frames have been added to allow an MN to connect to an AP at layer 2, and to add the possibility of an AP to reject the MN from accessing the network (for example, as part of a congestion control mechanism).

Upon detection of a new AP, a MN may decide to connect to the new network. In that case, an Association Request is sent to the AP. When the AP receives the request, it determines if the MN can be accepted. If so, it will return an Association Response message with a status=1 otherwise, the status=0. Upon receiving the Association Response, the MN will inform the upper layer for the success or failure of the operation.

3.3 Scanning

In order to evaluate handovers, it is necessary to be able to have multiple APs in a given topology. In the current implementation, in order for a MN to communicate with an AP, it must share the same channel (in term of NS-2 channel instance). So for a MN to go from one AP to another, it must be able to switch channel objects. If 2 APs are sharing the same channel, the MN can list to both APs at the same time which could cause problems. The MN communicating with one AP would interfere with the MNs communicating with the second AP. On the other side, if we use multiple channel objects to carry the messages, it would be more difficult to implement an interference model.

For these reasons, the solution adopted is to have all the wireless nodes sharing the same channel object and introducing a modified propagation model. The frequency at which the MAC operates will determine if a node will receive the packet or not. The technology will also be used if the interferences are enabled.

3.3.1 Physical layer

By using the same channel object, a new granularity has to be added to the channel object: the frequency used by the physical layer. Each station's physical layer uses a specific frequency (which reflects the channel used) such that only the stations using the same frequency will communicate with each other. The method propagating messages in NS-2 has been updated to do so. Additional methods have been added in order to dynamically assign the frequency of the physical layer (i.e changing its channel).

With these new capabilities, it is now possible to implement scanning mechanisms at the MAC layer.

3.3.2 MAC layer

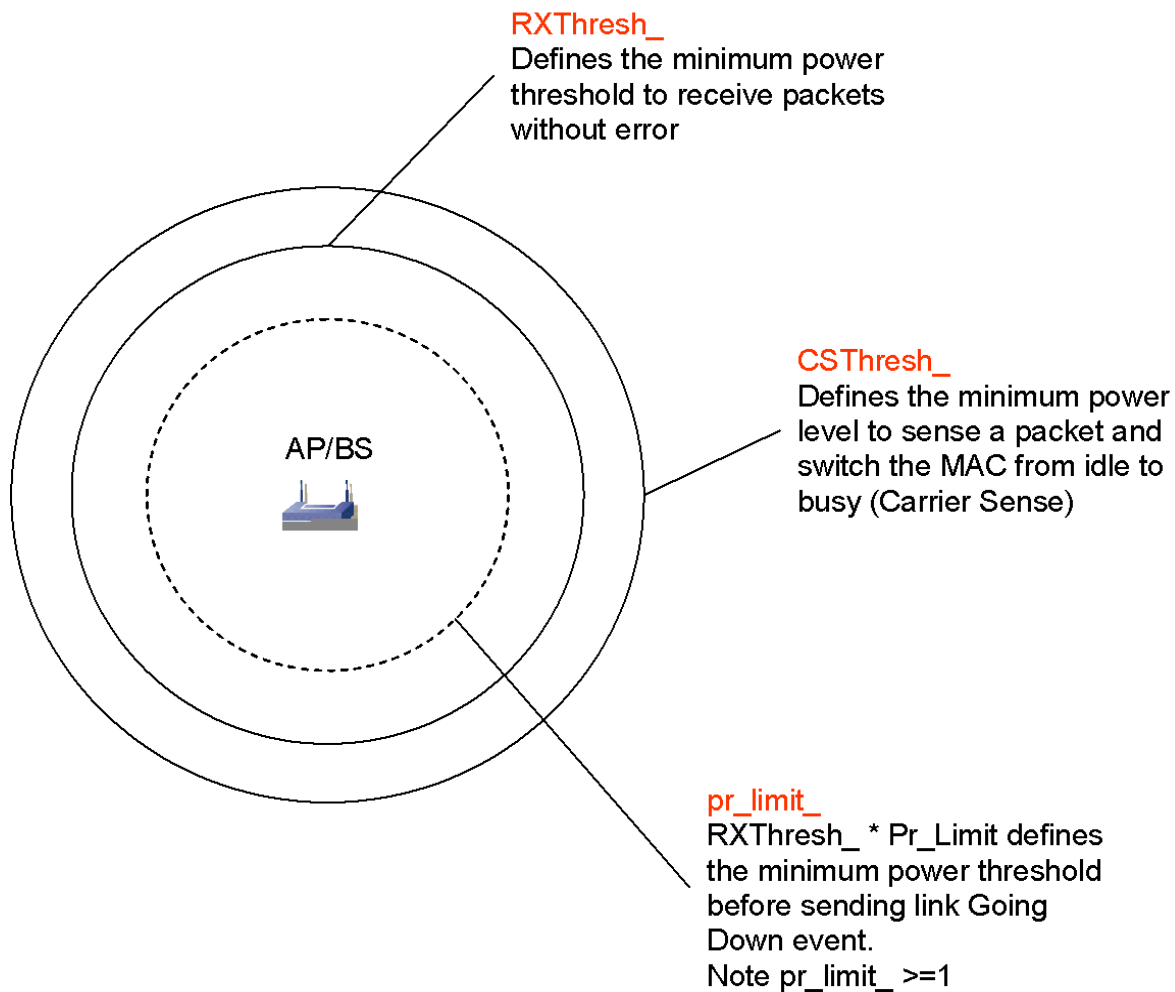
The MAC layer now supports scanning for new APs. The design is such that upper layers can configure the scanning by using a configuration parameter. It allows one to set the time to stay on each channel, the delay to use before sending a probe request, the channels to scan, and also the action to take if a new AP is found (i.e stay and stop scanning, scan all channels...).

3.4 Link triggers

As part of the integration with our IEEE 802.21 model, the MAC layer has been extended to provide the generation of MIH events. The events currently supported are:

- Link UP
- Link Down
- Link Going Down
- Link Detected
- Link Event Rollback
- Link Parameters Report
- Link Handover Imminent
- Link Handover Complete

The generation of Link Going Down is done using the power level of the received packets. To configure the power level threshold, we use a coefficient `pr_limit_` to set this threshold as shown below:



The higher the `pr_limit_` coefficient, the sooner the event will be generated. Setting the coefficient less than or equal to 1 (default value) will disable the generation of Link Going Down events.

3.5 Link commands

Link commands have been implemented to support the `MIH_LINK_SAP` defined in the IEEE 802.21 specifications. These commands allow for events registration and control of the MAC layer (to initiate a scanning or change AP).

The following link commands are supported:

- Link Event Subscribe
- Link Event Unsubscribe
- Link Configure Threshold
- Link Get Parameters

3.6 Link measurements

The MAC layer provides multiple measurements in order to identify the quality of the link. Each measurements use a weighted average mechanisms such as:

$$\text{Average} = \text{Alpha} * \text{new_value} + (1-\text{alpha}) * \text{Average}$$

With $0 < \text{Alpha} \leq 1$, configurable by tcl.

The following measurements are available in the MAC 802.11:

- Number of retransmission
- RTT
- Number of packets sent
- Number of packets received
- Queue length
- Queuing time
- Packet loss
- Transmission error
- Frame size
- Delay
- Jitter
- Occupied bandwidth
- Transmission throughput
- Receiving throughput

Some of these measurements are only for post processing and are just printed during the simulation while others can be requested by the upper layer to determine the status of the link.

4 Configuration

Command	Valid values	Description
enable-beacon	N/A	Enable the transmission of beacons. Must be enabled for APs.
disable-beacon	N/A	Disable the transmission of beacons.
autoscan	N/A	Initiate a link scan. The MN will stop at the first AP detected.
bss_id	Valid MAC id	Set the BSS_ID for the node. This modified method may generate a Link Down if the MN was previously connected to a different AP.
set-channel	Valid channel id (1-11)	Set the channel for the node. This will also modify the frequency at

		which the physical layer operates.
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Default values for parameters available in the standard distribution are defined in `tcl/lib/ns-default.tcl`. The values for the new parameters are defined in `tcl/lib/ns-hsntg-nist.tcl`.

A TCL example using interferences in 802.11 networks can be found in `tcl/hsntg/channel/node802.11.tcl`