

Appendix A

Pseudocode of the *wlan_mac* Process Model in OPNET

```
static void wlan_frame_transmit ()
{
char          msg_string [120];
char          msg_string1 [120];
WlanT_Hld_List_Elem* hld_ptr;
const WlanT_Data_Header_Fields* retx_header_ptr;
double        pkt_tx_time;
int           list_high_index;
int           list_low_index;
WlanT_Mac_Frame_Type type;
Boolean       pcf_frag_buf_empty;

/** Main procedure to invoke function for preparing and          **/
/** transmitting the appropriate frames.                        **/

/* Check if PCF is currently active and if time to transmit      */
/* the CFP end frame. If so check if more fragments have       */
/* to be transmitted. If none then, prepare to send the        */
/* cfp_end frame to indicate the end of the CFP period         */
/* Store the size of the PCF fragmentation buffer in a          */
/* local variable for quick access.                             */

/* Check if the transmission of the cf end frame has been      */
/* enabled. If so, make sure there are no more fragments       */
/* pending and the PCF fragmentation buffer is empty           */
/* If the AP needs to ACK to a previously received              */
/* frame send a CF_end_Ack frame, if not transmit CF end       */
/* Allocating pool memory to the higher layer data structure type.

/* Generate error message and abort simulation if no           */
/* memory left for data received from higher layer.

/* Set up dummy element to see if any more data for station currently being polled */

/* Set search bound for pcf higher layer data queue

/* If a poll fail count reached the max poll fail count or
/* the previous poll was successful and no more data from this
/* station and last data tx was successful and no more
/* fragments exist and no more data exist in the hlk queue
/* for this station then next station will start transmission
/* Increment polling index to next user.

/* Check whether the poll reached the specified limit.
/* Reset the relevant flags.
/* Set the retry count to the retry limit to drop the packet
/* Drop the packet. The function will also reset the
/* counter for failed polls.

/* If we finished polling all the pollable STAs in the list but
/* still have some contention free frames to send, then restart
```

```

/* polling the pollable STAs since we still have some CFP time to go. */
/* to go. */
    /* Restart the polling. */
    /* End the CFP prematurely since we have no stations to poll */
    /* and no CF frames to send. Also send an ACK if necessary */
    /* Destroy the dummy higher layer data entry used for */
    /* searching. */
}
}

/* Determine our data rate for our next poll. This is necessary */
/* if we are an 11g AP serving both 11g and 11b STAs. */
    /* First check whether we are polling the same STA. */
    /* Same STA. Don't change the data rate unless */
    /* previously we polled this 11g STA with low data rate */
    /* because that poll had a piggybacked ACK for an 11b STA */
        /* Go back to the regular rate and reset the flag. */
    /* Check whether the new STA 11g enabled. */
        /* Use the regular rate for the new 11g enabled STA */
        /* unless we also need to ACK an 11b STA. */
            /* Adjust the rate and reset the flag. */
            /* We can't increase the rate for the */
            /* current transmission because we also */
            /* need to ACK an 11b STA. Set the flag so */
            /* that we adjust the data rate before */
            /* the next poll. */
        /* The new STA is a non-ERP STA (not 11g enabled) */
        /* Lower our data rate so that it can decode our */
        /* transmission. Pick the highest 11b data rate */
        /* that is lower than our regular 11g data rate. */
        /* Go on using lowered data rate since the new STA */
        /* is not 11g enabled. Reset the flag, which may be */
        /* set.

/* Re init dummy element for new poll index. */
/* Set the destination address. */
/* First check if this is a retry. */
    /* Destroy the dummy higher layer data entry used for searching. */
    /* Set type to last frame type. */
    /* Retrieve the destination information from the frame. */
    /* Check the ACK status for retransmission. */
        /* The previous message was sent with an ACK, which */
        /* needs to be removed from this retransmission. */
    /* Perform the retransmission.

/* Check if fragmentation buffer is empty and if there is any data to send */
/* to this station. If no data, send ack / poll as needed. */
    /* Set active poll flag since poll will be transmitted. */
    /* If the AP has a pending ACK to transmit, send Ack-CF poll frame. */
    /* If no pending ACK for this station transmit the poll frame */
    /* Destroy the dummy higher layer data entry used for searching.

/* If we've come this far, there must be data for this user. */
/* If the fragmentation buffer is empty, get a new packet and */
/* setup fragmentation buffer. Tx of frame is queued outside this else if */
    /* First destroy the dummy higher layer data entry used for searching. */
    /* Get next packet for transmission from the higher layer queue.*/

```

```

        /* Make sure destination address matches polling address. */
        /* A packet must have been inserted into the queue by the */
        /* upper layers after I started polling for a lower */
        /* address. Increment an offset to track packets at the */
        /* head of the queue that have missed their opportunity */
        /* to transmit this CFP. Restore the packet to the */
        /* point where it was stored, and get the next packet for */
        /* transmission. */

    /* Remove packet from higher layer queue. */
    /* Setting destination address state variable. */
    /* Determine packet size - required to determine fragmentation */
    /* Packet seq number modulo 4096 counter. */
    /* Packet fragment number is initialized. */

    /* Packet needs to be fragmented if it is more than */
    /* fragmentation threshold, provided fragmentation is */
    /* enabled. Broadcast packets are not fragmented regardless */
    /* of their sizes.

        /* Determine number of fragments for the packet */
        /* and the size of the last fragment.

            /* If the remainder size is non zero it means that the */
            /* last fragment is fractional but since the number */
            /* of fragments is a whole number we need to transmit */
            /* one additional fragment to ensure that all of the */
            /* data bits will be transmitted */
            /* If no fragments needed then number of */
            /* packets to be transmitted is set to 1.

                /* Storing Data packet id for debugging purposes. */
                /* Insert packet to fragmentation buffer. */
                /* Computing packet duration in the queue in seconds */
                /* and reporting it to the statistics. */
                /* Printing out information to ODB.

                    /* Store the arrival time of the PCF packet.

                        /* Freeing up allocated memory for the data packet removed */
                        /* from the higher layer queue. */
                        /* Destroy the dummy higher layer data entry used earlier for searching.

                            /* Set active poll flag since poll will be transmitted

                                /* Time to transmit fragment - Retries happen automatically automatically. */
                                /* The order of else if statements here is very important, as */
                                /* the code uses it to enforce the proper preemption of various */
                                /* valid frame sequences while preventing the preemption of others.

                                    /* If not PCF, an Ack needs to be sent for the data prepare Ack for transmission */
                                    /* Break the routine once Ack is prepared to transmit.

                                        /* Beacon transmission has priority unless we are in the middle of */
                                        /* transmitting fragments of a data packet.
                                            /* Reset any pending responses since beacon will terminate sequence anyway */
                                            /* Prepare beacon frame to be transmitted */
                                            /* Break the routine once beacon prepared to transmit

```

```

/* DCF Transmission processing */
/* Send a CTS frame if it is the type of frame we need to send a response of */
/* Break the routine if Cts or Ack is already prepared to transmit. */

/* If it is a retransmission then check which type of frame needs to be */
/* retransmitted and then prepare and transmit that frame. */
/* If the last frame unsuccessfully transmitted was an RTS or a */
/* CTS-to-self then transmit it again. */

/* If our last transmission was a data packet, then it means it was */
/* not acknowledged. Restart the transmission process. Do the same */
/* if we are resuming our retransmission after sending a beacon */
/* frame or a management frame reporting end of CFP. */

/* Check whether we need to start the retransmission with an */
/* RTS message. */
/* Retransmit the RTS frame to again contend for the data . */

/* If we are an ERP-STA, and we are not going to use an */
/* 802.11/11b data rate for the transmission data, and there */
/* are non-ERP STAs in the BSS, then we need to "use protection" */
/* by sending an RTS or CTS-to-self message. */

/* Use the "CTS-to-self" approach if the option is enabled. */
/* Even it is enabled, switch using RTS/CTS for protection, */
/* if our previous trials have failed as suggested in the */
/* 802.11g standard (section 9.2.11), since the BSS can be */
/* suffering from hidden node problem. */

/* Otherwise initiate a RTS/CTS exchange as the protection */
/* mechanism. */
/* Just retransmit the data packet if no protection is needed. */
/* We continue with the retransmission process. Either we have */
/* received the expected CTS for our last RTS before and now we */
/* can retransmit our data frame, or we moved from DCF period */
/* into PCF period and have been polled by the AP for */
/* transmission. In case of PCF, also check whether we have an */
/* ACK to append to our data packet. */

/* If higher layer queue is not empty then dequeue a packet */
/* from the higher layer and insert it into fragmentation */
/* buffer check whether fragmentation and RTS-CTS exchange */
/* is needed based on thresholds */
/* Check if fragmentation buffer is empty. If it is empty */
/* then dequeue a packet from the higher layer queue. */
/* Remove packet from higher layer queue. */

/* Determine packet size to determine later whether fragmentation */
/* and/or rts-cts exchange is needed. */

/* Setting destination address state variable */
/* Packet seq number modulo 4096 counter. */
/* Packet fragment number is initialized. */
/* Packet needs to be fragmented if it is more than */
/* fragmentation threshold, provided fragmentation is */
/* enabled. Broadcast packets are not fragmented regardless */
/* of their sizes.

```

```

/* Determine number of fragments for the packet */
/* and the size of the last fragment. */
/* If the remainder size is non zero it means that the */
/* last fragment is fractional but since the number */
/* of fragments is a whole number we need to transmit */
/* one additional fragment to ensure that all of the */
/* data bits will be transmitted. */

/* Special case: data size is a multiple of the */
/* fragment size, so all the fragments will be the */
/* same size. To be consistent with other cases, */
/* set remainder size to the size of the last fragment */

/* If no fragments needed then number of */
/* packets to be transmitted is set to 1 */

/* Storing Data packet id for debugging purposes. */
/* Insert packet to fragmentation buffer. */
/* Computing packet duration in the queue in seconds */
/* and reporting it to the statistics */
/* Printing out information to ODB. */
/* Store the arrival time of the packet. */

/* Free up allocated memory for the data packet removed from the higher */
/* layer queue. */

/* Lower our data transmission rate, if it is an 11g data rate and we are */
/* either an AP or a STA in an IBSS, and there are non-ERP STAs in our BSS */
/* and our destination is one of them, so that it can decode our message. */
/* Check whether the destination is 11g enabled. If this is a broadcast */
/* transmission, use an 11b data rate since non-ERP STAs are present */
/* the BSS. */
/* Pick the highest 11b data rate that is lower than */
/* our regular 11g data rate. */

/* Send RTS if RTS is enabled and packet size is more than RTS threshold. */
/* No RTS message is sent for broadcast packets regardless of their sizes. */
/* Set the flag indicating that an RTS is needed for the current frame */
/* due to its size. */
/* Prepare RTS frame for transmission. */
/* Break the routine as RTS is already prepared. */
/* Reset the flag indicating an RTS was not necessary due to current */
/* frame size. */
/* If we are an ERP-STA, and we are not going to use an */
/* 802.11/11b data */
/* rate for the transmission data, and there are non-ERP STAs in the */
/* BSS, then we need to "use protection" by sending an RTS or */
/* CTS-to-self message. */
/* Use the "CTS-to-self" approach & send a CTS msg with */
/* destination address set to our own address, if CTS-to-self */
/* option is enabled or the data packet is a broadcast packet. */
/* Otherwise initiate a RTS/CTS exchange as the protection */
/* mechanism. */
/* Exit the function. */

/* Prepare data frame to transmit. First check whether the station */
/* has been polled (if it is in CFP). */

```

```
/* If there is no data to send select frame response */
/* accordingly if we need to send an ACK back. */
    /* We have data to respond to the poll. Also append the ACK */
    /* if we have an ACK to respond. */
/* This is a normal DCF transmission. Prepare the frame for transmission */
```

```

static void
wlan_prepare_frame_to_send (WlanT_Mac_Frame_Type frame_type)
{
    Packet*                seg_pkptr;
    OpT_Packet_Size        tx_datapacket_size;
    WlanT_Mac_Frame_Type  type;
    int                    i;
    int                    destination_addr;
    int                    add_beacon_size;
    double                 tx_data_rate;
    double                 duration, mac_delay;
    double                 total_pk_size;
    double                 tx_end_time, tx_delay;
    double                 total_plcp_overhead;
    WlanT_Data_Header_Fields* pk_dhstruct_ptr;
    WlanT_Control_Header_Fields* pk_chstruct_ptr;
    WlanT_Beacon_Body_Fields* pk_bbstruct_ptr;
    Packet*                wlan_transmit_frame_ptr;
    char                   msg_string [120];
    char                   frame_type_str [32];

    /** Prepare frames to transmit by setting appropriate fields in the      **/
    /** packet format for Data,Cts,Rts or Ack. If data or Rts packet needs **/
    /** to be retransmitted then the copy of the packet is resent.         **/

    /* First initialize the transmission data rate to the lowest supported    */
    /* data rate, which is the data rate used for control frames.             */
    /* Determine the destination address based on the type of the             */
    /* transmission (PCF data transmission by AP or not).                      */
    /* It this is a CP period and the frame to be transmitted is a data/ACK.  */
    /* Adjust the transmission data rate based on the operational speed.      */
    /* Set the variable which keeps track of the last transmitted frame.      */
    /* If it is a retransmission of a packet. Obtain the frame from the      */
    /* the copy pointer which was stored during the previous transmission     */
    /* If it is a retransmission then just transmit the previous frame */
    /* Reset header type in case Ack status has changed for frame */
    /* If retry count is non-zero means that the frame is a */
    /* retransmission of the last transmitted frame */
    /* Reset more_data bit in case queue status has changed since last transmission */
    /* If this STA has been polled, and there are additional packets remaining */
    /* Set more data bit to tell AP that STA has more packets */
    /* Printing out information to ODB. */

    /* Calculate NAV duration till the channel will be occupied by */
    /* station. The duration is SIFS time plus the ACK frame time, */
    /* which the station needs in response to the data frame (note: */
    /* no need to check for broadcast packets, since for broadcast */
    /* packets the encapsulating if condition will be never true). */

    /* Since the number of fragments for the last transmitted frame is */
    /* already decremented, there will be more fragments to transmit */
    /* if number of fragments is more than zero. */
    /* If more fragments need to be transmitted then the station */
    /* need to compute the duration until the receipt of the */
    /* the acknowledgement for the next fragment. 224 bits (header*/
    /* size) is the length of the control fields in the data */
    /* frame and needs to be accounted in the duration calculation.*/

```

```

/* Set the type of the expected response to "ACK". */
/* Station update its own nav_duration during CP */
/* NAV should be updated only during the CP period */
/* During CFP NAV duration is updated only during */
/* the transmission of the beacon frames */
/* Creating transmit data packet type. */

/* Prepare data frame fields for transmission. */
/* Calculate nav duration till the channel will be occupied by */
/* station. The duration is SIFS time plus the ack frame time */
/* which the station needs in response to the data frame. For */
/* broadcast packets, the duration is zero since they are not */
/* acknowledged. */

/* If there is more than one fragment to transmit then remove */
/* fragmentation threshold size length of data from the buffer */
/* for transmission.
    /* Remove next fragment from the fragmentation buffer for */
    /* transmission and set the appropriate fragment number.

    /* Indicate in transmission frame that more fragments need */
    /* to be sent.

    /* Since more fragments need to be transmitted then the */
    /* station need to broadcast the time until the receipt of */
    /* the acknowledgement for the next fragment. 224 bits */
    /* (header size) is the length of control fields in the */
    /* data frame and need to be accounted for in the duration */
    /* calculation.

    /* Set fragment number in packet field.
    /* Printing out information to ODB.
    /* Setting packet fragment number for next fragment to be */
    /* transmitted.
    /* Remove the last fragment from the fragmentation buffer for */
    /* transmission and disable more fragmentation bit.
    /* Printing out information to ODB.

/* Setting the Header field structure.

/** if this is the CF period and the STA has been polled */
/** then set the duration to the standard value.

    /* Duration should be set to 32768 during CFP.
    /* This is the CP, so set duration field.

/* In the BSS network the Data frame is going from AP to sta */
/* then fromds bit is set.
/* if in the BSS network the Data frame is going from sta to AP */
/* then tods bit is set.
    /* If Infrastructure BSS then the immediate destination */
    /* will be Access point, which
    /* then forward the frame to the appropriate destination.
/* If this STA has been polled, and there are additional packets */
/* remaining
    /* Set more data bit to tell AP that STA has more packets */
/* If we are sending the first fragment of the data fragment for the first */
/* time, then this is the end of media access duration, hence we must */

```

```

/* update the media access delay statistics. */
/* Populate the packet fields. */
/* Set the frame control field and nav duration. */
/* The actual data is placed in the Frame Body field. */
/* Add some bulk to the packet to model the transmission */
/* delay of PLCP fields accurately which are always */
/* transmitted at 1 Mbps regardless of the actual data rate */
/* used for data frames. */

/* Expect acknowledgement only for directed frames. */
/* Reset the retry count because we won't await an ACK. */
/* The retry count can be non-zero even for a broadcast */
/* frame since it can be proceeded by a CTS-to-self */
/* frame in an 11g WLAN, which may have been */
/* retransmitted. */

/* Due to possible earlier use of CTS-to-self frame */
/* exchange, reset the rts_sent flag. */
/* Transmission of a broadcast frame is always assumed */
/* successful. Hence, set the flag for CW backoff. */

/* Since the transmission of the higher layer packet is */
/* complete, update the queue size information and statistic. */
/* Ack frame is expected in response to data frame. */

/* Make copy of the frame before transmission -- make sure */
/* that a packet destined for broadcast addresses is not */
/* copied as that would never be destroyed (due to unACKing */
/* nature of broadcast traffic). */
/* Station update of its own nav_duration. */

/* Place the transmission data rate and physical layer */
/* technology information into the packet. */
/* Update the data traffic sent statistics. */
/* Write a value of 0 for the end of transmission. */

/* We can be sending this data message as a response to a CTS message */
/* we received. Therefore reset the "frame respond to send" variable. */

/* If there is nothing in the higher layer data queue and fragmentation buffer */
/* then disable the data frame flag which will indicate to the station to wait */
/* for the higher layer packet. */

/* If this is a contention free period and need to send a data/ack/poll. */
/* Preserve the frame type being transmitted . */

/* Adjust the transmission data rate based on the operational speed. */
/* Set active poll flag if this is a poll frame. */

/* If it is a retransmission of a packet then no need to prepare data frame. */
/* Creating transmit data packet type. */
/* Prepare data frame fields for transmission. */
/* If there is more than one fragment to transmit and there are */
/* equal sized fragments then remove fragmentation threshold size */
/* length of data from the buffer for transmission. */
/* Remove next fragment from the fragmentation buffer for */
/* transmission and set the appropriate fragment number. */

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```

        /* Indicate in transmission frame that more fragments need to be sent */
        /* if more than one fragments are left */
            /* If no more fragments to transmit then set more */
            /* fragment field to be 0 */

        /* Set fragment number in packet field */
        /* Printing out information to ODB. */
        /* Setting packet fragment number for next fragment to be transmitted */
        /* Remove last fragments (if any left) from the fragmentation buffer for */
        /* transmission and disable more fragmentation bit. */
        /* Printing out information to ODB. */

    /* Set duration field */
    /* During CFP the duration field should read 32768. (Section 7.1.3.2 of spec) */
    /* Setting the Header field structure. */
    /* In the BSS network the Data frame is going from AP to sta */
    /* then from DS bit is set. */

    /* if in the BSS network the Data frame is going from STA to AP */
    /* then to DS bit is set. */
        /* If Infrastructure BSS then the immediate destination */
        /* will be Access point, which */
        /* then forward the frame to the appropriate destination. */

    /* If we are sending the first fragment of the data fragment for the first */
    /* time, then this is the end of media access duration, hence we must */
    /* update the media access delay statistics. */

    /* Set the frame control field. */
    /* The actual data is placed in the Frame Body field */
    /* Add some bulk to the packet to model the transmission delay */
    /* of PLCP fields accurately which are always transmitted at */
    /* 1 Mbps regardless of the actual data rate used for data frames. */

    /* Make copy of the frame before transmission */
    /* If it is a retransmission then just transmit the previous frame. */

    /* If retry count is non-zero means that the frame is a */
    /* retransmission of the last transmitted frame. */

    /* Reset header type in case Ack status has changed for frame */
    /* read back duration field for debug stuff . */
    /* Printing out information to ODB. */

    /* Place the transmission data rate and physical layer */
    /* technology information into the packet. */
    /* Update the data traffic sent statistics. */
    /* Write a value of 0 for the end of transmission. */
    /* Only expect Acknowledgement for directed frames. */
        /* ACK frame is expected in response to data frame. */

    /* Reset the "frame to respond" variable since we have piggy- */
    /* backed an ACK to our message if we had to send one. */
    /* Preparing acknowledgement frame in response to the data frame */
    /* received from the remote stations. */

    /* Since an ACK is a control response frame, adjust its */
    /* transmission rate based on the data rate of the data frame we

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/* are ACKing, if operating in an 11a or all-11g BSS. Otherwise use */
/* 1 Mbps, the mandatory PHY rate of 802.11/11b. */

/* Creating ACK packet format type. */
/* Adjust the packet size if necessary to model the PLCP overhead */
/* accurately, which is physical layer technology dependent. The */
/* default value is set for infra-red technology. */

/* Setting ACK frame fields. */
/* If there are more fragments to transmit then broadcast the remaining */
/* duration for which the station will be using the channel. */

/* Destination station address. */
/* Setting ACK type. */
/* Setting the accept field to true, meaning the frame is a good frame. */

/* Place the transmission data rate and physical layer */
/* technology information into the packet. */
/* Since no frame is expected, the expected frame type field to nil. */
/* Once Ack is transmitted in response to Data frame then set the frame */
/* response indicator to none frame as the response is already generated */
/* Printing out information to ODB. */

/* Update the control traffic sent statistics. */
/* Write a value of 0 for the end of transmission. */
/* Creating Rts packet format type. */
/* Initializing RTS frame fields. */
/* Type of frame

/* if in the infrastructure BSS network then the immediate recipient for */
/* the transmitting station will always be an Access point. Otherwise the */
/* frame is directly sent to the final destination.
    /* If Infrastructure BSS then the immediate destination will be Access */
    /* point, which then forward the frame to the appropriate destination. */
    /* Otherwise set the final destination address.

/* Source station address.
/* Setting the RTS frame type.
/* Setting the accept field to true, meaning the frame is a good frame.

/* Setting the variable which keeps track of the last transmitted frame */
/* that needs response.

/* Determining the size of the first data fragment or frame that need */
/* to be transmitted following the RTS transmission.
    /* If there are more than one fragment to transmit then the */
    /* data segment of the first data frame will be the size of */
    /* fragmentation threshold. The total packet size will be */
    /* data plus the overhead (which is 224 bits).
    /* If there is one data frame to transmit then the */
    /* data segment of the first data frame will be the size of */
    /* the remainder computed earlier. The total packet size */
    /* will be data plus the overhead (which is 224 bits).

/* Station is reserving channel bandwidth by using RTS frame, so */
/* in RTS the station will broadcast the duration it needs to send */
/* one data frame and receive ACK for it. The total duration is the */
/* the time required to transmit one data frame, plus one CTS frame

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/* plus one ACK frame, and plus three SIFS intervals. While */
/* computing the duration, call the two macros at different lines */
/* to assure to use the correct value of the state variables within */
/* the macros. */

/* Setting RTS frame fields. */
/* Place the transmission data rate and physical layer technology */
/* information into the packet. */

/* Adjust the packet size to accurately model the RTS message and */
/* the PLCP overhead, which is physical layer technology dependent. */
/* The default value for PLCP overhead is set for infra-red technology */

/* Station update of its own nav_duration. */
/* CTS is expected in response to RTS. */
/* Printing out information to ODB. */

/* Update the control traffic sent statistics. */
/* Write a value of 0 for the end of transmission. */
/* Since we are sending this CTS message not a response, it is a */
/* CTS-to-self message used by ERP STAs (11g stations). */

/* Store the type of last transmission. IMPORTANT NOTE: In case of */
/* CTS transmissions, the value of the state variable */
/* last_frametx_type is set to WlanC_Cts ONLY for CTS-to-self */
/* transmissions (i.e. it is not updated for regular CTS messages). */

/* Create a control message. */
/* Adjust the packet size if necessary to model the PLCP overhead */
/* accurately, which is physical layer technology dependent. The */
/* default value is set for infra-red technology. */

/* Initializing RTS frame fields. */
/* Set the destination address to own address. */
/* Determining the size of the first data fragment or frame that */
/* need to be transmitted following the CTS-to-self transmission. */
/* If there are more than one fragment to transmit then the */
/* data segment of the first data frame will be the size of */
/* fragmentation threshold. The total packet size will be data */
/* plus the overhead (which is 224 bits). */
/* If there is one data frame to transmit then the data segment */
/* of the first data frame will be the size of the remainder */
/* computed earlier. The total packet size will be data plus */
/* the overhead (which is 224 bits). */

/* Compute the duration information that will be used by the */
/* recipient MACs to update their NAVs. The duration must include a */
/* SIFS time and the transmission time of the data frame that will */
/* follow this control message. Additionally, another sifs time and */
/* and an ACK transmission time must be included unless the data */
/* packet has a broadcast address, which don't require an ACK. */
/* While computing the duration, call the two macros at */
/* different lines to assure to use the correct value of the */
/* state variables within the macros. */

/* Setting CTS frame type. */
/* Initialize the "Accept" field.

```

```

/* Setting CTS frame fields. */
/* We expect to receive our own CTS when sending CTS-to-self. */
/* Update the control traffic sent statistics. */
/* Write a value of 0 for the end of transmission. */
/* We need to update our own NAV. */

/* Place the transmission data rate and physical layer technology
/* information into the packet. */
/* Send a copy of the packet to ourselves directly, since we will
/* not receive a transmission that is made by our own transmitter.
/* Add a very small delay to the transmission delay to guarantee
/* that we receive the copy a moment after our transmitter
/* completes our transmission.

/* Printing out information to ODB. */
/* Preparing CTS frame in response to the received RTS frame.

/* Since an CTS is a control response frame, adjust its
/* transmission rate based on the data rate of the RTS frame we
/* are replying, if operating in an 11a or all-11g BSS. Otherwise
/* use 1 Mbps, the mandatory PHY rate of 802.11/11b.

/* Creating CTS packet format type.

/* Adjust the packet size if necessary to model the PLCP overhead
/* accurately, which is physical layer technology dependent. The
/* default value is set for infra-red technology.

/* Initializing CTS frame fields.
/* Type of frame.
/* Destination station address.

/* Station is reserving channel bandwidth by using RTS frame, so
/* in RTS the station will broadcast the duration it needs to send
/* one data frame and receive ACK for it. Just subtract the
/* transmission of the CTS frame from updated NAV. Already waited
/* SIFS is subtracted within "current_time".

/* Setting CTS frame type. */
/* Initialize the "Accept" field. */
/* Setting CTS frame fields.

/* Place the transmission data rate and physical layer technology
/* information into the packet. */
/* Once CTS is transmitted in response to RTS then set the frame
/* response indicator to none frame as the response is already generated */
/* No frame is expected once CTS is transmitted. */
/* Printing out information to ODB. */
/* Update the control traffic sent statistics. */
/* Write a value of 0 for the end of transmission. */
/* Create packet container for beacon body.

/* Initialize the bit count that will be added to the size of the
/* beacon body to represent the size of the optional beacon frame
/* body elements.

/* Create beacon body.

```

```

/* Timestamp should be set to reference 1st bit of timestamp in      */
/* message at antenna (11.1.2.1). To reduce processing, it is      */
/* currently set for first bit of MAC frame at antenna (assuming no  */
/* PHY delay).                                                      */

/* if no PCF, No beacon starts a CFP.                               */
/* PCF implemented.                                                */
/* When cfp_count is computed as "0" then this beacon              */
/* advertises the start of a CFP. Subtract one while finding       */
/* out the transmission number of this beacon, since the first     */
/* beacon is sent at "beacon_int" seconds instead of 0 seconds. */

/* Set the flag if this beacon will initiate a contention free period */
/* Set CFP period.                                                 */
/* Set CFP maximum duration.                                       */
/* If beginning a CFP.                                             */
/* Find time remaining in current CFP.                             */
/* Add the size of "CF Parameter Set" element to the beacon       */
/* size, which is 8 bytes.                                         */

/* If we are an 11g supporting AP, then set the non_erp_present bit */
/* of the beacon if there are some non-ERP STAs in our BSS.       */
/* Lock the related mutex before checking the current number of   */
/* non-ERP STAs in our BSS.                                       */

/* Check whether there is a change in the count of non-ERP STAs   */
/* in our BSS.                                                     */
/* We have a new non-ERP STA in our BSS. Set the flag.           */
/* Increase the slot time to 20 usec and recompute the */
/* dependent parameters.                                          */
/* Reduce the control frame data rate to 802.11/11b              */
/* mandatory data rate.                                          */
/* All the non-ERP STAs have left our BSS. Reset the flag.      */

/* Decrease the slot time to 9 usec and recompute the            */
/* dependent parameters.                                          */

/* Set our data transmission rate to the original data rate,     */
/* since we could be using a lower data rate to communicate     */
/* with non-ERP STAs.                                           */

/* Reselect the control frame data rate. Choose the highest     */
/* mandatory data rate that is equal to or lower than the      */
/* data rate specified for data transmissions.                  */

/* Unlock the mutex since we are done accessing the BSS info. */
/* Set the non_erp_present bit value of the beacon frame.       */

/* Since we are an AP supporting 11g data rates, make sure that  */
/* we transmit our beacon messages with the lowest 802.11/11b   */
/* mandatory data rate so that if there are any roaming non-ERP  */
/* STAs in the network that are in the scanning process, they   */
/* can decode our beacons and join into our BSS.                */

/* Make additions to the size of beacon due to the 11g specific  */
/* elements added to the beacon frame body. 11g APs are assumed */
/* to support 12 data rates. Hence, increase the size of the    */
/* "Supported Rates" by six rates (= 6 bytes) and also add an

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/* "Extended Supported Rates" elements for the remaining 4 */
/* rates, which also becomes 6 bytes. Finally add the sizes of */
/* "DS Parameter Set" and "ERP Information" elements, which are */
/* both 3 bytes. */

/* 11a-APs support 8 data rates. Adjust the beacon body size */
/* for additional 6 rates in the "Supported Rates" element. */
/* DSSS-APs support 4 data rates. Adjust the beacon body size*/
/* for additional 2 rates in the "Supported Rates" element, and */
/* for the "DS Parameter Set" element. */
/* Add 7 bytes to the beacon size to represent the "FH */
/* Parameter Set" element, which exists in beacons generated */
/* by the APs using frequency-hopping PHYs. */

/* If any, add the bits of optional beacon frame body elements to */
/* the size of the beacon as bulk size. */
/* Use data frame format for beacon frame since we need frame body. */
/* Creating transmit data packet type. */
/* Set destination address to broadcast since unicast not supported. */

/* Prepare data frame fields for transmission. */
/* During CFP the duration field should read 32768. (Section 7.1.3.2 of spec) */
/* During CP should read zero since broadcast (Section 7.2.3) */
/* Setting the Header field structure. */

/* This value is checked at the receiving end to see if this frame was intended */
/* for this BSS id */
/* Management frames (Beacon) never involve DS. */

/* Start setting the packet fields. */
/* Set the frame control field. */
/* If this is the start of the CFP, reset the NAV */
/* Any frame sequences in progress will be interrupted anyway. */
/* The beacon body is placed in the Packet container. */
/* The beacon body "packet" is placed in the Frame Body field */

/* Place the transmission data rate and physical layer */
/* technology information into the packet. */
/* Adjust the packet size if necessary to model the PLCP overhead */
/* accurately, which is physical layer technology dependent. The */
/* default value is set for infra-red technology. */

/* Clear expected frame time since any existing valid frame sequences have */
/* been interrupted anyway. */

/* Printing out information to ODB. */
/* Clear tx beacon flag. */

/* Check if the frame type to be transmitted is a data null/cf ack/cf poll */
/* Preserve the frame being transmitted */
/* Adjust the transmission data rate based on the operational speed. */
/* Set active poll flag if this is a poll frame */
/* If it is a retransmission of a packet then no need of preparing data frame. */
/* Creating transmit data packet type. */

/* Prepare data frame fields for transmission. */
/* Set packet fragment fields */

```

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/* Set duration field */
/* During PCF the duration field should read 32768. (Section 7.1.3.2 of spec) */
/* Setting the Header field structure. */
/* In the BSS network the Data frame is going from AP to STA */
/* then from DS bit is set. */

/* if in the BSS network the Data frame is going from sta to AP */
/* then to DS bit is set. */
/* If Infrastructure BSS then the immediate destination */
/* will be Access point, which */
/* then forward the frame to the appropriate destination. */

/* Set the frame control field. */
/* Need to create dummy "Frame Body" so use beacon frame and */
/* set size to zero. Create packet container for beacon body. */
/* The actual data is placed in the Frame Body field. */
/* If enabled, print out an ODB trace message. */
/* Add some bulk to the packet to model the transmission delay */
/* of PLCP fields accurately which are always transmitted at */
/* 1 Mbps regardless of the actual data rate used for data frames */

/* Make copy of the frame before transmission */
/* If it is a retransmission then just transmit the previous frame */

/* If retry count is non-zero means that the frame is a */
/* retransmission of the last transmitted frame. */
/* Read back duration field for debug stuff. */
/* Re-write the packet type since the poll message sent */
/* earlier may have a piggy-backed ACK, which will not be */
/* repeated in this retransmission. */
/* If enabled, print out an ODB trace message. */

/* Place the transmission data rate and physical layer */
/* technology information into the packet. */
/* Update the data traffic sent statistics. */
/* Write a value of 0 for the end of transmission. */
/* No ACK expected for non-data poll frames but do expect some */
/* type of Data frame in response. */
/* Once Ack is transmitted in response to Data frame then set */
/* the frame response indicator to none frame as the response is already generated*/

/* Preparing Contention Free end frame if no more stations */
/* to poll or Cfp_End interrupt. */

/* Creating Cf_End packet format type. */
/* Setting ack frame fields. */
/* Set duration field */
/* CF_End duration should always read zero.(Section 7.2.1.6 of spec) */
/* CF End is a broadcast, so set destination address to -1. */
/* The tx address conveys our own BSS ID in the CF-End messages. */
/* Setting frame type. */
/* Setting the accept field to true, meaning the frame is a good frame. */
/* Place the transmission data rate and physical layer technology */
/* information into the packet. */
/* Adjust the packet size to model the Cf_End message and the PLCP */
/* overhead, which is physical layer technology dependent, */
/* accurately. The default value for PLCP overhead is set for */
/* infra-red technology. Also note that the size of CF End message

```

```
/* is equal to the size of the RTS message. */
/* Since no frame is expected, the expected frame type field to nil. */
/* No response is expected so set indicator accordingly */
/* Printing out information to ODB. */
/* Since CFP over, clean up indicators */
/* Check if a PCF beacon has been overrun before clearing pcf_active flag
   /* PCF beacon has been overrun so don't clear flag
/* Update the control traffic sent statistics.
/* Write a value of 0 for the end of transmission.

/* Send packet to the transmitter.
/* Clear ignore busy flag in case it was set.
/* Clear PCF side traffic flag in case it was set.
/* Clear polled flag in case it was set.
```