Carleton University

SYSC 5104 Assignment #1 - Fall 2020

Modeling a Typical Home Network

Name: Zein Hajj-Ali
Student ID: 101020677
Email: zeinhajjali@cmail.carleton.ca

Conceptual Model Description

A typical home network only needs a few devices to fulfill a basic standard of service. Most people use the modem/router combination given to them by their ISP as the main access point. Personal devices are required to communicate with one another as well as send and receive communication from the internet. A lot of the variability in the network comes from the speed of the connection to different servers on the internet.

The model I propose consists of 2 main components: Personal Devices, and the Modem/Router Combo. The Modem/Router Combo can be decomposed into two separate subcomponents (Modem, and Router). The Personal Devices communicate through the Router and the network is connected to the internet through the Modem. (see Figure 1)
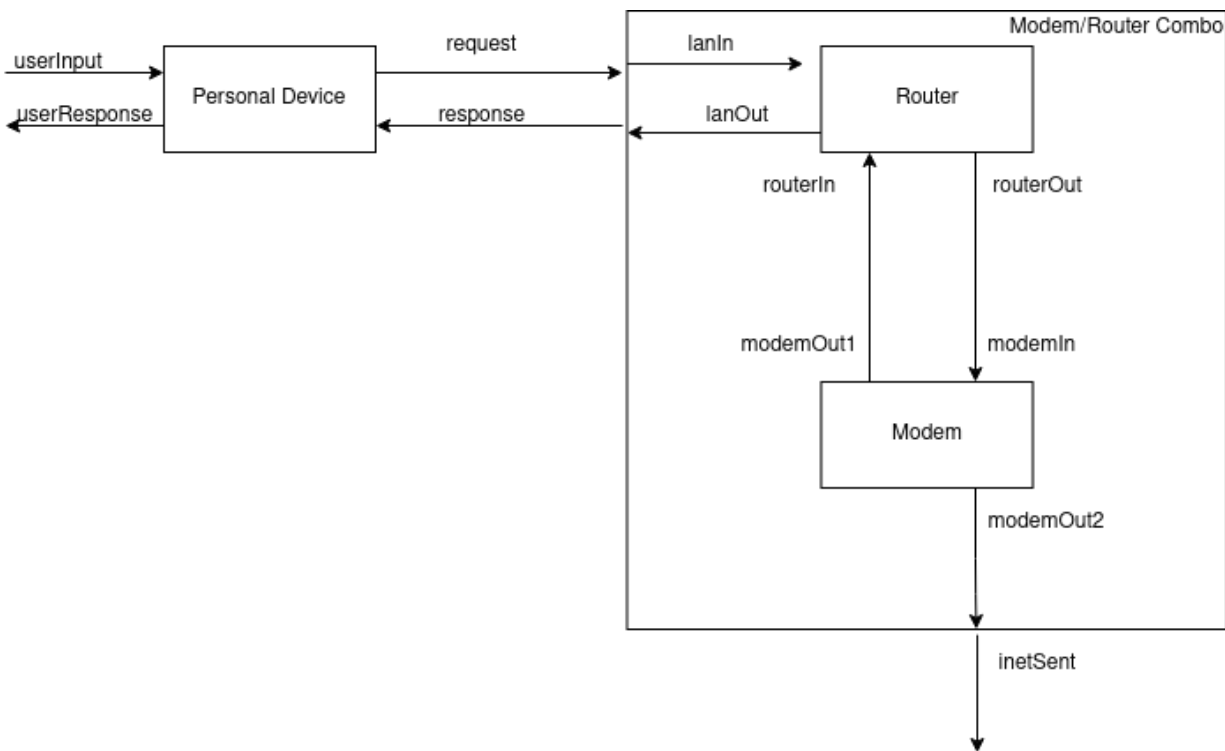
The Personal Device will simulate receiving a userInput (from a file) and sends a request to the Modem/Router Combo. It will wait to receive a response until a predetermined timeout and resend the same request if not received. If a response is received in time, it will output it as a userResponse and continue to the next userInput.

The behavior of the Modem is to receive a request and attempt to send it out to the internet. The Modem will have a randomized wait time between receiving a request and

sending the request out to the internet to simulate the variable upload speeds. If the randomized wait time is less than the predetermined timeout, the Modem will send a response as an acknowledgment back to the Router to be sent to the Personal Device.

The role of the Router is to pass on the requests from the Personal Device to the Modem in the Combo as well as the responses from the Modem back to the Personal Device. The Router will have a constant wait time to simulate the processing of the request.

The Typical Home Network has 1 input and 2 outputs. The userInput input controls when a message is sent from the PersonalDevice. The inetSent output shows the time the Modem sends the message to the internet. The userResponse output shows the time that the personal device receives the acknowledgment of its packet from the modem.The Typical Home Network is made up of 2 components: the PersonalDevice, and the Modem/Router Combo. The Modem/Router Combo can be decomposed into 2 subcomponents, one being a Router, and the other a Modem. The PersonalDevice sends messages to the Combo and receives and acknowledgement that the Modem successfully sent the message to the internet.

Formal Specification

The formal specification <S, X, Y, δint, δext, λ, ta> for the atomics are as follows:

Router:

State variables:
- Sigma = infinity
- Sending(phase) = false//true: sending message, false: passive
- SendingLan //true: sending on lanOut port, false: sending on routerOut port (only matters when Sending is true)
- Message //the message to be sent

So,

S = { Sigma, Sending, SendingLan, Message }

X = { lanIn, routerIn }

Y = { lanOut, routerOut }

δext (Sending, SendingLan, Message, e, x)

{

  If (router is sending)

    Ignore message

  Else

              If (message is received on lanIn)

                    Sending = true;

                    SendingLan = false;

                    Message = x;

                    Sigma = prepTime //transition to state of sending message

              Else if (x is receive on routerIn)

                    Sending = true;

                    SendingLan = true;

                    Message = x;

                    Sigma = prepTime

        }

        δint (sending) = { sending = false //passivated }

        δint (!sending) = {do nothing //passivated}

        λ(sending)

        {

            If (sendingLan is true)

                Send Message on lanOut port

            Else

                Send Message on routerOut port

        }

PersonalDevice:

    State variables:

- Sigma = infinity
- Phase = Passive
- Sending = false //true: sending message, false: waiting on an acknowledgment
- Data = 0 //the message data to be sent
- Ack = false //true: expected acknowledgement received, false: ack not received

    So,

    S = { phase, sigma, sending, data, ack }

    X = {userInput, response}

    Y = {userResponse, request}

    δext (Sending, ack, data, Message, e, x)

    { case phase:

        Passive:

            If (x is from userInput)

```
                        Data = x;
                        Sending = true;
                        Sigma = prepTime;
                        Phase = active;
                Else
                        Ignored (should not be here)
        Active:
                If (x is from response)
                        If (x has ack packetType & data in x is expected (==
Data))
                                Ack = true;
                                Sending = false;
                                Sigma = 0;
                Else:
                        Ignored (should not be here)
        }
        δint (ack, sending, e, x)
        { case phase
                Active:
                        If (act) //acknowledgment received
                                Phase = passive;
                                Sigma = infinity;
                        Else if (sending)
                                Sending = false;
                                Sigma = timeout;
                        Else //resend last message
                                Sending = true;
                                Sigma = prepTime;
                Passive: //never happens
        }
        λ(active & sending)
        {
                send message including Data and packetType to the port request
        }
        λ(active & !sending & ack)
        {
                send    Data    to    the    port    userResponse         //expected
        acknowledgement
        }
```

Modem:

State variables:
- Sigma = infinity
- Phase = Passive
- Sending = false //true when the message will be sent, false otherwise
- Message //the message including packetType and Data

So,

S = { phase, sigma, Message, sending}

X = {modemIn}

Y = {modemOut1, modemOut2}

δext (Message, sending, e, x)

{ case phase:

passive:

Message = x;

Phase = active

Sending = true if waitTime < timeout, false otherwise;

Sigma = the least between the timeout and the randomized wait time;

active:

Ignored (shouldnt be here)

}

δint (active)

{

Phase = passive;

Sending = false;

Sigma = infinity;

}

λ(active)

{

If (sending is true)

Send acknowledgement to port modemOut1;

send message including Data and packetType to the port modemOut2;

}

The formal specifications for the coupled models (Modem/Router Combo & TypicalHomeNetwork) are as follows:

Modem/Router Combo:
- X = { request };
- Y = { response, inetSent };
- D = { Modem, Router };
- EIC = { (ModemRouterCombo::request, Router::lanIn) }
- EOC = { (Router::lanOut, ModemRouterCombo::response), (Modem::modemOut2, ModemRouterCombo::inetSent) }
- IC = { (Router::routerOut, Modem::modemIn), (Modem::modemOut1, Router::routerIn) }

Top Model - TypicalHomeNetwork:
- X = { userInput };
- Y = { userResponse, inetSent };
- D = {PersonalDevice, Modem/Router Combo}
- EIC = { TypicalHomeNetwork::userInput, PersonalDevice::userInput };
- EOC = { (PersonalDevice::userResponse, TypicalHomeNetwork::userResponse), (ModemRouterCombo::inetSent, TypicalHomeNetwork::inetSent) }
- IC = { (PersonalDevice::request, ModemRouterCombo::request), (ModemRouterCombo::response, PersonalDevice::response) }

Testing Strategy

The atomic models and coupled models will be tested using the "black box" testing method. Test cases are created by adding different combinations of inputs to the test input text files, run the simulation (./TYPICALHOMENETWORK) and check whether the outputs in the output file are as expected.

Testing

PersonalDevice - Atomic

The PersonalDevice has 2 inputs: userInput, and response. The userInput should be a positive integer. It represents a dummy data value to be sent to the internet. If the userInput is negative, the input is ignored. The userInput triggers the PersonalDevice to send messages to the ModemRouterCombo if the PersonalDevice is passive. If the PersonalDevice was already active, the input is ignored. Response is the acknowledgment that should be received from the ModemRouterCombo when the message is successfully sent to the internet. It should have a packetType of 0 and a data value equal to the data last sent. If the acknowledgment is in the correct format and contains the correct data value, the PersonalDevice sends an output of the data on

the userResponse port and then passivates, waiting for the next userInput. If the acknowledgment is not received before the PersonalDevice reaches the timeout, it will resend the same message to the ModemRouterCombo.

personalDevice_input_test_userInput_In.txt:

```
00:00:00     1
00:00:15     -1
00:00:35     2
00:02:50     3
00:02:54     4
00:03:30     5
```

The lines in bold indicate that the inputs are ignored, at 00:15 because the input is negative, and at 2:54 because the input is received during the preparation time of the last message.

personalDevice_input_test_response_In.txt:

```
00:00:06 1 1
00:00:10 0 1
00:01:50 0 2
00:03:00 0 3
00:03:55 0 5
```

The line in bold indicates that the input is ignored, in this case because the packetType is not an acknowledgment (0). The line in italics (01:50) is highlighted show show a case where the response is received some time after the timeout (00:60), so the PersonalDevice will resend the message before receiving the response.

Cadmium - Modeling a Typical Home Network

Output - personalDevice_test_output_messages.txt:

```
 1 00:00:00:000
 2 00:00:00:000
 3 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {}] generated by model input_reader_userInput
 4 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {}] generated by model input_reader_response
 5 00:00:00:000
 6 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {1}] generated by model input_reader_userInput
 7 00:00:05:000
 8 [PersonalDevice_defs::request_out: {1 1}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
 9 00:00:06:000
10 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 1}] generated by model input_reader_response
11 00:00:10:000
12 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 1}] generated by model input_reader_response
13 00:00:10:000
14 [PersonalDevice_defs::request_out: {}, PersonalDevice_defs::userResponse_out: {1}] generated by model personalDevice1
15 00:00:15:000
16 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {-1}] generated by model input_reader_userInput
17 00:00:35:000
18 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {2}] generated by model input_reader_userInput
19 00:00:40:000
20 [PersonalDevice_defs::request_out: {1 2}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
21 00:01:40:000
22 [PersonalDevice_defs::request_out: {}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
23 00:01:45:000
24 [PersonalDevice_defs::request_out: {1 2}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
25 00:01:50:000
26 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 2}] generated by model input_reader_response
27 00:01:50:000
28 [PersonalDevice_defs::request_out: {}, PersonalDevice_defs::userResponse_out: {2}] generated by model personalDevice1
29 00:02:50:000
30 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {3}] generated by model input_reader_userInput
31 00:02:54:000
32 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {4}] generated by model input_reader_userInput
33 00:02:59:000
34 [PersonalDevice_defs::request_out: {1 3}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
35 00:03:00:000
36 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 3}] generated by model input_reader_response
37 00:03:00:000
38 [PersonalDevice_defs::request_out: {}, PersonalDevice_defs::userResponse_out: {3}] generated by model personalDevice1
39 00:03:30:000
40 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {5}] generated by model input_reader_userInput
41 00:03:35:000
42 [PersonalDevice_defs::request_out: {1 5}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
43 00:03:55:000
44 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 5}] generated by model input_reader_response
45 00:03:55:000
46 [PersonalDevice_defs::request_out: {}, PersonalDevice_defs::userResponse_out: {5}] generated by model personalDevice1
```

Output - personalDevice_test_output_state.txt:

```
 1 00:00:00:000
 2 State for model input_reader_userInput is next time: 00:00:00:000
 3 State for model input_reader_response is next time: 00:00:00:000
 4 State for model personalDevice1 is sending: 0 & data: -1
 5 00:00:00:000
 6 State for model input_reader_userInput is next time: 00:00:00:000
 7 State for model input_reader_response is next time: 00:00:06:000
 8 State for model personalDevice1 is sending: 0 & data: -1
 9 00:00:00:000
10 State for model input_reader_userInput is next time: 00:00:15:000
11 State for model input_reader_response is next time: 00:00:06:000
12 State for model personalDevice1 is sending: 1 & data: 1
13 00:00:05:000
14 State for model input_reader_userInput is next time: 00:00:15:000
15 State for model input_reader_response is next time: 00:00:06:000
16 State for model personalDevice1 is sending: 0 & data: 1
17 00:00:06:000
18 State for model input_reader_userInput is next time: 00:00:15:000
19 State for model input_reader_response is next time: 00:00:04:000
20 State for model personalDevice1 is sending: 0 & data: 1
21 00:00:10:000
22 State for model input_reader_userInput is next time: 00:00:15:000
23 State for model input_reader_response is next time: 00:01:40:000
24 State for model personalDevice1 is sending: 0 & data: 1
25 00:00:10:000
26 State for model input_reader_userInput is next time: 00:00:15:000
27 State for model input_reader_response is next time: 00:01:40:000
28 State for model personalDevice1 is sending: 0 & data: 1
29 00:00:15:000
30 State for model input_reader_userInput is next time: 00:00:20:000
31 State for model input_reader_response is next time: 00:01:40:000
32 State for model personalDevice1 is sending: 0 & data: -1
33 00:00:35:000
34 State for model input_reader_userInput is next time: 00:02:15:000
35 State for model input_reader_response is next time: 00:01:40:000
36 State for model personalDevice1 is sending: 1 & data: 2
37 00:00:40:000
38 State for model input_reader_userInput is next time: 00:02:15:000
39 State for model input_reader_response is next time: 00:01:40:000
40 State for model personalDevice1 is sending: 0 & data: 2
41 00:01:40:000
42 State for model input_reader_userInput is next time: 00:02:15:000
43 State for model input_reader_response is next time: 00:01:40:000
44 State for model personalDevice1 is sending: 1 & data: 2
45 00:01:45:000
46 State for model input_reader_userInput is next time: 00:02:15:000
47 State for model input_reader_response is next time: 00:01:40:000
48 State for model personalDevice1 is sending: 0 & data: 2
49 00:01:50:000
50 State for model input_reader_userInput is next time: 00:02:15:000
```

```
51 State for model input_reader_response is next time: 00:01:10:000
52 State for model personalDevice1 is sending: 0 & data: 2
53 00:01:50:000
54 State for model input_reader_userInput is next time: 00:02:15:000
55 State for model input_reader_response is next time: 00:01:10:000
56 State for model personalDevice1 is sending: 0 & data: 2
57 00:02:50:000
58 State for model input_reader_userInput is next time: 00:00:04:000
59 State for model input_reader_response is next time: 00:01:10:000
60 State for model personalDevice1 is sending: 1 & data: 3
61 00:02:54:000
62 State for model input_reader_userInput is next time: 00:00:36:000
63 State for model input_reader_response is next time: 00:01:10:000
64 State for model personalDevice1 is sending: 1 & data: 3
65 00:02:59:000
66 State for model input_reader_userInput is next time: 00:00:36:000
67 State for model input_reader_response is next time: 00:01:10:000
68 State for model personalDevice1 is sending: 0 & data: 3
69 00:03:00:000
70 State for model input_reader_userInput is next time: 00:00:36:000
71 State for model input_reader_response is next time: 00:00:55:000
72 State for model personalDevice1 is sending: 0 & data: 3
73 00:03:00:000
74 State for model input_reader_userInput is next time: 00:00:36:000
75 State for model input_reader_response is next time: 00:00:55:000
76 State for model personalDevice1 is sending: 0 & data: 3
77 00:03:30:000
78 State for model input_reader_userInput is next time: inf
79 State for model input_reader_response is next time: 00:00:55:000
80 State for model personalDevice1 is sending: 1 & data: 5
81 00:03:35:000
82 State for model input_reader_userInput is next time: inf
83 State for model input_reader_response is next time: 00:00:55:000
84 State for model personalDevice1 is sending: 0 & data: 5
85 00:03:55:000
86 State for model input_reader_userInput is next time: inf
87 State for model input_reader_response is next time: inf
88 State for model personalDevice1 is sending: 0 & data: 5
89 00:03:55:000
90 State for model input_reader_userInput is next time: inf
91 State for model input_reader_response is next time: inf
92 State for model personalDevice1 is sending: 0 & data: 5
```

Router - Atomic

The Router has 2 inputs: lanIn, and routerIn. Both lanIn and routerIn inputs must be messages in the format of {packetType, data}. The Router outputs any message it receives on lanIn to routerOut as-is, and any message it receives on routerIn on lanOut as-is. It has a preparation time and cannot accept messages while the current message is being prepared.

router_input_test_lan_In.txt:

> 00:00:10 0 1
> 00:00:30 1 2
> 00:01:30 6 3
> 00:03:00 0 4

router_input_test_router_In.txt:

> **00:00:13 0 5**
> 00:00:36 0 2
> 00:01:41 0 3
> 00:02:00 0 4

The bolded line indicates an ignored input. 00:13 is ignored since it is received while the Router is still preparing the lanIn message from 00:10.

Output - router_test_output_messages.txt:

```
 1 00:00:00:000
 2 00:00:00:000
 3 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {}] generated by model input_reader_lanInput
 4 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {}] generated by model input_reader_routerInput
 5 00:00:10:000
 6 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 1}] generated by model input_reader_lanInput
 7 00:00:13:000
 8 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 5}] generated by model input_reader_routerInput
 9 00:00:15:000
10 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {0 1}] generated by model router1
11 00:00:30:000
12 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 2}] generated by model input_reader_lanInput
13 00:00:35:000
14 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {1 2}] generated by model router1
15 00:00:36:000
16 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 2}] generated by model input_reader_routerInput
17 00:00:41:000
18 [Router_defs::lanOut_out: {0 2}, Router_defs::routerOut_out: {}] generated by model router1
19 00:01:30:000
20 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {6 3}] generated by model input_reader_lanInput
21 00:01:35:000
22 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {6 3}] generated by model router1
23 00:01:41:000
24 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 3}] generated by model input_reader_routerInput
25 00:01:46:000
26 [Router_defs::lanOut_out: {0 3}, Router_defs::routerOut_out: {}] generated by model router1
27 00:02:00:000
28 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 4}] generated by model input_reader_routerInput
29 00:02:05:000
30 [Router_defs::lanOut_out: {0 4}, Router_defs::routerOut_out: {}] generated by model router1
31 00:03:00:000
32 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {0 4}] generated by model input_reader_lanInput
33 00:03:05:000
34 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {0 4}] generated by model router1
```

Cadmium - Modeling a Typical Home Network

Output - router_test_output_state.txt:

```
 1 00:00:00:000
 2 State for model input_reader_lanInput is next time: 00:00:00:000
 3 State for model input_reader_routerInput is next time: 00:00:00:000
 4 State for model router1 is sending: 0 & sendingLan: 0 & data: 0
 5 00:00:00:000
 6 State for model input_reader_lanInput is next time: 00:00:10:000
 7 State for model input_reader_routerInput is next time: 00:00:13:000
 8 State for model router1 is sending: 0 & sendingLan: 0 & data: 0
 9 00:00:10:000
10 State for model input_reader_lanInput is next time: 00:00:20:000
11 State for model input_reader_routerInput is next time: 00:00:13:000
12 State for model router1 is sending: 1 & sendingLan: 0 & data: 1
13 00:00:13:000
14 State for model input_reader_lanInput is next time: 00:00:20:000
15 State for model input_reader_routerInput is next time: 00:00:23:000
16 State for model router1 is sending: 1 & sendingLan: 0 & data: 1
17 00:00:15:000
18 State for model input_reader_lanInput is next time: 00:00:20:000
19 State for model input_reader_routerInput is next time: 00:00:23:000
20 State for model router1 is sending: 0 & sendingLan: 0 & data: 1
21 00:00:30:000
22 State for model input_reader_lanInput is next time: 00:01:00:000
23 State for model input_reader_routerInput is next time: 00:00:23:000
24 State for model router1 is sending: 1 & sendingLan: 0 & data: 2
25 00:00:35:000
26 State for model input_reader_lanInput is next time: 00:01:00:000
27 State for model input_reader_routerInput is next time: 00:00:23:000
28 State for model router1 is sending: 0 & sendingLan: 0 & data: 2
29 00:00:36:000
30 State for model input_reader_lanInput is next time: 00:01:00:000
31 State for model input_reader_routerInput is next time: 00:01:05:000
32 State for model router1 is sending: 1 & sendingLan: 1 & data: 2
33 00:00:41:000
34 State for model input_reader_lanInput is next time: 00:01:00:000

35 State for model input_reader_routerInput is next time: 00:01:05:000
36 State for model router1 is sending: 0 & sendingLan: 1 & data: 2
37 00:01:30:000
38 State for model input_reader_lanInput is next time: 00:01:30:000
39 State for model input_reader_routerInput is next time: 00:01:05:000
40 State for model router1 is sending: 1 & sendingLan: 0 & data: 3
41 00:01:35:000
42 State for model input_reader_lanInput is next time: 00:01:30:000
43 State for model input_reader_routerInput is next time: 00:01:05:000
44 State for model router1 is sending: 0 & sendingLan: 0 & data: 3
45 00:01:41:000
46 State for model input_reader_lanInput is next time: 00:01:30:000
47 State for model input_reader_routerInput is next time: 00:00:19:000
48 State for model router1 is sending: 1 & sendingLan: 1 & data: 3
49 00:01:46:000
50 State for model input_reader_lanInput is next time: 00:01:30:000
51 State for model input_reader_routerInput is next time: 00:00:19:000
52 State for model router1 is sending: 0 & sendingLan: 1 & data: 3
53 00:02:00:000
54 State for model input_reader_lanInput is next time: 00:01:30:000
55 State for model input_reader_routerInput is next time: inf
56 State for model router1 is sending: 1 & sendingLan: 1 & data: 4
57 00:02:05:000
58 State for model input_reader_lanInput is next time: 00:01:30:000
59 State for model input_reader_routerInput is next time: inf
60 State for model router1 is sending: 0 & sendingLan: 1 & data: 4
61 00:03:00:000
62 State for model input_reader_lanInput is next time: inf
63 State for model input_reader_routerInput is next time: inf
64 State for model router1 is sending: 1 & sendingLan: 0 & data: 4
65 00:03:05:000
66 State for model input_reader_lanInput is next time: inf
67 State for model input_reader_routerInput is next time: inf
68 State for model router1 is sending: 0 & sendingLan: 0 & data: 4
```

Modem - Atomic

The Modem has one input (modemIn). It has a randomized wait time to simulate server speeds when uploading to the internet. If the wait time is less than the Modem's timeout, it sends back an acknowledgement to the PersonalDevice. It also sends the message out to the inetSent port.

modem_input_test_modemIn_In.txt:

> *00:00:10 1 1*
> **00:00:30 1 2**
> 00:00:45 1 3
> *00:01:30 1 4*
> 00:02:10 1 5
> 00:03:00 1 6

The bolded line is an input that is ignored since the model was active when it was received. The italicized lines are inputs that will not cause an output, since the random wait time will be longer than the timeout, the modem will timeout before it gets a chance to send the messages.

Output - modem_test_output_messages.txt:

```
 1 00:00:00:000
 2 00:00:00:000
 3 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {}] generated by model input_reader_modemIn
 4 00:00:10:000
 5 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 1}] generated by model input_reader_modemIn
 6 00:00:30:000
 7 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 2}] generated by model input_reader_modemIn
 8 00:00:40:000
 9 [Modem_defs::modemOut1_out: {}, Modem_defs::modemOut2_out: {}] generated by model modem1
10 00:00:45:000
11 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 3}] generated by model input_reader_modemIn
12 00:01:06:000
13 [Modem_defs::modemOut1_out: {0 3}, Modem_defs::modemOut2_out: {1 3}] generated by model modem1
14 00:01:30:000
15 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 4}] generated by model input_reader_modemIn
16 00:02:00:000
17 [Modem_defs::modemOut1_out: {}, Modem_defs::modemOut2_out: {}] generated by model modem1
18 00:02:10:000
19 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 5}] generated by model input_reader_modemIn
20 00:02:40:000
21 [Modem_defs::modemOut1_out: {0 5}, Modem_defs::modemOut2_out: {1 5}] generated by model modem1
22 00:03:00:000
23 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 6}] generated by model input_reader_modemIn
24 00:03:28:000
25 [Modem_defs::modemOut1_out: {0 6}, Modem_defs::modemOut2_out: {1 6}] generated by model modem1
```

Output - modem_test_output_state.txt:

```
 1 00:00:00:000
 2 State for model input_reader_modemIn is next time: 00:00:00:000
 3 State for model modem1 is model_active: 0 & sending: 0 & message: 0 0
 4 00:00:00:000
 5 State for model input_reader_modemIn is next time: 00:00:10:000
 6 State for model modem1 is model_active: 0 & sending: 0 & message: 0 0
 7 00:00:10:000
 8 State for model input_reader_modemIn is next time: 00:00:20:000
 9 State for model modem1 is model_active: 1 & sending: 0 & message: 1 1
10 00:00:30:000
11 State for model input_reader_modemIn is next time: 00:00:15:000
12 State for model modem1 is model_active: 1 & sending: 0 & message: 1 1
13 00:00:40:000
14 State for model input_reader_modemIn is next time: 00:00:15:000
15 State for model modem1 is model_active: 0 & sending: 0 & message: 1 1
16 00:00:45:000
17 State for model input_reader_modemIn is next time: 00:00:45:000
18 State for model modem1 is model_active: 1 & sending: 1 & message: 1 3
19 00:01:06:000
20 State for model input_reader_modemIn is next time: 00:00:45:000
21 State for model modem1 is model_active: 0 & sending: 0 & message: 1 3
22 00:01:30:000
23 State for model input_reader_modemIn is next time: 00:00:40:000
24 State for model modem1 is model_active: 1 & sending: 0 & message: 1 4
25 00:02:00:000
26 State for model input_reader_modemIn is next time: 00:00:40:000
27 State for model modem1 is model_active: 0 & sending: 0 & message: 1 4
28 00:02:10:000
29 State for model input_reader_modemIn is next time: 00:00:50:000
30 State for model modem1 is model_active: 1 & sending: 1 & message: 1 5
31 00:02:40:000
32 State for model input_reader_modemIn is next time: 00:00:50:000
33 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
34 00:03:00:000
35 State for model input_reader_modemIn is next time: inf
36 State for model modem1 is model_active: 1 & sending: 1 & message: 1 6
37 00:03:28:000
38 State for model input_reader_modemIn is next time: inf
39 State for model modem1 is model_active: 0 & sending: 0 & message: 1 6
```

Coupled Model - ModemRouterCombo:

ModemRouterCombo is a coupled model that consists of Modem and Router atomic models. All requests from the PersonalDevice go to the ModemRouterCombo. Inside the ModemRouterCombo decisions will be made on waitTime of sending the request out to the internet and whether to send back an acknowledgment or not. The Input of ModemRouterCombo is a Message that includes the packetType and the Data. The

outputs are the response (acknowledgment) send to the PersonalDevice, and the Message itself sent to the internet via the inetSent port.

MRC_input_test_request_In.txt:

> 00:00:13 1 5
> 00:00:36 1 2
> 00:01:41 1 3
> 00:02:00 1 4

With the randomness of the Modem's wait time, the only message that received a reply during my test is the one at 1:41 with data = 3.

Output - MRC_test_output_messages.txt:

```
 1 00:00:00:000
 2 00:00:00:000
 3 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {}] generated by model input_reader
 4 00:00:13:000
 5 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 5}] generated by model input_reader
 6 00:00:18:000
 7 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {1 5}] generated by model router1
 8 00:00:36:000
 9 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 2}] generated by model input_reader
10 00:00:41:000
11 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {1 2}] generated by model router1
12 00:00:48:000
13 [Modem_defs::modemOut1_out: {}, Modem_defs::modemOut2_out: {}] generated by model modem1
14 00:01:41:000
15 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 3}] generated by model input_reader
16 00:01:46:000
17 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {1 3}] generated by model router1
18 00:02:00:000
19 [cadmium::basic_models::pdevs::iestream_input_defs<Message_t>::out: {1 4}] generated by model input_reader
20 00:02:05:000
21 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {1 4}] generated by model router1
22 00:02:07:000
23 [Modem_defs::modemOut1_out: {0 3}, Modem_defs::modemOut2_out: {1 3}] generated by model modem1
24 00:02:12:000
25 [Router_defs::lanOut_out: {0 3}, Router_defs::routerOut_out: {}] generated by model router1
```

Output - MRC_test_output_state.txt:

```
 1 00:00:00:000
 2 State for model input_reader is next time: 00:00:00:000
 3 State for model router1 is sending: 0 & sendingLan: 0 & data: 0
 4 State for model modem1 is model_active: 0 & sending: 0 & message: 0 0
 5 00:00:00:000
 6 State for model input_reader is next time: 00:00:13:000
 7 State for model router1 is sending: 0 & sendingLan: 0 & data: 0
 8 State for model modem1 is model_active: 0 & sending: 0 & message: 0 0
 9 00:00:13:000
10 State for model input_reader is next time: 00:00:23:000
11 State for model router1 is sending: 1 & sendingLan: 0 & data: 5
12 State for model modem1 is model_active: 0 & sending: 0 & message: 0 0
13 00:00:18:000
14 State for model input_reader is next time: 00:00:23:000
15 State for model router1 is sending: 0 & sendingLan: 0 & data: 5
16 State for model modem1 is model_active: 1 & sending: 0 & message: 1 5
17 00:00:36:000
18 State for model input_reader is next time: 00:01:05:000
19 State for model router1 is sending: 1 & sendingLan: 0 & data: 2
20 State for model modem1 is model_active: 1 & sending: 0 & message: 1 5
21 00:00:41:000
22 State for model input_reader is next time: 00:01:05:000
23 State for model router1 is sending: 0 & sendingLan: 0 & data: 2
24 State for model modem1 is model_active: 1 & sending: 0 & message: 1 5
25 00:00:48:000
26 State for model input_reader is next time: 00:01:05:000
27 State for model router1 is sending: 0 & sendingLan: 0 & data: 2
28 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
29 00:01:41:000
30 State for model input_reader is next time: 00:00:19:000
31 State for model router1 is sending: 1 & sendingLan: 0 & data: 3
32 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
33 00:01:46:000
34 State for model input_reader is next time: 00:00:19:000
35 State for model router1 is sending: 0 & sendingLan: 0 & data: 3
36 State for model modem1 is model_active: 1 & sending: 1 & message: 1 3
37 00:02:00:000
38 State for model input_reader is next time: inf
39 State for model router1 is sending: 1 & sendingLan: 0 & data: 4
40 State for model modem1 is model_active: 1 & sending: 1 & message: 1 3
41 00:02:05:000
42 State for model input_reader is next time: inf
43 State for model router1 is sending: 0 & sendingLan: 0 & data: 4
44 State for model modem1 is model_active: 1 & sending: 1 & message: 1 3
45 00:02:07:000
46 State for model input_reader is next time: inf
47 State for model router1 is sending: 1 & sendingLan: 1 & data: 3
48 State for model modem1 is model_active: 0 & sending: 0 & message: 1 3
49 00:02:12:000
50 State for model input_reader is next time: inf
51 State for model router1 is sending: 0 & sendingLan: 1 & data: 3
52 State for model modem1 is model_active: 0 & sending: 0 & message: 1 3
```

Top Model - TypicalHomeNetwork (THN:

The top model consists of 1 coupled model (ModemRouterCombo) and 1 atomic model (PersonalDevice). The input of the top model should be an integer greater than or equal to 0 which represents a dummy data value to be sent through the modem to the internet. The top model has 2 outputs, userResponse which tells the user that the request was successfully sent from the modem, and inetSent which represents the message sent to the internet. I have created 2 input files for the THN, one of which I will display the outputs of here.

input_thn_0.txt:

```
00:00:10 5
00:15:00 3
```

These two inputs will show the process of how the PersonalDevice will resend it's message until the acknowledgment is successfully sent back.

Output - THN_output_messages.txt

```
 1 00:00:00:000
 2 00:00:00:000
 3 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {}] generated by model input_reader
 4 00:00:10:000
 5 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {5}] generated by model input_reader
 6 00:00:15:000
 7 [PersonalDevice_defs::request_out: {1 5}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
 8 00:00:20:000
 9 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {1 5}] generated by model router1
10 00:00:50:000
11 [Modem_defs::modemOut1_out: {}, Modem_defs::modemOut2_out: {}] generated by model modem1
12 00:01:15:000
13 [PersonalDevice_defs::request_out: {}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
14 00:01:20:000
15 [PersonalDevice_defs::request_out: {1 5}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
16 00:01:25:000
17 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {1 5}] generated by model router1
18 00:01:46:000
19 [Modem_defs::modemOut1_out: {0 5}, Modem_defs::modemOut2_out: {1 5}] generated by model modem1
20 00:01:51:000
21 [Router_defs::lanOut_out: {0 5}, Router_defs::routerOut_out: {}] generated by model router1
22 00:01:51:000
23 [PersonalDevice_defs::request_out: {}, PersonalDevice_defs::userResponse_out: {5}] generated by model personalDevice1
24 00:15:00:000
25 [cadmium::basic_models::pdevs::iestream_input_defs<int>::out: {3}] generated by model input_reader
26 00:15:05:000
27 [PersonalDevice_defs::request_out: {1 3}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
28 00:15:10:000
29 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {1 3}] generated by model router1
30 00:15:40:000
31 [Modem_defs::modemOut1_out: {}, Modem_defs::modemOut2_out: {}] generated by model modem1
32 00:16:05:000
33 [PersonalDevice_defs::request_out: {}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
34 00:16:10:000
35 [PersonalDevice_defs::request_out: {1 3}, PersonalDevice_defs::userResponse_out: {}] generated by model personalDevice1
36 00:16:15:000
37 [Router_defs::lanOut_out: {}, Router_defs::routerOut_out: {1 3}] generated by model router1
38 00:16:45:000
39 [Modem_defs::modemOut1_out: {0 3}, Modem_defs::modemOut2_out: {1 3}] generated by model modem1
40 00:16:50:000
41 [Router_defs::lanOut_out: {0 3}, Router_defs::routerOut_out: {}] generated by model router1
42 00:16:50:000
43 [PersonalDevice_defs::request_out: {}, PersonalDevice_defs::userResponse_out: {3}] generated by model personalDevice1
```

Output - THN_output_state.txt

```
 1 00:00:00:000
 2 State for model input_reader is next time: 00:00:00:000
 3 State for model personalDevice1 is sending: 0 & data: -1 & ack: 0
 4 State for model router1 is sending: 0 & sendingLan: 0 & data: 0
 5 State for model modem1 is model_active: 0 & sending: 0 & message: 0 0
 6 00:00:00:000
 7 State for model input_reader is next time: 00:00:10:000
 8 State for model personalDevice1 is sending: 0 & data: -1 & ack: 0
 9 State for model router1 is sending: 0 & sendingLan: 0 & data: 0
10 State for model modem1 is model_active: 0 & sending: 0 & message: 0 0
11 00:00:10:000
12 State for model input_reader is next time: 00:14:50:000
13 State for model personalDevice1 is sending: 1 & data: 5 & ack: 0
14 State for model router1 is sending: 0 & sendingLan: 0 & data: 0
15 State for model modem1 is model_active: 0 & sending: 0 & message: 0 0
16 00:00:15:000
17 State for model input_reader is next time: 00:14:50:000
18 State for model personalDevice1 is sending: 0 & data: 5 & ack: 0
19 State for model router1 is sending: 1 & sendingLan: 0 & data: 5
20 State for model modem1 is model_active: 0 & sending: 0 & message: 0 0
21 00:00:20:000
22 State for model input_reader is next time: 00:14:50:000
23 State for model personalDevice1 is sending: 0 & data: 5 & ack: 0
24 State for model router1 is sending: 0 & sendingLan: 0 & data: 5
25 State for model modem1 is model_active: 1 & sending: 0 & message: 1 5
26 00:00:50:000
27 State for model input_reader is next time: 00:14:50:000
28 State for model personalDevice1 is sending: 0 & data: 5 & ack: 0
29 State for model router1 is sending: 0 & sendingLan: 0 & data: 5
30 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
31 00:01:15:000
32 State for model input_reader is next time: 00:14:50:000
33 State for model personalDevice1 is sending: 1 & data: 5 & ack: 0
34 State for model router1 is sending: 0 & sendingLan: 0 & data: 5
35 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
36 00:01:20:000
37 State for model input_reader is next time: 00:14:50:000
38 State for model personalDevice1 is sending: 0 & data: 5 & ack: 0
39 State for model router1 is sending: 1 & sendingLan: 0 & data: 5
40 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
41 00:01:25:000
42 State for model input_reader is next time: 00:14:50:000
43 State for model personalDevice1 is sending: 0 & data: 5 & ack: 0
44 State for model router1 is sending: 0 & sendingLan: 0 & data: 5
45 State for model modem1 is model_active: 1 & sending: 1 & message: 1 5
46 00:01:46:000
47 State for model input_reader is next time: 00:14:50:000
48 State for model personalDevice1 is sending: 0 & data: 5 & ack: 0
49 State for model router1 is sending: 1 & sendingLan: 1 & data: 5
50 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
```

```
51 00:01:51:000
52 State for model input_reader is next time: 00:14:50:000
53 State for model personalDevice1 is sending: 0 & data: 5 & ack: 1
54 State for model router1 is sending: 0 & sendingLan: 1 & data: 5
55 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
56 00:01:51:000
57 State for model input_reader is next time: 00:14:50:000
58 State for model personalDevice1 is sending: 0 & data: 5 & ack: 1
59 State for model router1 is sending: 0 & sendingLan: 1 & data: 5
60 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
61 00:15:00:000
62 State for model input_reader is next time: inf
63 State for model personalDevice1 is sending: 1 & data: 3 & ack: 0
64 State for model router1 is sending: 0 & sendingLan: 1 & data: 5
65 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
66 00:15:05:000
67 State for model input_reader is next time: inf
68 State for model personalDevice1 is sending: 0 & data: 3 & ack: 0
69 State for model router1 is sending: 1 & sendingLan: 0 & data: 3
70 State for model modem1 is model_active: 0 & sending: 0 & message: 1 5
71 00:15:10:000
72 State for model input_reader is next time: inf
73 State for model personalDevice1 is sending: 0 & data: 3 & ack: 0
74 State for model router1 is sending: 0 & sendingLan: 0 & data: 3
75 State for model modem1 is model_active: 1 & sending: 0 & message: 1 3
76 00:15:40:000
77 State for model input_reader is next time: inf
78 State for model personalDevice1 is sending: 0 & data: 3 & ack: 0
79 State for model router1 is sending: 0 & sendingLan: 0 & data: 3
80 State for model modem1 is model_active: 0 & sending: 0 & message: 1 3
81 00:16:05:000
82 State for model input_reader is next time: inf
83 State for model personalDevice1 is sending: 1 & data: 3 & ack: 0
84 State for model router1 is sending: 0 & sendingLan: 0 & data: 3
85 State for model modem1 is model_active: 0 & sending: 0 & message: 1 3
86 00:16:10:000
87 State for model input_reader is next time: inf
88 State for model personalDevice1 is sending: 0 & data: 3 & ack: 0
89 State for model router1 is sending: 1 & sendingLan: 0 & data: 3
90 State for model modem1 is model_active: 0 & sending: 0 & message: 1 3
91 00:16:15:000
92 State for model input_reader is next time: inf
93 State for model personalDevice1 is sending: 0 & data: 3 & ack: 0
94 State for model router1 is sending: 0 & sendingLan: 0 & data: 3
95 State for model modem1 is model_active: 1 & sending: 1 & message: 1 3
96 00:16:45:000
97 State for model input_reader is next time: inf
98 State for model personalDevice1 is sending: 0 & data: 3 & ack: 0
99 State for model router1 is sending: 1 & sendingLan: 1 & data: 3
100 State for model modem1 is model_active: 0 & sending: 0 & message: 1 3
101 00:16:50:000
102 State for model input_reader is next time: inf
103 State for model personalDevice1 is sending: 0 & data: 3 & ack: 1
104 State for model router1 is sending: 0 & sendingLan: 1 & data: 3
105 State for model modem1 is model_active: 0 & sending: 0 & message: 1 3
106 00:16:50:000
107 State for model input_reader is next time: inf
108 State for model personalDevice1 is sending: 0 & data: 3 & ack: 1
109 State for model router1 is sending: 0 & sendingLan: 1 & data: 3
110 State for model modem1 is model_active: 0 & sending: 0 & message: 1 3
```

Conclusion

The TypicalHomeNetwork model simulated a network according to our specifications and outputted with the expected results. The models that run in the simulator follow the same formal specification that is given in this document. The data being sent to the internet is modeled as a simple integer dummy value for the purposes of this simulation. The THN simulator works as intended.