32 Understand the events involved in NetSim DES (Discrete Event Simulator) in simulating the flow of one packet from a Wired node to a Wireless node

32.1 Theory

NetSim's Network Stack forms the core of NetSim and its architectural aspects are diagrammatically explained below. Network Stack accepts inputs from the end-user in the form of Configuration file and the data flows as packets from one layer to another layer in the Network Stack. All packets, when transferred between devices move up and down the stack, and all events in NetSim fall under one of these ten categories of events, namely, **Physical IN, Data Link IN, Network IN, Transport IN, Application IN, Application Out, Transport OUT, Network OUT, Data Link OUT** and **Physical OUT**. The IN events occur when the packets are entering a device while the OUT events occur while the packet is leaving a device.

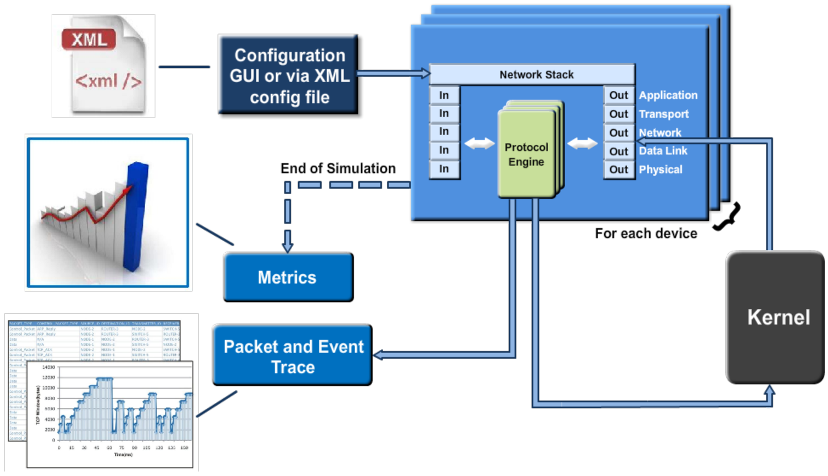


Figure 32-1: Flow of one packet from a Wired node to a Wireless node

Every device in NetSim has an instance of the Network Stack shown above. Switches & Access points have a 2-layer stack, while routers have a 3 layer stack. End-nodes have a 5-layer stack.

The protocol engines are called based on the layer at which the protocols operate. For example, TCP is called during execution of Transport IN or Transport OUT events, while 802.11b WLAN is called during execution of MAC IN, MAC OUT, PHY IN and PHY OUT events.

When these protocols are in operation, they in turn generate events for NetSim's discrete event engine to process. These are known as SUB EVENTS. All SUB EVENTS, fall into one of the above 10 types of EVENTS.

Each event gets added in the Simulation kernel by the protocol operating at the particular layer of the Network Stack. The required sub events are passed into the Simulation kernel. These sub events are then fetched by the Network Stack in order to execute the functionality of each protocol. At the end of Simulation, Network Stack writes trace files and the Metrics files that assist the user in analyzing the performance metrics and statistical analysis.

Event Trace

The event trace records every single event along with associated information such as time stamp, event ID, event type etc. in a text file or .csv file which can be stored at a user defined location.

32.2 Network Setup

Open NetSim and click **Examples > Experiments > Advanced:Simulation-events-in-NetSim-for-transmitting-one-packet > Sample-1** as shown below **Figure 32-2**.

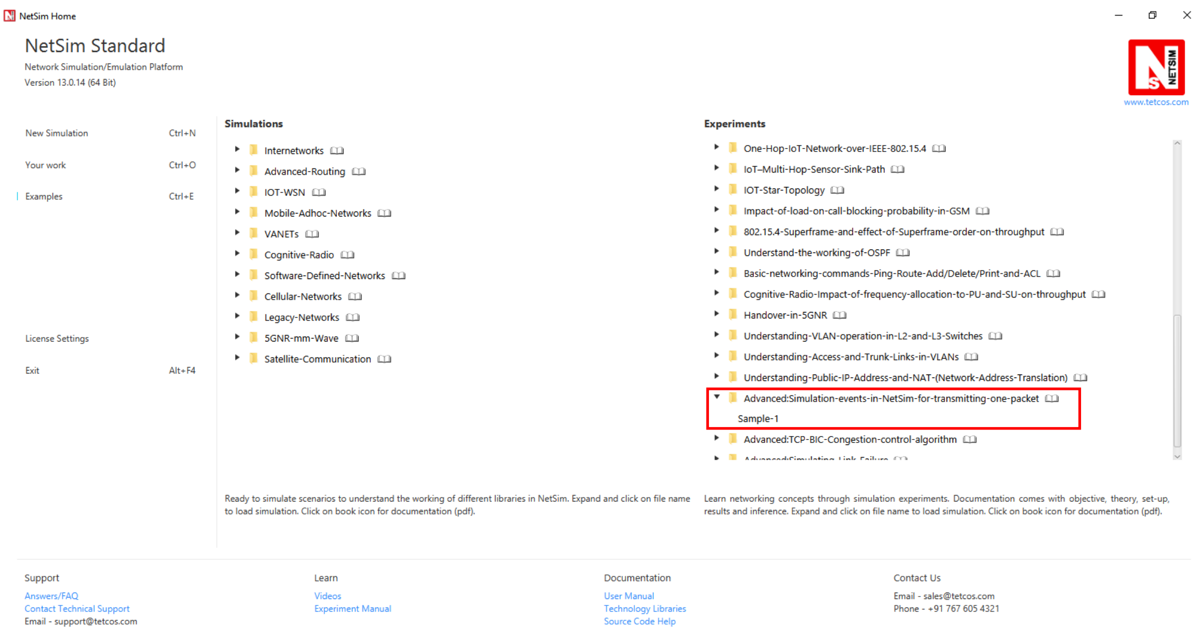


Figure 32-2: Experiments List

NetSim UI displays the configuration file corresponding to this experiment as shown below **Figure 32-3**.

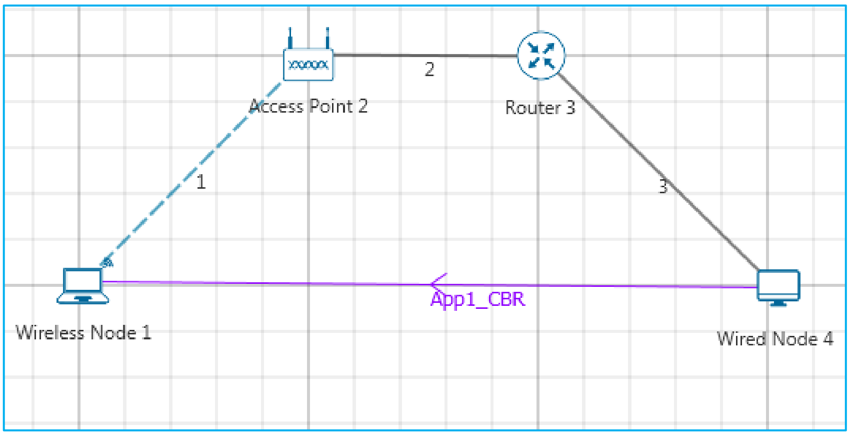


Figure 32-3: Application flow between wired node to wireless node

32.3 Procedure

The following set of procedures were done to generate this sample:

Step 1: A network scenario is designed in NetSim GUI comprising of 1 Wired Node, 1 Wireless Node, 1 Router, and 1 Access Point in the **"Internetworks"** Network Library.

Step 2: The device positions are set as per the below table **Table 32-1**.

Device Positions				
	Access Point 2	**Wired Node 4**	**Wireless Node 1**	**Router 3**
X / Lon	150	250	100	200
Y / Lat	50	100	100	50

Table 32-1: Devices Positions

Step 3: Right-click the link ID (of the wireless link) and select Properties to access the link's properties. The **"Channel Characteristics"** is set to NO PATHLOSS.

Step 4: Right click on the Application Flow **App1 CBR** and select Properties or click on the Application icon present in the top ribbon/toolbar.

A CBR Application is generated from Wired Node 4 i.e. Source to Wireless Node 1 i.e. Destination with Packet Size remaining 1460 Bytes and Inter Arrival Time remaining 20000µs. Transport Protocol is set to UDP instead of TCP.

Step 5: Event Trace is enabled in NetSim GUI. At the end of the simulation, a very large .csv file is containing all the TCP IN and OUT EVENTS is available for the users. Plots are enabled in NetSim GUI.

Note: *Event trace is only available only in NetSim Standard and Pro versions.*

32.4 Output

Once the simulation is complete, go to the Results Dashboard and in the left-hand-side of the window, click on the **"Open Event Trace"** Option. An Event trace file similar to the following opens in Excel as shown below:

Event_Id	Event_Type	Event_Time(US)	Device_Type	Device_Id	Interface_Id	Application_Id	Packet_Id	Segment_Id	Protocol_Name	Subevent_Type	Packet_Size(	Prev_Event_Id
1	TIMER_EVENT	0	NODE	1	0	0	0	0	IPV4	IP_INIT_TABLE	0	0
2	TIMER_EVENT	0	ROUTER	3	0	0	0	0	IPV4	IP_INIT_TABLE	0	0
3	TIMER_EVENT	0	NODE	4	0	0	0	0	IPV4	IP_INIT_TABLE	0	0
4	TIMER_EVENT	0	ACCESSPOINT	2	2	0	0	0	ETHERNET	ETH_IF_UP	0	0
5	TIMER_EVENT	0	ROUTER	3	1	0	0	0	ETHERNET	ETH_IF_UP	0	0
6	TIMER_EVENT	0	ROUTER	3	2	0	0	0	ETHERNET	ETH_IF_UP	0	0
7	TIMER_EVENT	0	NODE	4	1	0	0	0	ETHERNET	ETH_IF_UP	0	0
8	TIMER_EVENT	0	NODE	4	0	1	1	0	APPLICATION		1460	0
9	APPLICATION_OUT	0	NODE	4	0	1	1	0	APPLICATION	0	1460	8
10	TRANSPORT_OUT	0	NODE	4	0	1	1	0	UDP	0	1460	9
12	NETWORK_OUT	0	NODE	4	0	1	1	0	IPV4	0	1468	10
13	MAC_OUT	0	NODE	4	1	1	1	0	ETHERNET	0	1488	12
14	PHYSICAL_OUT	0	NODE	4	1	1	1	0	ETHERNET	0	1514	13
15	PHYSICAL_IN	127.08	ROUTER	3	2	1	1	0	ETHERNET	0	1514	14
16	MAC_IN	127.08	ROUTER	3	2	1	1	0	ETHERNET	0	1514	15
17	NETWORK_IN	127.08	ROUTER	3	2	1	1	0	IPV4	0	1488	16
18	NETWORK_OUT	127.08	ROUTER	3	2	1	1	0	IPV4	0	1468	17
19	MAC_OUT	127.08	ROUTER	3	1	1	1	0	ETHERNET	0	1488	18
20	PHYSICAL_OUT	127.08	ROUTER	3	1	1	1	0	ETHERNET	0	1514	19
21	PHYSICAL_IN	253.2	ACCESSPOINT	2	2	1	1	0	ETHERNET	0	1514	20
22	MAC_IN	253.2	ACCESSPOINT	2	2	1	1	0	ETHERNET	0	1514	21
23	MAC_OUT	253.2	ACCESSPOINT	2	1	1	1	0	WLAN	0	1488	22
24	MAC_OUT	253.2	ACCESSPOINT	2	1	1	1	0	WLAN	CS	1488	23
25	MAC_OUT	303.2	ACCESSPOINT	2	1	1	1	0	WLAN	IEEE802_11_EVENT	1488	24

Figure 32-4: Event trace

We start from the **APPLICATION_OUT** event of the first packet, which happens in the Wired Node and end with the **MAC_IN** event of the **WLAN_ACK** packet which reaches the Wired Node. Events in the event trace are logged with respect to the time of occurrence due to which, event id may not be in order.

32.4.1 Events Involved

Events are listed in the following format:

[EVENT_TYPE, EVENT_TIME, PROTOCOL, EVENT_NO, SUBEVENT_TYPE]

[APP_OUT, 20000, APP, 6, -]

[TRNS_OUT, 20000, UDP, 7, -]

[NW_OUT, 20000, IPV4, 9, -]

[MAC_OUT, 20000, ETH, 10, -]

[MAC_OUT, 20000, ETH, 11, CS]

[MAC_OUT, 20000.96, ETH, 12, IFG]

[PHY_OUT, 20000.96, ETH, 13, -]

[PHY_OUT, 20122.08, ETH, 14, PHY_SENSE]

[PHY_IN, 20127.08, ETH, 15, -]

[MAC_IN, 20127.08, ETH, 16, -]

[NW_IN, 20127.08, IPV4, 17, -]

[NW_OUT,	20127.08,	IPV4,	18,	-]
[MAC_OUT,	20127.08,	ETH,	19,	-]
[MAC_OUT,	20127.08,	ETH,	20,	CS]
[MAC_OUT,	20128.04,	ETH,	21,	IFG]
[PHY_OUT,	20128.04,	ETH,	22,	-]
[PHY_OUT,	20249.16,	ETH,	23,	PHY_SENSE]
[PHY_IN,	20254.16,	ETH,	24,	-]
[MAC_IN,	20254.16,	ETH,	25,	-]
[MAC_OUT,	20254.16,	WLAN,	26,	-]
[MAC_OUT,	20254.16,	WLAN,	27,	DIFS_END]
[MAC_OUT,	20304.16,	WLAN,	28,	BACKOFF]
[MAC_OUT,	20324.16,	WLAN,	29,	BACKOFF]
[MAC_OUT,	20344.16,	WLAN,	30,	BACKOFF]
[MAC_OUT,	20364.16,	WLAN,	31,	BACKOFF]
[PHY_OUT,	20364.16,	WLAN,	32,	-]
[TIMER,	21668.16,	WLAN,	35,	UPDATE_DEVICE_STATUS]
[PHY_IN,	21668.4,	WLAN,	33,	-]
[MAC_IN,	21668.4,	WLAN,	36,	RECEIVE_MPDU]
[NW_IN,	21668.4,	IPV4,	37,	-]
[MAC_OUT,	21668.4,	WLAN,	38,	SEND_ACK]
[TRNS_IN,	21668.4,	UDP,	39,	-]
[APP_IN,	21668.4,	APP,	41,	-]
[PHY_OUT,	21678.4,	WLAN,	40,	-]

[TIMER, 21982.4, WLAN, 43, UPDATE_DEVICE]

[PHY_IN, 21982.63, WLAN, 42, -]

[MAC_IN, 21982.63, WLAN, 44, RECEIVE_ACK]

[TIMER, 21985, WLAN, 34, ACK_TIMEOUT]

Event Flow Diagram for one packet from Wired Node to Wireless Node

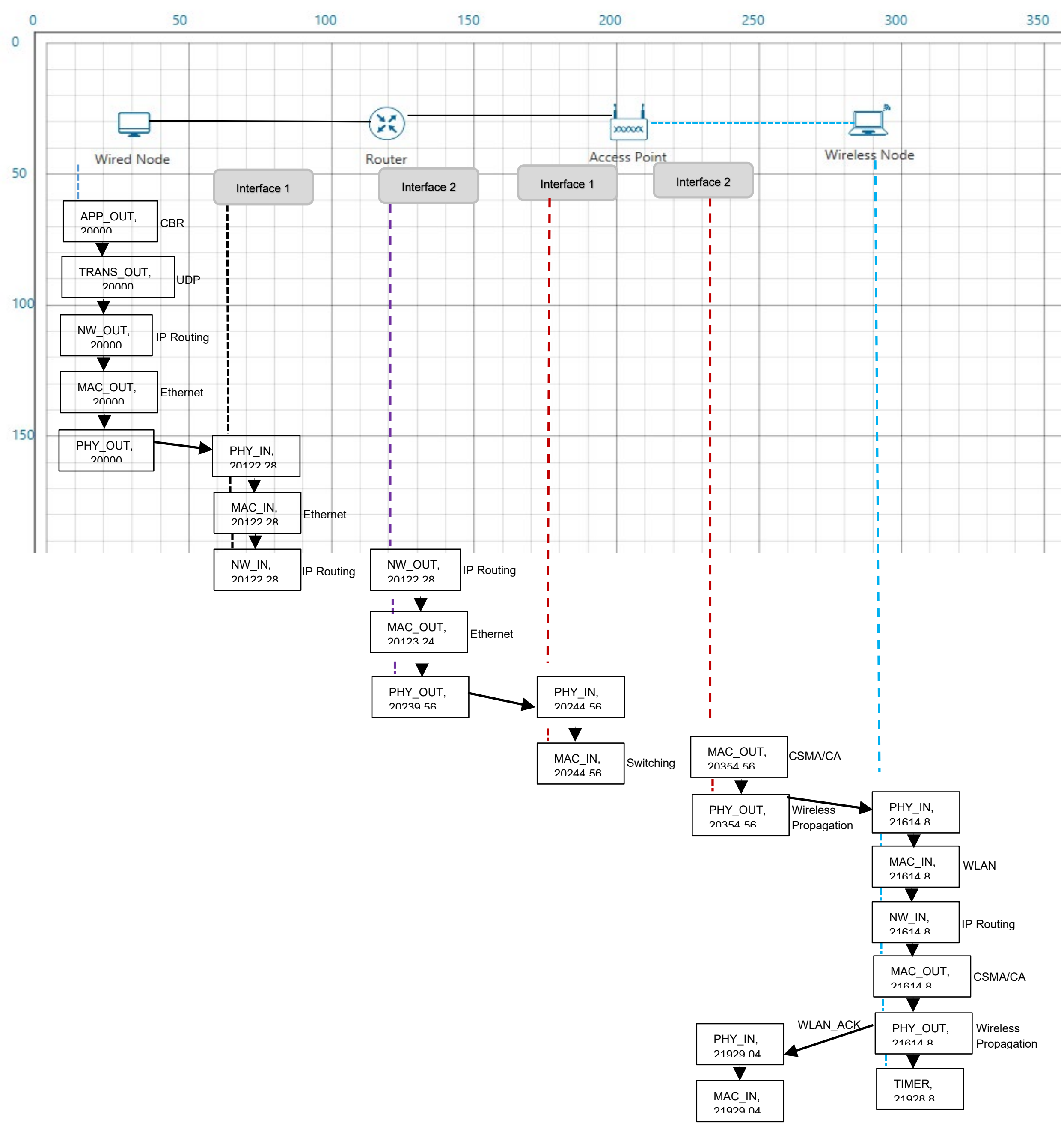


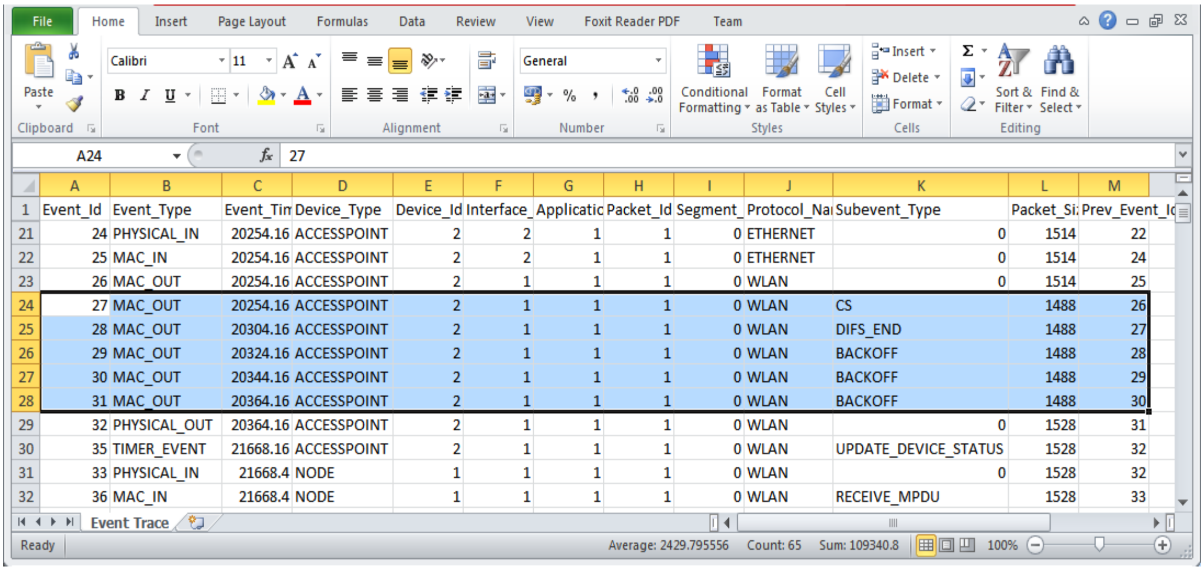
Figure 32-5: Event Flow Diagram for one packet from Wired Node to Wireless Node

For Example

MAC_OUT in the Access Point involves sub events like CS, DIFS_END and BACKOFF.

As you can see in the trace file shown below, CS happens at event time 20254.16,

Adding DIFS time of 50µs to this will give DIFS_END sub event at 20304.16. Further it is followed by three Backoff's each of 20 µs, at event time 20314.16, 20324.16, 20344.16 respectively.



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Event_Id	Event_Type	Event_Tin	Device_Type	Device_Id	Interface_	Applicatic	Packet_Id	Segment_	Protocol_Nai	Subevent_Type	Packet_Si:	Prev_Event_Ic
21	24	PHYSICAL_IN	20254.16	ACCESSPOINT	2	2	1	1	0	ETHERNET	0	1514	22
22	25	MAC_IN	20254.16	ACCESSPOINT	2	2	1	1	0	ETHERNET	0	1514	24
23	26	MAC_OUT	20254.16	ACCESSPOINT	2	1	1	1	0	WLAN	0	1514	25
24	27	MAC_OUT	20254.16	ACCESSPOINT	2	1	1	1	0	WLAN	CS	1488	26
25	28	MAC_OUT	20304.16	ACCESSPOINT	2	1	1	1	0	WLAN	DIFS_END	1488	27
26	29	MAC_OUT	20324.16	ACCESSPOINT	2	1	1	1	0	WLAN	BACKOFF	1488	28
27	30	MAC_OUT	20344.16	ACCESSPOINT	2	1	1	1	0	WLAN	BACKOFF	1488	29
28	31	MAC_OUT	20364.16	ACCESSPOINT	2	1	1	1	0	WLAN	BACKOFF	1488	30
29	32	PHYSICAL_OUT	20364.16	ACCESSPOINT	2	1	1	1	0	WLAN	0	1528	31
30	35	TIMER_EVENT	21668.16	ACCESSPOINT	2	1	1	1	0	WLAN	UPDATE_DEVICE_STATUS	1528	32
31	33	PHYSICAL_IN	21668.4	NODE	1	1	1	1	0	WLAN	0	1528	32
32	36	MAC_IN	21668.4	NODE	1	1	1	1	0	WLAN	RECEIVE_MPDU	1528	33

Figure 32-6: Sub events like CS, DIFS_END and BACKOFF event times

In this manner the event trace can be used to understand the flow of events in NetSim Discrete Event Simulator.

32.5 Discussion

In NetSim each event occurs at a particular instant in time and marks a change of state in the system. Between consecutive events, no change in the system is assumed to occur. Thus the simulation can directly jump in time from one event to the next.

This contrasts with continuous simulation in which the simulation continuously tracks the system dynamics over time. Because discrete-event simulations do not have to simulate every time slice, they can typically run much faster than the corresponding continuous simulation.

Understanding NetSim's Event trace and its flow is very much helpful especially when customizing existing code and debugging to verify the correctness the modified code. The event IDs provided in the event trace can be used to go to a specific event while debugging.