QNX® Momentics® Development Suite

System Analysis Toolkit
User's Guide

For QNX® Neutrino® 6.2.0 or later

Published under license by:

QNX Software Systems International Corporation
175 Terence Matthews Crescent
Kanata, Ontario
K2M 1W8
Canada
Voice: +1 613 591-0931
Fax: +1 613 591-3579
Email: `info@qnx.com`
Web: `http://www.qnx.com/`

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About This Guide

What you'll find in this guide

The QNX System Analysis Toolkit *User's Guide* contains the following sections and chapters:

To learn:	Go to:
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What generates events	Events and the Kernel
How the kernel buffers data	The Kernel Buffer Management
How to save data	User Data Capture
What the data tells you	User Data Interpretation
Different ways to reduce the amount of data	Filtering
Hands on	Tutorial
How to fix some of the more common problems	Hints and Troubleshooting
What commands are available	Functions
What specific events return	Kernel Call Arguments and Return Values

Typographical conventions

Throughout this manual, we use certain typographical conventions to distinguish technical terms. In general, the conventions we use conform to those found in IEEE POSIX publications. The following table summarizes our conventions:

Reference	Example
Code examples	`if( stream == NULL )`
Command options	`-lR`
Commands	**`make`**
Environment variables	**PATH**
File and pathnames	`/dev/null`
Function names	*exit()*
Keyboard chords	Ctrl-Alt-Delete
Keyboard input	**`something you type`**

continued...

Reference	Example
Keyboard keys	Enter
Program output	`login:`
Programming constants	NULL
Programming data types	`unsigned short`
Programming literals	`0xFF`, `"message string"`
Variable names	*stdin*
User-interface components	**Cancel**

We use an arrow (→) in directions for accessing menu items, like this:

> You'll find the **Other...** menu item under **Perspective→Show View**.

We use notes, cautions, and warnings to highlight important messages:

Notes point out something important or useful.

CAUTION: Cautions tell you about commands or procedures that may have unwanted or undesirable side effects.

WARNING: Warnings tell you about commands or procedures that could be dangerous to your files, your hardware, or even yourself.

Note to Windows users

In our documentation, we use a forward slash (`/`) as a delimiter in *all* pathnames, including those pointing to Windows files.

We also generally follow POSIX/UNIX filesystem conventions.

Technical support

To obtain technical support for any QNX product, visit the **Support + Services** area on our website (`www.qnx.com`). You'll find a wide range of support options, including community forums.

Chapter 1

Introduction

In this chapter. . .

What is the System Analysis Toolkit (SAT)?

In today's computing environments, developers need to monitor a dynamic execution of realtime systems with emphasis on their key architectural components. Such monitoring can reveal hidden hardware faults and design or implementation errors, as well as help improve overall system performance.

In order to accommodate those needs, we provide sophisticated tracing and profiling mechanisms, allowing execution monitoring in real time or offline. Because it works at the operating system level, the SAT, unlike debuggers, can monitor applications without having to modify them in any way.

The main goals for the SAT are:

1. Ease of use
2. Insight into system activity
3. High performance and efficiency with low overhead

Why is the SAT needed?

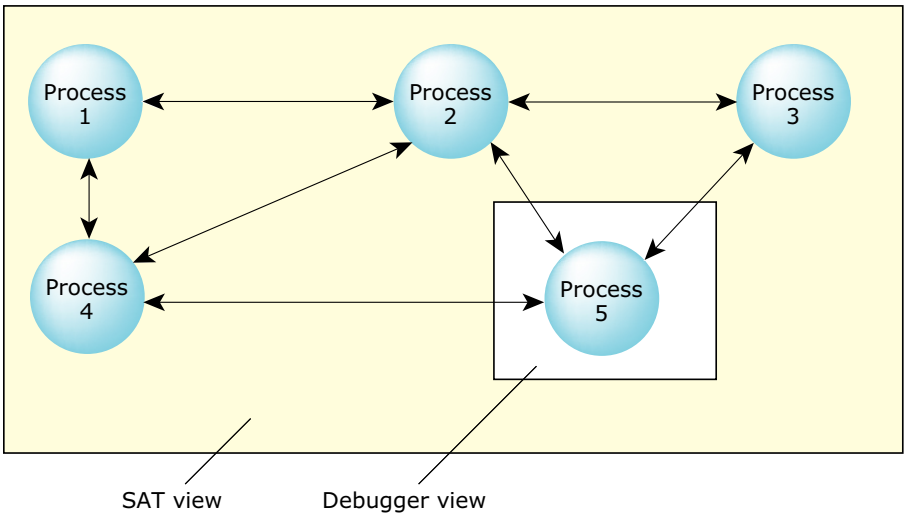
In a running system, many things occur behind the scenes:

- Kernel calls are being made
- Messages are being passed
- Interrupts are being handled
- Threads are changing states— they're being created, blocking, running, restarting, and dying

The result of this activity are changes to the system state that are normally hidden from developers. The SAT is capable of intercepting these changes and logging them. Each event is logged with a *timestamp* and the *ID of the CPU* that handled it.

For a full understanding of how the kernel works, see the Neutrino Microkernel chapter in the *System Architecture* guide.

The SAT offers valuable information at all stages of a product's life cycle, from prototyping to optimization to in-service monitoring and field diagnostics.



The SAT view and the debugger view

In complicated systems, the information provided by standard debugging programs may not be detailed enough to solve the problem. Or, the problem may not be a bug as much as a process that's not behaving as expected. Unlike the SAT, debuggers lack the execution history essential to solving the many complex problems involved in "application tuning." In a large system, often consisting of many interconnected components or processes, traditional debugging, which lets you look at only a single module, can't easily assist if the problem lies in how the modules interact with each other. Where a debugger can view a single process, the SAT can view *all* processes at the same time. Also, unlike debugging, the SAT doesn't need code augmentation and can be used to track the impact of external, precompiled code.

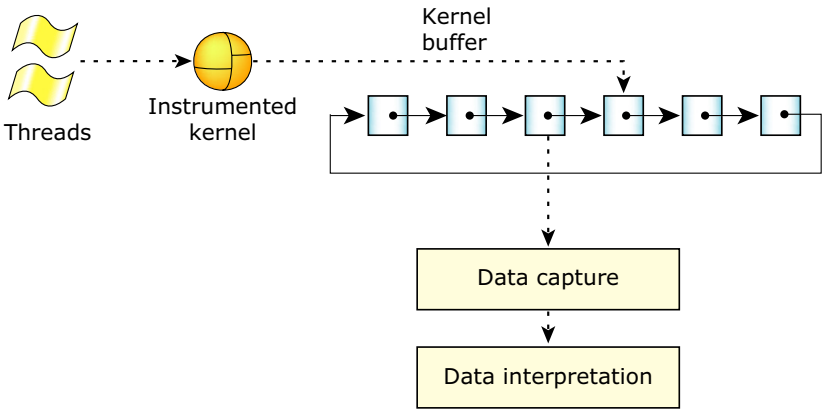
Because it offers a system-level view of the internal workings of the kernel, the SAT can be used for *performance analysis* and *optimization* of large interconnected systems as well as single processes.

It allows *realtime debugging* to help *pinpoint deadlock and race conditions* by showing what circumstances led up to the problem. Rather than just a "snapshot", the SAT offers a "movie" of what's happening in your system.

Because the instrumented version of the kernel runs with negligible performance penalties, you can optionally leave it in the final embedded system. Should any problems arise *in the field*, you can use the SAT for *low-level diagnostics*.

The SAT offers a nonintrusive method of instrumenting the code—programs can literally monitor themselves. In addition to *passive/non-intrusive event tracing*, you can *proactively trace events* by injecting your own "flag" events.

How the SAT works



The Instrumented Kernel

The Instrumented Kernel is actually the regular QNX microkernel with a small, highly efficient event-gathering module included. Except for the instrumentation, its operation is virtually indistinguishable—the Instrumented Kernel runs at 98% of the speed of our regular microkernel.

As threads run, the Instrumented Kernel continuously intercepts information about what the kernel is doing, generating time-stamped and CPU-stamped events that are stored in a *circular linked list of buffers*. Because the tracing occurs at the kernel level, the SAT can track the performance of *all* processes, including the data-capturing program.

Kernel buffer management

The kernel buffer is composed of many small buffers. Although the number of buffers is limited only by the amount of system memory, it's important to understand that this space must be managed carefully. If *all* of the events are being traced on an active system, the number of events can be quite large.

To allow the Instrumented Kernel to write to one part of the kernel buffer and store another part of it simultaneously, the kernel buffer is organized as a circular linked list. As the buffer data reaches a high-water mark (about 70% full), the Instrumented Kernel module sends a signal to the data-capture program with the address of the buffer. The data-capture program can then retrieve the buffer and save it to a storage location for offline processing or pass it to a data interpreter for realtime manipulation. In either case, once the buffer has been "emptied," it is once again available for use by the kernel.

The data-capture program

The SAT includes a **`tracelogger`** you can use to capture data. This data-capture program outputs the captured data in raw binary format to a device or file for processing.

Data interpretation

To aid in processing the binary trace event data, we provide the **`libtraceparser`** library. The API functions let you set up a series of functions that are called when complete buffer slots of event data have been received/read from the raw binary event stream.

We also provide a linear trace event printer (**`traceprinter`**) that outputs all of the trace events ordered linearly by their timestamp as they are emitted by the kernel. This utility makes use of the **`libtraceparser`** library. Advanced users may wish to either customize **`traceprinter`** to make their own output program or use the API to create an interface to do the following *offline* or in *real time*:

- perform analysis
- display results
- debug applications
- system self-monitoring
- show events ordered by process or by thread
- show thread states and transitions
- show currently running threads.

Chapter 2

What's in the SAT?

The QNX System Analysis Toolkit (SAT) consists of the following main components:

Instrumented Kernel

The Instrumented Kernel is an integral part of the SAT. In addition to being a fully functional QNX RTOS microkernel, it also intercepts time events and passes them to the **`tracelogger`** daemon for further processing.

The **`tracelogger`** utility

The **`tracelogger`** daemon receives events from the Instrumented Kernel and saves them to a file/device for later analysis.

The **`traceprinter`** utility

The **`traceprinter`** utility displays the trace event file in a readable form. Users can also modify the **`traceprinter`** source as a basis for their own custom programs.

Trace Control Interface

The SAT trace API uses a single *TraceEvent()* kernel call. The *TraceEvent()* call has over 30 different execution modes that enable the user to:

- create internal trace buffers
- set up filters
- control the tracing process
- insert user defined events

The Traceparser Library

The Traceparser library provides an API for parsing and interpreting the trace events that are stored in the event file. The library simplifies the parsing and interpretation process by allowing the user to easily:

- set up callback functions and associations for each event
- retrieve header and system information from the trace event file
- debug and control the parsing process.

Examples — You'll find numerous sample code listings (and source) that will take you from gathering a simple set of events through to sophisticated filtering and inserting your own events. You can modify the source and use snippets of it to more quickly create your own applications.

Source code — You have full source code for all of the following:

- the **`tracelogger`** utility
- the **`traceprinter`** utility
- the traceparser library
- sample test programs
- tutorial example programs

Chapter 3

Events and the Kernel

In this chapter. . .

What generates events

The QNX microkernel generates events for more than just system calls. The following are some of the activities that generate events:

- kernel calls
- scheduling activity
- interrupt handling
- thread/process creation, destruction, and state changes.

In addition, the Instrumented Kernel also inserts “artificial” events for:

- time events
- user events that may be used as “marker flags.”

Also, single kernel calls or system activities may actually generate more than one event.

Generating events: a typical scenario

One of the powerful features of the QNX RTOS is its ability to run multiple threads. Having more than one thread increases the level of complexity—the OS must handle threads of differing priorities competing with each other.

Multithreaded example:

In our example we’ll use two threads:

Thread	Priority
A	High
B	Low

Now we’ll watch them run, assuming both “start” at the same time:

When logging starts, the Instrumented Kernel sends information about each thread. Existing processes will appear to be created during this procedure.

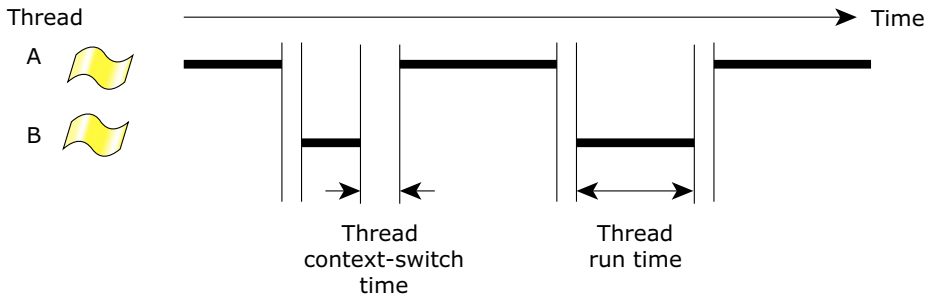
Time	Thread	Action	Explanation
t1	A	Create	Thread is created.
t2	A	Block	The thread is waiting for, say, I/O; it can’t continue without it.

continued...

Time	Thread	Action	Explanation
t3	B	Create	Rather than sit idle, the kernel runs next highest priority thread.
t4	B	Kernel Call	Thread B is working.
t4.5	n/a	n/a	I/O completed; Thread A is ready to run.
t5	B	Block	Thread A is now ready to run—it preempts thread B.
t6	A	Run	Thread A resumes.
t7	A	Dies	Its task complete, the thread terminates.
t8	B	Runs	Thread B continues from where it left off.
t9	...and so on...	...and so on...	...and so on...

Thread context-switch time

Threads don't switch instantaneously—after one thread blocks or yields to another, the kernel must save the settings before running another thread. The time to save this state and restore another is known as *thread context-switch time*. This context-switch time between threads is small, but important.



Thread context switching

In some cases, two or more threads (or processes) may switch back and forth without actually accomplishing much. This is akin to two overly polite people each offering to let the other pass through a narrow door first— neither of them gets to where they're going on time (two aggressive people encounter a similar problem). This type of problem is exactly what the SAT can quickly and easily highlight. By showing the context-switch operations in conjunction with thread state transitions, you can quickly see why otherwise fast systems seem to "crawl."

Thread restarting

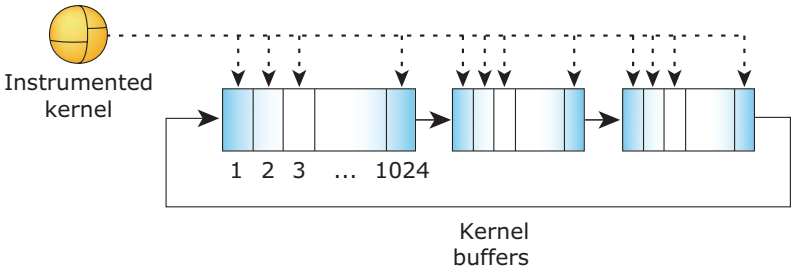
In order to achieve maximum responsiveness, much of the QNX microkernel is fully preemptable. In some cases, this means that when a thread is interrupted in a kernel call, it won't be able to restart exactly where it began. Instead, the kernel call will be restarted—it "rewinds" itself. The SAT tries to hide the spurious calls but may not succeed in suppressing them all. As a result, it's possible to see several events generated from a specific thread that has been preempted. If this occurs, the last event is the actual one.

Chapter 4

Kernel Buffer Management

In this chapter. . .

Instrumented Kernel and kernel buffer management



The kernel buffers

As the Instrumented Kernel intercepts events, it stores them in a *circular linked list of buffers*. As each buffer fills, the Instrumented Kernel sends a signal to the data-capturing program that the buffer is ready to be read.

Buffer specifications

Each buffer is of a fixed size and is divided into a fixed number of slots:

Event buffer slots per buffer	1024
Event buffer slot size	16 bytes
Buffer size	16 K

Some events are *single buffer slot events* (“simple events”) while others are *multiple buffer slot events* (“combine events”). In either case there is only *one* event, but the number of *event buffer slots* required to describe it may vary.

For details, see the User Data Interpretation chapter.

Circular linked lists

Linked list size

Although the size of the buffers is fixed, the maximum number of buffers used by a system is limited only by the amount of memory. (The **`tracelogger`** utility uses a default setting of 32 buffers, or about 500 K of memory.)

The buffers share kernel memory with the application(s) and the kernel automatically allocates memory at the request of the data-capture utility. The kernel allocates the buffers *contiguous physical memory space*. If the data-capture program requests a larger block than is available contiguously, the Instrumented Kernel will return an error message.

For all intents and purposes, the number of events the Instrumented Kernel generates is infinite. Except for severe filtering or logging for only a few seconds, the

Instrumented Kernel will probably exhaust the circular linked list of buffers, no matter how large it is. To allow the Instrumented Kernel to continue logging indefinitely, the data-capture program must continuously pipe (empty) the buffers.

Full buffers and the high-water mark

As each buffer becomes *full* (more on that shortly), the Instrumented Kernel sends a signal to the data-capturing program to save the buffer. Because the buffer size is fixed, the kernel sends only the buffer address; the length is constant.

The Instrumented Kernel can't flush a buffer or change buffers within an interrupt. If the interrupt wasn't handled before the buffer became 100% full, some of the events may be lost. To ensure this never happens, the Instrumented Kernel requests a buffer flush at the *high-water mark*.

The high-water mark is set at an efficient, yet conservative, level of about 70%. Most interrupt routines require fewer than 300 event buffer slots (approximately 30% of 1024 event buffer slots), so there's virtually no chance that any events will be lost. (The few routines that use extremely long interrupts should include a manual buffer-flush request in their code.)

Therefore, in a normal system, the kernel logs about 715 events of the fixed maximum of 1024 events before notifying the capture program.

Buffer overruns

The Instrumented Kernel is both the very core of the system and the controller of the event buffers.

When the Instrumented Kernel is busy, it logs more events. The buffers fill more quickly and the Instrumented Kernel requests buffer-flushes more often. The data-capture program handles each buffer-flush request; the Instrumented Kernel switches to the next buffer and continues logging events. In an extremely busy system, the data-capture program may not be able to flush the buffers as quickly as the Instrumented Kernel fills them.

In a three-buffer scenario, the Instrumented Kernel fills **`Buffer 1`** and signals the data-capture program that the buffer is full. The data-capture program takes "ownership" of **`Buffer 1`** and the Instrumented Kernel marks the buffer as "busy/in use." If, say, the file is being saved to a hard drive that happens to be busy, then the Instrumented Kernel may fill **`Buffer 2`** and **`Buffer 3`** before the data-capture program can release **`Buffer 1`**. In this case, the Instrumented Kernel skips **`Buffer 1`** and writes to **`Buffer 2`**. The previous contents of **`Buffer 2`** are overwritten and the timestamps on the event buffer slots will show a discontinuity.

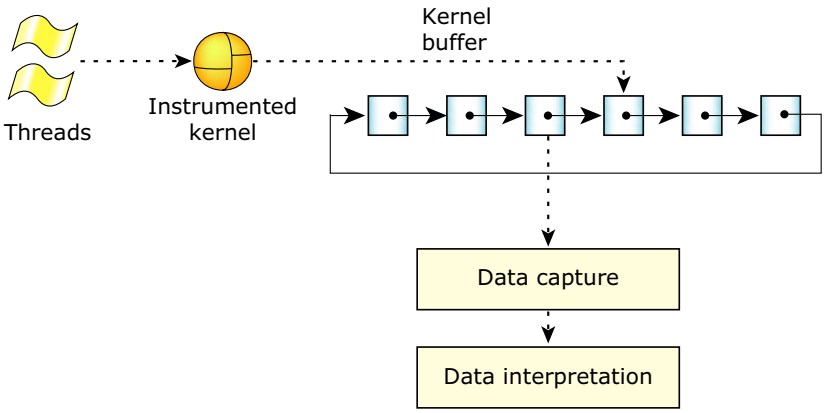
For more on buffer overruns, see the Tutorial chapter.

Chapter 5

User Data Capture

In this chapter. . .

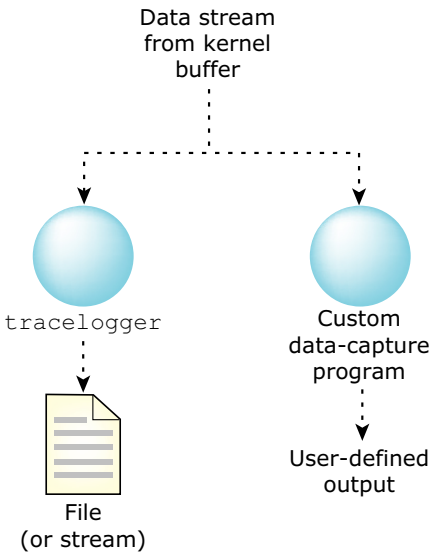
Overview



Overall view of the SAT

We've provided **`tracelogger`** as the default data-capture program. Although it's possible for you to write your own utility from scratch, there's little need to. More likely, you would tailor the **`tracelogger`** code to suit your own needs. Although this section describes the data-capturing process generically, much of it will focus on **`tracelogger`**'s capabilities.

What the data-capture utility does



Possible data capture configurations

Some of the general concepts are explained here, but for a full description of the **`tracelogger`** utility and its options, see **`tracelogger`** in the Utilities chapter in this guide.

The data-capture utility is the “messenger” between the Instrumented Kernel and the filesystem.
The main function of the data-capture utility is to save the buffers given to it by the Instrumented Kernel to an output device (which may be a file or something else). In order to accomplish this function, the utility must also:

- interface with the Instrumented Kernel
- specify data-filtering requirements the Instrumented Kernel will use.

The Instrumented Kernel is fully configurable to log *all* events or only a specified few. Also, it can gather simplified information (in “fast” mode) or detailed information (in “wide” mode).

Tracing settings

Normal mode and daemon mode

The **`tracelogger`** can run in one of two modes. Below is an outline of the strengths, weaknesses, and features of both:

Feature	Normal mode	Daemon mode
`tracelogger` support	Full	Limited
Controlability	Limited	Full
Events recorded by default	All	None
Configuration difficulty	Easy	Harder
Configuration method	Command line only	User program, using calls to *TraceEvent()*
Logging starts	Instantaneously	Through a user program; also calls to *TraceEvent()*

Simple and combine events

Most events can be described in a *single event buffer slot* (“simple event”). When there’s too much information to describe the event in a single buffer slot, the event is described in *multiple event buffer slots* (“combine event”). These events buffer slots all look the same so there’s no need for the data-capture program to distinguish between them.

For more information about simple events and combine events, see the User Data Interpretation chapter.

Wide mode and fast mode

In *wide mode*, the Instrumented Kernel uses as many buffer slots as are necessary to fully log the event— the amount of space is theoretically unlimited and can span

several kilobytes for a single event. Except for rare occasions, it doesn't exceed *four* 16-byte spaces.

In *fast mode*, the Instrumented Kernel uses *only one* buffer slot per event, no matter how many event buffer slots would be used to describe it in wide mode. Because *simple events* require only a *single event buffer slot* anyway, they are logged completely. On the other hand, *combine events* are "incomplete" because only the first of the event buffer slots is logged for each event.

For a detailed list of events and their respective entries, see the appendix.

Tracebuffer file

Because the circular linked list of buffers can't hope to store a complete log of event activity for any significant amount of time, the tracebuffer must be handed off to a data-capture program. Normally the data-capture program would pipe the information to either an output device or a file.

By default, the **`tracelogger`** utility saves the output to the binary file **`/dev/shmem/tracebuffer`** but you can specify a filename.

Configuring

Configuring the Instrumented Kernel

You must configure the Instrumented Kernel before logging. The Instrumented Kernel configuration settings include:

- buffer allocations (size)
- which events and classes of events are logged (filtering)
- whether to log in wide mode or fast mode.

The event configurations are made in an additive or subtractive manner—starting from no events, specific classes or events may be added, or starting from all events, specific ones may be excluded.

You may make these configurations through the data-capture program or another, independent program. The Instrumented Kernel retains the settings.

Multiple programs access a single Instrumented Kernel configuration. Changing settings in one process supercedes the settings in another. For this reason, you should always make the configurations in an additive manner when using multiple processes.

Configuring data capture

You must perform the data-capture configuration using a custom program. The **`tracelogger`** utility will do only very basic configuring, and only in normal mode, where it logs *all* events.

The custom program:

- manually starts and stops logging
- manually sends buffer flush requests (if needed)
- saves the buffer (to a file or other output method)
- configures all filters except the post-processing filters (the filters control which events and classes of events are logged.)

Note that the custom program would be created by the user.

The **`tracelogger`** utility handles only the buffer-saving function.

For configuration details, see the *TraceEvent()* function in the Functions chapter.

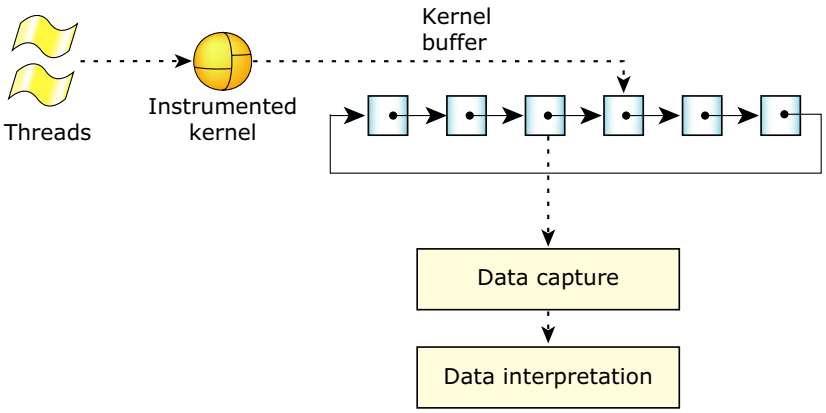
For sample configuration files, see the Tutorial chapter.

Chapter 6

User Data Interpretation

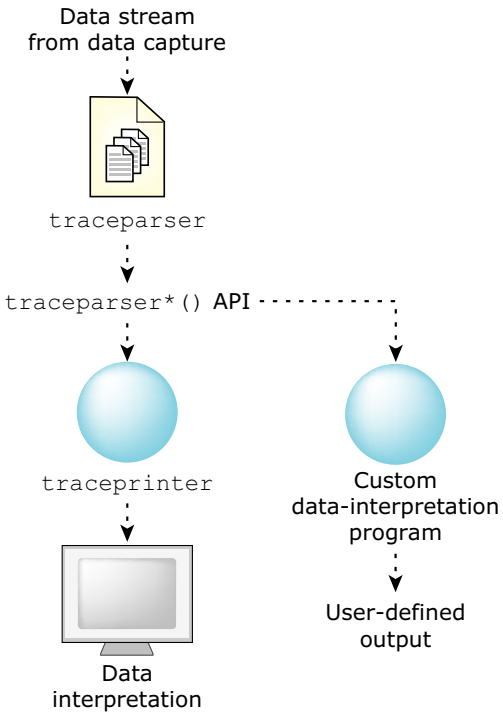
In this chapter. . .

Overview



Overall view of the SAT

Once the data has been captured, you may process it, either in real time or offline.



Possible data interpretation configurations

The `traceparser` library

The **`traceparser`** library provides a front end to facilitate the handling and parsing of events received from the Instrumented Kernel and the data-capture utility. The library serves as a thin middle layer to:

- assemble multiple buffer slots into a single event
- perform data parsing to execute user-defined callbacks triggered by certain events.

Interpreting events

Simple and combine events

A simple event is an event that can be described in a *single event buffer slot*; a combine event is an event that is larger and can be fully described only in *multiple event buffer slots*. Both simple and combine events consist of only *one* kernel event.

Each event buffer slot is an opaque **`traceevent_t`** structure.

The `traceevent_t` structure

The **`traceevent_t`** structure is *opaque*—although some details are provided, the structure shouldn't be accessed without the **`libtraceparser`** API.

The **`traceevent_t`** structure is only 16 bytes long, and only half of that describes the event. This small size reduces instrumentation overhead and improves granularity. Where the information required to represent the event won't fit into a single **`traceevent_t`** structure, it spans as many **`traceevent_t`** structures as required, resulting in a *combine event*. A combine event isn't actually several events combined, but rather a single, long event requiring a combination of **`traceevent_t`** elements to represent it.

In order to distinguish regular events from combine events, the **`traceevent_t`** structure includes a 2-bit flag that indicates whether the event is a single event or whether it's the first, middle, or last **`traceevent_t`** structure of the event. The flag is also used as a rudimentary integrity check. The timestamp element of the combine event is identical in each buffer slot; no other event will have the same timestamp.

Adding this "thin" protocol doesn't burden the Instrumented Kernel and keeps the **`traceevent_t`** structure small. The tradeoff, though, is that it may take many **`traceevent_t`** structures to represent a single kernel event.

Event interlacing

Although events are timestamped immediately, they may not be written to the buffer in one single operation (atomically). When *multiple buffer slot events* ("combine events") are being written to the buffer, the process is frequently interrupted in order to allow other threads and processes to run. Events triggered by higher-priority threads are often written to the buffer first. Thus, events may be *interlaced*. Although events may not be contiguous, they are *not* scrambled (unless there's a buffer overrun.) The sequential order of the combine event is always correct, even if it's interrupted with a different event.

In order to maintain speed during runtime, the Instrumented Kernel writes events unsorted as quickly as possible; reassembling the combine events must be done in post-processing. The **`libtraceparser`** API transparently reassembles the events.

Timestamp

The timestamp is the 32 Least Significant Bits (LSB) part of the 64-bit clock. Whenever the 32-bit portion of the clock rolls over, a control event is issued. Although adjacent events will never have the same exact timestamp, there may be some timestamp duplication due to the clock's rolling over.

The rollover control event includes the 32 Most Significant Bits (MSB), so you may reassemble the full clock time, if required. The timestamp includes only the LSB in order to reduce the amount of data being generated. (A 1 GHz clock rolls over every 4.29 sec—an eternity compared to the number of events generated.)

Although the majority of events are stored chronologically, you shouldn't write code that depends on events being retrieved chronologically. Some *multiple buffer slot events* (combine events) may be interlaced with others with *leading* timestamps. In the case of buffer overruns, the timestamps will definitely be scrambled, with entire blocks of events out of chronological order. Spurious gaps, while theoretically possible, are very unlikely.

The `traceprinter` utility

The **`traceprinter`** utility consists of a long list of callback definitions, followed by a fairly simple parsing procedure. Each of the callback definitions is for printing.

In its native form, the **`traceprinter`** utility is of limited use. However, it's been designed to be easily borrowed from, copied, or modified to allow you to customize your own utilities. See the copyright header included in the source for the full terms of use.

For functionality details, see the **`traceprinter`** utility in the Utilities chapter in this Guide.

Chapter 7

Filtering

In this chapter. . .

Overview

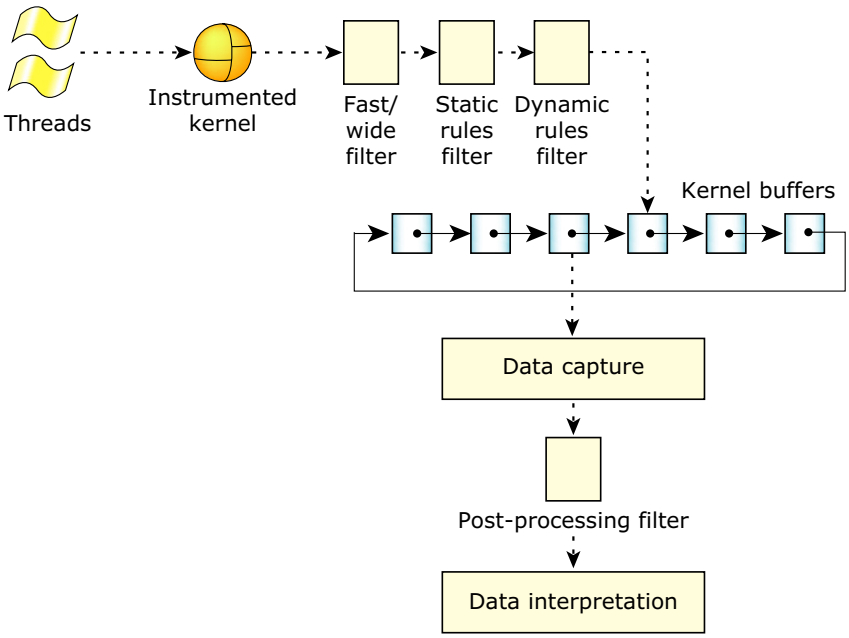
Because the amount of data the Instrumented Kernel generates can be overwhelming, the SAT includes several filters to reduce the amount of data to be processed. The filters can be customized to perform complex decision-making before filtering and other tasks.

Types of filters

The following filters are available:

- Fast/wide mask
- Static rules filter
- Dynamic rules filter
- Post-processing facility

Except for the post-processing facility, all the filters affect the amount of data being logged into the kernel buffers. Unlike the other filters, the post-processing facility doesn't discard data; it simply doesn't use it. If the data is stored, it can always be used later.



Overall view of the SAT and its filters

Tradeoffs

There are tradeoffs to consider when filtering:

- Gathering many events generates a lot of data, which requires *memory* and *processor time*.
- Filtered data is discarded; there's a chance some of the filtered data was useful (this doesn't apply to the post-processing facility.)

The fast/wide mask

The fast/wide mask affects whether data is gathered in fast mode or wide mode. The fast/wide settings can be made on a per-event class and type basis—some can be fast while others are wide.

In wide mode, the entire event is stored, using as many buffer slots as required. In fast mode, each event is stored as a single buffer slot—"multiple buffer slot events" (combine events) are simplified down to a single buffer slot.

In general, wide mode will generate several times more data than fast mode.

The fast/wide filter does *not* clip the tail end of "multiple buffer slot events" (combine events); it summarizes the most important aspects of the event in a single buffer slot. Thus, the first element of a "multiple buffer slot event" (combine event) *may not* be the same in fast and wide mode. (The fast/wide filter isn't a mask.)

The filter is set using the *TraceEvent()* function:

```
TraceEvent (
   _NTO_TRACE_SETALLCLASSESWIDE ); /* wide mode */
TraceEvent (
   _NTO_TRACE_SETALLCLASSESFAST ); /* fast mode */
```

For an example of using fast or wide mode, see the **`all_classes.c`** example in the Tutorial chapter.

For the specific output differences between fast and wide mode, see the Kernel Call Arguments and Return Values appendix.

The static rules filter

The static rules filter uses pre-defined classes and types defined in *TraceEvent()* that may be modified "on the fly" using a custom program.

The static rules filter is the best, most efficient method of data reduction. Because it's a fast filter, severe filtering will generally free up the processor while reducing the data rate to a comparative trickle. The filter is also useful for gathering large amounts of data periodically, or after many hours of logging without generating gigabytes of data in the interim.

Set the filter using the *TraceEvent()* function:

```
TraceEvent (
   _NTO_TRACE_ADDCLASS,
```

```
    _NTO_TRACE_INTENTER );
TraceEvent (
    _NTO_TRACE_SETCLASSPID,
    _NTO_TRACE_KERCALL,
    pid ); /* "pid" is pid number */
TraceEvent (
    _NTO_TRACE_SETCLASSTID,
    _NTO_TRACEPROCESS,
    pid,
    tid ); /* "tid" is tid number */
TraceEvent (
    _NTO_TRACE_ADDEVENT,
    _NTO_TRACE_THREAD,
    _NTO_TRACE_THRUNNING );
```

For an example using the static filter, see the **five_events.c** example in the Tutorial chapter.

The dynamic rules filter

The dynamic rules filter can do all the filtering that the static filter does, and more, but it isn't as fast.

The dynamic rules filter can be "turned on" with _NTO_TRACE_ADDEVENTHANDLER and _NTO_TRACE_ADDCLASSEVHANDLER modes. Using these modes, the user can attach its own custom defined function (event handler) that will control emission of trace events.

The dynamic filter is an event handler that works like an interrupt handler. When this filter is used, a section of your custom code is executed. The code can test for a set of conditions before determining whether the event should be stored. The code must return `0` to *prevent* the event from being stored. On any return except zero, the event is stored.

For example, a dynamic control of one particular event from one particular class can be performed using _NTO_TRACE_ADDEVENTHANDLER interface mode as:

```
TraceEvent(_NTO_TRACE_ADDEVENTHANDLER,
           class,
           event,
           int (*event_hdlr)(event_data_t*),
           event_data_t* data_struct)
```

A permanent "ON" state of the filter can be achieved with a very simple event handler defined as:

```
int event_handler(event_data_t* dummy_pt)
{
 return(1);
}
```

In addition to deciding whether or not the event should be logged, the dynamic rules filter can be used to output events to external hardware or to perform other tasks— it's up to you because it's your code. Naturally, you should write the code as efficiently as possible in order to minimize the overhead.

It is possible to access the information about the intercepted event within the event handler. This can be done by examining members of **even_data_t** structure passed as an argument to the event handler. More detail description of the **event_data_t** members can be found in **Dynamic rules filter configuration** of the *TraceEvent()* function.

For example of using the dynamic filter, see the **eh_simple.c** example in the Tutorial chapter.

The post-processing facility

The post-processing facility is different from the other filters in that it reacts to the events without permanently discarding them (or having to choose not to). Because the processing would be done on the captured data, often saved as a file, you could make multiple passes on the same data without changing it—one pass could count the number of thread state changes, another pass could display all the kernel events.

The post-processing facility is really a collection of callback functions that decide what to do for each event.

For an example of a post-processing facility, see the source code for **traceprinter**.

Chapter 8

Tutorial

In this chapter. . .

Starting out

Setting up the Instrumented Kernel

The Instrumented Kernel is a drop-in replacement for the noninstrumented kernel. In fact, when you're not tracing any events, the Instrumented Kernel operates at almost the same speed as the normal kernel. To use the Instrumented Kernel rather than the normal kernel:

1. In your buildfile, replace the entry for **procnto** with **procnto-instr**.
2. Run the **mkifs** utility to rebuild the image.
3. Replace your current boot image with the new one.
4. Add **tracelogger** and **traceprinter** to your buildfile or target.

Note that the Instrumented Kernel is slightly larger than the normal kernel.

For more information about **mkifs**, see the *Utilities Reference*.

Tutorial overview

As you go through this tutorial, we'll ask you to save files.

The "tracebuffer" files are binary files that can be interpreted only with the **libtraceparser** library, which the **traceprinter** utility uses. To help you ensure you're getting the right results, we've used the same names in our documentation. For example, when we ask you to save to the file **tb.bare**, we'll show the **traceprinter** output here as **tb.bare.txt**, which is a file you can view with your favorite text editor.

Because the default number of buffers is 32, which produces a rather large file, we'll use the **-n** option to limit the number of buffers to a reasonable number. Feel free to use the default, but expect a large file.

The `tracelogger` in normal mode

Interrupts, iterations, and events

With no other processes running, type: **tracelogger -f tb.bare**

You'll see that the **interrupts** increment concurrently with the **iterations**. This is a good indication that the system was partially idle during the logging process.

The interrupts are not the traditional interrupts — they're "fake" ones during which the **tracelogger** saves the buffer just before flushing it.

You should also note that every entry for **events** tends to be 715, or very nearly 715. This is a count of how many events were logged in each buffer before **tracelogger** issued an interrupt to start writing to a new buffer. The default buffer holds 1024 events, numbered from 0 to 1023. At the high-water mark, when the buffer is 70% full, the system writes the buffer to file and flushes the buffer from memory.

Slow systems and busy systems

The Instrumented Kernel kernel has been designed to be quite rugged and to have only a small performance penalty. Because the **tracelogger**, in its normal mode, saves large chunks of data, the amount of data it has to handle may overwhelm slow systems or systems with limited resources.

Since we all have different systems and there's no easy way to slow them down consistently, we'll cheat and set the buffer to 1. The default number of buffers is 32, which is plenty to keep the system running along without problems. When the buffer is only 1, the system tries to save the buffer at the high-water mark while at the same time rewriting it from the beginning. Because it's impossible to save the entire buffer before any more kernel calls occur, what's saved is garbage data or, at best, partial data.

Enter:

```
tracelogger -b 1
```

The results show the number of events as being nowhere near 715. Even though it won't happen in this example, *if the number of events is 0, you likely have a problem*.

As a general rule, the number of events should be consistently the high-water mark of the maximum number of events.

The **iterations** are the number of times the system has written to the buffer and the **interrupts** are an indication of how often the system saved (or tried to save) the buffer. If the number of **interrupts** is less than the number of **iterations**, it's a good indication that some data has been lost. This is particularly true if the number of **events** is ever shown to be 0. It's not serious if **interrupts** trail **iterations** by only 1.

The `tracelogger` in daemon mode

Overview

Normal mode vs. Daemon mode

In normal mode, **tracelogger** by default gathers *all* events in *fast* mode.

In daemon mode, **tracelogger** gathers *no* events—you must specify the events you wish to gather.

When you run **tracelogger** from the command line, the default is in normal mode. Normal mode allows for fast setup but the amount of information it generates is overwhelming.

Daemon mode can provide only the information you want, but at the expense of setup time and complexity. To start daemon mode, use the **tracelogger -d1** option. In daemon mode, **tracelogger** waits for a signal to start. We'll provide the start signal with a program.

Understanding the tutorial format

To reduce repetition and keep the programs simple, some functionality has been put into a header file. You'll have to save the included **instrex.h** file in order for the programs to compile.

Each of these sample programs uses a similar format:

1. Compile the **C file** into a file of the same name, without the **.c** extension
2. Run the **Command**.
3. In a *separate* terminal window, run the compiled **C file**. Some examples use options. Watch the first terminal window. In a few seconds the **tracelogger** will finish running.
4. If you run the program, it generates its own **Sample result file**; if you didn't run the program, take a look at our **traceprinter** output. (Note that different versions and systems will create slightly different results.)

You may include these samples in your code as long as you comply with the copyright.

Gathering all events from all classes

C File	**all_classes.c**
Command	**tracelogger -d1 -n 3 -f all_classes.results**
Running C File	**all_classes**
Sample result file	**all_classes.results.txt**
Viewing	**traceprinter -f all_classes.results**

In our first example, we'll set up daemon mode to gather *all* events from *all* classes. Despite how quickly the program ran, the amount of data it generated is rather overwhelming. Feel free to interrupt the **traceprinter**— it'll list data for a while.

This example demonstrates the capability of the trace module to capture *huge* amounts of data about the events.

While it's good to know how to gather everything, we'll clearly need to be able to refine our search.

Gathering all events from one class

C File	**one_class.c**
Command	**tracelogger -d1 -n 3 -f one_class.results**
Running C File	**one_class**

Sample result file	**one_class.results.txt**
Viewing	**traceprinter -f one_class.results**

Now we'll gather *all* events from only *one* class— _NTO_TRACE_THREAD. This class is arbitrarily chosen to demonstrate filtering by classes; there's nothing particularly special about this class versus any other. For a full list of the possible classes, see *TraceEvent()*.

Notice that the results are a little more refined as well as consistent.

Gathering five events from four classes

C File	**five_events.c**
Command	**tracelogger -d1 -n 3 -f five_events.results**
Running C File	**five_events**
Sample result file	**five_events.results.txt**
Viewing	**traceprinter -f five_events.results**

Now that we can gather specific classes of events, we'll refine our search even further and gather only five specific types of events from four classes. We've now begun to selectively pick and choose events—the massive amount of data is now much more manageable.

Gathering kernel calls

C File	**ker_calls.c**
Command	**tracelogger -d1 -n 3 -f ker_calls.all.results**
Running C File	**ker_calls**
Sample result file	**ker_calls.all.results.txt**
Viewing	**traceprinter -f ker_calls.all.results**

The kernel calls are arguably the most important class of calls. This example shows not only filtering, but also the arguments intercepted by the Instrumented Kernel. In its base form, this program is similar to the **one_class.c** example that gathered only one class.

C File	**ker_calls.c**
Command	**tracelogger -d1 -n 3 -f ker_calls.14.results**
Running C File	**ker_calls -n 14**

Sample result file	**ker_calls.14.results.txt**
Viewing	**traceprinter -f ker_calls.14.results**

Our **C File** has an extra feature in it that lets us view only one type of kernel call—the number 14 signifies __KER_MSG_RECEIVE. For a full list of the values associated with the **-n** option, see **/usr/include/sys/kercalls.h**.

Event handling - simple

C File	**eh_simple.c**
Command	**tracelogger -d1 -n 3 -f eh_simple.results**
Running C File	**eh_simple**
Sample result file	**eh_simple.results.txt**
Viewing	**traceprinter -f eh_simple.results**

Now, two events from two different classes are intercepted. Each event has an event handler attached to it; the event handlers are closing and opening the stream.

This is an important example because it demonstrates the use of the dynamic rules filter to perform tasks beyond basic filtering.

User event - simple

C File	**usr_event_simple.c**
Command	**tracelogger -d1 -n 3 -f usr_event_simple.results**
Running C File	**usr_event_simple**
Sample result file	**usr_event_simple.results.txt**
Viewing	**traceprinter -f usr_event_simple.results**

This example demonstrates the insertion of a user event into the event stream.

Being able to insert “artificial” events allows you to “flag” events or “bracket” groups of events to isolate them for study. It’s also useful for inserting internal, customized information into the event stream.

Header file: instrex.h

```
/*
 * Copyright 2003, QNX Software Systems Ltd. All Rights Reserved.
 *
 * This source code may contain confidential information of QNX Software
 * Systems Ltd.  (QSSL) and its licensors. Any use, reproduction,
 * modification, disclosure, distribution or transfer of this software,
 * or any software which includes or is based upon any of this code, is
 * prohibited unless expressly authorized by QSSL by written agreement. For
 * more information (including whether this source code file has been
```

```
 * published) please email licensing@qnx.com.
 */

/*
 *  instrex.h instrumentation examples - public definitions
 *
 */

#ifndef __INSTREX_H_INCLUDED

#include <errno.h>
#include <stdio.h>
#include <string.h>

/*
 * Supporting macro that intercepts and prints a possible
 * error states during calling TraceEvent(...)
 *
 * Call TRACE_EVENT(TraceEvent(...))  <=>  TraceEvent(...)
 *
 */
#define TRACE_EVENT(prog_name, trace_event) \
if((int)((trace_event))==(-1)) \
{ \
(void) fprintf \
( \
 stderr, \
 "%s: line:%d function call TraceEvent() failed, errno(%d): %s\n", \
 prog_name, \
 __LINE__, \
 errno, \
 strerror(errno) \
); \
 \
return (-1); \
}

/*
 * Prints error message
 */
#define TRACE_ERROR_MSG(prog_name, msg) \
(void) fprintf(stderr,"%s: %s\n", prog_name, msg)

#define  __INSTREX_H_INCLUDED
#endif
```

C File: all_classes.c

```
/*
 * Copyright 2003, QNX Software Systems Ltd. All Rights Reserved.
 *
 * This source code may contain confidential information of QNX Software
 * Systems Ltd.  (QSSL) and its licensors. Any use, reproduction,
 * modification, disclosure, distribution or transfer of this software,
 * or any software which includes or is based upon any of this code, is
 * prohibited unless expressly authorized by QSSL by written agreement. For
 * more information (including whether this source code file has been
 * published) please email licensing@qnx.com.
 */

#ifdef __USAGE
%C - instrumentation example

%C - example that illustrates the very basic use of
  the TraceEvent() kernel call and the instrumentation
  module with tracelogger in a daemon mode.

  All classes and their events are included and monitored.

  In order to use this example, start the tracelogger
  in the deamon mode as:

  tracelogger -n iter_number -d1
```

```
  with iter_number = your choice of 1 through 10

  After executing the example, the tracelogger (daemon)
  will log the specified number of iterations and then
  terminate. There are no messages printed uppon successful
  completion of the example. You can view the intercepted
  events with the traceprinter utility.

  See accompanied documentation and comments within
  the example source code for more explanations.
#endif

#include <sys/trace.h>

#include "instrex.h"

int main(int argc, char **argv)
{
/*
 * Just in case, turn off all filters, since we
 * don't know their present state - go to the
 * known state of the filters.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_DELALLCLASSES));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_THREAD));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_THREAD));

/*
 * Set fast emitting mode for all classes and
 * their events.
 * Wide emitting mode could have been
 * set instead, using:
 *
 *  TraceEvent(_NTO_TRACE_SETALLCLASSESWIDE)
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_SETALLCLASSESFAST));

/*
 * Intercept all event classes
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_ADDALLCLASSES));

/*
 * Start tracing process
 *
 * During the tracing process, the tracelogger (which
 * is being executed in a daemon mode) will log all events.
 * The number of full logged iterations is user specified.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_START));

/*
 * The main() of this execution flow returns.
 * However, the main() function of the tracelogger
 * will return after registering the specified number
 * of events.
 */
return (0);
}
```

Sample result file: all_classes.results.txt

```
TRACEPRINTER version 0.97
TRACEPARSER LIBRARY version 0.98
 -- HEADER FILE INFORMATION --
       TRACE_FILE_NAME:: /dev/shmem/tracebuffer
            TRACE_DATE:: Fri Aug 17 09:08:06 2001
       TRACE_VER_MAJOR:: 0
       TRACE_VER_MINOR:: 97
   TRACE_LITTLE_ENDIAN:: TRUE
```



```
       TRACE_ENCODING:: 16 byte events
      TRACE_BOOT_DATE:: Fri Aug 17 09:02:16 2001
  TRACE_CYCLES_PER_SEC:: 132980400
        TRACE_CPU_NUM:: 1
        TRACE_SYSNAME:: QNX
       TRACE_NODENAME:: localhost
    TRACE_SYS_RELEASE:: 6.1.0
    TRACE_SYS_VERSION:: 2001/08/15-08:15:15
        TRACE_MACHINE:: x86pc
    TRACE_SYSPAGE_LEN:: 2248
 -- KERNEL EVENTS --
t:0xbcb12bdf CPU:00 CONTROL :TIME msb:0x0000000b, lsb(offset):0xbcb128b3
t:0xbcb135fb CPU:00 PROCESS :PROCCREATE_NAME
                     ppid:0
                      pid:1
                     name:/home/mmacies/instrumentation/x86/procnto-instr
.
.
.
t:0xbcb1db36 CPU:00 THREAD  :THRUNNING     pid:98319 tid:1
t:0xbcb1e090 CPU:00 KER_EXIT:TRACE_EVENT/01 ret_val:0x00000000 empty:0x00000000
t:0xbcb1f03c CPU:00 KER_CALL:THREAD_DESTROY/47 tid:-1 status_p:0
t:0xbcb1f870 CPU:00 KER_EXIT:THREAD_DESTROY/47 ret_val:0x00000030 empty:0x00000000
t:0xbcb1fab2 CPU:00 KER_CALL:THREAD_DESTROYALL/48 empty:0x00000000 empty:0x00000000
t:0xbcb1fcdb CPU:00 THREAD  :THDESTROY     pid:98319 tid:1
t:0xbcb20055 CPU:00 THREAD  :THDEAD        pid:98319 tid:1
t:0xbcb2021e CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0xbcb21262 CPU:00 THREAD  :THREADY       pid:1 tid:5
t:0xbcb21d61 CPU:00 KER_EXIT:MSG_RECEIVEV/14 rcvid:0x00000000 rmsg:"" (0x00000000)
t:0xbcb234e8 CPU:00 INT_ENTR:0x00000000 (0) inkernel=0x00000001
t:0xbcb238b4 CPU:00 INT_EXIT:0x00000000 (0) inkernel=0x00000001
t:0xbcb2905f CPU:00 KER_CALL:INTERRUPT_UNMASK/60 intr:10 id:5
t:0xbcb297e2 CPU:00 KER_EXIT:INTERRUPT_UNMASK/60 mask_level:0x00000000 empty:0x00000000
t:0xbcb29d28 CPU:00 KER_CALL:MSG_RECEIVEV/14 chid:0x00000005 rparts:1
t:0xbcb29fca CPU:00 THREAD  :THRECEIVE     pid:7 tid:5
t:0xbcb2a177 CPU:00 THREAD  :THRUNNING     pid:7 tid:11
t:0xbcb2a4c8 CPU:00 KER_EXIT:SYNC_CONDVAR_WAIT/82 ret_val:0 empty:0x00000000
t:0xbcb2b8de CPU:00 KER_CALL:SYNC_CONDVAR_SIGNAL/83 sync_p:807144c all:0
t:0xbcb2bf6c CPU:00 THREAD  :THREADY       pid:7 tid:8
t:0xbcb2c256 CPU:00 KER_EXIT:SYNC_CONDVAR_SIG/83 ret_val:0 empty:0x00000000
t:0xbcb2c8ec CPU:00 KER_CALL:SYNC_CONDVAR_WAIT/82 sync_p:8071b90 mutex_p:8071b88
t:0xbcb2cdd4 CPU:00 THREAD  :THCONDVAR     pid:7 tid:11
t:0xbcb2cf82 CPU:00 THREAD  :THRUNNING     pid:1 tid:5
t:0xbcb2d438 CPU:00 INT_CALL:KER_MSG_RECEIVEV/14
t:0xbcb2e00c CPU:00 KER_CALL:RING0/02 func_p:ff836f16 arg_p:e3fd2ee0
t:0xbcb2e470 CPU:00 KER_EXIT:RING0/02 ret_val:0xe313c7b8 empty:0x00000000
t:0xbcb2e93c CPU:00 KER_CALL:RING0/02 func_p:ff83562c arg_p:e313c8ac
t:0xbcb2eb46 CPU:00 KER_EXIT:RING0/02 ret_val:0x00000002 empty:0x00000000
t:0xbcb2eee8 CPU:00 KER_CALL:RING0/02 func_p:ff836f16 arg_p:e3fd2e54
.
.
.
t:0xbcd2a81c CPU:00 INT_ENTR:0x00000000 (0) inkernel=0x00000081
t:0xbcd2a9a4 CPU:00 INT_EXIT:0x00000000 (0) inkernel=0x00000081
t:0xbcd2ac29 CPU:00 KER_EXIT:RING0/02 ret_val:0x00000000 empty:0x00000000
t:0xbcd2ae9a CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
```

C File: one_class.c

```
/*
 * Copyright 2003, QNX Software Systems Ltd. All Rights Reserved.
 *
 * This source code may contain confidential information of QNX Software
 * Systems Ltd.  (QSSL) and its licensors. Any use, reproduction,
 * modification, disclosure, distribution or transfer of this software,
 * or any software which includes or is based upon any of this code, is
 * prohibited unless expressly authorized by QSSL by written agreement. For
 * more information (including whether this source code file has been
 * published) please email licensing@qnx.com.
 */

#ifdef __USAGE
%C - instrumentation example
```

```
%C - example that illustrates the very basic use of
  the TraceEvent() kernel call and the instrumentation
  module with tracelogger in a daemon mode.

  Only events from the thread class (_NTO_TRACE_THREAD)
  are monitored (intercepted).

  In order to use this example, start the tracelogger
  in the deamon mode as:

  tracelogger -n iter_number -d1

  with iter_number = your choice of 1 through 10

  After executing the example, the tracelogger (daemon)
  will log the specified number of iterations and then
  terminate. There are no messages printed uppon successful
  completion of the example. You can view the intercepted
  events with the traceprinter utility.

  See accompanied documentation and comments within
  the example source code for more explanations.
#endif

#include <sys/trace.h>

#include "instrex.h"

int main(int argc, char **argv)
{
/*
 * Just in case, turn off all filters, since we
 * don't know their present state - go to the
 * known state of the filters.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_DELALLCLASSES));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_THREAD));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_THREAD));

/*
 * Intercept only thread events
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_ADDCLASS, _NTO_TRACE_THREAD));

/*
 * Start tracing process
 *
 * During the tracing process, the tracelogger (which
 * is being executed in daemon mode) will log all events.
 * The number of full logged iterations is user specified.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_START));

 /*
 * The main() of this execution flow returns.
 * However, the main() function of the tracelogger
 * will return after registering the specified number
 * of events.
 */
return (0);
}
```

Sample result file: one_class.results.txt

```
TRACEPRINTER version 0.97
TRACEPARSER LIBRARY version 0.98
 -- HEADER FILE INFORMATION --
       TRACE_FILE_NAME:: /dev/shmem/tracebuffer
            TRACE_DATE:: Fri Aug 17 09:15:34 2001
       TRACE_VER_MAJOR:: 0
       TRACE_VER_MINOR:: 97
```

```
   TRACE_LITTLE_ENDIAN:: TRUE
        TRACE_ENCODING:: 16 byte events
       TRACE_BOOT_DATE:: Fri Aug 17 09:02:16 2001
  TRACE_CYCLES_PER_SEC:: 132980400
         TRACE_CPU_NUM:: 1
         TRACE_SYSNAME:: QNX
        TRACE_NODENAME:: localhost
     TRACE_SYS_RELEASE:: 6.1.0
     TRACE_SYS_VERSION:: 2001/08/15-08:15:15
         TRACE_MACHINE:: x86pc
     TRACE_SYSPAGE_LEN:: 2248
 -- KERNEL EVENTS --
t:0x9bebdaf3 CPU:00 THREAD  :THCREATE      pid:1 tid:1
t:0x9bebdd74 CPU:00 THREAD  :THREADY       pid:1 tid:1
t:0x9bebde66 CPU:00 THREAD  :THCREATE      pid:1 tid:2
t:0x9bebdf46 CPU:00 THREAD  :THRECEIVE     pid:1 tid:2
t:0x9bebe05c CPU:00 THREAD  :THCREATE      pid:1 tid:3
.
.
.
t:0x9bebe120 CPU:00 THREAD  :THRECEIVE     pid:1 tid:3
t:0x9bebe25e CPU:00 THREAD  :THCREATE      pid:1 tid:4
t:0x9bebe31c CPU:00 THREAD  :THRECEIVE     pid:1 tid:4
t:0x9bebe42c CPU:00 THREAD  :THCREATE      pid:1 tid:5
t:0x9bebe4ea CPU:00 THREAD  :THRECEIVE     pid:1 tid:5
t:0x9bebe5e4 CPU:00 THREAD  :THCREATE      pid:1 tid:6
t:0x9bebe6a2 CPU:00 THREAD  :THRECEIVE     pid:1 tid:6
t:0x9c436edf CPU:00 THREAD  :THREADY       pid:8 tid:5
.
.
.
t:0x9c437a15 CPU:00 THREAD  :THRECEIVE     pid:7 tid:2
t:0x9c437be0 CPU:00 THREAD  :THRUNNING     pid:8 tid:5
```

C File: five_events.c

```
/*
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 *
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 * more information (including whether this source code file has been
 * published) please email licensing@qnx.com.
 */

#ifdef __USAGE
%C - instrumentation example

%C - example that illustrates the very basic use of
  the TraceEvent() kernel call and the instrumentation
  module with tracelogger in a daemon mode.

  Only five events from four classes are included and
  monitored. Class _NTO_TRACE_KERCALL is intercepted
  in a wide emitting mode.

  In order to use this example, start the tracelogger
  in the deamon mode as:

  tracelogger -n iter_number -d1

  with iter_number = your choice of 1 through 10

  After executing the example, the tracelogger (daemon)
  will log the specified number of iterations and then
  terminate. There are no messages printed uppon successful
  completion of the example. You can view the intercepted
  events with the traceprinter utility.

  See accompanied documentation and comments within
  the example source code for more explanations.
```

```
#endif

#include <sys/trace.h>
#include <sys/kercalls.h>

#include "instrex.h"

int main(int argc, char **argv)
{
/*
 * Just in case, turn off all filters, since we
 * don't know their present state - go to the
 * known state of the filters.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_DELALLCLASSES));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_THREAD));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_THREAD));

/*
 * Set wide emitting mode
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_SETALLCLASSESWIDE));

/*
 * Intercept two events from class _NTO_TRACE_THREAD
 */
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENT, _NTO_TRACE_THREAD, _NTO_TRACE_THRUNNING)
);
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENT, _NTO_TRACE_THREAD, _NTO_TRACE_THCREATE)
);

/*
 * Intercept one event from class _NTO_TRACE_PROCESS
 */
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENT, _NTO_TRACE_PROCESS, _NTO_TRACE_PROCCREATE_NAME)
);

/*
 * Intercept one event from class _NTO_TRACE_INTENTER
 */
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENT, _NTO_TRACE_INTENTER, _NTO_TRACE_INTFIRST)
);

/*
 * Intercept one event from class _NTO_TRACE_KERCALLEXIT,
 * event __KER_MSG_READV.
 */
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENT, _NTO_TRACE_KERCALLEXIT, __KER_MSG_READV)
);

/*
 * Start tracing process
 *
 * During the tracing process, the tracelogger (which
 * is being executed in a daemon mode) will log all events.
 * The number of full logged iterations is user specified.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_START));
```

```
/*
 * The main() of this execution flow returns.
 * However, the main() function of the tracelogger
 * will return after registering the specified number
 * of events.
 */
return (0);
}
```

Sample result file: five_events.results.txt

```
TRACEPRINTER version 0.97
TRACEPARSER LIBRARY version 0.98
 -- HEADER FILE INFORMATION --
       TRACE_FILE_NAME:: /dev/shmem/tracebuffer
            TRACE_DATE:: Fri Aug 17 09:15:51 2001
       TRACE_VER_MAJOR:: 0
       TRACE_VER_MINOR:: 97
   TRACE_LITTLE_ENDIAN:: TRUE
        TRACE_ENCODING:: 16 byte events
       TRACE_BOOT_DATE:: Fri Aug 17 09:02:16 2001
  TRACE_CYCLES_PER_SEC:: 132980400
         TRACE_CPU_NUM:: 1
         TRACE_SYSNAME:: QNX
        TRACE_NODENAME:: localhost
     TRACE_SYS_RELEASE:: 6.1.0
     TRACE_SYS_VERSION:: 2001/08/15-08:15:15
         TRACE_MACHINE:: x86pc
     TRACE_SYSPAGE_LEN:: 2248
 -- KERNEL EVENTS --
t:0x3abf47cf CPU:00 PROCESS :PROCCREATE_NAME
                      ppid:0
                       pid:1
                      name:/home/mmacies/instrumentation/x86/procnto-instr
t:0x3abf50b1 CPU:00 THREAD  :THCREATE      pid:1 tid:1
t:0x3abf5208 CPU:00 THREAD  :THCREATE      pid:1 tid:2
t:0x3abf5326 CPU:00 THREAD  :THCREATE      pid:1 tid:3
t:0x3abf546a CPU:00 THREAD  :THCREATE      pid:1 tid:4
t:0x3abf5554 CPU:00 THREAD  :THCREATE      pid:1 tid:5
t:0x3abf5654 CPU:00 THREAD  :THCREATE      pid:1 tid:6
t:0x3abf57d8 CPU:00 THREAD  :THCREATE      pid:1 tid:7
t:0x3abf58d8 CPU:00 THREAD  :THCREATE      pid:1 tid:8
.
.
.
t:0x3abfd7da CPU:00 THREAD  :THRUNNING     pid:184335 tid:1
t:0x3abff400 CPU:00 THREAD  :THRUNNING     pid:7 tid:11
t:0x3ac02c55 CPU:00 THREAD  :THRUNNING     pid:1 tid:5
t:0x3ac051d8 CPU:00 THREAD  :THCREATE      pid:184335 tid:1
t:0x3ac0535b CPU:00 THREAD  :THRUNNING     pid:184335 tid:1
t:0x3ac0a687 CPU:00 THREAD  :THRUNNING     pid:4 tid:1
t:0x3ac0e597 CPU:00 KER_EXIT:MSG_READV/16
                    rbytes:47
                      rmsg:"" (0x6f72500a 0x73736563 0x34383120)
t:0x3ac1ad22 CPU:00 INT_ENTR:0x00000000 (0) inkernel=0x00000001
t:0x3ac3b3fc CPU:00 INT_ENTR:0x00000000 (0) inkernel=0x00000001
t:0x3ac5baba CPU:00 INT_ENTR:0x00000000 (0) inkernel=0x00000001
t:0x3ac5bf32 CPU:00 THREAD  :THRUNNING     pid:1 tid:5
t:0x3ac5c9f8 CPU:00 THREAD  :THRUNNING     pid:4 tid:1
.
.
.
t:0x3b8a6de3 CPU:00 THREAD  :THRUNNING     pid:7 tid:11
t:0x3b8a7d4e CPU:00 INT_ENTR:0x00000000 (0) inkernel=0x00000001
t:0x3b8a984c CPU:00 THREAD  :THRUNNING     pid:7 tid:8
```

C File: ker_calls.c

```
/*
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 *
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 * more information (including whether this source code file has been
 * published) please email licensing@qnx.com.
 */

#ifdef __USAGE
%C - instrumentation example

%C - [-n num]

%C - example that illustrates the very basic use of
  the TraceEvent() kernel call and the instrumentation
  module with tracelogger in a daemon mode.

  All thread states and all/one (specified) kernel
  call number are intercepted. The kernel call(s)
  is(are) intercepted in wide emitting mode.

Options:
-n <num> kernel call number to be intercepted
   (defult is all)

  In order to use this example, start the tracelogger
  in the deamon mode as:

  tracelogger -n iter_number -d1

  with iter_number = your choice of 1 through 10

  After executing the example, the tracelogger (daemon)
  will log the specified number of iterations and then
  terminate. There are no messages printed uppon successful
  completion of the example. You can view the intercepted
  events with the traceprinter utility.

  See accompanied documentation and comments within
  the example source code for more explanations.
#endif

#include <sys/trace.h>
#include <unistd.h>
#include <stdlib.h>

#include "instrex.h"

int main(int argc, char **argv)
{
int arg_var;       /* input arguments parsing support      */
int call_num=(-1); /* kernel call number to be intercepted */

/* Parse command line arguments
 *
 * - get optional kernel call number
 */
while((arg_var=getopt(argc, argv,"n:"))!=(-1)) {
switch(arg_var)
{
case 'n': /* get kernel call number */
call_num = strtoul(optarg, NULL, 10);
break;
default:  /* unknown */
TRACE_ERROR_MSG
(
 argv[0],
 "error parsing command-line arguments - exitting\n"
);
```

```
return (-1);
}
}

/*
 * Just in case, turn off all filters, since we
 * don't know their present state - go to the
 * known state of the filters.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_DELALLCLASSES));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_THREAD));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_THREAD));

/*
 * Set wide emitting mode for all classes and
 * their events.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_SETALLCLASSESWIDE));

/*
 * Intercept _NTO_TRACE_THREAD class
 * We need it to know the state of the active thread.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_ADDCLASS, _NTO_TRACE_THREAD));

/*
 * Add all/one kernel call
 */
if(call_num != (-1)) {
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENT, _NTO_TRACE_KERCALL, call_num)
);
} else {
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDCLASS, _NTO_TRACE_KERCALL)
);
}

/*
 * Start tracing process
 *
 * During the tracing process, the tracelogger (which
 * is being executed in a daemon mode) will log all events.
 * The number of full logged iterations is user specified.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_START));

/*
 * The main() of this execution flow returns.
 * However, the main() function of the tracelogger
 * will return after registering the specified number
 * of events.
 */
return (0);
}
```

Sample result file: ker_calls.all.results.txt

```
TRACEPRINTER version 0.97
TRACEPARSER LIBRARY version 0.98
 -- HEADER FILE INFORMATION --
       TRACE_FILE_NAME:: /dev/shmem/tracebuffer
            TRACE_DATE:: Fri Aug 17 09:17:00 2001
       TRACE_VER_MAJOR:: 0
       TRACE_VER_MINOR:: 97
   TRACE_LITTLE_ENDIAN:: TRUE
        TRACE_ENCODING:: 16 byte events
```

```
      TRACE_BOOT_DATE:: Fri Aug 17 09:02:16 2001
  TRACE_CYCLES_PER_SEC:: 132980400
        TRACE_CPU_NUM:: 1
        TRACE_SYSNAME:: QNX
       TRACE_NODENAME:: localhost
    TRACE_SYS_RELEASE:: 6.1.0
    TRACE_SYS_VERSION:: 2001/08/15-08:15:15
        TRACE_MACHINE:: x86pc
    TRACE_SYSPAGE_LEN:: 2248
 -- KERNEL EVENTS --
t:0x35b45a23 CPU:00 THREAD  :THCREATE      pid:1 tid:1
t:0x35b45b6e CPU:00 THREAD  :THREADY       pid:1 tid:1
t:0x35b45c86 CPU:00 THREAD  :THCREATE      pid:1 tid:2
.
.
.
t:0x35b45d54 CPU:00 THREAD  :THRECEIVE     pid:1 tid:2
t:0x35b45e8c CPU:00 THREAD  :THCREATE      pid:1 tid:3
t:0x35b45f50 CPU:00 THREAD  :THRECEIVE     pid:1 tid:3
t:0x35b4608e CPU:00 THREAD  :THCREATE      pid:1 tid:4
t:0x35b4614c CPU:00 THREAD  :THRECEIVE     pid:1 tid:4
t:0x35b4622e CPU:00 THREAD  :THCREATE      pid:1 tid:5
t:0x35b462ec CPU:00 THREAD  :THRECEIVE     pid:1 tid:5
t:0x35b463e6 CPU:00 THREAD  :THCREATE      pid:1 tid:6
t:0x35b464a4 CPU:00 THREAD  :THRECEIVE     pid:1 tid:6
t:0x35b4663a CPU:00 THREAD  :THCREATE      pid:1 tid:7
t:0x35b466f8 CPU:00 THREAD  :THRECEIVE     pid:1 tid:7
t:0x35b467f2 CPU:00 THREAD  :THCREATE      pid:1 tid:8
t:0x35b468b0 CPU:00 THREAD  :THRECEIVE     pid:1 tid:8
t:0x35b46b20 CPU:00 THREAD  :THCREATE      pid:2 tid:1
.
.
.
t:0x35bbdee9 CPU:00 THREAD  :THREADY       pid:4 tid:1
t:0x35bbe032 CPU:00 THREAD  :THRUNNING     pid:1 tid:5
t:0x35bbe97a CPU:00 KER_CALL:MSG_RECEIVEV/14 chid:0x00000001 rparts:2080
t:0x35bbec68 CPU:00 THREAD  :THRECEIVE     pid:1 tid:5
t:0x35bbee10 CPU:00 THREAD  :THRUNNING     pid:4 tid:1
t:0x35c2f825 CPU:00 THREAD  :THREADY       pid:208911 tid:1
t:0x35c2ff68 CPU:00 KER_CALL:MSG_RECEIVEV/14 chid:0x00000001 rparts:2077
t:0x35c30190 CPU:00 THREAD  :THRECEIVE     pid:4 tid:1
t:0x35c302c6 CPU:00 THREAD  :THRUNNING     pid:208911 tid:1
t:0x35c32979 CPU:00 THREAD  :THREPLY       pid:208911 tid:1
t:0x35c32c6f CPU:00 THREAD  :THRUNNING     pid:4 tid:1
t:0x35c33487 CPU:00 KER_EXIT:MSG_RECEIVEV/14
                     rcvid:0x00000012
                      rmsg:"" (0x00040116 0x0000002d 0x00000000)
                 info->nd:0
               info->srcnd:0
                 info->pid:208911
                 info->tid:1
                info->chid:1
               info->scoid:1073741842
                info->coid:0
              info->msglen:4
           info->srcmsglen:4
           info->dstmsglen:2147483647
            info->priority:15
               info->flags:0
            info->reserved:0
t:0x35c35919 CPU:00 THREAD  :THREADY       pid:208911 tid:1
t:0x35c36032 CPU:00 KER_CALL:MSG_RECEIVEV/14 chid:0x00000001 rparts:2077
.
.
.
t:0x35da1b25 CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x35da1c4e CPU:00 THREAD  :THREADY       pid:1 tid:1
```

Sample result file: ker_calls.14.results.txt

```
TRACEPRINTER version 0.97
TRACEPARSER LIBRARY version 0.98
 -- HEADER FILE INFORMATION --
       TRACE_FILE_NAME:: /dev/shmem/tracebuffer
            TRACE_DATE:: Wed Aug 22 09:52:49 2001
       TRACE_VER_MAJOR:: 0
       TRACE_VER_MINOR:: 97
   TRACE_LITTLE_ENDIAN:: TRUE
        TRACE_ENCODING:: 16 byte events
       TRACE_BOOT_DATE:: Tue Aug 21 14:03:25 2001
  TRACE_CYCLES_PER_SEC:: 132961600
         TRACE_CPU_NUM:: 1
         TRACE_SYSNAME:: QNX
        TRACE_NODENAME:: localhost
     TRACE_SYS_RELEASE:: 6.1.0
     TRACE_SYS_VERSION:: 2001/08/21-14:05:41
         TRACE_MACHINE:: x86pc
     TRACE_SYSPAGE_LEN:: 2248
 -- KERNEL EVENTS --
t:0x4c091677 CPU:00 THREAD  :THCREATE      pid:1 tid:1
t:0x4c0917ec CPU:00 THREAD  :THREADY       pid:1 tid:1
t:0x4c098b66 CPU:00 THREAD  :THDEAD        pid:12302 tid:1
                    .
                    .
                    .
t:0x4c099ed2 CPU:00 THREAD  :THREADY       pid:1 tid:1
t:0x4c09a422 CPU:00 INT_CALL:KER_MSG_RECEIVEV/14
t:0x4c09c872 CPU:00 THREAD  :THCREATE      pid:12302 tid:1
t:0x4c09c97c CPU:00 THREAD  :THWAITTHREAD  pid:1 tid:2
t:0x4c09cabf CPU:00 THREAD  :THRUNNING     pid:12302 tid:1
t:0x4c09d17c CPU:00 THREAD  :THREADY       pid:1 tid:2
t:0x4c0a13db CPU:00 THREAD  :THREPLY       pid:12302 tid:1
t:0x4c0a1618 CPU:00 THREAD  :THREADY       pid:4 tid:1
t:0x4c0a1786 CPU:00 THREAD  :THRUNNING     pid:4 tid:1
t:0x4c0a205f CPU:00 KER_EXIT:MSG_RECEIVEV/14
                     rcvid:0x00000011
                      rmsg:"" (0x00100102 0x0000002c 0x00000000)
                 info->nd:0
               info->srcnd:0
                 info->pid:12302
                 info->tid:1
                info->chid:1
               info->scoid:1073741841
                info->coid:2
              info->msglen:60
           info->srcmsglen:60
           info->dstmsglen:2147483647
            info->priority:15
               info->flags:0
            info->reserved:0
t:0x4c0b89e9 CPU:00 THREAD  :THREADY       pid:4 tid:1
t:0x4c0b8b2e CPU:00 THREAD  :THRUNNING     pid:1 tid:2
                    .
                    .
                    .
t:0x5a0dc58d CPU:00 THREAD  :THRUNNING     pid:7 tid:6
t:0x5a0dc6d0 CPU:00 THREAD  :THREADY       pid:1 tid:1
t:0x5a0dcb88 CPU:00 KER_EXIT:MSG_RECEIVEV/14
                     rcvid:0x00000000
                      rmsg:"" (0x00000000 0x00000000 0x00000030)
                 info->nd:0
               info->srcnd:0
                 info->pid:0
                 info->tid:0
                info->chid:0
               info->scoid:0
                info->coid:0
              info->msglen:0
           info->srcmsglen:0
           info->dstmsglen:0
            info->priority:0
               info->flags:0
            info->reserved:0
t:0x5a0dd3f8 CPU:00 KER_CALL:MSG_RECEIVEV/14 chid:0x00000009 rparts:16
```

```
t:0x5a0dd58a CPU:00 THREAD  :THRECEIVE     pid:7 tid:6
t:0x5a0dd6f6 CPU:00 THREAD  :THRUNNING     pid:1 tid:1
```

C File: eh_simple.c

```
/*
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 *
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 * modification, disclosure, distribution or transfer of this software,
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 * more information (including whether this source code file has been
 * published) please email licensing@qnx.com.
 */

#ifdef __USAGE
%C - instrumentation example

%C - example that illustrates the very basic use of
  the TraceEvent() kernel call and the instrumentation
  module with tracelogger in a daemon mode.

  Two events from two classes are included and monitored
  interchangeably. The flow control of monitoring the
  specified events is controlled with attached event
  handlers.

  In order to use this example, start the tracelogger
  in the deamon mode as:

  tracelogger -n 1 -d1

  After executing the example, the tracelogger (daemon)
  will log the specified number of iterations and then
  terminate. There are no messages printed uppon successful
  completion of the example. You can view the intercepted
  events with the traceprinter utility.

  See accompanied documentation and comments within
  the example source code for more explanations.
#endif

#include <unistd.h>
#include <sys/trace.h>
#include <sys/kercalls.h>

#include "instrex.h"

/*
 * Prepare event structure where the event data will be
 * stored and passed to an event handler.
 */
event_data_t e_d_1;
_Uint32t     data_array_1[20]; /* 20 elements for potential args. */

event_data_t e_d_2;
_Uint32t     data_array_2[20]; /* 20 elements for potential args. */

/*
 * Global state variable that controls the
 * event flow between two events
 */
int g_state;

/*
 * Event handler attached to the event "ring0"
 * from the _NTO_TRACE_KERCALL class.
 */
int call_ring0_eh(event_data_t* e_d)
{
if(g_state) {
g_state = !g_state;
```

```
return (1);
}

return (0);
}

/*
 * Event handler attached to the event _NTO_TRACE_THRUNNING
 * from the _NTO_TRACE_THREAD (thread) class.
 */
int thread_run_eh(event_data_t* e_d)
{
if(!g_state) {
g_state = !g_state;
return (1);
}

return (0);
}


int main(int argc, char **argv)
{
/*
 * First fill arrays inside event data structures
 */
e_d_1.data_array = data_array_1;
e_d_2.data_array = data_array_2;

/*
 * Just in case, turn off all filters, since we
 * don't know their present state - go to the
 * known state of the filters.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_DELALLCLASSES));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_THREAD));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_THREAD));

/*
 * Set fast emitting mode
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_SETALLCLASSESFAST));

/*
 * Obtain I/O privileges before adding event handlers
 */
if (ThreadCtl(_NTO_TCTL_IO, 0)!=EOK) { /* obtain I/O privileges         */
(void) fprintf(stderr, "argv[0]: Fail to obtain I/O privileges - root privileges\n");

return (-1);
}

/*
 * Intercept one event from class _NTO_TRACE_KERCALL,
 * event __KER_MSG_READV.
 */
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENT, _NTO_TRACE_KERCALLENTER, __KER_RING0)
);

/*
 * Add event handler to the event "ring0"
 * from _NTO_TRACE_KERCALL class.
 */
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENTHANDLER,
                   _NTO_TRACE_KERCALLENTER, __KER_RING0, call_ring0_eh, &e_d_1)
);
```

```
/*
 * Intercept one event from class _NTO_TRACE_THREAD
 */
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENT, _NTO_TRACE_THREAD, _NTO_TRACE_THRUNNING)
);


/*
 * Add event event handler to the _NTO_TRACE_THRUNNING event
 * from the _NTO_TRACE_THREAD (thread) class.
 */
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_ADDEVENTHANDLER,
                    _NTO_TRACE_THREAD, _NTO_TRACE_THRUNNING, thread_run_eh, &e_d_2)
);

/*
 * Start tracing process
 *
 * During the tracing process, the tracelogger (which
 * is being executed in a daemon mode) will log all events.
 * The number of full logged iterations has been specified
 * to be 1.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_START));

/*
 * During one second collect all events
 */
(void) sleep(1);

/*
 * Stop tracing process by closing the event stream.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_STOP));

/*
 * Flush the internal buffer since the number
 * of stored events could be less than
 * "high water mark" of one buffer (715 events).
 *
 * The tracelogger will probably terminate at
 * this point, since it has been executed with
 * one iterration (-n 1 "option").
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_FLUSHBUFFER));

/*
 * Delete event handlers before exiting to avoid execution
 * in the missing address space.
 */
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_DELEVENTHANDLER, _NTO_TRACE_KERCALLENTER, __KER_RING0)
);
TRACE_EVENT
(
 argv[0],
 TraceEvent(_NTO_TRACE_DELEVENTHANDLER, _NTO_TRACE_THREAD, _NTO_TRACE_THRUNNING)
);

/*
 * Wait one second before terminating to hold the address space
 * of the event handlers.
 */
(void) sleep(1);

return (0);
}
```

Sample result file: eh_sample.results.txt

```
TRACEPRINTER version 0.97
TRACEPARSER LIBRARY version 0.98
 -- HEADER FILE INFORMATION --
       TRACE_FILE_NAME:: /dev/shmem/tracebuffer
            TRACE_DATE:: Fri Aug 17 09:18:04 2001
       TRACE_VER_MAJOR:: 0
       TRACE_VER_MINOR:: 97
   TRACE_LITTLE_ENDIAN:: TRUE
        TRACE_ENCODING:: 16 byte events
       TRACE_BOOT_DATE:: Fri Aug 17 09:02:16 2001
  TRACE_CYCLES_PER_SEC:: 132980400
         TRACE_CPU_NUM:: 1
         TRACE_SYSNAME:: QNX
        TRACE_NODENAME:: localhost
     TRACE_SYS_RELEASE:: 6.1.0
     TRACE_SYS_VERSION:: 2001/08/15-08:15:15
         TRACE_MACHINE:: x86pc
     TRACE_SYSPAGE_LEN:: 2248
 -- KERNEL EVENTS --
.
.
.
t:0x31ea0f3d CPU:00 THREAD  :THRUNNING     pid:245775 tid:1
t:0x31ebec31 CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x31eca36f CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x31eea437 CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x31ef5e6d CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x31f15ab9 CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x31f21f4f CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x31f41a0b CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x31f4dfa9 CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x31f6d8a7 CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x31f79c47 CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x31f99525 CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x31fa5d5f CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x31fc59a9 CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x31fd2879 CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x31ff2137 CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x31fffe11 CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x32031b27 CPU:00 KER_CALL:RING0/02 func_p:ff836f16 arg_p:e3ff5e9c
t:0x3203584f CPU:00 THREAD  :THRUNNING     pid:98317 tid:1
t:0x3204df2d CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x32058db7 CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x32078fcd CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x32084dbb CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x320a471b CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x320c3501 CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x320e2ebd CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
.
.
.
t:0x35e2c6cf CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x35e38657 CPU:00 THREAD  :THRUNNING     pid:7 tid:5
t:0x35e59269 CPU:00 KER_CALL:RING0/02 func_p:ff82874e arg_p:0
t:0x35e6766d CPU:00 THREAD  :THRUNNING     pid:7 tid:5
```

C File: usr_event_simple.c

```
/*
 * Copyright 2003, QNX Software Systems Ltd. All Rights Reserved.
 *
 * This source code may contain confidential information of QNX Software
 * Systems Ltd.  (QSSL) and its licensors. Any use, reproduction,
 * modification, disclosure, distribution or transfer of this software,
 * or any software which includes or is based upon any of this code, is
 * prohibited unless expressly authorized by QSSL by written agreement. For
 * more information (including whether this source code file has been
 * published) please email licensing@qnx.com.
 */
```

```
#ifdef __USAGE
%C - instrumentation example

%C - example that illustrates the very basic use of
  the TraceEvent() kernel call and the instrumentation
  module with tracelogger in a daemon mode.

  All classes and their events are included and monitored.
  Additionally, four user generated simple events and
  one string event are intercepted.

  In order to use this example, start the tracelogger
  in the deamon mode as:

  tracelogger -n iter_number -d1

  with iter_number = your choice of 1 through 10

  After executing the example, the tracelogger (daemon)
  will log the specified number of iterations and then
  terminate. There are no messages printed uppon successful
  completion of the example. You can view the intercepted
  events with the traceprinter utility. The intercepted
  user events (class USREVENT) have event id(s)
  (EVENT) equal to: 111, 222, 333, 444 and 555.

  See accompanied documentation and comments within
  the example source code for more explanations.
#endif

#include <sys/trace.h>
#include <unistd.h>

#include "instrex.h"

int main(int argc, char **argv)
{
/*
 * Just in case, turn off all filters, since we
 * don't know their present state - go to the
 * known state of the filters.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_DELALLCLASSES));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_KERCALL));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSPID, _NTO_TRACE_THREAD));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_CLRCLASSTID, _NTO_TRACE_THREAD));

/*
 * Set fast emitting mode for all classes and
 * their events.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_SETALLCLASSESFAST));

/*
 * Intercept all event classes
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_ADDALLCLASSES));

/*
 * Start tracing process
 *
 * During the tracing process, the tracelogger (which
 * is being executed in a daemon mode) will log all events.
 * The number of full logged iterations is user specified.
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_START));

/*
 * Insert four user defined simple events and one string
 * event into the event stream. The user events have
 * arbitrary event id(s): 111, 222, 333, 444 and 555
 * (possible values are in the range 0...1023).
 * Every user event with id=(111, ..., 555) has attached
```

```
 * two numerical data (simple event): ({1,11}, ..., {4,44})
 * and string (string event id=555) "Hello world".
 */
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_INSERTSUSEREVENT, 111, 1, 11));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_INSERTSUSEREVENT, 222, 2, 22));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_INSERTSUSEREVENT, 333, 3, 33));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_INSERTSUSEREVENT, 444, 4, 44));
TRACE_EVENT(argv[0], TraceEvent(_NTO_TRACE_INSERTUSRSTREVENT,555, "Hello world" ));

/*
 * The main() of this execution flow returns.
 * However, the main() function of the tracelogger
 * will return after registering the specified number
 * of events.
 */
return (0);
}
```

Sample result file: usr_event_simple.results.txt

```
TRACEPRINTER version 1.02
TRACEPARSER LIBRARY version 1.02
 -- HEADER FILE INFORMATION --
       TRACE_FILE_NAME:: /dev/shmem/tracebuffer
            TRACE_DATE:: Mon Apr 25 05:37:55 1988
       TRACE_VER_MAJOR:: 1
       TRACE_VER_MINOR:: 02
   TRACE_LITTLE_ENDIAN:: TRUE
        TRACE_ENCODING:: 16 byte events
       TRACE_BOOT_DATE:: Mon Apr 25 02:28:06 1988
  TRACE_CYCLES_PER_SEC:: 400013900
          TRACE_CPU_NUM:: 2
          TRACE_SYSNAME:: QNX
         TRACE_NODENAME:: localhost
     TRACE_SYS_RELEASE:: 6.2.1
     TRACE_SYS_VERSION:: 2002/12/09-10:13:08est
         TRACE_MACHINE:: x86pc
     TRACE_SYSPAGE_LEN:: 2400
 -- KERNEL EVENTS --
t:0x74a43dfa CPU:01 CONTROL :TIME msb:0x00000427, lsb(offset):0x74a43cb6
                            .
                            .
                            .
t:0x74a4d699 CPU:01 PROCESS :PROCCREATE_NAME
                     ppid:10
                      pid:28686
name:/cvs/utils/t/traceprinter/examples/usr_event_simple/nto/x86/o/examples-usr_event_simple
t:0x74a4dcb2 CPU:01 THREAD  :THCREATE      pid:28686 tid:1
t:0x74a4ddb7 CPU:01 THREAD  :THRUNNING     pid:28686 tid:1
t:0x74a4e0a8 CPU:01 KER_EXIT:TRACE_EVENT/01 ret_val:0x00000000 empty:0x00000000
t:0x74a4e3a2 CPU:01 KER_CALL:TRACE_EVENT/01 mode:0x4000001e class[header]:0x0000006f
t:0x74a4e4f1 CPU:01 USREVENT:EVENT:111, d0:0x00000001 d1:0x0000000b
t:0x74a4e650 CPU:01 KER_EXIT:TRACE_EVENT/01 ret_val:0x00000000 empty:0x00000000
t:0x74a4e8e5 CPU:01 KER_CALL:TRACE_EVENT/01 mode:0x4000001e class[header]:0x000000de
t:0x74a4e9dc CPU:01 USREVENT:EVENT:222, d0:0x00000002 d1:0x00000016
t:0x74a4eb51 CPU:01 KER_EXIT:TRACE_EVENT/01 ret_val:0x00000000 empty:0x00000000
t:0x74a4ee23 CPU:01 KER_CALL:TRACE_EVENT/01 mode:0x4000001e class[header]:0x0000014d
t:0x74a4ef07 CPU:01 USREVENT:EVENT:333, d0:0x00000003 d1:0x00000021
t:0x74a4f07c CPU:01 KER_EXIT:TRACE_EVENT/01 ret_val:0x00000000 empty:0x00000000
t:0x74a4f300 CPU:01 KER_CALL:TRACE_EVENT/01 mode:0x4000001e class[header]:0x000001bc
t:0x74a4f41e CPU:01 USREVENT:EVENT:444, d0:0x00000004 d1:0x0000002c
t:0x74a4f58a CPU:01 KER_EXIT:TRACE_EVENT/01 ret_val:0x00000000 empty:0x00000000
t:0x74a4f826 CPU:01 KER_CALL:TRACE_EVENT/01 mode:0x30000020 class[header]:0x0000022b
t:0x74a4fa4f CPU:01 USREVENT:EVENT:555 STR:"Hello world"
t:0x74a4fc63 CPU:01 KER_EXIT:TRACE_EVENT/01 ret_val:0x00000000 empty:0x00000000
                            .
                            .
                            .
```

Chapter 9

Hints and Troubleshooting

In this chapter. . .

How to check for the Instrumented Kernel mode

When in Instrumented Kernel mode, nothing is visibly different. The performance won't noticeably change either. Thus, it can be tough to tell whether you've successfully changed into Instrumented Kernel mode. And forgetting to start the Instrumented Kernel is something we all do once in a while.

To check for Instrumented Kernel mode, type:

```
ls /proc/boot
```

If one of the files listed is **procnto-*instr**, you're successfully running the Instrumented Kernel. But if the file is **procnto**, you're running the noninstrumented kernel

To start the Instrumented Kernel, see the Tutorial chapter.

Run as `root`

The data-capture utilities require **root** privileges to allocate buffer memory or to use functions such as *InterruptHookTrace()*. Data-capture utilities won't work properly without these privileges.

Monitor diskspace

Because the **tracelogger** may write data at rates well in excess of 20 M/min, running it for prolonged periods or running it repeatedly can use up a surprisingly large amount of space. If diskspace is low, wipe old log files regularly. (In its default mode, **tracelogger** overwrites its previous default file.)

Chapter 10

Functions

This chapter includes descriptions of the functions of the System Analysis Toolkit.

- *InterruptHookTrace()*
- *TraceEvent()*
- *traceparser()*
- *traceparser_cs()*
- *traceparser_cs_range()*
- *traceparser_debug()*
- *traceparser_destroy()*
- *traceparser_get_info()*
- *traceparser_init()*

InterruptHookTrace()

Attach the pseudo interrupt handler that's used by the instrumented module

Synopsis:

```
#include <sys/neutrino.h>

int InterruptHookTrace(
   const struct sigevent * (* handler)(int),
   unsigned flags );
```

Library:

```
libc
```

Description:

The *InterruptHookTrace()* function attaches the pseudo interrupt handler *handler* which is used by the instrumented module.

Before calling this function, the thread must request I/O privileges by calling:

```
ThreadCtl( _NTO_TCTL_IO, 0 );
```

The *handler* argument specifies the pseudo interrupt handler that receives trace events from the kernel.

The *flags* argument is a bitwise OR of the following values, or 0:

Flag	Description
_NTO_INTR_FLAGS_END	Put the new handler at the end of the list of existing handlers (for shared interrupts) instead of the start.

_NTO_INTR_FLAGS_END

The interrupt structure allows trace interrupts to be shared. For example, if two processes take over the same trace interrupt, both handlers are invoked consecutively. When a handler attaches, it's placed in front of any existing handlers for that interrupt and is called first. This behavior can be changed by setting the _NTO_INTR_FLAGS_END flag in the *flags* argument. This adds the handler at the end of any existing handlers.

Blocking states

This call doesn't block.

Returns:

An interrupt function ID, or -1 if an error occurs (*errno* is set).

Errors:

EAGAIN	All kernel interrupt entries are in use.
EFAULT	A fault occurred when the kernel tried to access the buffers provided.
EPERM	The process doesn't have superuser capabilities.

Classification:

QNX Neutrino

Safety	
Cancellation point	No
Interrupt handler	No
Signal handler	Yes
Thread	Yes

See also:

TraceEvent()

Synopsis:

```
#include <sys/neutrino.h>
#include <sys/trace.h>

int TraceEvent( int mode,
                ... );
```

Library:

libc

Description:

The *TraceEvent()* function controls all stages of the instrumentation process including initialization, starting, stopping, filter control and event insertion. These stages are broadly grouped into the following categories:

- Buffer and execution control
- Fast/wide mask configuration
- Static rules filter configuration
- Dynamic rules filter configuration
- User-generated trace events

This description also includes these sections:

- Argument descriptions
- *class* argument descriptions

Filter and mask settings are made regardless of the previous settings. Use care to not accidentally override or delete previous configurations.

Buffer and execution control

These modes control the buffer set up as well as start and stop logging.

_NTO_TRACE_ALLOCBUFFER, _NTO_TRACE_DEALLOCBUFFER

```
TraceEvent(_NTO_TRACE_ALLOCBUFFER, uint bufnum, void** linkliststart)
TraceEvent(_NTO_TRACE_DEALLOCBUFFER)
```

The allocation option creates and initializes the internal circular link list of trace buffers. The created and initialized trace buffers hold the emitting trace events.

bufnum	Number of buffers to allocate.
**linkliststart*	Physical address of the beginning of the circular link list of allocated trace buffers.

Allocated trace buffers can store 1024 simple trace events.

If your application calls this mode, it must run as **root**.

The deallocation option deallocates all of the previously allocated trace buffers. All events stored inside of the trace buffers are lost.

_NTO_TRACE_FLUSHBUFFER

```
TraceEvent(_NTO_TRACE_FLUSHBUFFER)
```

Forces flashing of the buffer regardless of the trace event number it contains.

_NTO_TRACE_QUERYEVENTS

```
TraceEvent(_NTO_TRACE_QUERYEVENTS)
```

Returns the number of simple trace events that's currently stored in the trace buffer.

_NTO_TRACE_START, _NTO_TRACE_STARTNOSTATE, _NTO_TRACE_STOP

```
TraceEvent(_NTO_TRACE_START)
TraceEvent(_NTO_TRACE_STARTNOSTATE)
TraceEvent(_NTO_TRACE_STOP)
```

Starts/stops the instrumentation process. The event stream containing the trace events is opened/closed.

The _NTO_TRACE_START and _NTO_TRACE_STARTNOSTATE options are the same except the latter suppresses the initial system state information (names of processes and thread IDs.)

_NTO_TRACE_SETRINGMODE

```
TraceEvent(_NTO_TRACE_SETRINGMODE)
```

Sets a ring mode of the internal circular link list. When an external application uses this mode, the kernel stores all events in a circular fashion inside the link list without flushing them. The maximum capturing time (without history overwriting) is determined by the number of allocated buffers, as well as by the number of generated trace events.

_NTO_TRACE_SETLINEARMODE

```
TraceEvent(_NTO_TRACE_SETLINEARMODE)
```

Sets a default linear mode of the internal circular link list. When using this mode, every filled-up buffer is captured and flushed immediately.

Fast/wide mask configuration

These modes control the operation of the fast/wide mask. For more information about this mask, see the Filtering chapter in this guide.

Currently, only the kernel call related classes are affected by the fast/wide modes. In fast mode, only two of the most important kernel call arguments and two of the most important kernel call return values are intercepted. See the Kernel call arguments and return values appendix for the list of the intercepted arguments and return values.

_NTO_TRACE_SETALLCLASSESFAST, _NTO_TRACE_SETALLCLASSESWIDE

```
TraceEvent(_NTO_TRACE_SETALLCLASSESFAST)
TraceEvent(_NTO_TRACE_SETALLCLASSESWIDE)
```

Sets the fast/wide emitting mode for all classes and events.

_NTO_TRACE_SETCLASSFAST, _NTO_TRACE_SETCLASSWIDE

```
TraceEvent(_NTO_TRACE_SETCLASSFAST, int class)
TraceEvent(_NTO_TRACE_SETCLASSWIDE, int class)
```

Sets the fast/wide emitting mode for all events within the specified *class*.

_NTO_TRACE_SETEVENTFAST, _NTO_TRACE_SETEVENTWIDE

```
TraceEvent(_NTO_TRACE_SETEVENTFAST, int class, int event)
TraceEvent(_NTO_TRACE_SETEVENTWIDE, int class, int event)
```

Sets the fast/wide emitting mode for the specified *event* for the specified *class*.

Static rules filter configuration

These modes control the operation of the static rules filter. For more information about this filter, see the Filtering chapter in this guide.

_NTO_TRACE_ADDALLCLASSES, _NTO_TRACE_DELALLCLASSES

```
TraceEvent(_NTO_TRACE_ADDALLCLASSES)
TraceEvent(_NTO_TRACE_DELALLCLASSES)
```

Emit/suppress trace events for all classes and events.

_NTO_TRACE_ADDCLASS, _NTO_TRACE_DELCLASS

```
TraceEvent(_NTO_TRACE_ADDCLASS, class)
TraceEvent(_NTO_TRACE_DELCLASS, class)
```

Emit/suppress all trace events from a specific *class*.

_NTO_TRACE_ADDEVENT, _NTO_TRACE_DELEVENT

```
TraceEvent(_NTO_TRACE_ADDEVENT, class, event)
TraceEvent(_NTO_TRACE_DELEVENT, class, event)
```

Emit/suppress a trace *event* from a specific *class*.

_NTO_TRACE_SETCLASSPID, _NTO_TRACE_CLRCLASSPID, _NTO_TRACE_SETCLASSTID, _NTO_TRACE_CLRCLASSTID

```
TraceEvent(_NTO_TRACE_SETCLASSPID, int class, pid_t pid)
TraceEvent(_NTO_TRACE_CLRCLASSPID, int class)
TraceEvent(_NTO_TRACE_SETCLASSTID, int class, pid_t pid, tid_t tid)
TraceEvent(_NTO_TRACE_CLRCLASSTID, int class)
```

Emits/suppresses all events from a specified process ID (and thread ID).

_NTO_TRACE_SETEVENTPID, _NTO_TRACE_CLREVENTPID, _NTO_TRACE_SETEVENTTID, _NTO_TRACE_CLREVENTTID,

```
TraceEvent(_NTO_TRACE_SETEVENTPID, int class, int event, pid_t pid)
TraceEvent(_NTO_TRACE_CLREVENTPID, int class, int event)
TraceEvent(_NTO_TRACE_SETEVENTTID, int class, int event, pid_t pid, tid_t tid)
TraceEvent(_NTO_TRACE_CLREVENTTID, int class, int event)
```

Emits/suppresses a specific *event* for a specified process ID (and thread ID.)

Dynamic rules filter configuration

These modes control the operation of the dynamic rules filter. For more information about this filter, see the Filtering chapter in this guide.

Event Handler Data Access

The access to the trace event information from within the event handler can be done using members of the **event_data_t**.

The valid layout of the **event_data_t** structure (declared in sys/trace.h) is as follow:

```
/* event data filled by an event handler */
typedef struct
    {
    __traceentry header;      /* same as traceevent header    */
    _Uint32t*    data_array;  /* initialized by the user      */
    _Uint32t     el_num;      /* number of elements returned  */
    void*        area;        /* user data                    */
    _Uint32t     feature_mask;/* bits indicate valid features */
    _Uint32t     feature[_NTO_TRACE_FI_NUM]; /* feature array
                                             - additional data */
    } event_data_t;
```

The bits of the member feature_mask are related to any additional feature (argument) that could be accessed inside the event handler. All standard data arguments, the ones that correspond to the data arguments of the trace-event, are delivered without changes within array data_array[]. If any particular bit of the feature_mask is set to value equal to 1, then, the feature corresponding to this bit can be accessed within array feature[]. Otherwise, the feature should not be accessed. For example, if the expression:

```
feature_mask & _NTO_TRACE_FMPID
```

has its logical value equal to TRUE, then, the additional feature corresponding to identifier _NTO_TRACE_FMPID (PID) can be accessed as:

```
my_pid = feature[_NTO_TRACE_FIPID];
```

For every additional feature there have been provided two constants:

_NTO_TRACE_FM* -** feature parameter masks

_NTO_TRACE_FI* -** feature index parameters

to check and to access the given feature.

_NTO_TRACE_ADDEVENTHANDLER, _NTO_TRACE_DELEVENTHANDLER

```
TraceEvent(_NTO_TRACE_ADDEVENTHANDLER,
           class,
           event,
           int (*event_hdlr)(event_data_t*),
           event_data_t* data_struct)
TraceEvent(_NTO_TRACE_DELEVENTHANDLER,
           class,
           event)
```

_NTO_TRACE_ADDCLASSEVHANDLER, _NTO_TRACE_DELCLASSEVHANDLER

```
TraceEvent(_NTO_TRACE_ADDCLASSEVHANDLER,
           class,
           int (*event_hdlr)(event_data_t*),
           event_data_t* data_struct)

TraceEvent(_NTO_TRACE_DELCLASSEVHANDLER,
           class)
```

Attaches/deletes the event handler for a specified class, where:

event_hdlr Pointer to the event handler.

data_struct Pointer to the data structure **event_data_t**.

In order to emit an event data, a dynamic filter (event handler) has to return 1. If both types of the dynamic filters (event handler and class event handler) are applicable to a particular event, the event is emitted if both event handlers return 1.

User-generated trace events

These modes control the insertion of “fake” events into the event stream.

_NTO_TRACE_INSERTEVENT

```
TraceEvent(_NTO_TRACE_INSERTEVENT, int head, int stamp, int data0, int data1)
```

Inserts a generic, “real” event into the event stream. It’s powerful but because the API doesn’t do any of the interpretation for you, this function should be used with care by advanced users only. The data-interpretation program must be modified to properly interpret the event.

The arguments are:

head Header of the trace event.

stamp Time stamp.

data0 Data d0.

data1 Data d1.

_NTO_TRACE_INSERTSUSEREVENT, _NTO_TRACE_INSERTCUSEREVENT, _NTO_TRACE_INSERTUSRSTREVENT

```
TraceEvent(_NTO_TRACE_INSERTSUSEREVENT, int event, int data0, int data1)
TraceEvent(_NTO_TRACE_INSERTCUSEREVENT, int event,  unsigned * buf, unsigned len)
TraceEvent(_NTO_TRACE_INSERTUSRSTREVENT, int event, const char * str)
```

The *len* argument represents the number of integers in *buf*.

These modes insert user-created events into the event stream. Because the API handles details such as timestamping, they're reasonably easy to use.

_NTO_TRACE_INSERTSUSEREVENT

Simple user event.

_NTO_TRACE_INSERTCUSEREVENT

Complex user event.

_NTO_TRACE_INSERTUSRSTREVENT

User string event.

The arguments are:

event	User defined event code. The value should be between _NTO_TRACE_USERFIRST and _NTO_TRACE_USERLAST.
str	Null terminated string.
data0	Data d0.
data1	Data d1.

The *TraceEvent()* function controls all stages of the instrumentation process such as initialization, starting, execution control, and stopping. These stages consist of the following activities:

- creating an internal circular linked list of trace buffers
- initializing filters
- turning on or off the event stream
- deallocating the internal circular linked list of trace buffers

The *TraceEvent()* function accepts any number of arguments grouped logically as follows:

```
TraceEvent(mode [,class [,event]] [,p1 [,p2 [,p3 ... [,pn]]]])
```

Here's a description of the arguments:

mode

Specifies a control action (compulsory).

You'll find a description for each *mode* argument listed below in the *mode* argument descriptions section.

Some *mode* arguments require additional arguments; see the table of argument hierarchy for details. Valid arguments are:

_NTO_TRACE_ADDALLCLASSES
_NTO_TRACE_ADDCLASS
_NTO_TRACE_ADDEVENT
_NTO_TRACE_ADDEVENTHANDLER
_NTO_TRACE_ALLOCBUFFER
_NTO_TRACE_CLRCLASSPID
_NTO_TRACE_CLRCLASSTID
_NTO_TRACE_CLREVENTPID
_NTO_TRACE_CLREVENTTID
_NTO_TRACE_DEALLOCBUFFER
_NTO_TRACE_DELALLCLASSES
_NTO_TRACE_DELCLASS
_NTO_TRACE_DELEVENT
_NTO_TRACE_DELEVENTHANDLER
_NTO_TRACE_FLUSHBUFFER
_NTO_TRACE_INSERTCUSEREVENT
_NTO_TRACE_INSERTEVENT
_NTO_TRACESUSEREVENT
_NTO_TRACE_INSERTUSRSTREVENT
_NTO_TRACE_QUERYEVENTS
_NTO_TRACE_SETRINGMODE
_NTO_TRACE_SETLINEARMODE
_NTO_TRACE_SETALLCLASSESFAST
_NTO_TRACE_SETALLCLASSESWIDE
_NTO_TRACE_SETCLASSFAST
_NTO_TRACE_SETCLASSPID
_NTO_TRACE_SETCLASSTID
_NTO_TRACE_SETCLASSWIDE
_NTO_TRACE_SETEVENTFAST
_NTO_TRACE_SETEVENTPID
_NTO_TRACE_SETEVENTTID
_NTO_TRACE_SETEVENTWIDE
_NTO_TRACE_START
_NTO_TRACE_STOP
_NTO_TRACE_STARTNOSTATE

class

You'll find a description for each *class* argument listed below in the *class* argument descriptions section. Some *class* arguments may require additional arguments; see the table of argument hierarchy for details.

Valid arguments are:

_NTO_TRACE_CONTROL
_NTO_TRACE_INT
_NTO_TRACE_INTENTER
_NTO_TRACE_INTEXIT
_NTO_TRACE_KERCALL
_NTO_TRACE_KERCALLENTER
_NTO_TRACE_KERCALLEXIT
_NTO_TRACE_PROCESS
_NTO_TRACE_THREAD
_NTO_TRACE_VTHREAD

event

Redirects the control action specified by the *mode* and *class* towards a trace event within the class.

You'll find a description for each *event* argument listed below in the *event* argument descriptions section. Some *event* arguments may require additional arguments; see the table of argument hierarchy for details.

The following table shows the valid *event* arguments for a particular *class*:

If the value of *class* is:	**Then a valid *event* argument is:**
_NTO_TRACE_CONTROL	_NTO_TRACE_CONTROLTIME
_NTO_TRACE_INT, _NTO_TRACE_INTENTER, _NTO_TRACE_INTEXIT	a logical interrupt vector number
_NTO_TRACE_KERCALL, _NTO_TRACE_KERCALLENTER, _NTO_TRACE_KERCALLEXIT	A valid __KER_* keyword from **<sys/kercalls.h>** (such as __KER_MSG_SENDV.)
_NTO_TRACE_PROCESS	_NTO_TRACE_PROCCREATE, _NTO_TRACE_PROCCREATE_NAME, _NTO_TRACE_PROCDESTROY, _NTO_TRACE_PROCDESTROY_NAME

continued...

If the value of *class* is:	Then a valid *event* argument is:
_NTO_TRACE_THREAD	_NTO_TRACE_THCONDVAR, _NTO_TRACE_THCREATE, _NTO_TRACE_THDEAD, _NTO_TRACE_THDESTROY, _NTO_TRACE_THINTR, _NTO_TRACE_THJOIN, _NTO_TRACE_THMUTEX, _NTO_TRACE_THNANOSLEEP, _NTO_TRACE_THNET_REPLY, _NTO_TRACE_THNET_SEND, _NTO_TRACE_THREADY, _NTO_TRACE_THRECEIVE, _NTO_TRACE_THREPLY, _NTO_TRACE_THRUNNING, _NTO_TRACE_THSEM, _NTO_TRACE_THSEND, _NTO_TRACE_THSIGSUSPEND, _NTO_TRACE_THSIGWAITINFO, _NTO_TRACE_THSTACK, _NTO_TRACE_THSTOPPED, _NTO_TRACE_THWAITCTX, _NTO_TRACE_THWAITPAGE, _NTO_TRACE_THWAITTHREAD

continued...

If the value of *class* is:	Then a valid *event* argument is:
_NTO_TRACE_VTHREAD	_NTO_TRACE_VTHCONDVAR, _NTO_TRACE_VTHCREATE, _NTO_TRACE_VTHDEAD, _NTO_TRACE_VTHDESTROY, _NTO_TRACE_VTHINTR, _NTO_TRACE_VTHJOIN, _NTO_TRACE_VTHMUTEX, _NTO_TRACE_VTHNANOSLEEP, _NTO_TRACE_VTHNET_REPLY, _NTO_TRACE_VTHNET_SEND, _NTO_TRACE_VTHREADY, _NTO_TRACE_VTHRECEIVE, _NTO_TRACE_VTHREPLY, _NTO_TRACE_VTHRUNNING, _NTO_TRACE_VTHSEM, _NTO_TRACE_VTHSEND, _NTO_TRACE_VTHSIGSUSPEND, _NTO_TRACE_VTHSIGWAITINFO, _NTO_TRACE_VTHSTACK, _NTO_TRACE_VTHSTOPPED, _NTO_TRACE_VTHWAITCTX, _NTO_TRACE_VTHWAITPAGE, _NTO_TRACE_VTHWAITTHREAD

p1...pn

Specifies any additional parameters that are required to perform the desired control action.

Argument descriptions

The following are the generic arguments used for the *TraceEvent()* modes. Mode-specific arguments accompany the mode description:

mode The control action. The *mode* is always the first argument in the *TraceEvent()* function. Depending upon the value of *mode*, further arguments may be necessary. The description of what each *mode* does appears earlier in this section. Examples of the *mode* include: _NTO_TRACE_ALLOCBUFFER,, _NTO_TRACE_SETCLASSFAST.

class The category of events. All the events are logically grouped into several classes. A list of valid classes is given in *class* argument descriptions, later in this section.

event The event. Because the events are grouped by *class*, the *event* must be a member of the *class* in order to be valid. A list of events can be found in the Kernel Call Arguments and Return Values chapter in this guide.

pid Process ID to be registered.

tid Thread ID to be registered.

class argument descriptions

The *class* argument may be one of the following:

_NTO_TRACE_CONTROL

Specifies the set of control events (i.e. time-overflow event) that're used by the communication protocol between the microkernel and **`tracelogger`**.

_NTO_TRACE_INTENTER,
_NTO_TRACE_INTEXIT

Specifies the set of interrupt entry/exit events.

_NTO_TRACE_KERCALLENTER,
_NTO_TRACE_KERCALLEXIT

Specifies the set of kernel call entry/exit events.

_NTO_TRACE_PROCESS

Specifies the set of events associated with process creation and destruction.

_NTO_TRACE_THREAD,
_NTO_TRACE_VTHREAD

Specifies the set of *class* arguments that contain thread (or virtual thread) state changes, and create or destroy events.

There are also "pseudo classes" offered as a convenience:

_NTO_TRACE_KERCALL

Specifies all of the kernel call events: _NTO_TRACE_KERCALLENTER and _NTO_TRACE_KERCALLEXIT.

_NTO_TRACE_INT

Specifies all of the interrupt events: _NTO_TRACE_INTENTER and _NTO_TRACE_INTEXIT.

Returns:

If *mode* is set to _NTO_TRACE_QUERYEVENTS

Number of events in the buffer, or -1 if an error occurs (*errno* is set).

If *mode* isn't set to _NTO_TRACE_QUERYEVENTS

0 for success, or -1 if an error occurs (*errno* is set).

Errors:

ECANCELED	The requested action has been canceled.
EFAULT	Bad internal trace buffer address. The requested action has been specified out of order.
ENOMEM	Insufficient memory to allocate the trace buffers.
ENOSUP	The requested action isn't supported.
EPERM	The application doesn't have permission to perform the action.

Classification:

QNX Neutrino

Safety	
Cancellation point	No
Interrupt handler	Read the *Caveats*
Signal handler	Yes
Thread	Yes

Caveats:

You can call *TraceEvent()* from an interrupt/event handler. However, not all trace modes are valid in this case. The valid trace modes are:

- _NTO_TRACE_INSERTSUSEREVENT
- _NTO_TRACE_INSERTCUSEREVENT
- _NTO_TRACE_INSERTUSRSTREVENT
- _NTO_TRACE_INSERTEVENT
- _NTO_TRACE_STOP
- _NTO_TRACE_STARTNOSTATE
- _NTO_TRACE_START

See also:

InterruptAttach(), InterruptHookTrace()

traceparser()

Execute a parsing procedure with user data

Synopsis:

```
#include <sys/traceparser.h>

extern int traceparser (
   struct traceparser_state * stateptr,
   void * userdata,
   const char * filename );
```

Library:

libtraceparser

Description:

The *traceparser()* function starts the parsing procedure *filename*. It also executes the user defined callback functions and passes the *userdata* to it. The *stateptr* argument is an opaque structure obtained from *traceparser_init()*.

Returns:

0 Success

-1 Failure; *errno* is set. See also *traceparser_get_info()* for further details.

Classification:

QNX Neutrino

Safety	
Cancellation point	No
Interrupt handler	No
Signal handler	No
Thread	No

See also:

traceparser_get_info(), *traceparser_init()*

traceparser_cs()

Attach a callback

Synopsis:

```
#include <traceparser.h>

int traceparser_cs (
   struct traceparser_state * stateptr,
   void * userdata,
   tracep_callb_func_t funcptr,
   unsigned class,
   unsigned event );
```

Library:

libtraceparser

Description:

The *traceparser_cs()* function attaches one callback function, specified by the pointer *funcptr*, to one particular *event*, from one particular *class*. The user data (*userdata*) is passed to the attached callback function upon execution. The *stateptr* is an opaque structure obtained from *traceparser_init()*.

Returns:

0 Success; a pointer to the event

-1 Failure; *errno* is set. See also *traceparser_get_info()* for further details.

Classification:

QNX Neutrino

Safety	
Cancellation point	No
Interrupt handler	No
Signal handler	No
Thread	No

See also:

traceparser_get_info(), *traceparser_init()*

traceparser_cs_range()

Attach a callback to a range of events

Synopsis:

```
#include <traceparser.h>

int traceparser_cs_range (
   struct traceparser_state * stateptr,
   void * userdata,
   tracep_callb_func_t funcptr,
   unsigned class,
   unsigned firstevent,
   unsigned lastevent );
```

Library:

libtraceparser

Description:

The *traceparser_cs_range()* function attaches one callback function, given by the pointer *funcptr*, to a range of events from *firstevent* through to *lastevent* inclusive, from one particular *class*. The user data (*userdata*) is passed to the registered callback function (*funcptr*) upon execution. The *stateptr* is an opaque structure obtained from *traceparser_init()*.

Returns:

0 Success; a pointer to the list of events.

-1 Failure; *errno* is set. See also *traceparser_get_info()* for further details

Classification:

QNX Neutrino

Safety	
Cancellation point	No
Interrupt handler	No
Signal handler	No
Thread	No

See also:

traceparser_get_info(), traceparser_init()

traceparser_debug()

Set the traceparser debug modes

Synopsis:

```
#include <traceparser.h>

int traceparser_debug (
   struct traceparser_state * stateptr,
   FILE * streamptr,
   unsigned flags );
```

Library:

```
libtraceparser
```

Description:

The *traceparser_debug()* function sets the debug modes of the traceparser module. The *streamptr* argument is a pointer to the debug output stream; *flags* specifies the debug category. The *stateptr* is an opaque structure obtained from *traceparser_init()*.

Debug *flags*

The following is a list of the arguments that may be used for *flags* and the debug level for each:

_TRACEPARSER_DEBUG_ALL
: Everything.

_TRACEPARSER_DEBUG_ERRORS
: Critical errors only.

_TRACEPARSER_DEBUG_EVENTS
: Row input events only.

_TRACEPARSER_DEBUG_HEADER
: Header information only.

_TRACEPARSER_DEBUG_NONE
: No debugging.

_TRACEPARSER_DEBUG_SYSPAGE
: Syspage data only.

Returns:

> 0	Success; a pointer to the event
-1	Failure; *errno* is set. See also *traceparser_get_info()* for further details.

Classification:

QNX Neutrino

Safety	
Cancellation point	No
Interrupt handler	No
Signal handler	No
Thread	Yes

See also:

traceparser_get_info(), traceparser_init()

traceparser_destroy()

Destroys a traceparser state structure

Synopsis:

```
#include <traceparser.h>

void traceparser_destroy (
   struct traceparser_state ** stateptr );
```

Library:

```
libtraceparser
```

Description:

The *traceparser_destroy()* function destroys a previously initialized traceparser state structure, *stateptr*.

Classification:

QNX Neutrino

Safety	
Cancellation point	No
Interrupt handler	No
Signal handler	No
Thread	No

See also:

traceparser_get_info(), traceparser_init()

traceparser_get_info()

Get information about traceparser

Synopsis:

```
#include <sys/traceparser.h>

void * traceparser_get_info (
   struct traceparser_state * stateptr,
    info_modes_t infomodes,
    unsigned * len );
```

Library:

libtraceparser

Description:

The *traceparser_get_info()* function gets information related to the state of the traceparser. The *infomodes* argument may be any of the constants shown below and are defined in **traceparser.h**.

The *len* argument is a pointer to the size of the return buffer. When specified, its contents are changed to indicate the size of the return. This is primarily for the _TRACEPARSER_SYSPAGE and _TRACEPARSER_HEADER_KEYWORDS modes but it'll work for all the modes. For most of the modes, *len* may be NULL.

The *stateptr* is an opaque structure obtained from *traceparser_init()*.

User info modes for *info_modes*

The following are valid user info modes; see the list below for others.

Value for *info_modes* and Pointer to return data type, cast as `void`	**Description**
_TRACEPARSER__INFO_SYSPAGE **`syspage_entry`**	Returns a pointer to the syspage entry.
_TRACEPARSER_INFO_ENDIAN_CONV **`unsigned`**	Returns a dereferenced pointer; 1 if the endian conversion has been applied, 0 if no conversion has been performed.
_TRACEPARSER_INFO_NOW_CALLBACK_CLASS, _TRACEPARSER_INFO_NOW_CALLBACK_EVENT **`unsigned`**	Returns the class or event numerical value of the currently executed callback function. The numerical values are considered opaque and should be used only for other traceparser functions.
_TRACEPARSER_INFO_PREV_CALLBACK_CLASS _TRACEPARSER_INFO_PREV_CALLBACK_EVENT **`unsigned`**	As above, but returns the class or event numerical value of the previously executed callback function.
_TRACEPARSER_INFO_PREV_CALLBACK_RETURN **`int`**	Returns the value of the previously executed callback function.

continued...

Value for *info_modes* and Pointer to return data type, cast as `void`	Description
_TRACEPARSER_INFO_DEBUG **`unsigned`**	Returns the debug category.
_TRACEPARSER_INFO_ERROR **`unsigned`**	Returns the traceparser error level. It must be used to determine traceparser library related errors. (See **`sys/traceparser.h`** for a list of the returned error values.)

Other valid user info modes

The following modes return a pointer to the header field of the buffer. All data types are **`void`**.

- TRACEPARSER_INFO_FILE_NAME
- TRACEPARSER_INFO_DATE
- TRACEPARSER_INFO_VER_MAJOR
- TRACEPARSER_INFO_VER_MINOR
- TRACEPARSER_INFO_LITTLE_ENDIAN
- TRACEPARSER_INFO_BIG_ENDIAN
- TRACEPARSER_INFO_MIDDLE_ENDIAN
- TRACEPARSER_INFO_ENCODING
- TRACEPARSER_INFO_BOOT_DATE
- TRACEPARSER_INFO_CYCLES_PER_SEC
- TRACEPARSER_INFO_CPU_NUM
- TRACEPARSER_INFO_SYSNAME
- TRACEPARSER_INFO_NODENAME
- TRACEPARSER_INFO_SYS_RELEASE
- TRACEPARSER_INFO_SYS_VERSION
- TRACEPARSER_INFO_MACHINE
- TRACEPARSER_INFO_SYSPAGE_LEN

Returns:

A pointer to `void`	Success.
Null	Failure; *errno* is set. See also the _TRACEPARSER_ERROR section of this function for further details.

Classification:

QNX Neutrino

Safety	
Cancellation point	No
Interrupt handler	No
Signal handler	No
Thread	No

See also:

traceparser_get_info(), *traceparser_init()*

traceparser_init()

Initialize or get the state of the traceparser library

Synopsis:

```
#include <sys/traceparser.h>

struct traceparser_state * traceparser_init (
   struct traceparser_state * stateptr );
```

Library:

libtraceparser

Description:

The *traceparser_init()* function initializes the state of the traceparser library. To initialize the library, execute the function with the *stateptr* argument as null; the function returns the initialized state structure.

The **traceparser_state** structure is an opaque structure for use by the other SAT functions.

Returns:

A pointer to a valid initialized state structure

Success.

NULL Failure; *errno* is set. See also *traceparser_get_info()* for further details.

Classification:

QNX Neutrino

Safety	
Cancellation point	No
Interrupt handler	No
Signal handler	No
Thread	No

See also:

traceparser_get_info(), traceparser_init()

Appendix A

Kernel Call Arguments and Return Values

The following table lists the wide- and fast-emitting mode kernel call arguments and return values for each kernel call.

Many functions listed below are internal function calls that you won't find documented in the *Library Reference*. They're included in this table because you may see them listed in your trace output. *Some* of the internal functions include:

- All functions that begin with _
- *InterruptDetachFunc()*
- *SignalFault()*.

All functions with a **`_r`** (restartable) use the same call arguments and return values as the equivalent function without the **`_r`**.

The **`rmsg`** tag indicates the contents of the message. When several are specified, the contents of **`rmsg`** are bytes 0-3 in the first, 4-7 in the second, and so on.

Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
_bad()	A1: empty, A2: empty	A1: empty, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty
ChannelCreate()	A1: flags, A2: empty	A1: flags, A2: empty	R1: chid, R2: empty	R1: chid, R2: empty
ChannelDestroy()	A1: chid, A2: empty	A1: chid, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty
ClockAdjust()	A1: id, A2: new->tick_count, A3: new->tick_nsec_inc	A1: id, A2: new->tick_count	R1: ret_val, R2: old->tick_count, R3: old->tick_nsec_inc	R1: ret_val, R2: old->tick_count
ClockId()	A1: pid, A2: tid	A1: pid, A2: tid	R1: ret_val, R2: empty	R1: ret_val, R2: empty
ClockPeriod()	A1: id, A2: new->nsec, A3: new->fract	A1: id, A2: new->nsec	R1: ret_val, R2: old->nsec, R3: old->fract	R1: ret_val, R2: old
ClockTime()	A1: id, A2: new(sec), A3: new(nsec)	A1: id, A2: new(sec)	R1: ret_val, R2: old(sec), R3: old(nsec)	R1: ret_val, R2: old

continued...

Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
ConnectAttach()	A1: nd, A2: pid, A3: chid, A4: index, A5: flags	A1: nd, A2: pid	R1: coid, R2: empty	R1: coid, R2: empty
ConnectClientInfo()	A1: scoid, A2: ngroups	A1: scoid, A2: ngroups	R1: ret_val, R2: info->nd, R3: info->pid, R4: info->sid, R5: flags, R6: info->ruid, R7: info->euid, R8: info->suid, R9: info->rgid, R10: info->egid, R11: info->sgid, R12: info->ngroups, R13: info->grouplist[0], R14: info->grouplist[1], R15: info->grouplist[2], R16: info->grouplist[3], R17: info->grouplist[4], R18: info->grouplist[5], R19: info->grouplist[6], R20: info->grouplist[7]	R1: ret_val, R2: info->nd
ConnectDetach()	A1: coid, A2: empty	A1: coid, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty
ConnectFlags()	A1: pid, A2: coid, A3: masks, A4: bits	A1: coid, A2: bits	R1: old_flags, R2: empty	R1: old_flags, R2: empty

continued...

Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
ConnectServerInfo()	A1: pid, A2: coid	A1: pid, A2: coid	R1: coid, R2: info->nd, R3: info->srcnd, R4: info->pid, R5: info->tid, R6: info->chid, R7: info->scoid, R8: info->coid, R9: info->msglen, R10: info->srcmsglen, R11: info->dstmsglen, R12: info->priority, R13: info->flags, R14: info->reserved	R1: coid, R2: info->nd
InterruptAttach()	A1: intr, A2: handler_p, A3: area_p, A4: areasize, A5: flags	A1: intr, A2: flags	R1: int_fun_id, R2: empty	R1: int_fun_id, R2: empty
InterruptDetachFunc()	A1: intr, A2: handler_p	A1: intr, A2: handler_p	R1: ret_val, R2: empty	R1: ret_val, R2: empty
InterruptMask()	A1: intr, A2: id	A1: intr, A2: id	R1: mask_level, R2: empty	R1: mask_level, R2: empty
InterruptUnmask()	A1: intr, A2: id	A1: intr, A2: id	R1: mask_level, R2: empty	R1: mask_level, R2: empty
InterruptWait()	A1: flags, A2: timeout_tv_sec, A3: timeout_tv_nsec	A1: flags, A2: empty	R1: ret_val, R2: timeout_p	R1: ret_val, R2: empty
MsgDeliverEvent()	A1: rcvid, A2: event->sigev_notify, A3: event->sigev_notify_function_p, A4: event->sigev_value, A5: event->sigev_notify_attributes_p	A1: rcvid, A2: event->sigev_notify	R1: ret_val, R2: event_p	R1: ret_val, R2: empty
MsgError()	A1: rcvid, A2: err	A1: rcvid, A2: err	R1: ret_val, R2: empty	R1: ret_val, R2: empty

continued...

Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
MsgInfo()	A1: rcvid, A2: info_p	A1: rcvid, A2: info_p	R1: ret_val, R2: info->nd, R3: info->srcnd, R4: info->pid, R5: info->tid, R6: info->chid, R7: info->scoid, R8: info->coid, R9: info->msglen, R10: info->srcmsglen, R11: info->dstmsglen, R12: info->priority, R13: info->flags, R14: empty	R1: ret_val, R2: info->nd
MsgKeyData()	A1: rcvid, A2: op	A1: rcvid, A2: op	R1: ret_val, R2: newkey	R1: ret_val, R2: newkey
MsgReadv()	A1: rcvid, A2: rmsg_p, A3: rparts, A4: offset	A1: rcvid, A2: offset	R1: rbytes, R2: rmsg, R3: rmsg, R4: rmsg	R1: rbytes, R2: rmsg
MsgReceivePulse()	A1: chid, A2: rparts	A1: chid, A2: rparts	R1: ret_val, R2: rmsg, R3:rmsg, R4:rmsg	R1: ret_val, R2: empty
MsgReceivev()	A1: chid, A2: rparts	A1: chid, A2: rparts	R1: rcvid, R2: rmsg, R3: rmsg, R4: rmsg, R5: info->nd, R6: info->srcnd, R7: info->pid, R8: info->tid, R9: info->chid, R10: info->scoid, R11: info->coid, R12: info->msglen, R13: info->srcmsglen, R14: info->dstmsglen, R15: info->priority, R16: info->flags, R17: empty, R18:empty	R1: rcvid, R2: rmsg

continued...

Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
MsgReplyv()	A1: rcvid, A2: sparts, A3: status, A4: smsg, A5: smsg, A6: smsg	A1: rcvid, A2: status	R1: ret_val, R2: empty	R1: ret_val, R2: empty
MsgSendPulse()	A1: coid, A2: priority, A3: code, A4: value	A1: coid, A2: code	R1: status, R2: empty	R1: status, R2: empty
MsgSendv()	A1: coid, A2: sparts, A3: rparts, A4: msg, A5: msg, A6: msg	A1: coid, A2: msg	R1: status, R2: rmsg, R3: rmsg, R4: rmsg	R1: status, R2:rmsg (pid returns 0 for network processes)
MsgSendvnc()	A1: coid, A2: sparts, A3: rparts, A4: msg, A5: msg, A6: msg	A1: coid, A2: msg	R1: status, R2: rmsg, R3: rmsg, R4: rmsg	R1: status, R2:rmsg (pid returns 0 for network processes)
MsgVerifyEvent()	A1: rcvid, A2: event->sigev_notify, A3: event->sigev_notify_function_p, A4: event->sigev_value, A5: event->sigev_notify_attributes_p	A1: rcvid, A2: event->sigev_notify	R1: status, R2: empty	R1: status, R2: empty
MsgWritev()	A1: rcvid, A2: sparts, A3: offset, A4: msg, A5: msg, A6: msg	A1: rcvid, A2: offset	R1: wbytes, R2: empty	R1: wbytes, R2: empty

Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
NetCred()	A1: coid, A2: info_p	A1: coid, A2: info_p	R1: ret_val, R2: info->nd, R3: info->pid, R4: info->sid, R5: info->flags, R6: info->ruid, R7: info->euid, R8: info->suid, R9: info->rgid, R10: info->egid, R11: info->sgid, R12: info->ngroups, R13: info->grouplist[0], R14: info->grouplist[1], R15: info->grouplist[2], R16: info->grouplist[3], R17: info->grouplist[4], R18: info->grouplist[5], R19: info->grouplist[6], R20: info->grouplist[7]	R1: ret_val, R2: info->nd
NetInfoscoid()	A1: scoid, A2: empty	A1: scoid, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty
NetSignalKill()	A1: cred->ruid, A2: cred->euid, A3: nd, A4: pid, A5: tid, A6: signo, A7: code, A8: value	A1: pid, A2: signo	R1: empty, R2: empty	R1: status, R2: empty
NetUnblock()	A1: vtid, A2: empty	A1: vtid, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty

continued...

Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
NetVtid()	A1: vtid, A2: info_p, A3: tid, A4: coid, A5: priority, A6: srcmsglen, A7: keydata, A8: srcnd, A9: dstmsglen, A10: zero	A1: vtid, A2: info_p	R1: ret_val, R2: empty	R1: ret_val, R2: empty
_nop()	A1: dummy, A2: empty	A1: dummy, A2: empty	R1: empty, R2: empty	R1: empty, R2: empty
_Ring0()	A1: func_p, A2: arg_p	A1: func_p, A2: arg_p	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SchedGet()	A1: pid, A2: tid	A1: pid, A2: tid	R1: ret_val, R2: sched_priority, R3: sched_curpriority, R4: param.__ss_low_priority, R5: param.__ss_max_repl, R6: param.__ss_repl_period.tv_sec, R7: param.__ss_repl_period.tv_nsec, R8: param.__ss_init_budget.tv_sec, R9: param.__ss_init_budget.tv_nsec, R10: param.empty, R11: param.empty	R1: ret_val, R2: sched_priority
SchedInfo()	A1: pid, A2: policy	A1: pid, A2: policy	R1: ret_val, R2: priority_min, R3: priority_max, R4: interval_sec, R5: interval_nsec, R6: priority_priv,	R1: ret_val, R2: priority_max

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Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
SchedSet()	A1: pid, A2: tid, A3: policy, A4: sched_priority, A5: sched_curpriority, A6: param.__ss_low_priority, A7: param.__ss_max_repl, A8: param.__ss_repl_period.tv_sec, A9: param.__ss_repl_period.tv_nsec, A10: param.__ss_init_budget.tv_sec, A11: param.__ss_init_budget.tv_nsec, A12: param.empty, A13: param.empty	A1: pid, A2: priority	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SchedYield()	A1: empty, A2: empty	A1: empty, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SignalAction()	A1: pid, A2: sigstub_p, A3: signo, A4: act->sa_handler_p, A5: act->sa_flags, A6: act->sa_mask.bits[0], A7: act->sa_mask.bits[1]	A1: signo, A2: act->sa_handler_p	R1: ret_val, R2: oact->sa_handler_p, R3: oact->sa_flags, R4: oact->sa_mask.bits[0], R5: oact->sa_mask.bits[1]	R1: ret_val, R2: oact->sa_handler_p
SignalFault()	A1: sigcode, A2: addr	A1: sigcode, A2: addr	R1: ret_val, R2: reg_1, R3: reg_2, R4: reg_3, R5: reg_4, R6: reg_5	R1: ret_val, R2: reg_1
SignalKill()	A1: nd, A2: pid, A3: tid, A4: signo, A5: code, A6: value	A1: pid, A2: signo	R1: ret_val, R2: empty	R1: ret_val, R2: empty

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Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
SignalProcmask()	A1: pid, A2: tid, A3: how, A4: sig_blocked->bits[0], A5: sig_blocked->bits[1]	A1: pid, A2: tid	R1: ret_val, R2: old_sig_blocked->bits[0], R3: old_sig_blocked->bits[1]	R1: ret_val, R2: old_sig_blocked->bits[0]
SignalReturn()	A1: s_p, A2: empty	A1: s_p, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SignalSuspend()	A1: sig_blocked->bits[0], A2: sig_blocked->bits[1]	A1: sig_blocked->bits[0], A2: sig_blocked->bits[1]	R1: ret_val, R2: sig_blocked_p	R1: ret_val, R2: sig_blocked_p
SignalWaitinfo()	A1: sig_wait->bits[0], A2: sig_wait->bits[1]	A1: sig_wait->bits[0], A2: sig_wait->bits[1]	R1: sig_num, R2: si_signo, R3: si_code, R4: si_errno, R5: p[0], R6: p[1], R7: p[2], R8: p[3], R9: p[4], R10: p[5], R11: p[6]	R1: sig_num, R2: si_code
SyncCondvarSignal()	A1: sync_p, A2: all, A3: sync->count, A4: sync->owner	A1: sync_p, A2: all	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SyncCondvarWait()	A1: sync_p, A2: mutex_p, A3: sync->count, A4: sync->owner, A5: mutex->count, A6: mutex->owner	A1: sync_p, A2: mutex_p	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SyncCtl()	A1: cmd, A2: sync_p, A3: data_p, A4: count, A5: owner	A1: cmd, A2: sync_p	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SyncDestroy()	A1: sync_p, A2: count, A3: owner	A1: sync_p, A2: owner	R1: ret_val, R2: empty	R1: ret_val, R2: empty

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Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
SyncMutexLock()	A1: sync_p, A2: count, A3: owner	A1: sync_p, A2: owner	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SyncMutexRevive()	A1: sync_p, A2: count, A3: owner	A1: sync_p, A2: owner	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SyncMutexUnlock()	A1: sync_p, A2: count, A3: owner	A1: sync_p, A2: owner	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SyncSemPost()	A1: sync_p, A2: count, A3: owner	A1: sync_p, A2: count	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SyncSemWait()	A1: sync_p, A2: try, A3: count, A4: owner	A1: sync_p, A2: count	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SyncTypeCreate()	A1: type, A2: sync_p, A3: count, A4: owner, A5: protocol, A6: flags, A7: prioceiling, A8: clockid	A1: type, A2: sync_p	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SysCpupageGet()	A1: index, A2: empty	A1: index, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty
SysCpupageSet()	A1: index, A2: value	A1: index, A2: value	R1: ret_val, R2: empty	R1: ret_val, R2: empty
ThreadDestroyAll()	A1: empty, A2: empty	A1: empty, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty
ThreadCancel()	A1: tid, A2: canstub_p	A1: tid, A2: canstub_p	R1: ret_val, R2: empty	R1: ret_val, R2: empty

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Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
ThreadCreate()	A1: pid, A2: func_p, A3: arg_p, A4: flags, A5: stacksize, A6: stackaddr_p, A7: exitfunc_p, A8: policy, A9: sched_priority, A10: sched_curpriority, A11: param.__ss_low_priority, A12: param.__ss_max_repl, A13: param.__ss_repl_period.tv_sec, A14: param.__ss_repl_period.tv_nsec, A15: param.__ss_init_budget.tv_sec, A16: param.__ss_init_budget.tv_nsec, A17: param.empty, A18: param.empty, A19: guardsize, A20: empty, A21: empty, A22: empty	A1: func_p, A2: arg_p	R1: thread_id, R2: owner	R1: thread_id, R2: owner
ThreadCtl()	A1: cmd, A2: data_p	A1: cmd, A2: data_p	R1: ret_val, R2: empty	R1: ret_val, R2: empty
ThreadDestroy()	A1: tid, A2: priority, A3: status_p	A1: tid, A2: status_p	R1: ret_val, R2: empty	R1: ret_val, R2: empty
ThreadDetach()	A1: tid, A2: empty	A1: tid, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty
ThreadJoin()	A1: tid, A2: status_pp	A1: tid, A2: status_pp	R1: ret_val, R2: status_p	R1: ret_val, R2: status_p

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Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
TimerAlarm()	A1: id, A2: itime->nsec(sec), A3: itime->nsec(nsec), A4: itime->interval_nsec(sec), A5: itime->interval_nsec(nsec)	A1: id, A2: itime->nsec(sec)	R1: ret_val, R2: oitime->nsec(sec), R3: oitime->nsec(nsec), R4: oitime->interval_nsec(sec), R5: oitime->interval_nsec(nsec)	R1: ret_val, R2: oitime->nsec(sec)
TimerCreate()	A1: id, A2: event->sigev_notify, A3: event- >sigev_notify_function_p, A4: event->sigev_value, A5: event- >sigev_notify_attributes_p	A1: id, A2: event->sigev_notify	R1: timer_id, R2: empty	R1: timer_id, R2: empty
TimerDestroy()	A1: id, A2: empty	A1: id, A2: empty	R1: ret_val, R2: empty	R1: ret_val, R2: empty

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Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
TimerInfo()	A1: pid, A2: id, A3: flags, A4: info_p	A1: pid, A2: id	R1: prev_id, R2: info->itime.nsec(sec), R3: info->itime.nsec(nsec), R4: info->itime.interval_nsec(sec), R5: info->itime.interval_nsec(nsec), R6: info->otime.nsec(sec), R7: info->otime.nsec(nsec), R8: info->otime.interval_nsec(sec), R9: info->otime.interval_nsec(nsec), R10: info->flags, R11: info->tid, R12: info->notify, R13: info->clockid, R14: info->overruns, R15: info->event.sigev_notify, R16: info->event.sigev_notify_function_p, R17: info->event.sigev_value, R18: info->event.sigev_notify_attributes_p	R1: prev_id, R2: info->itime.nsec(sec)
TimerSettime()	A1: id, A2: flags, A3: itime->nsec(sec), A4: itime->nsec(nsec), A5: itime->interval_nsec(sec), A6: itime->interval_nsec(nsec)	A1: id, A2: itime->nsec(sec)	R1: ret_val, R2: oitime->nsec(sec), R3: oitime->nsec(nsec), R4: oitime->interval_nsec(sec), R5: oitime->interval_nsec(nsec)	R1: ret_val, R2: oitime->nsec(sec)

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Function	Wide-emitting call arguments	Fast-emitting call arguments	Wide-emitting return values	Fast-emitting return values
TimerTimeout()	A1: id, A2: timeout_flags, A3: ntime(sec), A4: ntime(nsec), A5: event->sigev_notify, A6: event->sigev_notify_function_p, A7: event->sigev_value, A8: event->sigev_notify_attributes_p	A1: timeout_flags, A2: ntime(sec)	R1: prev_timeout_flags, R2: otime(sec), R3: otime(nsec)	R1: prev_timeout_flags, R2: otime(sec)
TraceEvent()	A1: mode, A2: class[header], A3: event[time_off], A4: data_1, A5: data_2	A1: mode, A2: class	R1: ret_val, R2: empty	R1: ret_val, R2: empty

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