EventSource User’s Guide

EventSource is the central class that allows a developer to create strongly typed events to be captured by event tracing for Windows (ETW).

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# Programmer’s Guide

The purpose of EventSource is to allow a managed-code developer to easily create a strongly typed specification for logging (possibly high volume) ETW events. This allows you to write code like this at the site you wish to log an event

MinimalEventSource.Log.Load(0x40000, "MyFile0");

Notice that the only information that is present is the minimum necessary, namely

1. The logging object itself (MinimalEventSource.Log)
2. A method representing the event to log (Load)
3. Optional parameters which are strongly typed (all Load events always have an int and a string values passed to them).

In particular there are not verbosity levels, event ID, or anything that does not need to be at the call site. All of that moved to the definition of the EventSource.

## Defining a Minimal Event Source

One nice attribute of strongly typed eventing is that the call site for logging an event is ‘minimal’. This is because the user of EventSource needs to define a class that describes all the different kinds of events the user is interested in generating. Here is an example of such a class.

public sealed class MinimalEventSource : EventSource

{

public void Load(long baseAddress, string imageName) { WriteEvent(1, baseAddress, imageName);}

public void Unload(long baseAddress) { WriteEvent(2, baseAddress);}

public static MinimalEventSource Log = new MinimalEventSource();

}

The basic structure of these derived classes of EventSource is always the same. In particular

* The class inherits from EventSource.
* For each different type of event that the user wishes to generate, a method needs to be defined. This method should be
  + Named the name of the event being raised
  + If the event has additional data, these should be passed as arguments. Currently only primitive types, DateTime, and string are allowed to be logged with the event.
* Each method has a body that simply calls ‘WriteEvent’ passing it an ID (a numeric value that represents this event), and the arguments of the event method. This ID needs to be unique within the EventSource. EventSource allows two mechanisms for assigning these IDs. They are either
  + The ordinal number of the method in the class (thus the first method in the class is 1, second 2 …), or
  + Explicitly assigned using the Event attribute for the event method. More on this mechanism later…
* EventSources are intended to be singleton instances (one per appdomain is all you need). Thus it is convenient to define a static variable (by convention called ‘Log’ that represents this singleton.

## Compiling Your EventSource

To actually compile the simple example above you need only reference the EventSource class itself. This class is part of the .NET Runtime Version 4.5. It is defined in mscorlib (so it is present in the default assembly references for ANY .NET application), and it lives in the System.Diagnostics.Tracing namespace.

In addition to the version of EventSource built into V4.5 there is an EventSource NuGet package which is a ‘stand alone’ version of the class. This is useful if

1. You want to use EventSource on versions of the framework before V4.5 or
2. You want some very new feature of EventSource that is not yet present in the Framework version

Search for ‘EventSource’ on <https://www.nuget.org/> to find this package.

There is also a very useful ‘EventSource Samples’ Nuget package available. This gives you working code for a variety of common scenarios. These samples are well commented to explain why the code is the way it is. To use the samples

1. Create a new Console application called ‘DemoEventSource’
2. Reference the ‘EventSource Samples’ package from your application (right click on the ‘References’ node of the project and select ‘Managed Nuget Packages’ and search for ‘EventSource’).
3. Add the call ‘EventSourceSamples.AllSamples.Run()’ to your main program.

## Enabling your EventSource

Once you have defined an EventSource, you will want to see its events. One way of doing this is through Event Tracing for Windows (ETW). For example, there is a tool called [PerfView](http://www.microsoft.com/en-us/download/details.aspx?id=28567) that will let you enable ETW providers, and in particular EventSources. The command

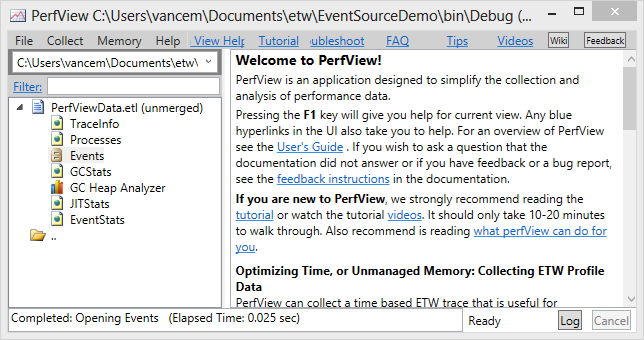
PerfView /onlyProviders=\*MinimalEventSource run **YOUR\_APP**

Will turn on any EventSource called ‘MinimalEventSource’ on the system, and then run **YOUR\_APP**.

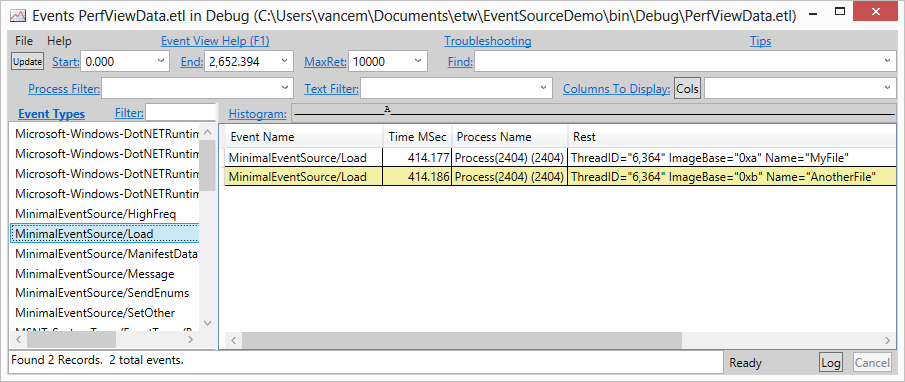
PerfView /onlyProviders=\*MinimalEventSource collect

Will do the same and wait until you tell it to stop (thus you can run your command in another window).

In either case it will generate a binary log file (an .ETL file), that contains the events, and can be viewed in PerfView’s ‘events’ viewer.



Opening that viewer yields something like the



Notice that the viewer shows you the event name, the (very accurate) time, the process thread and all the values of the payload. The payload values are strongly typed (it knows that ‘ImageBase’ is an integer and ‘Name’ is a string, and no ‘parsing’ is necessary (Because it was never a string blob anywhere in the event pipeline). If you wish to programmatically manipulate your data, you should download the ‘TraceEvent’ Nuget package (and in particular the ‘TraceEvent Samples’ Nuget Package.

## Recap

So there you have it, a quick end-to-end example of using EventSource. The steps were

1. Define and class that inherits from EventSource that defines each event.
2. Call these methods in your code
3. Use something (in the case above ETW) to turn on your provider and process the events.

# Picky Details

Now that you have the basic outline of what an EventSource is, here we describe some of the details for using it properly.

## Rules for defining EventSource Classes

1. Classes that derive from EventSource should be sealed. EventSource does not expect non-trivial hierarchy in the inheritance chain
2. Implementing interfaces on EventSource classes, while not strictly prohibited, is certainly not expected usage.
3. Methods in an EventSource are ASSUMED to log data unless otherwise declared (even if they are private). If you have a need for ‘helper’ methods, you must put the [NonEvent] attribute on them to declare they are NOT methods that log events.
4. Generally the name of the EventSource class is a bad ‘public’ name for the EventSource. Public names (the names that ETW use) has to be globally unique in the WORLD. Thus it is good practice to give your EventSource a good official name using the [EventSource] attribute.

[EventSource(Name=”Samples-EventSourceDemos-Minimal”)]

public sealed class MinimalEventSource : EventSource

{

public void Load(long baseAddress, string imageName) { WriteEvent(1, baseAddress, imageName);}

public void Unload(long baseAddress) { WriteEvent(2, baseAddress);}

public static MinimalEventSource Log = new MinimalEventSource();

}

## Typical Customizations

More advanced uses of an event source may

* define new ETW keywords, tasks, and opcodes for customizing the ETW event method definition,
* define new enumerated types for ETW event method arguments to replace less descriptive int arguments,
* define [NonEvent] methods

Here’s an example (with previously illustrated concepts grayed-out):

[EventSource(Name = "Samples-EventSourceDemos-Customized")]

public sealed class CustomizedEventSource : EventSource

{

#region Singleton instance

static public CustomizedEventSource Log = new CustomizedEventSource();

#endregion

[Event(1, Keywords = Keywords.Requests,

Task = Tasks.Request, Opcode=EventOpcode.Start)]

public void RequestStart(int RequestID, string Url)

{ WriteEvent(1, RequestID, Url); }

[Event(2, Keywords = Keywords.Requests, Level = EventLevel.Verbose,

Task = Tasks.Request, Opcode=EventOpcode.Info)]

public void RequestPhase(int RequestID, string PhaseName)

{ WriteEvent(2, RequestID, PhaseName); }

[Event(3, Keywords = Keywords.Requests,

Task = Tasks.Request, Opcode=EventOpcode.Stop)]

public void RequestStop(int RequestID)

{ WriteEvent(3, RequestID); }

[Event(4, Keywords = Keywords.Debug)]

public void DebugTrace(string Message)

{ WriteEvent(4, Message); }

#region Keywords / Tasks / Opcodes

public class Keywords // This is a bitvector

{

public const EventKeywords Requests = (EventKeywords)0x0001;

public const EventKeywords Debug = (EventKeywords)0x0002;

}

public class Tasks

{

public const EventTask Request = (EventTask)0x1;

}

#endregion

}

## Optimizing Performance for High Volume Events

The EventSource class has a number of overloads for WriteEvent, including one for variable number of arguments. When none of the other overloads matches, the “params” method is called. Unfortunately, the “params” overload is relatively expensive, in particular it

1. Allocates an array to hold the variable arguments
2. Casts each parameter to an object (which causes allocations for primitive types)
3. Assigns these objects to the array
4. Calls the function, which then
5. Figures out the type of each argument, to determine how to serialize it to ETW

This is probably 10 to 20 times as expensive as specialized types. This probably does not matter much for low volume cases (because you only pay it when the provider is on, and low volume events simply don’t happen enough to matter), but for high volume events it can be important.

There are two important cases for insuring that the ‘params’ overload is not used

1. Ensure that enumerated types are cast to ‘int’ so that they match one of the fast overloads.
2. Create new fast WriteEvent overloads for high volume payloads.

Here is an example for adding a WriteEvent overload that takes four integer arguments.

[NonEvent]

public unsafe void WriteEvent(int eventId, int arg1, int arg2,

int arg3, int arg4)

{

EventData\* descrs = stackalloc EventProvider.EventData[4];

descrs[0].DataPointer = (IntPtr)(&arg1);

descrs[0].Size = 4;

descrs[1].DataPointer = (IntPtr)(&arg2);

descrs[1].Size = 4;

descrs[2].DataPointer = (IntPtr)(&arg3);

descrs[2].Size = 4;

descrs[3].DataPointer = (IntPtr)(&arg4);

descrs[3].Size = 4;

WriteEventCore(eventId, 4, (IntPtr)descrs);

}

## Localization

Some of the ETW metadata (event messages, tasks, keywords, maps) are designed to be human readable and as such are localizable. EventSource leverages standard .NET localization techniques to support ETW localization.

To enable localization of an event source class one needs to perform three steps:

1. In the assembly that contains the event source define resource sets for every language to support (e.g. you can add LesResource.resx and LesResource.fr-FR.resx to support localizing your event source in the neutral language and in French).
2. Add string entries to the StringTable resource following the following naming pattern for the keys:

event\_***eventName***

task\_***taskName***

opcode\_***opcodeName***

keyword\_***keywordName***

map\_***enumShortTypeName***.***enumValueName***

1. Specify the new resource in the LocalizationResources property of your EventSourceAttribute:

[EventSource(Name = "Microsoft-EventSourceDemos-Localized",

LocalizationResources ="YourRootNamespace.LesResource")]

public sealed class LocalizedEventSource : EventSource

Here’s an example of localizing an event source (with previously illustrated concepts grayed-out):

[EventSource(Name = "Samples-EventSourceDemos-Localized",

LocalizationResources = "YourRootNamespace.LesResource")]

public sealed class LocalizedEventSource : EventSource

{

[same as above]

}

where LesResource.resx might contain these two definitions:

event\_RequestStart=Start processing request for URL '{1}' (id = {0})

event\_RequestStop=Stop processing request (id = {0})

and LesResource.fr-FR.resx might contain this (automatic translation used):

event\_RequestStart=Commencer le traitement de la demande d'URL '{1}' (id = {0})

event\_RequestStop=Arrêter le traitement de la demande (id = {0})

For performance purposes an event source will cache these strings the first time it needs them (either when an ETW controller is enabling the event source or when an EventListener calls EventListener.EnableEvents for this event source), so the thread’s UI culture at that time determines the language of the messages reported by the event source instance for the remaining of its lifetime.

## Activity Tracing Support

[Supported starting with .NET 4.5.1 and the NuGet package]

Details to come.

## Static and Dynamic Registration

Traditional ETW providers need to have their manifest registered on the machine using the wevtutil.exe tool – let’s refer to this as static registration. EventSource pioneered a new approach to registration by including its manifest in the event stream, or by returning it in response to a (now) standard ETW command – let’s refer to this as dynamic registration.

Clearly dynamic registration has some definite advantages over static registration:

1. If the event data is moved to a different machine, the manifest metadata continues to be available as it is embedded in the event stream
2. The need for deployment time registration is eliminated. Administrative privileges needed to run wevtutil.exe are not required in this case.

Unfortunately, event sources that require ETW channel support will continue to need static registration.

## ETW Channel Support

[Supported starting with the EventSource version shipping in the NuGet package]

Channel support in event source allows a developer to specify channels as additional destinations for an event. Developers can do this simply by specifying a value for the Channel property on an EventAttribute:

[Event(1, Keywords = Keywords.Requests, Task = Tasks.Request,

Opcode = EventOpcode.Start, Message = "{0} / {1}"Channel = EventChannel.Admin)]

public void RequestStart(int RequestID, string Url)

{ WriteEvent(1, RequestID, Url); }

This model has the definite advantage of simplicity but it does not support [imported channels](http://msdn.microsoft.com/en-us/library/windows/desktop/dd996911(v=vs.85).aspx) nor does it allow certain advanced customization of the defined channel.

One requirement introduced by channel support is the need to statically register the ETW provider manifest. The NuGet package supports generating the files needed for static registration as part of your build. After your build completes a new step is run that generates a pair of files for each of the event source types defined in the project:

<AssemblyName>.<EventSourceTypeName>.etwManifest.man and <AssemblyName>.<EventSourceTypeName>.etwManifest.dll.

The first file contains the ETW manifest while the second one contains the binary form of the ETW manifest plus any needed native resources (localization string tables in particular).

The tool that generates the above two files is “eventRegister.exe” and it performs two functions:

1. It ensures the registration files are generated for all event source types that need static registration, and
2. It performs a number of validation checks on all the event source types defined in the output assembly.

Deploying your component will need to include these files and perform one registration step at installation time and one un-registration step at un-installation time.

Registration:

wevtutil.exe im <EtwManifestManFile> /rf:"<EtwManifestDllFullPathName>" /mf:"<EtwManifestDllFullPathName>"

Unregistration:

wevtutil.exe um <EtwManifestManFile>

For static registration eventRegister.exe generates manifests that include all localization information. This is needed because the manifest is generated at build time, when there’s no information regarding the culture in which the final application will run.

# Event Source Design Guidelines

**Do** use the EventRegister NuGet package or the standalone eventRegister.exe tool, to run build-time validation of the event source classes defined in your assemblies.

**Do** use the EventSourceAttribute’s Name property to provide a descriptive, qualified name for the ETW event provider represented by your event source. The default is the short name of your event source type, which can easily lead to collisions, as ETW provider names share one machine-wide namespace. An example of a good provider name “<CompanyName>-<Product>-<Component>”. Following this 3-element convention will ensure Event Viewer displays your event logs in a logical folder hierarchy: “Application and Services Logs/<CompanyName>/<Product>/<Component>”.

**Do not** specify an explicit value for EventSourceAttribute’s Guid property, unless you need it for backwards compatibility reasons. The default Guid value is derived from the ETW event provider’s name, which allows tools to accept the more human-readable name and derive the same Guid.

**Do** define a singleton instance of your event source and use it for logging.

**[Perf] Do** try to minimize the number of distinct EventSources defined in your product: logically related components that are deployed together should share an EventSource.

**Do** keep the ETW user interface simple:

* Events that fire less than 100 times a second on average generally don't need separate keywords, they could be covered by a catch all 'Default' keyword.
* Events that fire more than 1K times a second on average need keywords to turn them off when they are not needed.
* Events in between 100 and 1K are a judgment call

**Do** define keywords from a **user**’s (or **scenario**) point of view. While most users will simply use the default (turn everything on) keywords are the preferred mechanism for filtering events.

**Do** use Levels less than Informational for relatively rare warnings or errors. When in doubt stick with the default of Informational, and use Verbose for events that can happen more than 1K events / second. Typically users would use keywords more often than Level for filtering, so don't worry about it too much.

# Event Source Troubleshooting

The EventSource class was designed so that it would NEVER FAIL by default. This is a useful property, as logging is often “optional” and you don’t want some startup error with ETW to cause your application to fail. However this makes finding any mistake in your EventSource very difficult.

Starting with the NuGet package version of EventSource we can perform a number of validation checks on your event source types at build time – through eventRegister.exe, a tool that now integrates in your build. This will flag a number of issues that, if not fixed, could lead to later runtime failures.

Starting with v4.5.1 failures in event source initialization will be visible in the ETW event stream, as events with ID 0, and a string detailing the error. The same string will be output to any debugger that may be attached to the process. Additionally EventSource now exposes a property “ConstructionException” that contains any exception that may have occurred during the initialization of the event source instance.

In v4.5 exceptions thrown during event source initialization can be observed as first chance exceptions, either in a debugger or with an ETW listener. See [this blog post](http://blogs.msdn.com/b/vancem/archive/2012/12/21/why-my-doesn-t-my-eventsource-produce-any-events.aspx) for details.

# Event Source Assumptions and Validation

Event source relies on a number of conventions to ensure it works properly. There are several levels of validation for these assumptions:

* Build-time validation (starting with the NuGet package) performed by the EventRegister NuGet package. Violations detected at this time will result in build errors.
* Runtime validation. Violations detected at this time can result in dropped messages.
* No validation due to the performance impact. Violations of these assumptions can lead to runtime exceptions.

## Event Source Constraints

1. Event source classes must be sealed. Enforced by eventRegister.exe starting with NuGet package.
2. Event source classes enforce a “singleton pattern”.

## ETW Event Methods Constraints

The following constraints exist when defining an ETW event method:

1. An ETW event method must directly call either
   1. one of the EventSource.WriteEvent() overloads,
   2. EventSource.WriteEventCore(), or
   3. for an ETW transfer event method call EventSource.WriteEventWithRelatedActivityId() or EventSource.WriteEventWithRelatedActivityIdCore() (v4.5.1, or the NuGet package)

Not currently enforced.

1. The event ID (whether implied or explicitly specified using the EventAttribute on the method) must match the first argument passed to the EventSource API it calls.

Weakly enforced (EventSource attempts to identify a call to WriteEvent a.o. and to retrieve the first argument passed in, and if it succeeds it validates the argument passed in against the attribute’s value)

1. If the ETW event method is not a transfer method, the number and types of arguments passed to the ETW method must exactly match the types passed to the WriteEvent overload it calls. For example:

[Event(2, Level = EventLevel.Informational)]

public void Info(string message, int count)

{

base.WriteEvent(2, message, count);

}

Not enforced.

1. Must specify unique (task / opcodes) pairs. Enforced by eventRegister.exe starting with NuGet package.
2. If an ETW event method specifies a non-default opcode it \*must\* also specify an explicit task. Enforced by eventRegister.exe starting with NuGet package.
3. Event methods must match exactly the types of the WriteEvent overload it calls, in particular you should avoid implicit scalar conversions are dangerous because the manifest is generated based on the signature of the ETW event method, but the values passed to ETW are based on the signature of the WriteEvent overload.

Here’s an example:

[Event(3, Level = EventLevel.Informational)]

public void Info(int arg1, long arg2, int arg3)

{

base.WriteEvent(3, arg1, arg2, arg3);

}

Since there is no EventSource.WriteEvent overload that takes (int, int, long, int) arguments, the best match is WriteEvent(int, long, long, long). The generated manifest assumes 16 bytes of payload, with a layout given by (int, long, int), while WriteEvent ends up writing 24 bytes…

## ETW Transfer Event Methods Constraints

If the ETW event method is a transfer method it must:

1. Specify as its first parameter a Guid named relatedActivityId. Not enforced.
2. Specify either EventOpcode.Send or EventOpcode.Receive as the Opcode property on its EventAttribute. Weak runtime enforcement (throw if m\_throwOnEventWriteErrors is true).
3. Call EventSource.WriteEventWithRelatedActivityId or EventSource.WriteEventWithRelatedActivityIdCore, and pass in the event ID, the Guid, followed by all the parameters it is passed, in the order in which they were passed in. Not enforced.
4. For performance sensitive events you could define a [NonEvent] overload for WriteEventWithRelatedActivityId that takes the parameter types of interest, and call this from your [Event] methods:

[NonEvent]

unsafe protected void WriteEventWithRelatedActivityId(int eventId,

Guid relatedActivityId, string message, int count)

{

if (IsEnabled())

{

if (message == null) message = string.Empty;

fixed (char\* stringBytes = message)

{

EventData\* descrs = stackalloc EventData[2];

descrs[0].DataPointer = (IntPtr)stringBytes;

descrs[0].Size = ((message.Length + 1) \* 2);

descrs[1].DataPointer = (IntPtr)(&count);

descrs[1].Size = 4;

WriteEventWithRelatedActivityIdCore(eventId,

&relatedActivityId, 2, descrs);

}

}

}

# EventSource Versions

The EventSource class first shipped with the .NET Framework Library in version 4.5. The type is included in mscorlib.dll, and is defined in the System.Diagnostics.Tracing namespace.

Version 4.5.1 of the framework delivers an improved class with support for additional features, the most significant being support for activity tracing and better diagnostics for tracing failures.

A NuGet package (Microsoft.Diagnostics.Tracing.EventSource) containing most of the 4.5.1 features as well as new ETW channel support is shipping out of band at roughly the same time as the 4.5.1 release. This NuGet package is meant to be used in projects that (a) either need EventSource support on .NET v4.0 Framework or (b) projects that need these additional features before they will get integrated back into a future version of System.Diagnostics.Tracing.EventSource.

The NuGet package defines the EventSource class and its associated types in a separate namespace: Microsoft.Diagnostics.Tracing. This will make migration between the NuGet package and the Framework version an explicit source-level option, where the code needs to reference either one of the two types.

In the user guide below unqualified statements will refer to support existing in 4.5. Whenever a feature applies only to more recent versions the fact will be explicitly called out.

# Glossary

For detailed information on Event tracing for Windows see [this page](http://msdn.microsoft.com/en-us/library/windows/desktop/bb968803(v=vs.85).aspx).

**ETW provider:** (native concept) a component capable of firing ETW events.

**ETW manifest:** (native concept)metadata describing an ETW provider and the detailed information on the ETW events it might fire.

**ETW keywords:** (native concept)bit-flags thatcan be associated with events to create event “categories”.

**ETW tasks:** (native concept)small integers thatcan be associated with events to define “task-oriented” groupings. Generally used in conjunction with opcodes.

**ETW opcodes:** (native concept)small integers thatidentify an operation within a Task. The value of Opcodes is that there are some well-known ones like ‘Start’ and ‘Stop’ which allow tools to operate on events in a generic way.

**Event Source:** a user-defined sealed class derived from the EventSource type.

**ETW Event Method:** a method defined in an Event Source that fires an ETW event. This must be an instance **not** marked with the [NonEvent] attribute. Virtual or void-returning methods are included (starting with the NuGet version of EventSource) only if they are marked with the [Event] attribute.

**ETW Transfer Event Method:** an ETW event method that marks a relation between the current activity and a related activity (supported starting with v4.5.1 and the NuGet package).

# Resources

[Event Tracing for Windows](http://msdn.microsoft.com/en-us/library/bb968803(VS.85).aspx) – Windows based infrastructure for logging events in a strongly typed way

[ETW Manifest Schema](http://msdn.microsoft.com/en-us/library/aa384043(v=VS.85).aspx) – Description of the events particular ETW provider can generate.

[Vance Morrison’s EventSource blog entries](http://blogs.msdn.com/b/vancem/archive/tags/eventsource/) – Reference information for event sources