

ANTS Memory Profiler 5.0

June 2009

Note: these pages apply to a version of this product that is not the current released version.

For the latest support documentation, please see <http://documentation.red-gate.com>

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Getting started

ANTS Memory Profiler enables you to profile memory usage of applications written in any of the languages available for the .NET Framework, including Visual Basic .NET, C#, and Managed C++. This is useful, for example, to improve memory usage by identifying the objects and classes that use most memory, and objects that remain live the longest.

You can use ANTS Memory Profiler to profile .NET desktop applications, ASP.NET web applications hosted in Internet Information Services (IIS) or the ASP.NET Development Server, .NET Windows services, COM+ server applications, Silverlight 4 or later applications, and XBAPs. In addition, you can profile applications that host the .NET Runtime, for example Visual Studio .NET plug-ins.

You can use ANTS Memory Profiler with the following versions of the .NET Framework:

- 1.1 (32-bit applications only)
- 2.0 (32-bit or 64-bit applications)
- 3.0 (32-bit or 64-bit applications)
- 3.5 (32-bit or 64-bit applications)
- 4.0 (32-bit or 64-bit applications)

ANTS Memory Profiler: step-by-step

1. Use the Profiler Project Wizard to specify the details of the application that you want to profile.
2. Take one or more memory snapshots.
3. Analyze the profiling results.

Analyzing memory usage

You can analyze memory usage by looking at a snapshot of memory at a specific point in time, or by comparing two snapshots. This topic outlines how to use the main ANTS Memory Profiler features to analyze memory usage.

Start by choosing an application to profile, and then take one or more snapshots, depending on the analysis you want to perform. ANTS Memory Profiler displays a summary of memory usage in your selected snapshots. Analyzing memory usage has the following main stages:

1. Snapshot analysis
2. Class analysis
3. Instance analysis

Before you begin, it may be useful to read background information about memory:

- Read suggested strategies for specific types of memory analysis
- Watch .NET memory management introduction video (http://www.red-gate.com/products/ants_memory_profiler/DOTNET_Memory_Management/index.html)

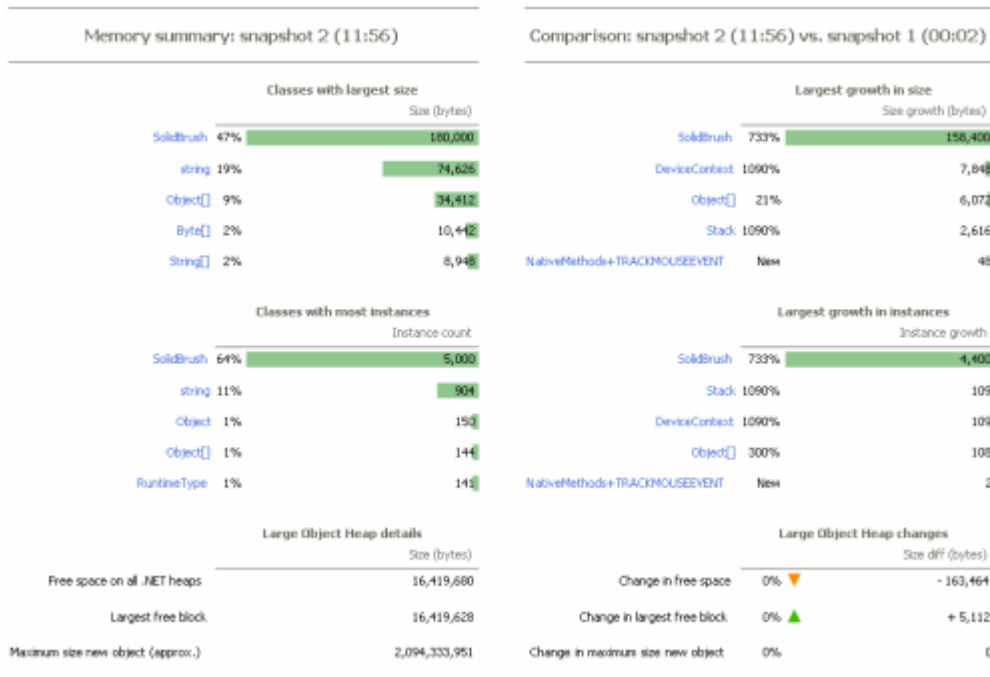
1. Snapshot analysis

Start by looking for classes that may indicate a memory leak, or classes with unexpectedly high memory usage. Use object filters to restrict your investigation to objects with specific characteristics or specific parts of the application.

The **summary** shows an overview of the main areas of memory usage; if you are comparing two snapshots, this includes an overview of the main differences in memory usage between the snapshots. In the summary or class list, look for classes with unexpectedly high memory usage, or a large increase in size between snapshots.

The large object heap data can be useful for identifying fragmentation problems.

Find out more about what to look for in the summary



- The **class list** shows detail of memory usage per class. On the summary or class list, look for classes with unexpectedly high memory usage, or a large increase in size between snapshots.

Find out more about what to look for in the class list

Namespace	Class Name	Live Size (bytes)	Size Diff (bytes +/-)	Live Instances	Instance Diff (+/-)
System.Drawing	SolidBrush	180,000	+156,400	5,000	+4,400
System	string	74,626	-286	904	-2
System	Object[]	34,412	+6,072	144	+108
System	Byte[]	10,442	0	4	0
System	String[]	8,948	0	16	0
System.Windows.Fo...	DeviceContext	8,568	+7,048	119	+109
System.Collections	Hashtable+Bucket[]	8,184	0	31	0
System.Configuration	FactoryRecord	5,320	0	95	0
System.Collections	Stack	2,856	+2,616	119	+109
System	RuntimeType	2,820	+20	141	+1
System.Drawing	Point[]	2,700	0	75	0
ShapePainter	EllipseShape	2,640	0	66	0
System	Int32[]	2,556	0	24	0
ShapePainter	RectangleShape	2,360	0	59	0
ShapePainter	TriangleShape	2,100	0	75	0
System	Char[]	1,910	0	23	0
System	Object	1,800	-12	150	-1

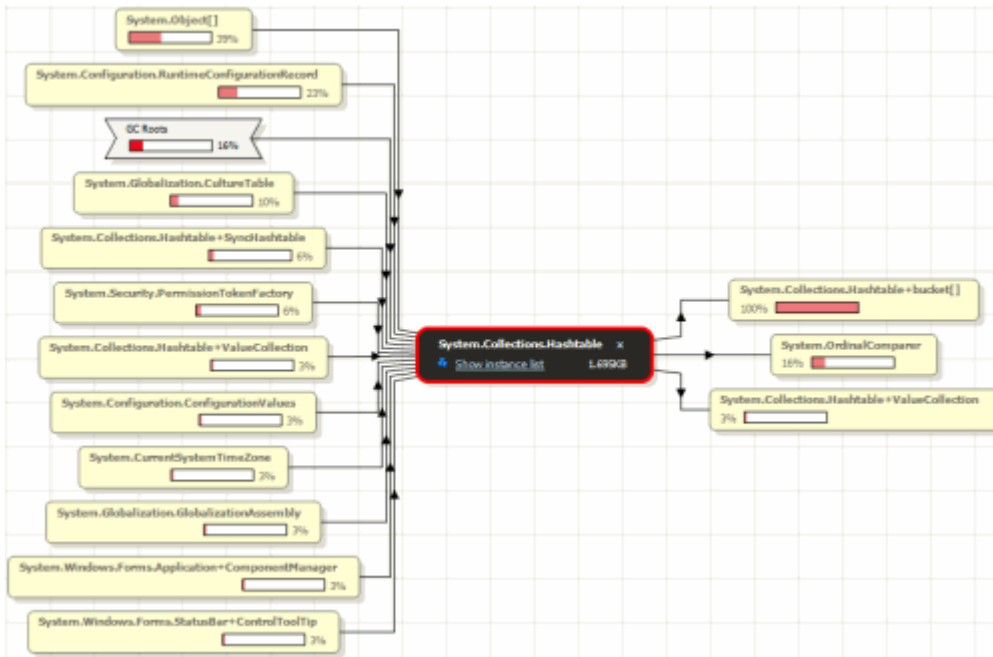
2. Class analysis

Identify instances of classes which you do not expect to be in memory, or instances with unexpectedly high memory usage. Use object filters to restrict your investigation to objects with specific characteristics or specific parts of the application.

- The **class reference explorer** shows reference relationships between classes, which can help identify instances which are unexpectedly kept in memory. This can be particularly useful if your snapshot analysis identifies a class you do not recognize:

Use the explorer to follow chains of references to the class, until you reach a class you recognize which may be responsible for the memory usage.

Find out more about what to look for on the class reference explorer



- The **instance list** shows detail for all instances of a class, which can help identify instances which are the likely cause of a memory problem.

Find out more about what to look for in the instance list

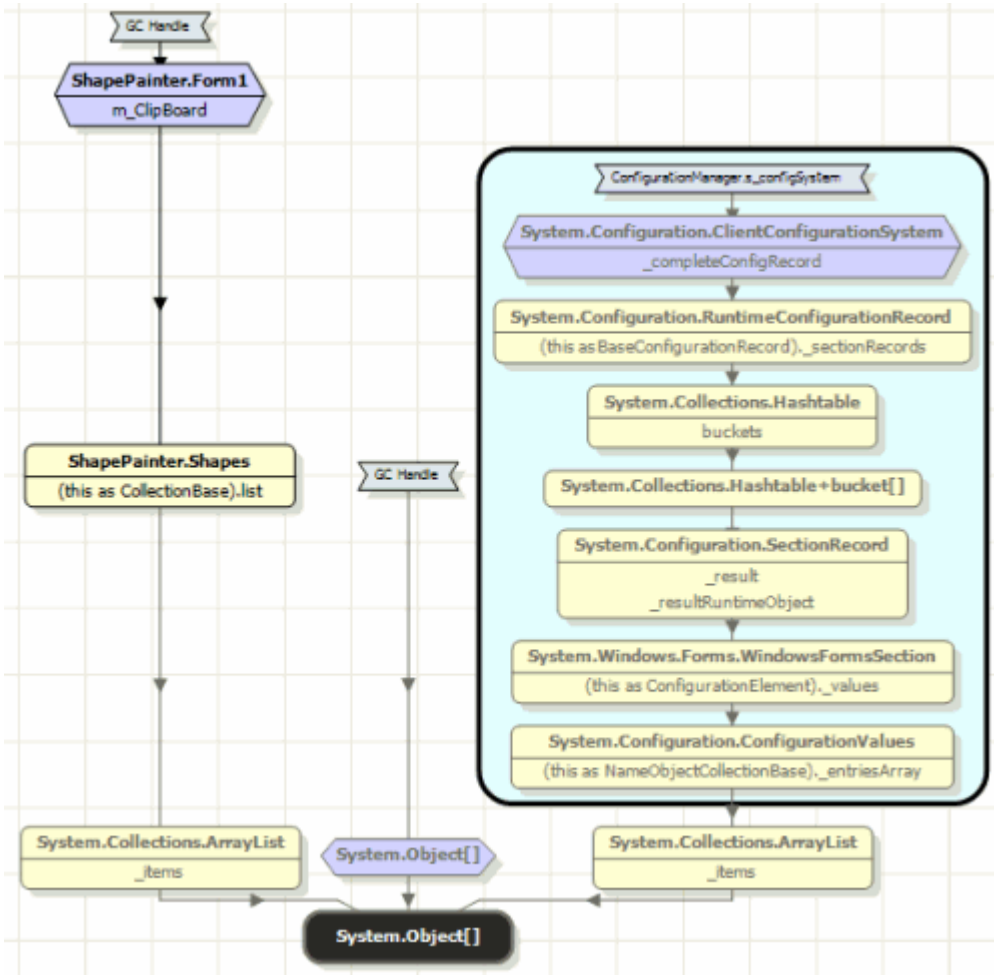
New Object	Value	Size (bytes)	Size with Children (bytes)	GC Root Object	Distance from GC Root
No	Signature	48	60	No	7
Yes	Signature	48	60	No	7
No	Signature	48	68	No	3
Yes	Signature	48	72	No	10
Yes	Signature	48	68	No	10
Yes	Signature	48	72	No	10
Yes	Signature	48	68	No	10
Yes	Signature	48	72	No	10
Yes	Signature	48	68	No	10
Yes	Signature	48	72	No	10

3. Instance analysis

Investigate what is keeping a selected object in memory unexpectedly.

The **object retention graph** shows chains of references between GC roots and your selected object. Start at your selected object and follow the chains of references up towards the GC roots, to identify references that are preventing the garbage collector from collecting your object. When you find an unexpected reference, modify your code to break the reference, and then profile the application again to check the problem is fixed.

Find out more about what to look for on the object retention graph



Strategies for memory profiling

This topic contains guidelines and recommendations about common memory profiling scenarios, including some heuristics about memory usage patterns that might indicate a memory problem. Of course, every application is different, so these guidelines only outline strategies for memory profiling; to apply these strategies you will need a good understanding of your application.

- Finding a memory leak
- Checking that a memory leak is fixed
- Finding out what is using most memory
- Checking for memory problems

More information about memory management

When you are investigating memory usage, background information about .NET memory management may be useful. Some good starting points:

.NET Memory Management (video overview)

http://www.red-gate.com/products/ants_memory_profiler/DOTNET_Memory_Management/index.html
(http://www.red-gate.com/products/ants_memory_profiler/DOTNET_Memory_Management/index.html)

Garbage Collection: Automatic Memory Management in the Microsoft .NET Framework

<http://msdn.microsoft.com/en-us/magazine/bb985010.aspx>
(<http://msdn.microsoft.com/en-us/magazine/bb985010.aspx>)

Memory Management in .NET

<http://www.c-sharpcorner.com/UploadFile/tkagarwal/MemoryManagementInNet11232005064832AM/MemoryManagementInNet.aspx>
(<http://www.c-sharpcorner.com/UploadFile/tkagarwal/MemoryManagementInNet11232005064832AM/MemoryManagementInNet.aspx>)

CLR Inside Out: Large Object Heap Uncovered

<http://msdn.microsoft.com/en-us/magazine/cc534993.aspx>
(<http://msdn.microsoft.com/en-us/magazine/cc534993.aspx>)

Dangers of the Large Object Heap

<http://www.simple-talk.com/dotnet/.net-framework/the-dangers-of-the-large-object-heap/> (<http://www.simple-talk.com/dotnet/.net-framework/the-dangers-of-the-large-object-heap/>)

Finding and fixing a memory leak

The following examples outline some approaches to finding a memory leak for some common scenarios.

We recommend that you make a note of the steps you take when you are looking for a memory leak, so that you can perform the same actions later to check that you have fixed the leak.

The snapshots and analysis you perform depend on the functionality of your application.

Example A: opening and closing a dialog box

This scenario is the most straightforward, so it is recommended as the preferred way of finding a memory leak.

1. Start ANTS Memory Profiler and start profiling your application. Get the application into the state in which you are interested in its memory.
2. Take two snapshots, so you can compare memory usage before and after the action that you believe leaks memory:

- a. Take the first snapshot.
- b. Perform an action that you believe causes a leak; then perform the actions that should clean up any objects created by the first action.

For example, open a dialog box, change some settings, and then close the dialog box.

- c. Take a second snapshot.

Objects created by the action should be cleaned up before the second snapshot, so any new objects created in the second snapshot are likely to indicate a memory leak.

3. Apply the **Only new objects** filter to show only the classes with new instances in the second snapshot.
4. On the class list, look for classes with a high positive value in the **Instance Diff** or **Size Diff** column. These values indicate the classes responsible for increased memory usage in your second snapshot, so they are good indicators of the likely cause of a memory leak. At this stage, we recommend that you look at *all* classes (not just the classes you recognize): although your own classes may be responsible for the memory leak, the symptoms of the leak may be increased usage in other classes, such as *System.String*.
5. Look at instances of classes with unexpectedly high growth in size or number of instances:
 - ◆ If the class that looks interesting is one you recognize, look at instances on the instance list.
 - ◆ If the class that looks interesting is not one you recognize, use the class reference explorer to navigate along the chain of references to objects in this class, until you reach a class you recognize. Next, look at instances of that class on the instance list.
6. On the instance list, look for objects with a high value in the **Distance from GC Root** column.

Often, leaked objects are found at a greater distance from their nearest GC root because all the obvious, shorter chains of reference from a GC root to an object have been broken already.

7. Show the object retention graph for the object that looks interesting. Follow chains of references up the graph to identify objects keeping your object in memory unexpectedly.
8. When you find an unexpected reference, modify your code to break the reference, and then profile the application again to check the problem is fixed.

Example B: populating and clearing a list

1. Start ANTS Memory Profiler and start profiling your application. Get the application into the state in which you are interested in its memory.
2. Take two snapshots, so you can compare memory usage before and after the action that you believe leaks memory:
 - a. Perform the action that you believe causes a leak. For example, populate a list with data.
 - b. Take the first snapshot during or immediately after this action - that is, before any clean-up happens.
 - c. Perform the action that should clean up the objects created by the first action. For example, clear the data from your list.
 - d. Take a second snapshot.

Objects should be cleaned up between snapshots, so any remaining objects were probably created by the first action.

3. Apply the **Only surviving objects** filter to show only classes that exist in both snapshots.
4. On the class list, look for classes with a high value in the **Live Instances** or **Live Size** column. These values indicate the classes responsible for memory usage in your snapshots. At this stage, we recommend that you look at *all* classes (not just the classes you recognize): although your own classes may be responsible for the memory leak, the symptoms of the leak may be increased usage in other classes, such as *System.String*.
5. Look at instances of the class with unexpectedly high size or number of instances:
 - ◆ If the class that looks interesting is one you recognize, look at instances on the instance list.
 - ◆ If the class that looks interesting is not one you recognize, use the class reference explorer to navigate along the chain of references to objects in this class, until you reach a class you recognize. Next, look at instances of that class on the instance list.
6. On the instance list, look for objects with a high value in the **Distance from GC Root** column. Often, leaked objects are found at a greater distance from their nearest GC root because all the obvious, shorter chains of reference from a GC root to an object have been broken already.
7. Show the object retention graph for the object that looks interesting. Follow chains of references up the graph to identify objects keeping your object in memory unexpectedly.

8. When you find an unexpected reference, modify your code to break the reference, and then profile the application again to check the problem is fixed.

Example C: general strategy recommendation

This way of finding a memory leak is recommended:

- if you are not sure what functionality or actions are causing the memory leak
 - for applications where you expect memory to be constant, but instead memory usage increases slowly
 - for applications that do not have functionality that you can manually execute and then clean up
1. Start ANTS Memory Profiler and start profiling your application.
 2. Run your application and monitor memory usage on the timeline. When memory usage starts to increase, take several snapshots (the frequency and number of snapshots you need to take depends on your application and how rapidly memory increases).
 3. Select two snapshots to compare.
 4. If there are classes that you expect to be large or increasing in size, apply the **Never referenced by an instance of class** filter to remove these classes from the results.
 5. On the class list, look for classes with a high value in the **Size Diff** column. This value indicates the growing classes, so it is a good indicator of a memory leak. At this stage, we recommend that you look at *all* classes (not just the classes you recognize): although your own classes may be responsible for the memory leak, the symptoms of the leak may be increased usage in other classes, such as *System.String*.
 6. Look at instances of the class with the largest difference in size between snapshots:
 - ◆ If the class that looks interesting is one you recognize, look at instances on the instance list.
 - ◆ If the class that looks interesting is not one you recognize, use the class reference explorer to navigate along the chain of references to objects in this class, until you reach a class you recognize. Next, look at instances of that class on the instance list.
 7. On the instance list, apply the **Only surviving objects** filter to show only the classes that exist in both snapshots, and then look for high values in the **Live Size** column. This identifies the largest objects, which have stayed in memory for longest, so may indicate the cause of a leak.
 8. Show the object retention graph for the largest object that should not be in memory. Follow chains of references up the graph to identify objects keeping your object in memory unexpectedly.
 9. When you find an unexpected reference, modify your code to break the reference, and then profile the application again to check the problem is fixed.

Checking that a memory leak is fixed

The following steps outline how to check that a memory leak you previously identified is now fixed:

1. Repeat the steps you used to find the memory leak. If you are looking for a particular class or object, it may be useful to use the 🔍 find box to locate the class or object you are interested in.
2. If you have fixed the leak, the objects should not be in memory.

If an unexpected instance *does* seem to still be in memory, display the object on the object retention graph, and check whether it is on the finalizer queue (clear the **Hide finalizer queue GC roots** option on the bar above the graph). If your object is on the finalizer queue, take another snapshot and check again: the object may be removed when the garbage collector runs.

Finding out what is using most memory

The following steps outline how to find out what classes are using most memory in your application.

1. Start ANTS Memory Profiler and start profiling your application. Get the application into the state in which you are interested in its memory, and then take a memory snapshot.
2. On the class list, look for the largest classes, or the classes with the highest number of instances. For this analysis, you are going to explore memory usage by following references to a class, so it is not important if you do not recognize these classes.
3. Select a class and display the class reference explorer. Use the explorer to look at what is keeping your selected class in memory.

Start by looking at the class with the highest number of direct references to objects in your selected class (this is the class at the top of the graph, to the left of your selected class). Click on the class to show classes that refer to it, and then continue to follow the chain of references to understand what is keeping the instances of your selected class in memory.

For example, *System.String* is often the largest class; using this class reference explorer you can find out what is keeping strings in memory.

Checking for memory problems

The following steps outline how to carry out a systematic check of memory usage, to determine whether there are any memory problems.

1. Before you start, work out a plan for what functionality or states you want to check. You will need to be methodical about taking snapshots at the appropriate times to check these states, and you will need to have a good understanding of the expected memory usage - so you can identify unexpected memory usage.
2. Start ANTS Memory Profiler and start profiling your application. Take a snapshot of the application in each of the states you want to compare. Depending on what you are trying to discover, it may be sufficient to take a snapshot before and after performing actions, or you may need to take additional snapshots during use, so that you can analyze memory usage throughout.

3. It may help with your analysis if you change the name of the snapshots so that they are easier to recognize.
4. For each state that you want to check on, select a baseline and current snapshot in the **Snapshots** bar. Alternatively, you can check on memory usage in a single state in isolation: from the **Current** list, select the snapshot you are interested in; from the **Baseline** list, select *No baseline*.
 - ◆ Look at each snapshot to understand where memory is being used in each state.
Find out more about how to identify what is using most memory
 - ◆ Compare pairs of snapshots to check for memory leaks.
Read suggested strategies for finding memory leaks
 - ◆ Use the object filters to check for common indicators of memory leaks.
Find out more about using filters
 - ◆ Look for fragmentation problems on the large object heap
Read tips on identifying fragmentation problems on the large object heap

Video tutorials

Watch the video tutorials to see examples of ANTS Memory Profiler in action, and learn more about some areas of functionality:

- Finding a memory leak (http://www.red-gate.com/products/ants_memory_profiler/overview.htm)
- Using filters to speed up your search for memory problems (http://www.red-gate.com/products/ants_memory_profiler/filters.htm)
- Using the class reference explorer to find a memory leak (http://www.red-gate.com/products/ants_memory_profiler/class_reference.htm)
- Using the timeline (http://www.red-gate.com/products/ants_memory_profiler/timeline.htm)

For a general introduction to .NET memory management:

- .NET memory management (http://www.red-gate.com/products/ants_memory_profiler/DOTNET_Memory_Management/index.html)

What to look for in the summary

The **summary** shows an overview of the main areas of memory usage; if you are comparing two snapshots, this includes an overview of the main differences in memory usage between the snapshots. In the summary or class list, look for classes with unexpectedly high memory usage, or a large increase in size between snapshots.

The large object heap data can be useful for identifying fragmentation problems.

Memory summary: snapshot 2 (11:56)		Comparison: snapshot 2 (11:56) vs. snapshot 1 (00:02)	
Classes with largest size Size (bytes)		Largest growth in size Size growth (bytes)	
SolidBrush	47% 180,000	SolidBrush	733% 158,400
string	19% 74,625	DeviceContext	1090% 7,848
Object[]	9% 34,412	Object[]	21% 6,072
Byte[]	2% 10,442	Stack	1090% 2,616
String[]	2% 8,948	NativeMethods+TRACKMOUSEEVENT	New 48
Classes with most instances Instance count		Largest growth in instances Instance growth	
SolidBrush	64% 5,000	SolidBrush	733% 4,400
string	11% 904	Stack	1090% 109
Object	1% 152	DeviceContext	1090% 109
Object[]	1% 144	Object[]	300% 108
RuntimeType	1% 141	NativeMethods+TRACKMOUSEEVENT	New 2
Large Object Heap details Size (bytes)		Large Object Heap changes Size diff (bytes)	
Free space on all .NET heaps	16,419,680	Change in free space	0% ▼ -163,464
Largest free block	16,419,628	Change in largest free block	0% ▲ +5,112
Maximum size new object (approx.)	2,094,333,951	Change in maximum size new object	0%

Memory usage by class

The charts for size and number of instances can be useful starting points for identifying the classes that use most memory.

If you are comparing two snapshots, the charts for growth in size and number of instances show the five classes which are responsible for the largest increase between the two snapshots. This information can be useful for identifying classes which are growing.

Click on a class to show more detail about it on the class list.

Large object heap charts

The large object heap charts show an overview of memory availability for the large object heap.

- **Free space on all .NET heaps** shows the total amount of memory reserved for .NET but not currently used.
- **Largest free block** shows the size of the largest block of unused memory that is currently reserved for .NET.
- **Max. size of new object** shows an estimate of the size of the largest object that can be allocated. This value is always at least the size of the largest free block, and may be larger where it is possible to extend the large object heap by reserving more memory.

This information is not available when you profile a .NET 1.1 application.

More information about the large object heap

CLR Inside Out: Large Object Heap Uncovered
<http://msdn.microsoft.com/en-us/magazine/cc534993.aspx>
 (http://msdn.microsoft.com/en-us/magazine/cc534993.aspx)

Dangers of the Large Object Heap
<http://www.simple-talk.com/dotnet/.net-framework/the-dangers-of-the-large-object-heap/> (http://www.simple-talk.com/dotnet/.net-framework/the-dangers-of-the-large-object-heap/)

Tips

- The following states can indicate fragmentation problems:
 - ◆ The **Largest free block** size is small, but the **Free space on all .NET heaps** size is large. Although there is plenty of unused memory, the blocks of contiguous unused memory are small, so there may be a danger of running out of memory because the memory is not used efficiently.
 - ◆ The **Max. size of new object** size is small, but the **Free space on all .NET heaps** size is large. Although there is plenty of unused memory, it may not be possible to allocate memory for new large objects, because available contiguous memory slots are small and it is not possible to allocate more memory to increase the size of the large object heap.

When **Max. size of new object** is smaller than the amount of memory that your application tries to allocate for a new object, the application will fail with an *OutOfMemoryException*.


- To investigate objects on the large object heap further, apply the **Objects on the large object heap** filter. This can be useful, for example, to find out which objects are currently in memory, and why they are in memory.

See also


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What to look for in the class list



The **class list** shows detail of memory usage per class. On the summary or class list, look for classes with unexpectedly high memory usage, or a large increase in size between snapshots.

When you enable filters or use the find  box, the values in the list only include objects that match the selected criteria.

Namespace	Class Name	Live Size (bytes)	Size Diff (bytes +/-)	Live Instances	Instance Diff (+/-)
System.Drawing	SolidBrush	180,000	+ 150,400 ▲	5,000	+ 4,400 ▲
System	string	74,626	- 286 ▼	924	- 2 ▼
System	Object[]	34,412	+ 6,072 ▲	144	+ 108 ▲
System	Byte[]	10,142	0 =	4	0 =
System	String[]	8,948	0 =	16	0 =
System.Windows.Fo...	DeviceContext	8,568	+ 7,048 ▲	119	+ 109 ▲
System.Collections	Hashtable+Bucket[]	8,184	0 =	31	0 =
System.Configuration	FactoryRecord	5,320	0 =	95	0 =
System.Collections	Stack	2,856	+ 2,616 ▲	119	+ 109 ▲
System	RuntimeType	2,820	+ 20 ▲	141	+ 1 ▲
System.Drawing	Point[]	2,700	0 =	75	0 =
ShapePainter	EllipseShape	2,640	0 =	66	0 =
System	Int32[]	2,556	0 =	24	0 =
ShapePainter	RectangleShape	2,360	0 =	59	0 =
ShapePainter	TriangleShape	2,100	0 =	75	0 =
System	Char[]	1,910	0 =	23	0 =
System	Object	1,800	- 12 ▼	150	- 1 ▼


If you are *performing a general check on memory usage*, or *checking where most memory is used*, it can be useful to start by looking at **Live Size** or **Live Instances**. Click on the column heading to sort the column, and look for classes with unexpectedly large size or number of instances. Right-click on a class and select  **Show Class Reference Explorer** to see where instances of the class are being referenced.

If you are *looking for a memory leak*, it can be useful to begin by looking for unexpected differences between two snapshots in the **Size Diff** or **Instance Diff** columns. Click on the column heading to sort the column, and then look for classes whose memory usage or instance count has increased significantly. Use the **Comparing snapshots** filters to focus your analysis, depending on the snapshots you are comparing: if you are looking for objects which exist in both the baseline and the current snapshot, select **Only surviving objects**; if you are looking for objects which were created between the two snapshots, select **Only new objects**.

- If the class that looks interesting is one you recognize, right-click and select  **Show Instance List** to look for instances of the class.
- If the class that looks interesting is not one you recognize, right-click and select  **Show Class Reference Explorer** to find out where instances of the class are being referenced.

Tips

Namespace and Class Name

To find a specific namespace or class, type part of the name in the find  box. This can be useful, for example, if you are checking back on a memory leak you have fixed. In many

cases, we do not recommend starting your investigation by looking for specific classes; instead, start by looking at the size or instances columns.

We recommend this approach because a lot of the code being executed by your application is likely to be part of the .NET framework libraries or other third-party libraries, so you are likely to see leaks in classes which are not your own - even where your code is the cause of the leak.

Live Size and Live Instances

The **Live Size** column shows the total size of instances of the class in the current snapshot.

The **Live Instances** column shows the total number of instances of the selected class in the current snapshot.

The values do not include instances of classes referenced by the selected class.

These values can be good starting points for finding out where most memory is being used by your application.

To investigate why a class has a large size or high number of instances:

- look at instances of the class on the instance list

or:

- investigate whether another class is keeping instances of your class in memory unexpectedly, on the class reference explorer

Size Diff and Instance Diff

When you compare two snapshots, the **Size Diff** and **Instance Diff** column show the differences between the baseline and current snapshots.

An unexpected increase in the size of a class or number of instances may indicate a memory leak. For example, if you perform an action where you expect new objects to be cleaned up between the snapshots (such as opening and closing a dialog box), you would not expect the class to increase in size or number of instances.

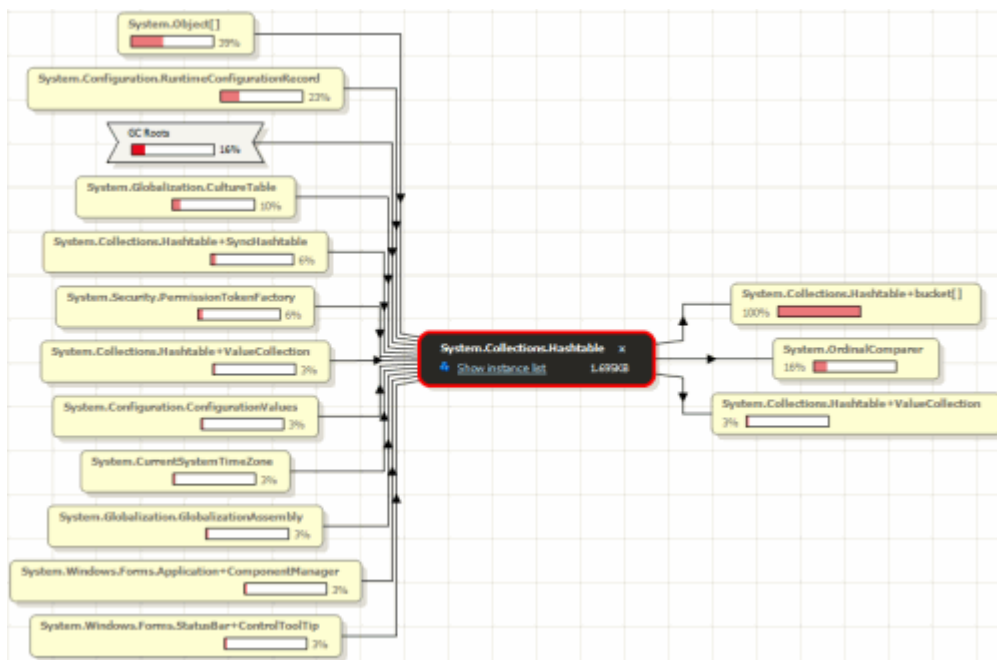
There are also cases where an increase in size or number of instances does not indicate a leak:

- For an application that includes a text editor, the size of the text buffer would be expected to increase as the user adds more text to a document. In this case, the **Size Diff** column for the text buffer class shows an increase in size, but this is not an indication of a memory leak.
- For an application with a text editor backed by a DOM, the number of nodes of a DOM would be expected to increase. In this case, the **Instance Diff** column for the DOM classes shows an increase, but this is not an indication of a memory leak.

What to look for on the class reference explorer

The **class reference explorer** shows reference relationships between classes, which can help identify instances which are unexpectedly kept in memory. This can be particularly useful if your snapshot analysis identifies a class you do not recognize: Use the explorer to follow chains of references to the class, until you reach a class you recognize which may be responsible for the memory usage.


When you enable filters, the values on the graph only include objects that match the selected criteria.



Your selected class is shown at the center of the graph (in black). Classes to the left have instances which reference instances of the selected class; classes to the right have instances which are referenced by instances of the selected class.

Tips

- The percentage shown on a class indicates the proportion of instances of the selected class (in the center) that are connected to it by references along that path. This information can be useful for understanding why instances of your selected class are in memory: look at the percentages on classes to the left of the selected class for an overview of what classes are responsible for instances of the selected class being in memory.
- To find out why your selected class is unexpectedly large, look at the class that is responsible for most references to the selected class. This is the class at the top-left of the graph. Click the class to expand the graph, showing classes that reference this class.
- The graph shows all references between classes, so you may find that as you expand classes and follow references along a particular path you start to see the same classes

repeatedly in the path. This is a circular reference chain, and you are unlikely to find useful information by continuing to follow it. Instead, click  **Show instances of this class on this path** to display the instance list for one of the classes on this path, and then display the object retention graph for an instance, to investigate why the instance is in memory.

See also

What to look for in the summary	15
What to look for on the class reference explorer	19
What to look for on the object retention graph	24

What to look for in the instance list

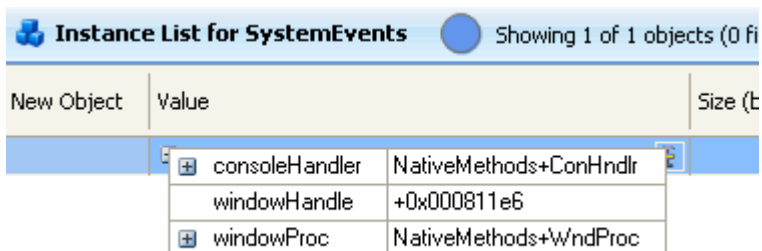
The **instance list** shows detail for all instances of a class, which can help identify instances which are the likely cause of a memory problem.

When you enable filters, the list only includes objects that match the selected criteria.



New Object	Value	Size (bytes)	Size with Children (bytes)	GC Root Object	Distance from GC Root
No	Signature	48	60	No	7
Yes	Signature	48	60	No	7
No	Signature	48	68	No	3
Yes	Signature	48	72	No	10
Yes	Signature	48	68	No	10
Yes	Signature	48	72	No	10
Yes	Signature	48	68	No	10
Yes	Signature	48	72	No	10
Yes	Signature	48	68	No	10
Yes	Signature	48	72	No	10

The instance list is useful for understanding what instances of a class are in memory, and for identifying objects which are likely to be involved in a memory leak.

Click  in the **Value** column to find out more about the properties of a specific instance.



Instance List for SystemEvents Showing 1 of 1 objects (0 fi

New Object	Value	Size (t
	 consoleHandler NativeMethods+ConHndlr	
	windowHandle +0x000811e6	
	 windowProc NativeMethods+WndProc	

Tips

New Object

The **New Object** column indicates whether the object was created between two snapshots you are comparing, or whether it existed already in the earlier snapshot. (This column is only populated when you are comparing two snapshots.)

When you are comparing two snapshots, either *Yes* or *No* in the **New Object** column may be an indication of leaked objects, depending on when you took your snapshots.

- *Yes* may indicate a memory leak when you are comparing snapshots and you expect instances of the selected class to be cleaned up between snapshots. For example, you take a snapshot before and after opening and closing a dialog box. Objects created by

the action should be cleaned up before you take the second snapshot, so new objects in the second snapshot are likely to indicate a memory leak.

When you investigate these new objects further, apply the **Only new objects** filter; this ensures you are only looking at objects which are new in the second snapshot.


- *No* may indicate a memory leak when you are comparing snapshots and you expect instances that exist before the first snapshot to be cleaned up by an action you take between snapshots. For example, you populate a list with data, and then take a snapshot before and after clearing the list. Objects created before the first snapshot should be cleaned up before you take the second snapshot, so old objects in the second snapshot are likely to indicate a memory leak.

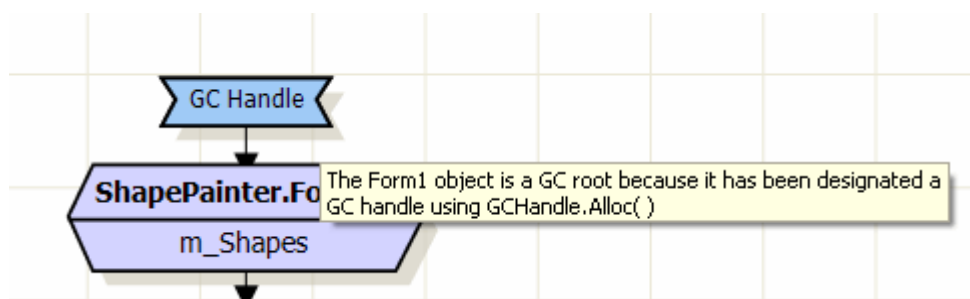
When you investigate these objects further, apply the **Only surviving objects** filter; this ensures you are only looking at objects which exist in both snapshots.

GC Root Object

The **GC Root Object** column indicates whether the object is a GC root object. A GC root can be any storage slot to which the running program has access, such as a local variable, static variables, or even a CPU register. (Strictly speaking, the object itself is not the GC root; the storage slot that holds the reference to the object is the GC root.)

When the garbage collector runs it determines which objects are not garbage by walking the heap, starting at the GC roots. Objects which can be reached by following a chain of references from a GC root are designated as not garbage, and are not collected.

To find out why an object in the instance list is a GC root, right-click on it and then select  **Show object retention graph**. Information on the graph shows why the object is a GC root.



GC root objects are not usually the source of memory leaks. However, they can be useful in *finding* memory leaks because there is always a chain of references between the leaked object and one or more GC roots. To enable the garbage collector to clean up the object, you need to break this chain of references by changing your code to remove one of the "links" in the chain.

Distance from GC Root

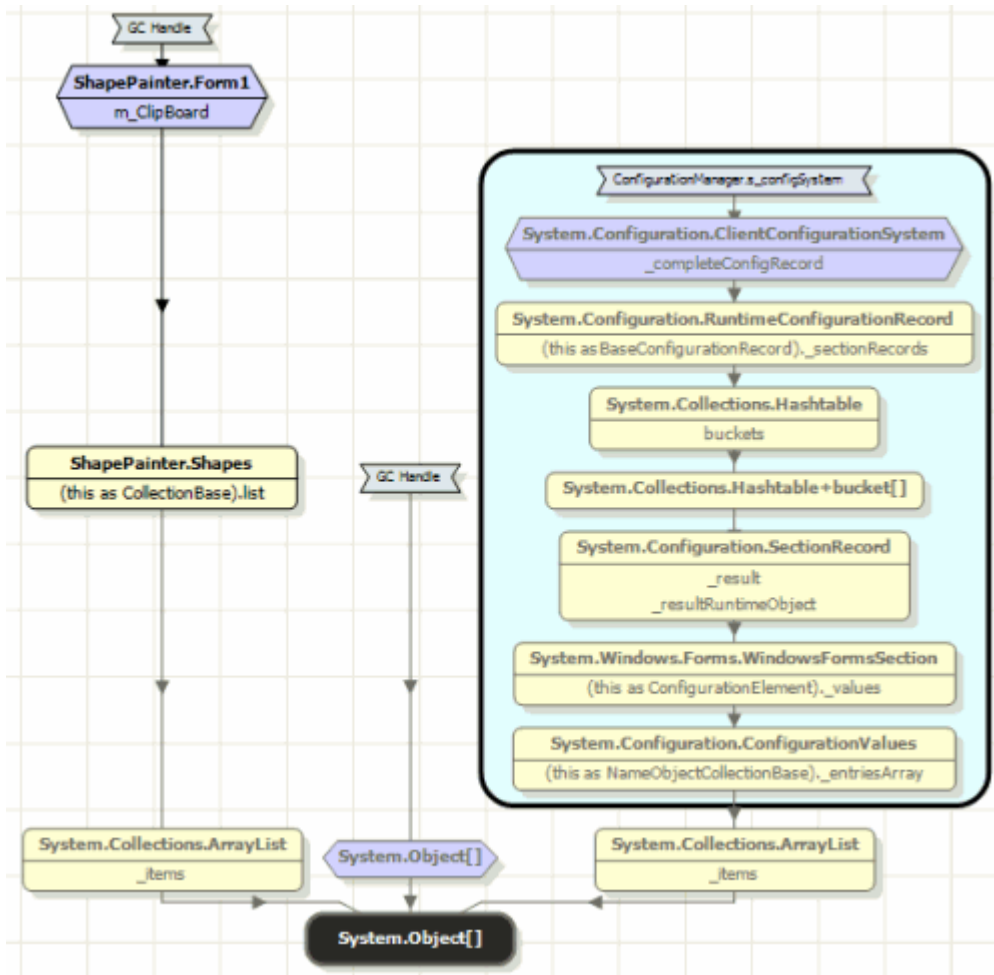
The **Distance from GC Root** column shows the number of references in the chain between the object and its nearest GC root.

It is likely that shorter, more obvious chains of references between objects and their GC roots have been broken already. Often objects which are at a greater distance from a GC

root may be involved in a memory leak, because the chain of references from the GC root to the object is more complex.

What to look for on the object retention graph

The **object retention graph** shows chains of references between GC roots and your selected object. Start at your selected object and follow the chains of references up towards the GC roots, to identify references that are preventing the garbage collector from collecting your object. When you find an unexpected reference, modify your code to break the reference, and then profile the application again to check the problem is fixed.



The object you selected is shown at the bottom of the graph (in black); GC root objects are shown at the top of the graph, with an indication of the reason that the object is a GC root.

For more information about specific objects on the graph, move the mouse cursor over the object; details are displayed in a tooltip.

Tips

- The object retention graph only shows the shortest chain of references from each GC root to your selected object. When you break this chain of references, the object may still be kept in memory by a longer chain of references.

After you have modified your code to break the first chain of references, profile your application again; the object retention graph updates to show the chain of references which is now the shortest chain. You will need to modify your code again, to break this chain of references, and repeat until all the chains of references are broken and the object is no longer in memory.

- Objects grouped in a box are strongly connected; every object references every other object in the group (the reference may be direct or indirect). To remove an object from memory, you do not normally need to break all the references between a GC root and your object: only *one* of the references needs to be removed to prevent your object from being kept in memory.

However, the relationship between strongly connected objects is complex, so in this case you may need to break more than one reference to prevent your object from being held in memory. Break the references one at a time, and take new snapshots each time to check whether your object is still in memory.

- If there is an event handler in the chain of references from a GC root to your object, look at the objects that directly reference the event handler; these references are often a good point to break the chain of references to your object.
- If your graph shows an object which seems to not be referenced by anything, it may be because this object is on the finalizer queue. The graph hides finalizer queue GC roots by default, because they do not normally indicate a memory problem. To show these objects on the graph, clear the **Hide finalizer queue GC roots** option (in the bar above the graph).

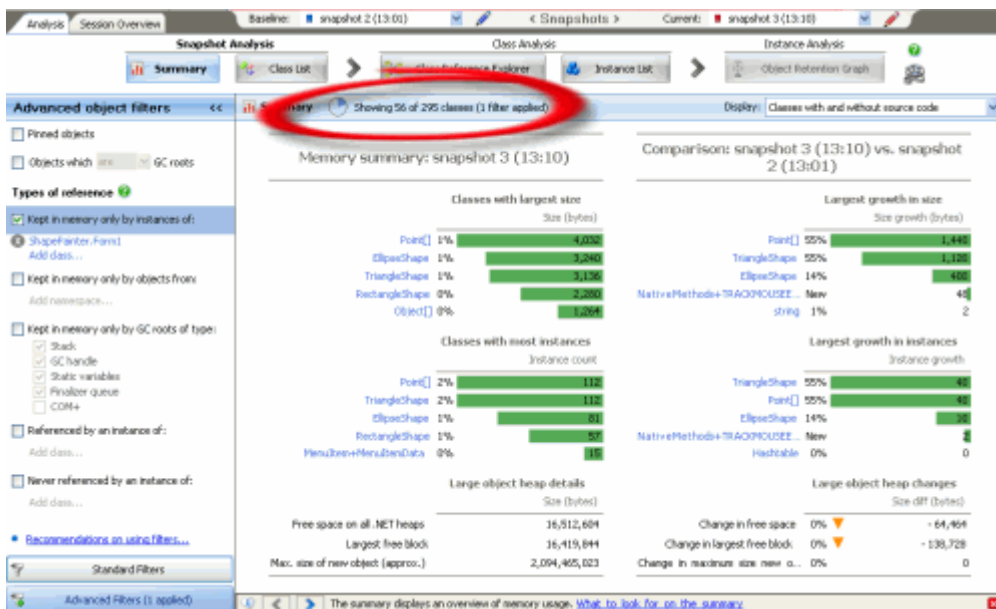
If the graph shows your object is being kept in memory by an object on the finalizer queue, take another memory snapshot. Taking a snapshot forces the garbage collector to run, so your object should now be removed from memory.

Using filters to find objects

Use the object filters to focus your memory usage investigation on objects that are more likely to be of interest.

Select one or more of the filters to show only objects that meet all of the selected criteria. Other objects are hidden.

The bar above the results area indicates the number of objects affected by the current filters:



Suggestions for using filters

Filters alone cannot identify memory problems, but they can help narrow down your search space. The following notes suggest filters that can be useful in some conditions.

Filters which can help find a memory leak

The following filters can be useful in finding a memory leak:

Disposed objects which are still in memory

Kept in memory only by event handlers

Kept in memory only by disposed objects

Only zombie objects (in the **Comparing snapshots** filters)

Filters which can help focus on a specific part of your application

The following filters can be particularly useful when you want to focus on a specific part of an application, or exclude a specific part of an application:

Objects on *large object* / *Gen 0* / *Gen 1* / *Gen 2* heap

Kept in memory only by objects from *namespace*

Never referenced by an instance of *class*

You can also focus on a specific part of an application by using the **Process** selection filter.

See Strategies for memory profiling for examples of how to incorporate filtering in your memory profiling workflow.

Relationships between filters

When you apply multiple filters, only objects which match **all** the filters are shown (i.e. there is an AND relationship between filters).

For example, select the following filters:

- **Disposed objects which are still in memory**
- **Objects on *Gen 1* heap**

Objects are only shown if Dispose() has been called on them *and* they are on the Gen 1 heap.

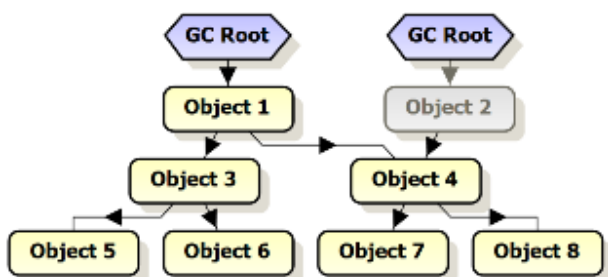
Relationships between objects

Some of the filters enable you to narrow down your search for memory problems by concentrating on certain types of relationships between objects.

"Referenced by"

Objects may be in memory because another object references them; the object is on **at least one of** the chains of references between the selected object and a GC root.

Example: objects referenced by *Object 1*

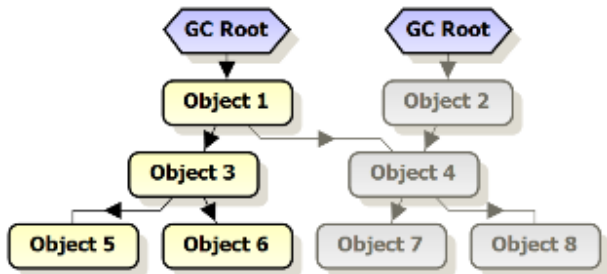


In this example all objects except *Object 2* are referenced by *Object 1*, either directly or indirectly. Note that the filter selection includes the specified object, *Object 1*.

"Kept in memory only by"

Some filters show objects where the selected object is in **all** chains of references between the objects and a GC root - that is, objects are kept in memory *only* by the selected object.

Example: objects kept in memory by *Object 1* (note that the filter includes the selected object, *Object 1*)



In this example, only four objects are kept in memory only by *Object 1*. *Object 1* is not in all the chains of references between the remaining objects and their GC roots; for example, *Object 4* has another GC root which references it via *Object 2*. Note that the filter selection includes the specified object, *Object 1*.

See also

Using filters to find objects..... 26

List of object filters

Object filters enable you to focus your analysis on specific types of object or specific parts of the application. This topic describes the available filters, and suggests situations in which they might be useful.

Standard filters

Disposed objects which are still in memory

Show only objects on which `Dispose()` has been called, but which cannot be garbage-collected because a reference to the object still exists in memory.

Disposed objects should not normally be kept in memory, so this filter can be a good indicator of a memory leak.

When you have identified a disposed object with this filter, display it on the object retention graph, then follow the chains of references to identify the objects keeping the disposed object in memory.

This filter is not available when you are profiling a .NET 1.1 application.

Objects on the *large object / Gen 0 / Gen 1 / Gen 2 heap*

Show only objects in the selected area of memory.

This filter is not available when you are profiling a .NET 1.1 application.

Objects on finalizer queue but not disposed

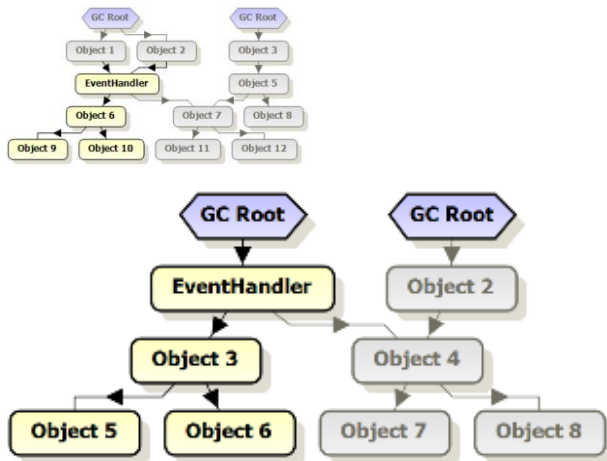
Show only objects on the finalizer queue on which `Dispose()` should be called.

Kept in memory only by event handlers

Show only objects where all chains of references between the object and a GC root go through an event handler.

Examples: objects kept in memory only by event handlers

(note that the event handler is included in the objects shown)



Event handlers should not normally be the only reason an object is kept in memory, so this filter can help identify a memory leak.

When you have identified an object that is kept in memory only by an event handler, display it on the object retention graph, and follow the chain of references from the object to the event handler; it is likely that the cause of the problem is an object close to the event handler.

Note: Objects which match your criteria but are on the finalizer queue are *not* shown.

Kept in memory only by disposed objects

Show:

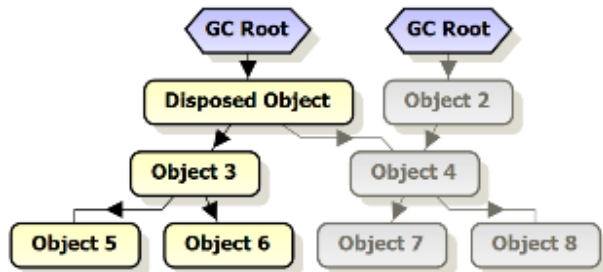
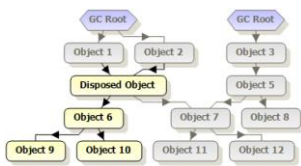
- disposed objects

and

- objects where all chains of references between the object and a GC root go through a disposed object

Examples: objects kept in memory only by disposed objects

(note that the disposed object is included in the objects shown)



Disposed objects should not normally be kept in memory, so this filter can help identify a memory leak.

When you have identified an object that is kept in memory only by a disposed object, display it on the object retention graph, and follow the chains of references to identify the objects keeping the selected object in memory.

Note: Objects which match your criteria but are on the finalizer queue are *not* shown.

This filter is not available when you are profiling a .NET 1.1 application.

Comparing snapshots

Show objects in your current snapshot, based on the comparison with your baseline snapshot.

Only new objects

Show only objects created between the baseline snapshot and the current snapshot.

Only surviving objects

Show only objects that remain in memory in both the baseline snapshot and the current snapshot.

Only zombie objects

Show only objects that showed indications in the baseline snapshot that they would not survive in the current snapshot, but which are still in memory in the current snapshot.

This includes objects with the following characteristics:

- Objects on which Dispose() has been called in the baseline snapshot, but which are still in memory in the current snapshot because garbage collection was prevented for some reason
- Objects on the finalizer queue in the baseline snapshot (this includes objects still on the finalizer queue in the current snapshot and objects which are no longer on the finalizer queue in the current snapshot)

These objects should not normally still be in memory in the current snapshot, so they can be useful for identifying a memory problem.

Advanced filters

Pinned objects

Show only objects marked to not be moved in memory. An increasing number of these objects could indicate that the objects are not being unpinned for some reason.

Large numbers of pinned objects can cause performance problems because of the way the garbage collector handles these objects.

Objects which *are* / *are not* GC roots

Hide GC root objects or show only GC root objects.

If you are investigating a memory leak, it may be useful to hide GC root objects, because they are not generally the source of leaks.

If you are performing a general check on memory usage, it may be useful to show only GC root objects. Show the class list to see details of classes with instances which are GC roots, and then use the class reference explorer to investigate the relationships between these classes and other classes with instances in memory.

Tip: To look for specific types of GC roots, combine this filter with the **Kept in memory only by GC roots of type** filter.

Kept in memory only by instances of *class*

Show:

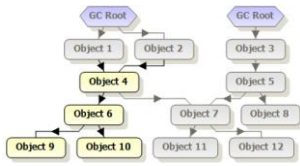
- instances of the specified class

and

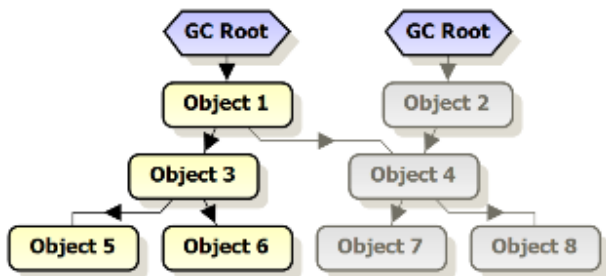
- objects where instances of the specified class exist in all chains of references between the object and a GC root

Example: objects kept in memory only by the class that *Object 4* is an instance of

(note that *Object 4* - which is an instance of the specified class - is included in the objects shown)



Example: objects kept in memory only by the class that *Object 1* is an instance of



This filter shows objects where instances of the specified class exist in *all* chains of references between the object and a GC root. To show objects where instances of the specified class exist in *at least one* chain of references (but not necessarily in *all* chains of references) between the object and a GC root, use the **Referenced by instances of class** filter.

Note: Objects which match your criteria but are on the finalizer queue are *not* shown.

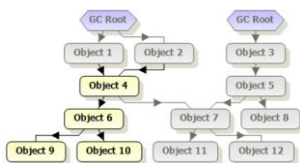
Kept in memory only by instances of *namespace*

Show:

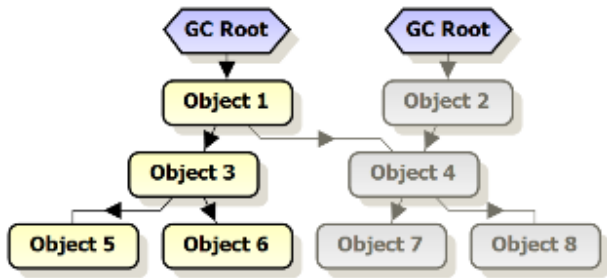
- objects from the specified namespace
- and
- objects where instances of classes from the specified namespace exist in all chains of references between the object and a GC root

Example: objects kept in memory only by a class from the namespace that *Object 4* is an instance of

(note that *Object 4* - which is an instance of the a class in the specified namespace - is included in the objects shown)



Example: object kept in memory only by a class from the namespace that *Object 1* is an instance of



When you select multiple namespaces for this filter, objects are shown if they are instances of classes in any of the namespaces.

Note: Objects which match your criteria but are on the finalizer queue are *not* shown.

Kept in memory only by GC roots of type *GC root type*

Show objects with GC roots of the specified types (includes objects which are GC roots).

When you select more than one type of GC root, objects are shown if they have a GC root which is any of the selected types.

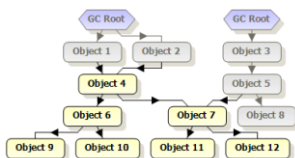
Tip: To look for specific types of GC roots, combine this filter with the **Objects which are GC roots** filter.

Referenced by an instance of *class*

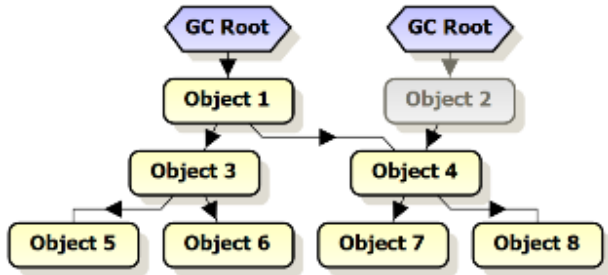
Show only objects which are referenced by one or more instances of the specified class. The reference may be direct or indirect.

Example: objects referenced by the class that *Object 4* is an instance of

(note that *Object 4* - which is an instance of the specified class - is included in the objects shown)



Example: objects referenced by the class that *Object 1* is an instance of



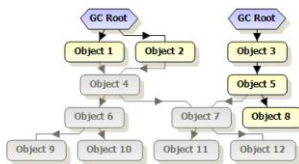
When you select multiple classes for this filter, objects are only shown if they are referenced by all of the selected classes.

This filter shows objects where instances of the specified class exist in *at least one* chain of references between the object and a GC root. To show objects where instances of the specified class exist in *all* chains of references between the object and a GC root, use the **Kept in memory only by instances of class** filter.

Never referenced by an instance of class

Show only objects which are never referenced by an instance of the specified class. This includes direct and indirect references.

Example: objects never referenced by the class that *Object 4* is an instance of



When you select multiple classes for this filter, objects are only shown if they are not referenced by any of the selected classes.

Note: Objects which match your criteria but are on the finalizer queue are *not* shown.

Some examples of when you might want to use this filter:

- You know that all the data in your application should be referenced by a single main class. Apply the **Never referenced by an instance of class** filter to remove objects referenced by the main class from the results.
- Your application performs caching (for example, web applications that cache the query results). Cached objects are deliberately kept in memory for a period of time. Apply the **Never referenced by an instance of class** filter to exclude objects referenced by a cache class (for example, *System.Web.Caching.Cache*, for ASP.NET applications).