

Диагностика производительности .NET приложений в production

Дмитрий Левченко,
Ведущий разработчик, Arcadia



О чем будем говорить

- Анализ производительности: с чего начать
- Использование PerfView для диагностики CPU и памяти
- Автоматизация PerfView
- Создание и использование дампов памяти процесса
- Продвинутое инструменты

.NET production

- .NET Framework на Windows
- .NET Core
- Управляемое облачное окружение (Azure, Amazon etc.)
- Остальное

.NET production

- **.NET Framework на Windows**
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Частые проблемы

- Загрузка CPU
- Высокое потребление памяти
- Низкая скорость работы
- Неожиданное завершение работы

Что стоит сделать заранее

- Знать, как система должна работать в обычном режиме, что ожидать
- Знать требования к производительности
- Логирование и самодиагностика приложения
- Настроить окружение и утилиты

Что использовать, чтобы понять, что именно идёт не так

- Диспетчер задач
- Монитор ресурсов
 - Файл подкачки
 - Дисковая и сетевая активность
 - Открытые порты
- Монитор производительности


Недостатки использования профайлеров в production

- Заметно влияют на производительность приложения
- Могут требовать перезапуска приложения
- Требуют предварительной установки и настройки
- \$\$\$

PerfView

- Сделана инженерами для инженеров
- Мощная
- Не требует установки
- Низкие накладные расходы
- Бесплатная

PerfView: использование CPU

 CPU Stacks(10,381 metric) PerfViewData.etl in PerfView (C:\SpbDotNet36\Tools\PerfView\PerfViewData.etl)

File View Diff Regression Preset Help [Stack View Help \(F1\)](#) [Understanding Perf Da](#) [Starting an Analysis](#) [Troubleshooting](#)

Update Back Forward Totals Metric: 10,381.0 Count: 10,381.0 First: 1,971.777 Last: 12,528.236 Last-First: 10,556.459 Metric/Interval

Start: 0 End: 12,528.527 Find:

GroupPats: [no grouping] Fold%: 0 FoldPats: ntoskrnl!%ServiceC IncPats: Process% Demo-C Ex

By Name ? Caller-Callee ? CallTree ? Callers ? Calleees ? Flame Graph ? Notes ?

Methods that are called by demo-cpu!Demo_Cpu.Program.Main()

Name ?	Inc	Inc ?
<input checked="" type="checkbox"/> demo-cpu!Demo_Cpu.Program.Main()	95.9	9,956.0
+ <input checked="" type="checkbox"/> demo-cpu!Demo_Cpu.Program.MethodA(class System.Collections.Generic.List`1 <class System.String>)	85.8	8,910.0
+ <input type="checkbox"/> mscorlib.ni!System.Collections.Generic.List`1[System.__Canon].Sort(System.Comparison`1 <System.__Canon>)	85.8	8,907.0
+ <input type="checkbox"/> system.core.ni!?	0.0	3.0
+ <input type="checkbox"/> system.core.ni!?	4.7	485.0
+ <input type="checkbox"/> demo-cpu!Demo_Cpu.Program.RandomString(int32)	4.5	470.0
+ <input type="checkbox"/> mscorlib.ni!System.Text.StringBuilder.ToString()	0.8	83.0

PerfView: выделение памяти

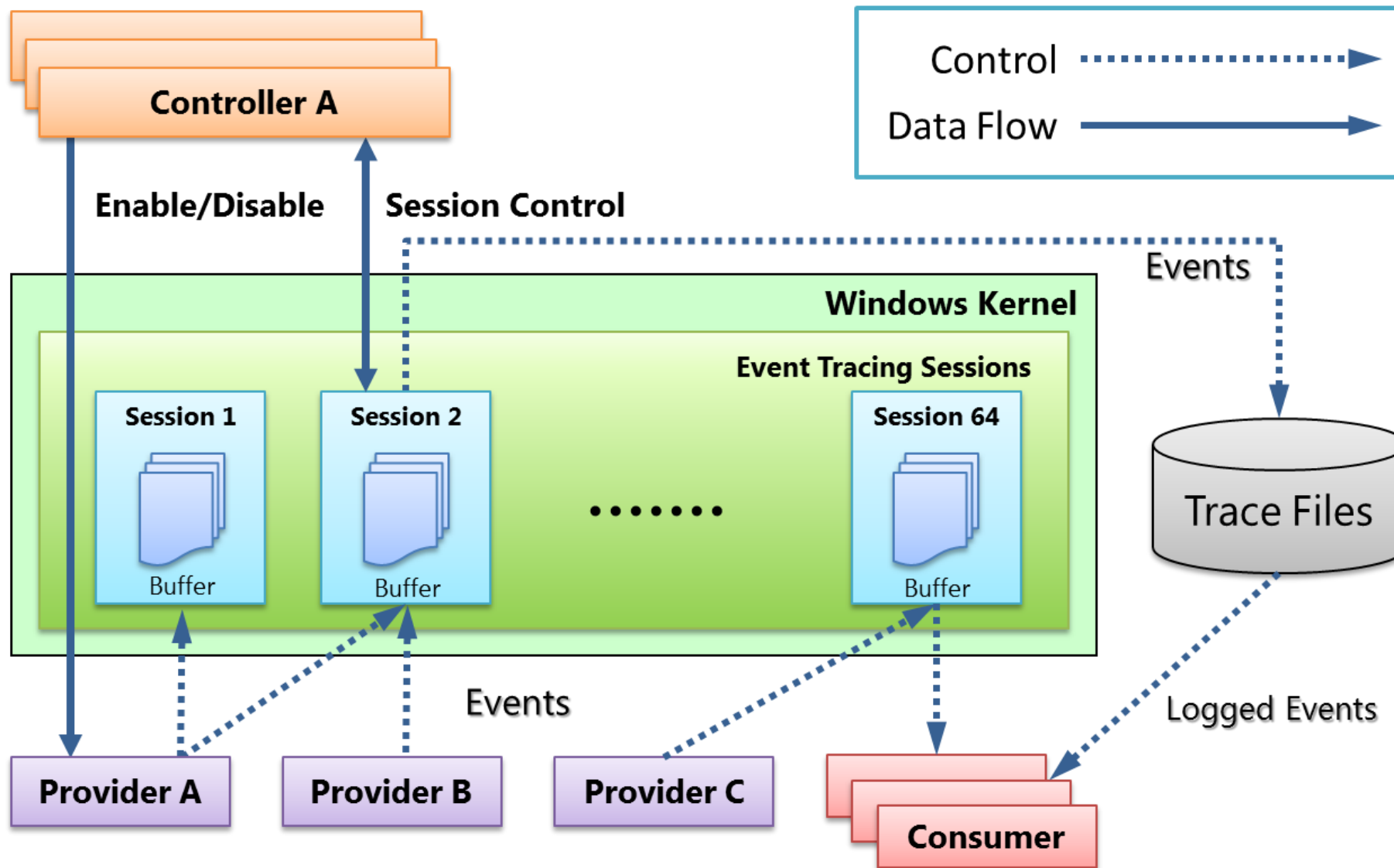
 GC Heap Alloc Ignore Free Stacks(70,039,820 metric) PerfViewData.etl in PerfView (C:\SpbDotNet36\Tools\PerfView\PerfViewD...

File	View	Diff	Regression	Preset	Help	Stack View Help (F1)		Understanding Perf Data					
Update	Back	Forward	Totals Metric: 70,039,820.0			Count: 700,076.0	First: 2,083.469	Last: 12,572.076	Last-First: 10,488.606	Metric:			
Start:		0.000	▼	End:		12,572.076	▼	Find:					
GroupPats:		[no grouping]					▼	Fold%:	1	▼	FoldPats:	ntoskrnl!%ServiceCopyEnd	
By Name ?		Caller-Callee ?		CallTree ?		Callers ?		Callees ?		Flame Graph ?		Notes ?	

Methods that are called by demo-cpu!Demo_Cpu.Program.Main()

Name ?	Inc	Inc ?
<input checked="" type="checkbox"/> demo-cpu!Demo_Cpu.Program.Main()	99.9	70,001,250.0
+ <input type="checkbox"/> demo-cpu!Demo_Cpu.Program.RandomString(int32)	63.9	44,789,610.0
+ <input type="checkbox"/> system.core.nil?	20.0	14,003,280.0
+ <input type="checkbox"/> demo-cpu!Demo_Cpu.Program.MethodA(class System.Collections.Generic.List`1 <class System.String>)	8.0	5,604,464.0
+ <input type="checkbox"/> mscorlib.ni!System.Collections.Generic.List`1[System.__Canon]..ctor(Int32)	8.0	5,600,168.0
+ <input type="checkbox"/> clr!?	0.0	744.0

Event Tracing for Windows (ETW)



<https://docs.microsoft.com/en-us/windows-hardware/test/weg/instrumenting-your-code-with-etw>

Примеры источников данных ETW

- Kernel CPU sample provider – call stack каждую 1 мс.
- CLR Garbage collection
- CLR Allocation Tick
- CLR Exception thrown
- File I/O, Registry, Network, и другие...

PerfView: исключения, JIT

By Name [?](#) Caller-Callee [?](#) CallTree [?](#) Callers [?](#) Calleees [?](#) Flame Graph [?](#) Notes [?](#)

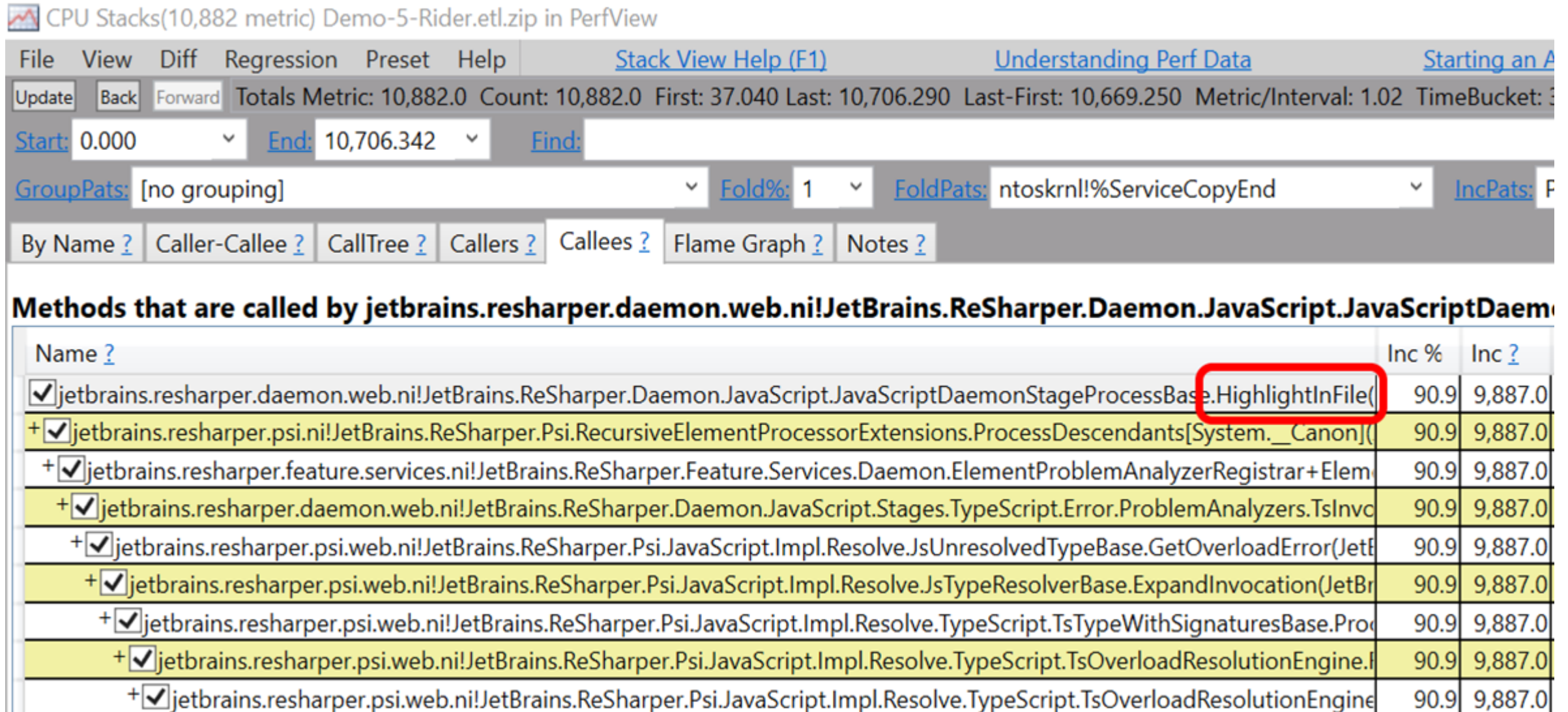
Methods that call Throw(Newtonsoft.Json.JsonReaderException) Input string '450.5' is not a valid integer. Path 'width',

Name ?	Inc % ?	Inc ?
<input checked="" type="checkbox"/> Throw(Newtonsoft.Json.JsonReaderException) Input string '450.5' is not a valid integer. Path 'width', line 1, position 14.	6.3	1.0
+ <input checked="" type="checkbox"/> Newtonsoft.Json!Newtonsoft.Json.JsonTextReader.ParseNumber(value class Newtonsoft.Json.ReadType)	6.3	1.0
+ <input checked="" type="checkbox"/> Newtonsoft.Json!Newtonsoft.Json.JsonTextReader.ReadNumberValue(value class Newtonsoft.Json.ReadType)	6.3	1.0
+ <input checked="" type="checkbox"/> Newtonsoft.Json!Newtonsoft.Json.JsonTextReader.ReadAsInt32()	6.3	1.0
+ <input checked="" type="checkbox"/> Newtonsoft.Json!Newtonsoft.Json.Serialization.JsonSerializerInternalReader.ReadForType(class Newtonsoft.Json.JsonRea	6.3	1.0
+ <input checked="" type="checkbox"/> Newtonsoft.Json!Newtonsoft.Json.Serialization.JsonSerializerInternalReader.PopulateObject(class System.Object,class N	6.3	1.0
+ <input checked="" type="checkbox"/> Newtonsoft.Json!Newtonsoft.Json.Serialization.JsonSerializerInternalReader.CreateObject(class Newtonsoft.Json.Jsonf	6.3	1.0
+ <input checked="" type="checkbox"/> Newtonsoft.Json!Newtonsoft.Json.Serialization.JsonSerializerInternalReader.Deserialize(class Newtonsoft.Json.JsonR	6.3	1.0
+ <input checked="" type="checkbox"/> Newtonsoft.Json!Newtonsoft.Json.JsonSerializer.DeserializeInternal(class Newtonsoft.Json.JsonReader,class System	6.3	1.0
+ <input checked="" type="checkbox"/> System.Net.Http.Formatting!System.Net.Http.Formatting.BaseJsonMediaTypeFormatter.ReadFromStream(class Sy	6.3	1.0
+ <input checked="" type="checkbox"/> System.Net.Http.Formatting!System.Net.Http.Formatting.BaseJsonMediaTypeFormatter.ReadFromStream(class S	6.3	1.0
+ <input checked="" type="checkbox"/> System.Net.Http.Formatting!System.Net.Http.Formatting.BaseJsonMediaTypeFormatter.ReadFromStreamAsync	6.3	1.0
+ <input checked="" type="checkbox"/> System.Net.Http.Formatting!System.Net.Http.Formatting.MediaTypeFormatter.ReadFromStreamAsync(class S	6.3	1.0
+ <input checked="" type="checkbox"/> System.Net.Http.Formatting!System.Net.Http.HttpContentExtensions+ <ReadAsStringAsync>d__0`1[System._	6.3	1.0
+ <input checked="" type="checkbox"/> mscorlib!System.Runtime.CompilerServices.AsyncTaskMethodBuilder`1[System.__Canon].Start(!0&)	6.3	1.0
+ <input checked="" type="checkbox"/> System.Net.Http.Formatting!System.Net.Http.HttpContentExtensions.ReadAsStringAsync(class System.Net	6.3	1.0

JetBrains Rider: когда что-то пошло не так

Task Manager						
File Options View						
Processes	Performance	App history	Startup	Users	Details	Services
Name			Status	12% CPU	79% Memory	
▼ RD JetBrains Rider (18)				0.2%	14,221.3 MB	
R# JetBrains JetBrains.ReSharper.Host				0.1%	9,419.8 MB	
R# JetBrains JetBrains.ReSharper.Host				0.1%	3,391.0 MB	
RD JetBrains Rider				0%	1,218.1 MB	
Node.js: Server-side JavaScript				0%	108.3 MB	
Node.js: Server-side JavaScript				0%	56.1 MB	
MSBuild.exe (32 bit)				0.1%	9.4 MB	

JetBrains Rider: использование CPU



JetBrains Rider: использование памяти

Stacks(5,409,918,000 metric) Demo-5-Rider-10g.gcdump in PerfView

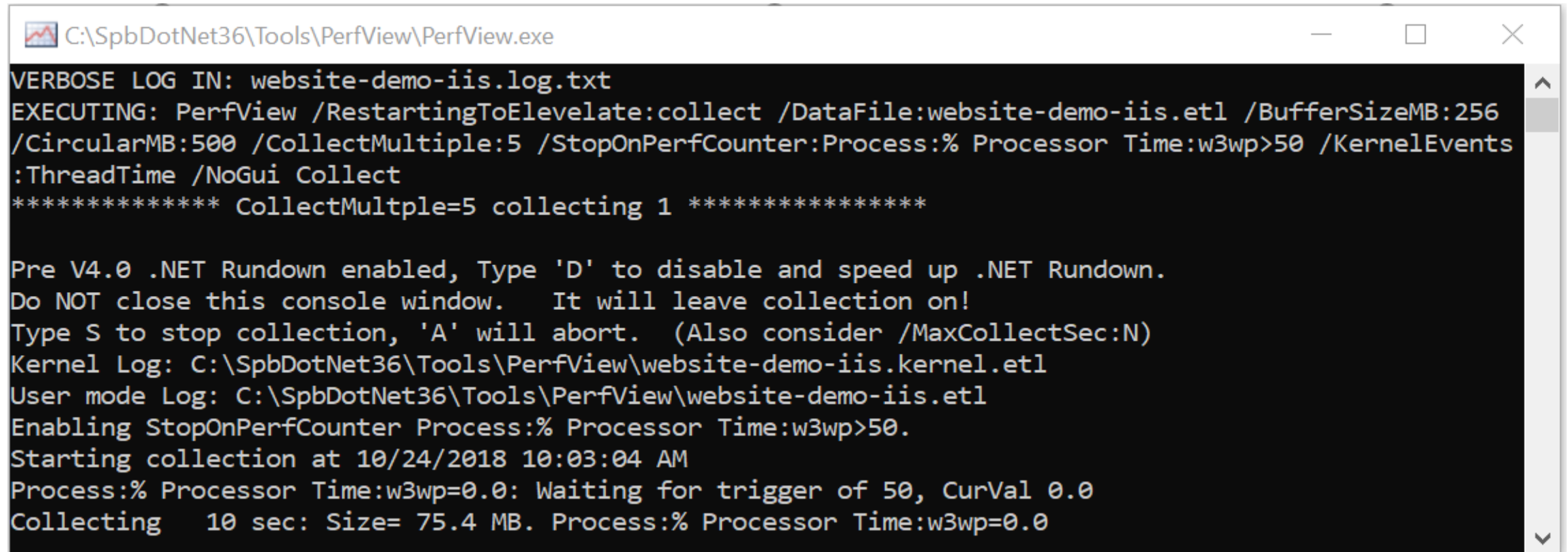
File	View	Diff	Regression	Preset	Help	Stack View Help (F1)	Understanding Perf Data	Starting an Analysis
Update	Back	Forward	Totals Metric: 5,409,918,000.0 Count: 16,777,220.0 First: 0.000 Last: 10,556,898,808.000 Last-First: 10,556,898,808.000 Metric/Interval: 0.51 TimeBucket					
Start:	0	End:	10,556,924,8	Priority:	v4.0.30319\%!\>-1;v2.0.507	Pri1Only:	<input type="checkbox"/>	Find:
GroupPats:	[group Framework] mscorlib!=>LIB;System%!=>LIE							
Fold%:	1	FoldPats:	[];mscorlib!String					
IncPats:								
By Name	RefFrom-RefTo	RefTree	Referred-From	Refs-To	Flame Graph	Notes		
Name	Inc %	Inc						
+ <input checked="" type="checkbox"/> JetBrains.Platform.ComponentModel!JetBrains.Application.Components.ComponentStorage	99.9	5,401,849,000.0						
+ <input checked="" type="checkbox"/> LIB <<mscorlib!Dictionary<JetBrains.Application.Components.IComponentDescriptor,JetBrains.DataFlow.Lifetime>>>	99.9	5,401,812,000.0						
+ <input checked="" type="checkbox"/> JetBrains.Platform.ComponentModel!JetBrains.Application.Extensibility.PartCatalogTypeComponentDescriptor	99.9	5,401,810,000.0						
+ <input type="checkbox"/> JetBrains.dotCover.Ide.Core!JetBrains.dotCover.Ide.Core.UnitTesting.Model.ContinuousTesting.PsiBasedAffectedTestsDet	70.7	3,825,570,000.0						
+ <input type="checkbox"/> JetBrains.ReSharper.Psi!JetBrains.ReSharper.Psi.Files.PsiFilesCache2	43.1	2,332,763,000.0						
+ <input type="checkbox"/> JetBrains.ReSharper.Host!JetBrains.ReSharper.Host.Features.LiveTemplates.RiderLiveTemplateHost	6.6	357,101,300.0						
+ <input type="checkbox"/> JetBrains.ReSharper.Psi.Web!JetBrains.ReSharper.Psi.JavaScript.Impl.Caches.JavaScriptTypeCacheMaintainer	1.2	67,517,070.0						
+ <input type="checkbox"/> JetBrains.ReSharper.Psi!JetBrains.ReSharper.Psi.Caches.SymbolCache.SymbolCache	1.2	62,497,380.0						
+ <input checked="" type="checkbox"/> [static var JetBrains.Application.BuildScript.Application.Catalogs.CalculateModuleZoneTraitsForPartCatalogTables.TraitNamespace]	0.0	0.0						
+ <input checked="" type="checkbox"/> [static var JetBrains.Application.BuildScript.GlobalDefines.EapSuffixString] {MinDepth 3}	0.0	0.0						
+ <input checked="" type="checkbox"/> [static var JetBrains.Application.BuildScript.GlobalDefines.MarketingVersionStringWithoutSuffix] {MinDepth 3}	0.0	0.0						
+ <input checked="" type="checkbox"/> [static var JetBrains.Application.Settings.Implementation.StoreToStorageTranslation+Metadata+WithMetadataPrefixComposed.At	0.0	0.0						

Прочие возможности PerfView

- Wall Clock Time анализ
- Поддержка TPL (async/await)
- Создание легковесных дампов памяти процесса и функция сравнения
- Принудительный вызов сборки мусора в процессе
- Интерфейс командной строки
- Средства автоматизации

Демо: АВТОМАТИЧЕСКИЙ МОНИТОРИНГ

- Perfview /NoGui collect "/StopOnPerfCounter=Process:%% Processor Time:w3wp>50" - MinSecForTrigger:3 -ThreadTime -CircularMB:500 -CollectMultiple:5 -accepteula website-demo-iis.etl



```
C:\SpbDotNet36\Tools\PerfView\PerfView.exe
VERBOSE LOG IN: website-demo-iis.log.txt
EXECUTING: PerfView /RestartingToElevelate:collect /DataFile:website-demo-iis.etl /BufferSizeMB:256
/CircularMB:500 /CollectMultiple:5 /StopOnPerfCounter:Process:%% Processor Time:w3wp>50 /KernelEvents
:ThreadTime /NoGui Collect
***** CollectMultiple=5 collecting 1 *****
Pre V4.0 .NET Rundown enabled, Type 'D' to disable and speed up .NET Rundown.
Do NOT close this console window. It will leave collection on!
Type S to stop collection, 'A' will abort. (Also consider /MaxCollectSec:N)
Kernel Log: C:\SpbDotNet36\Tools\PerfView\website-demo-iis.kernel.etl
User mode Log: C:\SpbDotNet36\Tools\PerfView\website-demo-iis.etl
Enabling StopOnPerfCounter Process:%% Processor Time:w3wp>50.
Starting collection at 10/24/2018 10:03:04 AM
Process:%% Processor Time:w3wp=0.0: Waiting for trigger of 50, CurVal 0.0
Collecting 10 sec: Size= 75.4 MB. Process:%% Processor Time:w3wp=0.0
```

Дампы памяти

Demo_Dump.exe_181024_113850.dmp - Microsoft Visual Studio (Administrator)

File Edit View Project Debug Team Tools Test Analyze Window Help

Quick Launch (Ctrl+Q) Levchenko, Dmitrii

Demo_Dump.exe_181024_113850.dmp

Minidump File Summary

10/24/2018 11:38:51 AM

^ Dump Summary

Dump File: Demo_Dump.exe_181024_113850.dmp : C:\SpbDotNet36\Demo 3 - Dump\Demo_Dump.exe_181024_113850.dmp

Last Write Time: 10/24/2018 11:38:51 AM

Process Name: Demo_Dump.exe : C:\SpbDotNet36\Demo 3 - Dump\Demo_Dump.exe

Process Architecture: x64

Exception Code: 0xC0000094

Exception Information: The thread tried to divide an integer value by an integer divisor of zero.

Heap Information: Present

Error Information:

^ Actions

- ▶ Debug with Managed Only
- ▶ Debug with Mixed
- ▶ Debug with Native Only
- 📁 Set symbol paths
- 📄 Copy all to clipboard

^ System Information

OS Version: 10.0.17134

CLR Version(s): 4.7.3132.0

^ Modules

Search

Module Name	Module Version	I
Demo_Dump.exe	1.0.0.0	C.
ntdll.dll	6.2.17134.228	C.
mscorlib.dll	6.2.17134.1	C.

Output

Ready Add to Source Control

Продвинутые инструменты

- WinDbg
 - Отладка
 - Анализ дампов памяти
 - Поиск взаимных блокировок потоков
 - Поддержка расширений
- CLRMD
 - Программный анализ дампов памяти
 - Возможность анализа работающего процесса

Пример использования CLRMD

```
using (var dataTarget = DataTarget.AttachToProcess(pid, 5000, AttachFlag.Invasive))
{
    var runtime =
dataTarget.ClrVersions[0].CreateRuntime(dataTarget.ClrVersions[0].LocalMatchingDac);
    Console.WriteLine($"Thread count: {runtime.Threads.Count} ");

    foreach (var thread in runtime.Threads)
    {
        Console.WriteLine($"### Thread {thread.OSThreadId}");
        Console.WriteLine("Stack trace:");
        foreach (var stackFrame in thread.EnumerateStackTrace())
        {
            Console.WriteLine($"* {stackFrame.DisplayString}");
        }
    }
}
```

ССЫЛКИ

- PerfView <https://github.com/microsoft/perfview>
- ETW Events <https://docs.microsoft.com/en-us/dotnet/framework/performance/etw-events>
- Vance Morrison <https://blogs.msdn.microsoft.com/vancem/>
- <https://channel9.msdn.com/Series/PerfView-Tutorial>
- ProcDump <https://docs.microsoft.com/en-us/sysinternals/downloads/procdump>
- ClrMD <https://github.com/microsoft/clrmd>
- Sasha Goldshtein <https://sashagoldshtein.me/>
- Ben Watson <https://www.writinghighperf.net/>

Спасибо!

Dmitrii.Levchenko@softwarecountry.ru

