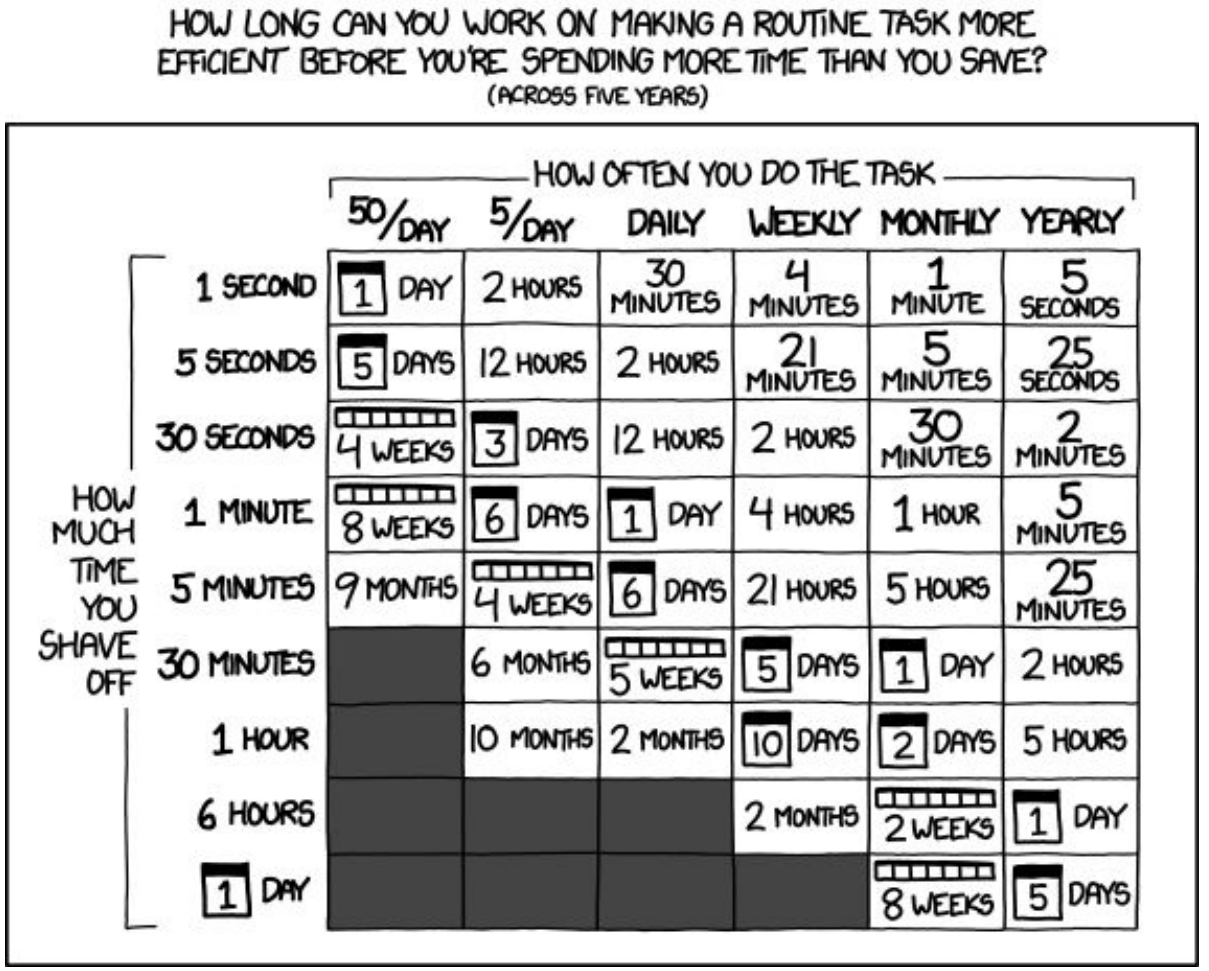
.Net Performance

Tips & Tricks

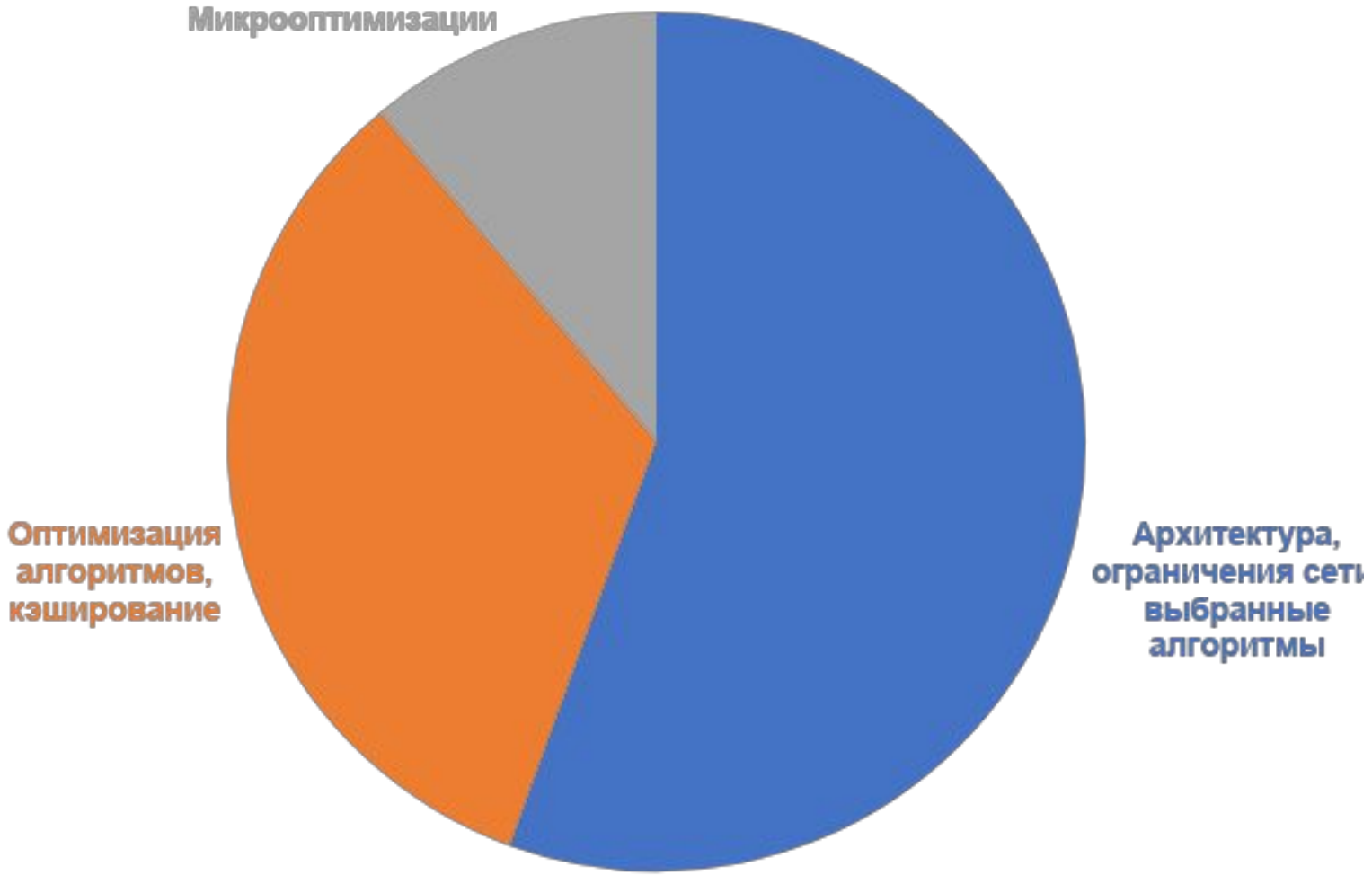
Сафин Рустам

DIRECTUM

Зачем нужна производительность?



Как понять, на каком уровне проблема?



Инструменты

Visual Studio profiler

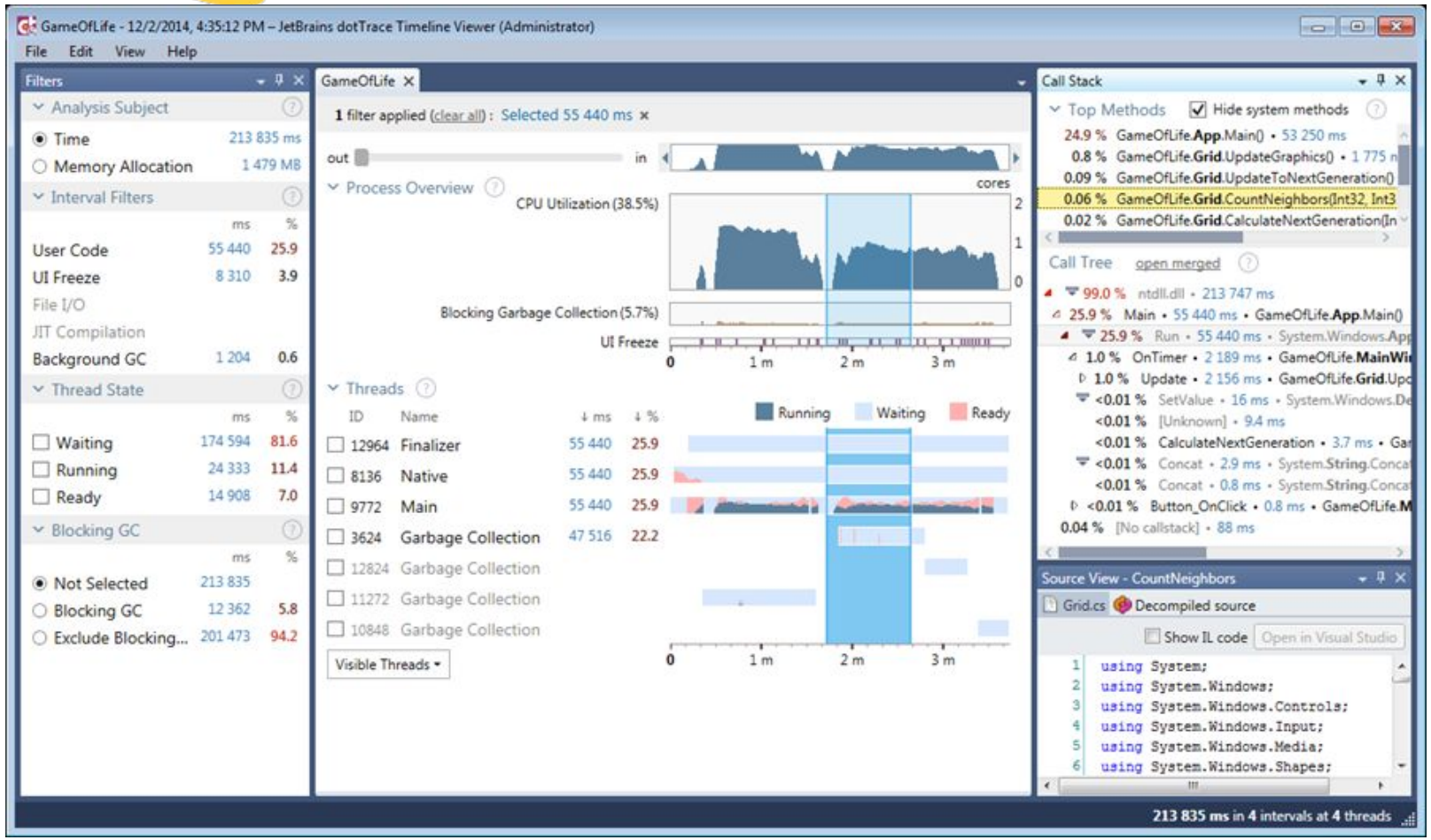
dotTrace

dotMemory

BenchmarkDotNet

CodeTrack

CLR Profiler



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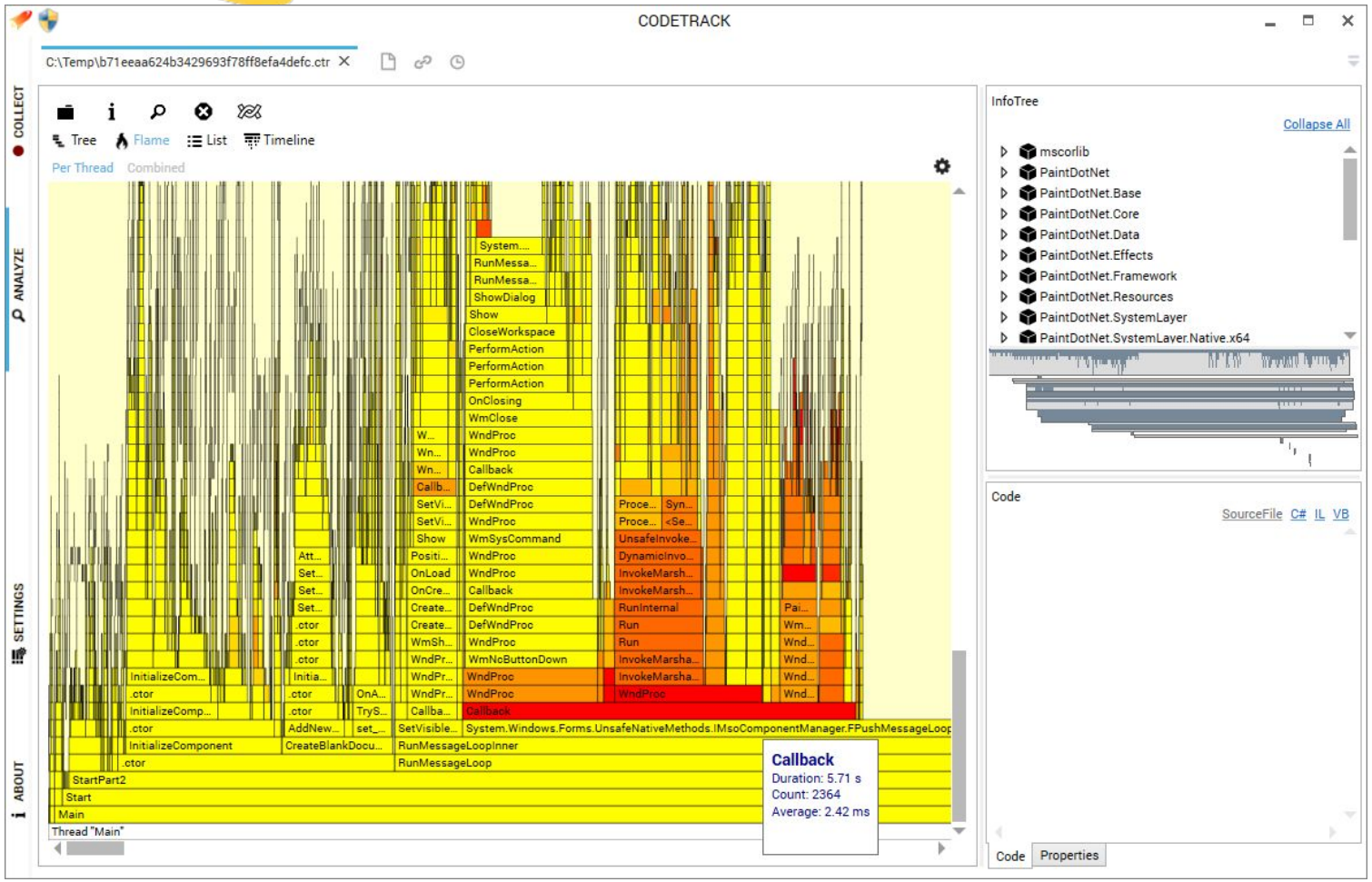
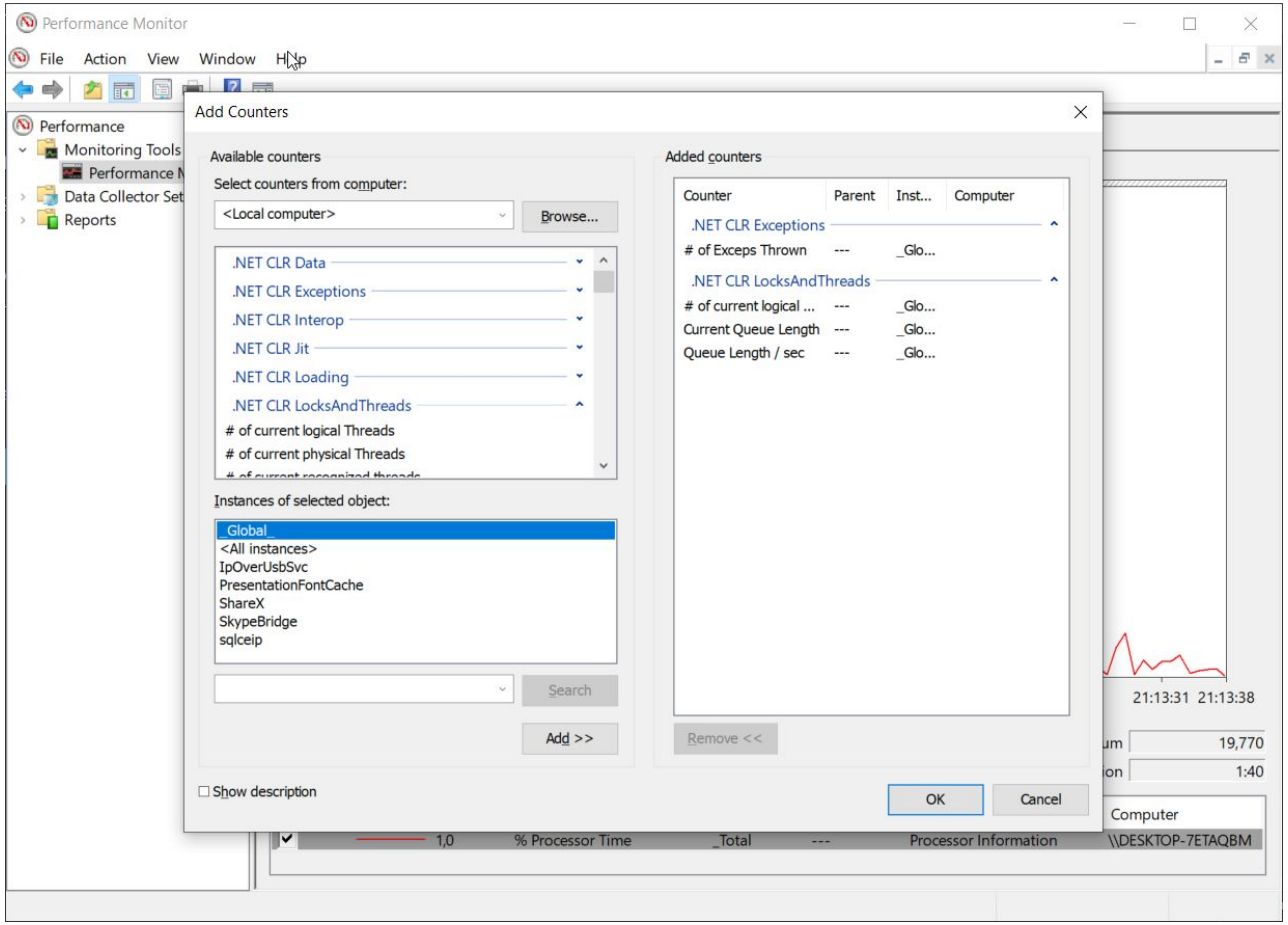


Инструменты

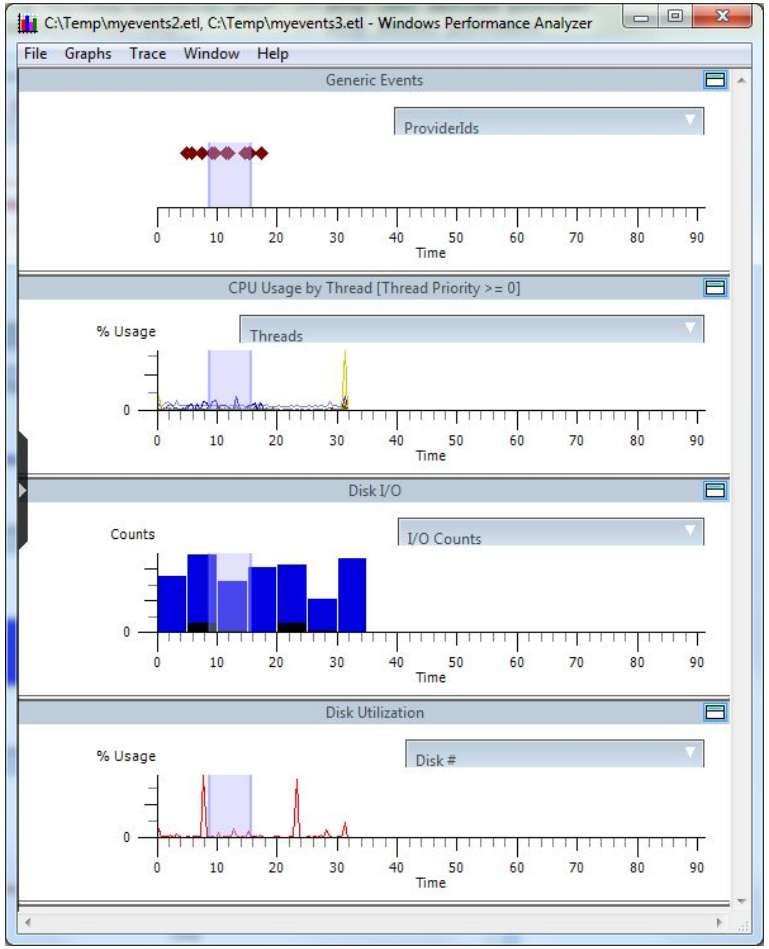
Performance Monitor



Инструменты

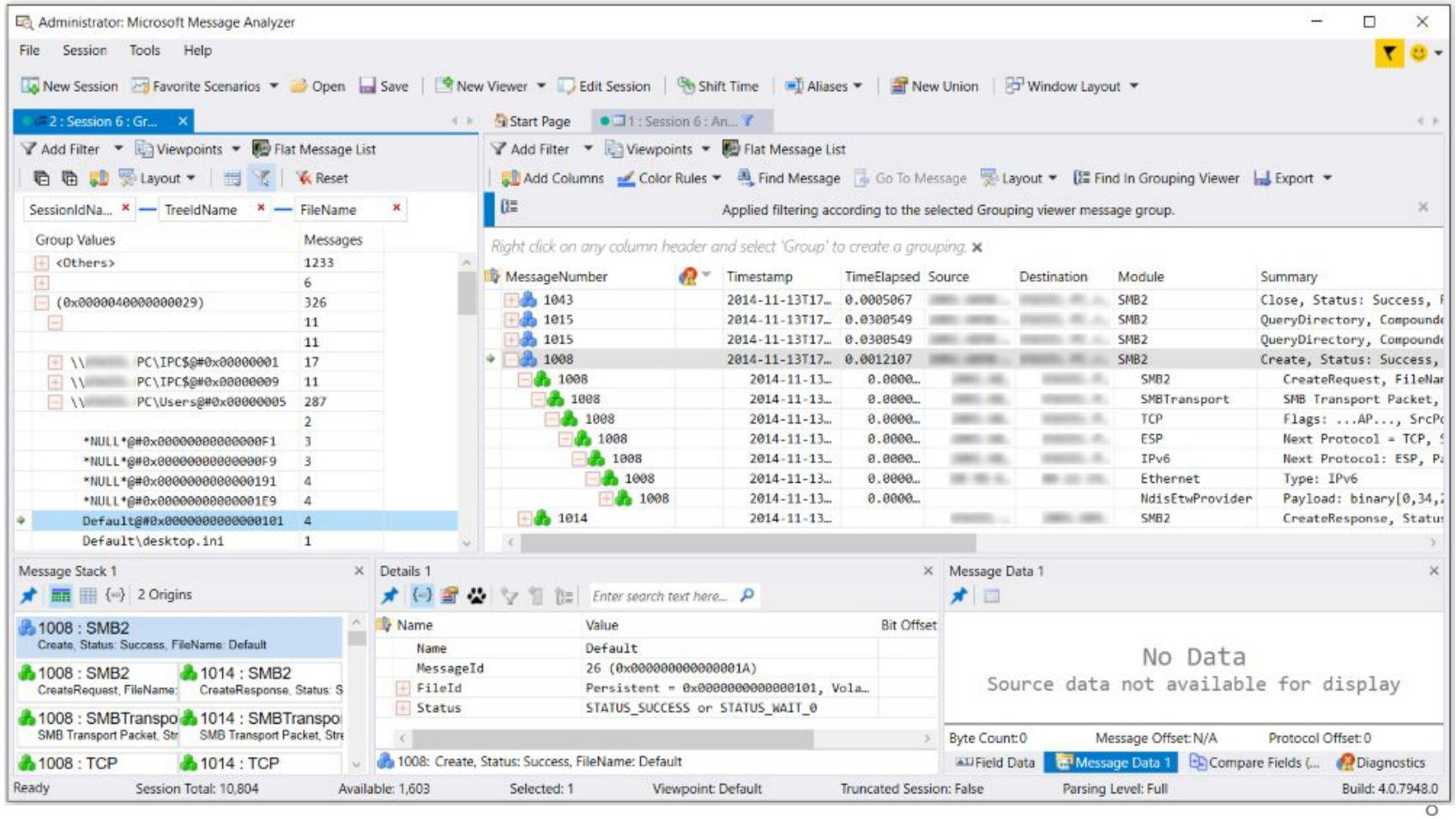
ETW

Windows Performance Analyzer

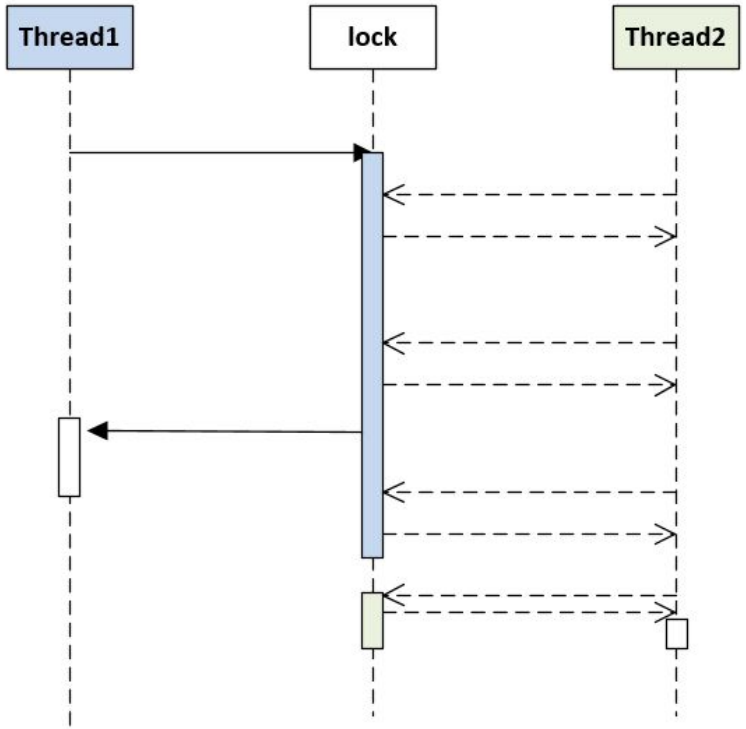


Инструменты

MS Message Analyzer



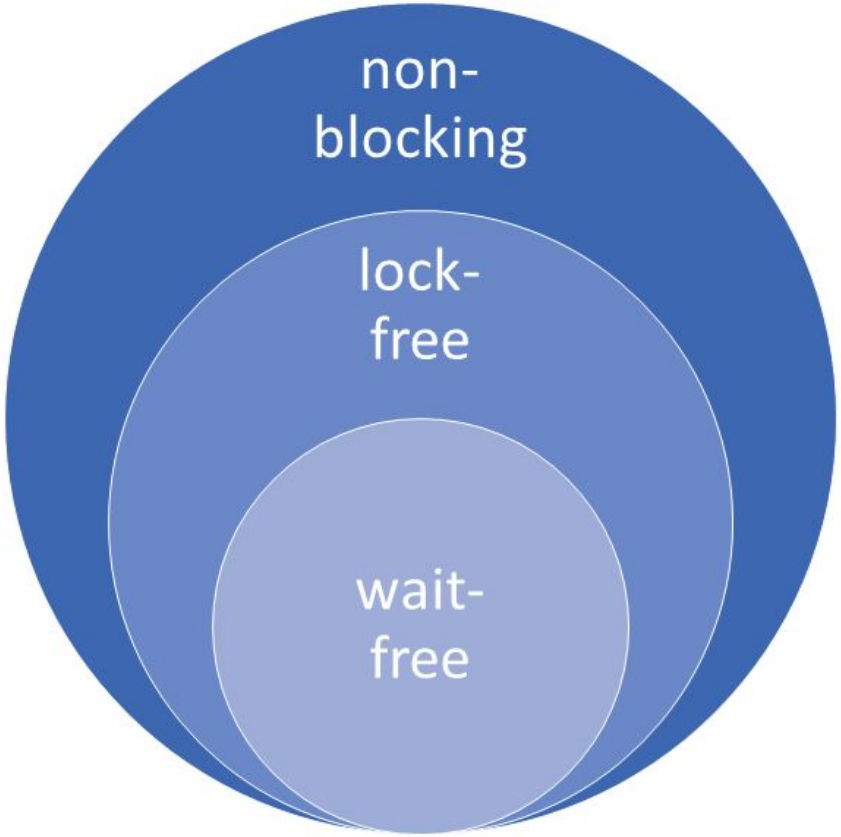
Lock-free & Wait-free



A Comparison of Locking Constructs

Construct	Overhead*
lock (**Monitor.Enter / Monitor.Exit**)	20ns
Mutex	1000ns
SemaphoreSlim (introduced in Framework 4.0)	200ns
Semaphore	1000ns
ReaderWriterLockSlim (introduced in Framework 3.5)	40ns
ReaderWriterLock (effectively deprecated)	100ns

Lock-free & Wait-free

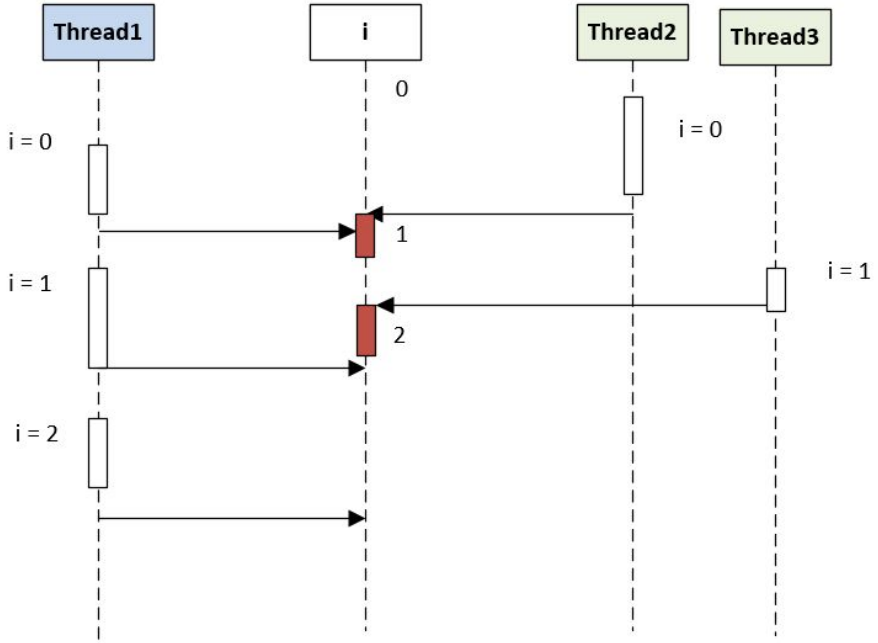


Lock-free & Wait-free

Compare and Swap

`Interlocked`

```
double CompareExchange (ref double location1, double value, double comparand);
```

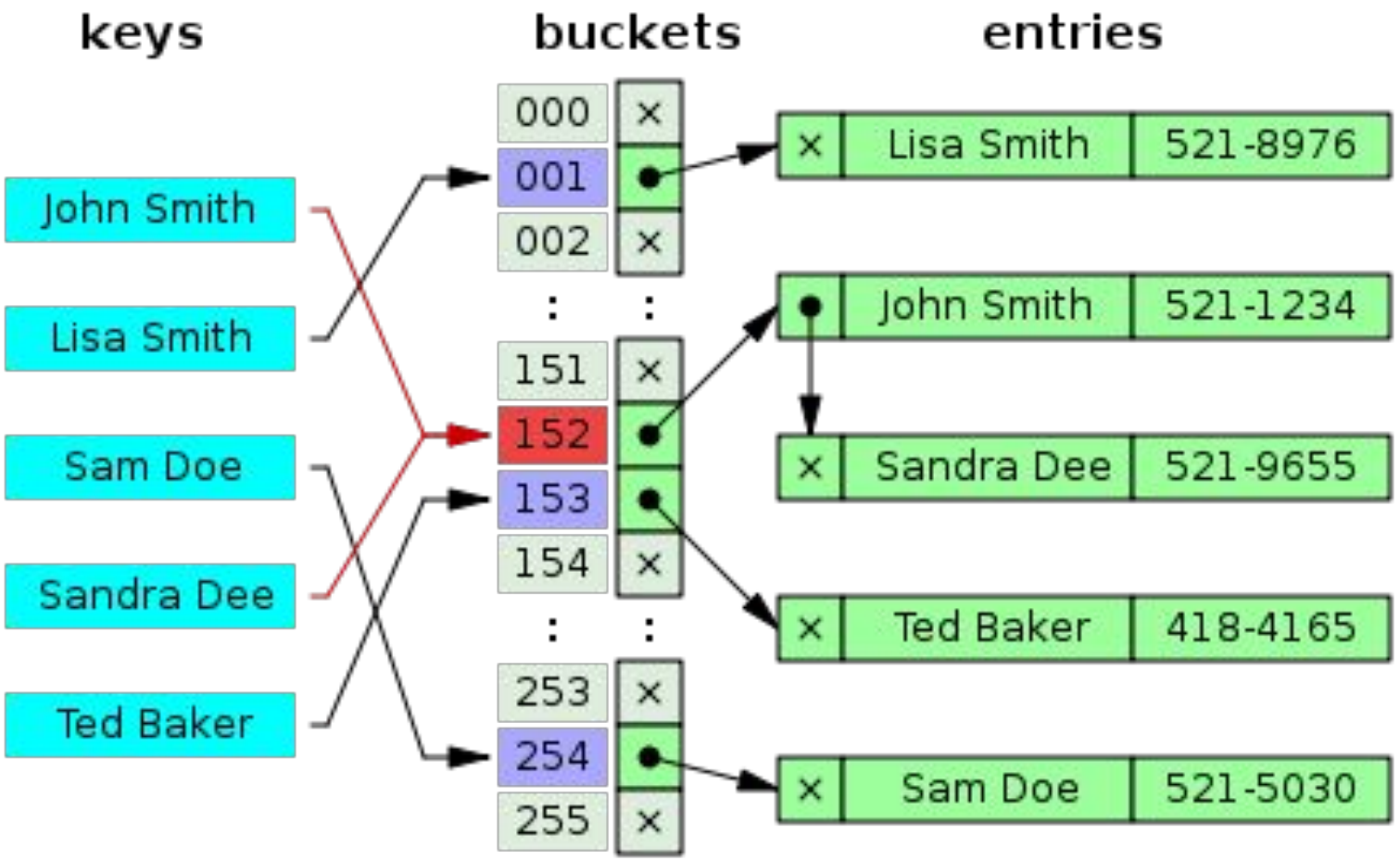



```
int InterlockedMultiply(ref int x, int y) {
  int t, r;
  do {
    t = x;
    r = t * y;
  }
  while (Interlocked.CompareExchange(ref x, r, t) != t);
  return r;
}
```

New Value

Comparand

ConcurrentDictionary



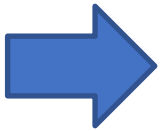
ConcurrentDictionary

Сильная деградация при попытке получить все блокировки

Method	Time	Memory	Locks
ContainsKey	O(1)	O(1)	none
TryGetValue	O(1)	O(1)	none
TryAdd	O(1)	O(1)	1
TryRemove	O(1)	O(1)	1
TryUpdate	O(1)	O(1)	1
Clear	O(K)	O(K)	K
Count	O(K)	O(1)	K
IsEmpty	O(K)	O(1)	K
Keys	O(N)	O(N)	K
Values	O(N)	O(N)	K
Enumeration	O(N)	O(1)	none

Single instruction, Multiple data

```
float[] values = GetValues();
float increment = GetIncrement();

for (int i = 0; i < values.Length; i++)
{
   values[i] += increment;
}
```

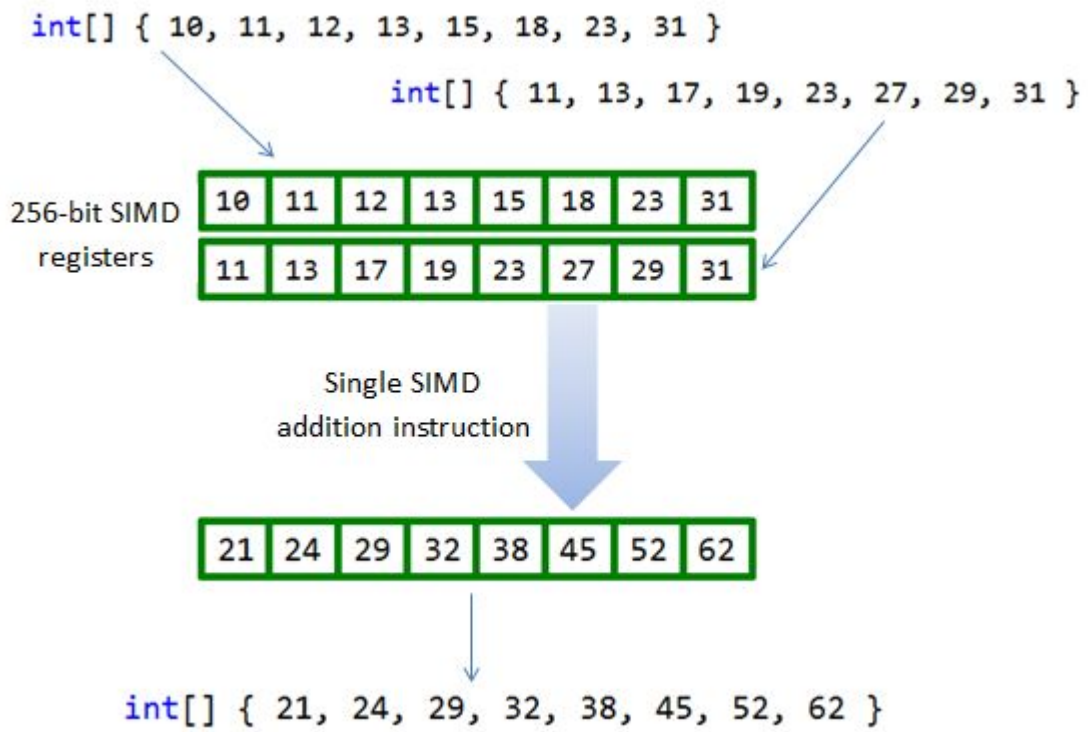


```
Vector<float> values = GetValues();
Vector<float> increment =
GetIncrement();

Vector<float> result = values +
increment;
```

Vector.IsHardwareAccelerated

SIMD

Single instruction, Multiple data



Task.Yield

```
async Task LongRunningCpuBoundWorkAsync()
{

    for (int i = 0; i != 1000000; ++i)
    {
        ... // CPU-bound work.
    }
}
```

Task.Yield

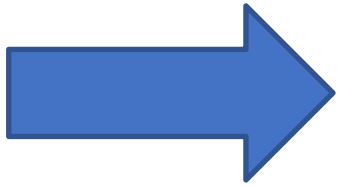
```
async Task LongRunningCpuBoundWorkAsync()
{

    for (int i = 0; i != 1000000; ++i)
    {
        ... // CPU-bound work.
        await Task.Yield();
    }
}
```

Long switch-case

```
switch (packetID)
{
  case BncsPacketId.Null:
    break;

  case BncsPacketId.EnterChat:
    string ecUniqueName = pck.ReadNTString();
    string ecStatstring = pck.ReadNTString();
    string ecAcctName = pck.ReadNTString();
    var args = new EventArgs(ecUniqueName, ecStatstring, ecAcctName);
    OnEnteredChat(args);
    break;

  ...
  // ну и так и далее
}
```

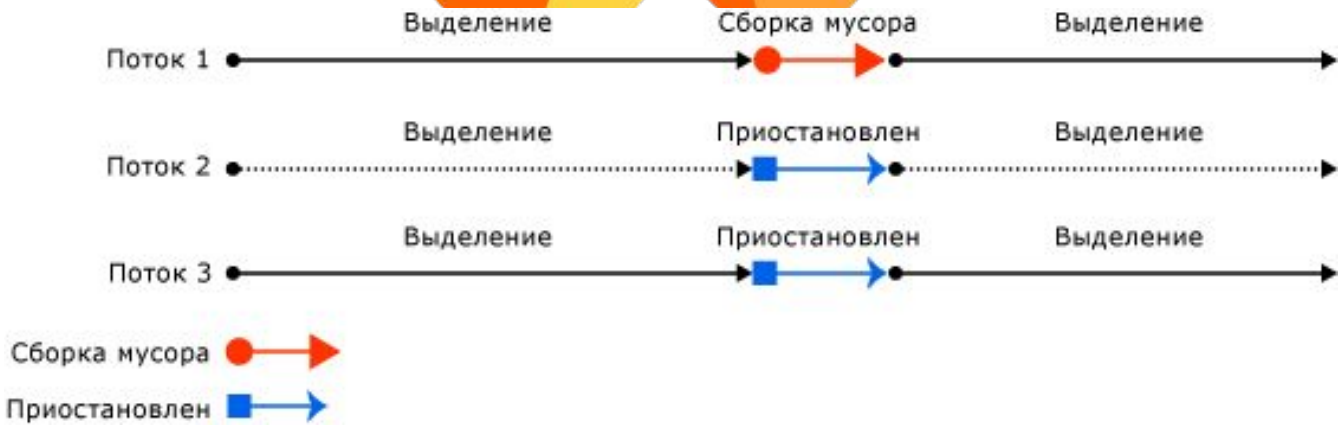
Long switch-case

```
switch (packetID)
{
  case BncsPacketId.Null:
    break;

  case BncsPacketId.EnterChat:
    string ecUniqueName = pck.ReadNTString();
    string ecStatstring = pck.ReadNTString();
    string ecAcctName = pck.ReadNTString();
    var args = new EventArgs(ecUniqueName, ecStatstring, ecAcctName);
    OnEnteredChat(args);
    break;

  ...
  // ну и так и далее
}
```

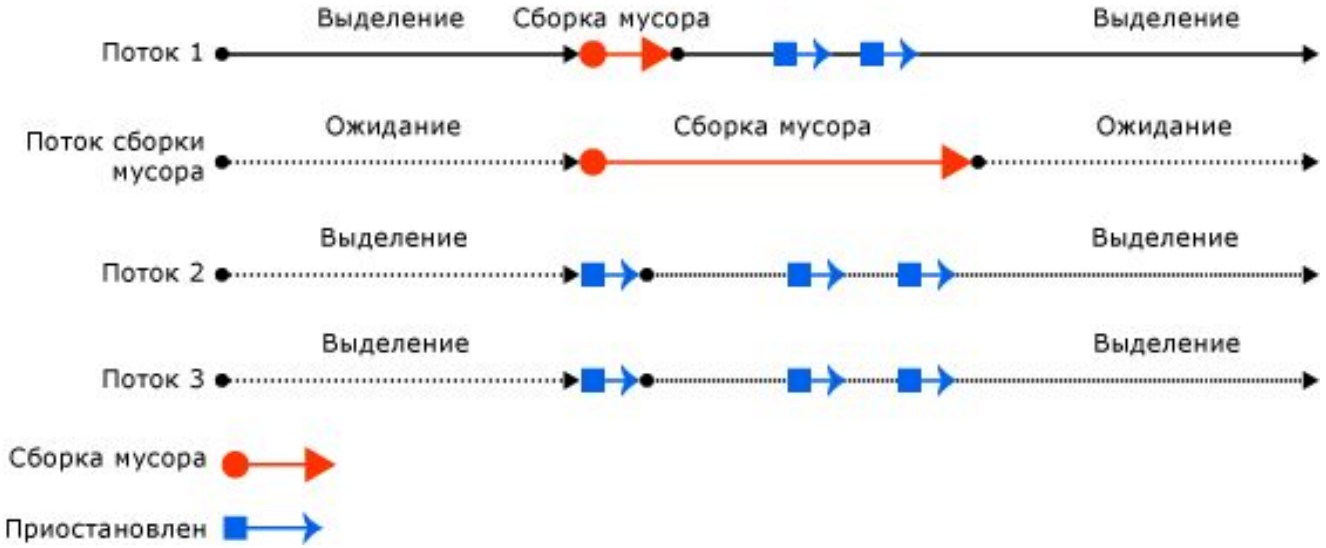


Dictionary<string, Action<T>>

Клиентский режим

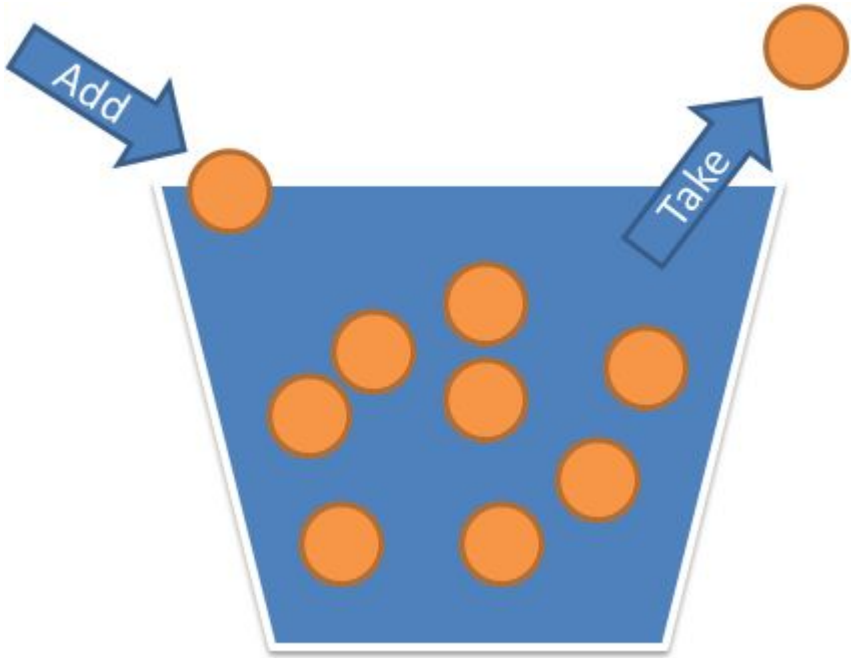


Серверный режим



ConcurrentBag

Оптимизация потребления памяти



async/await

```
private readonly Dictionary<string, string> cache = new Dictionary<string, string>();

public Task<string> GetValueAsync(string key)
{
  string result;
  if (cache.TryGetValue(key, out result))
    return Task.FromResult(result);
  return DoGetValueAsync(key);
}

private async Task<string> DoGetValueAsync(string key)
{
  HttpClient client = new HttpClient();
  var response =  await client.GetAsync(key);
  var text = await response.Content.ReadAsStringAsync();
  this.cache[key] = text;
  return text;
}
```

async/await

```
public struct TaskAwaiter<TResult>: INotifyCompletion
  {
    private readonly Task<TResult> m_task;

    internal TaskAwaiter(Task<TResult> task)
    {
      this.m_task = task;
    }

    public bool IsCompleted
       {
         get
         {
           return this.m_task.IsCompleted;
         }
       }
```

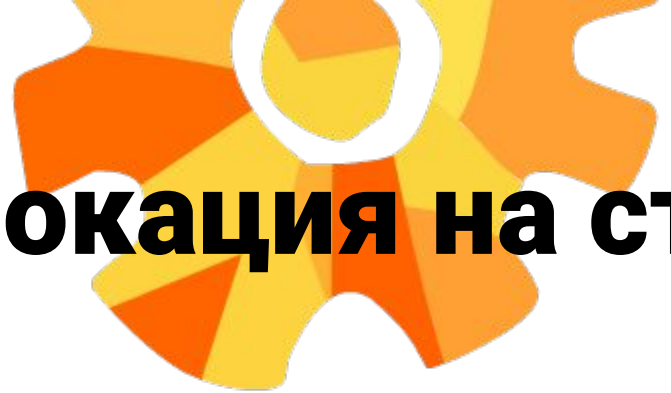
async/await

```
private readonly Dictionary<string, Task<string>> cache = new Dictionary<string, Task<string>>();

public Task<string> GetValueAsync(string key)
{
  Task<string> result;
  if (cache.TryGetValue(key, out result))
    return result;
  return DoGetValueAsync(key);
}

private async Task<string> DoGetValueAsync(string key)
{
  HttpClient client = new HttpClient();
  var response =  await client.GetAsync(key);
  var text = response.Content.ReadAsStringAsync();
  this.cache[key] = text;
  return await text;
}
```

async/await

.Net 4.6

`Task.FromResult(0)` → `Task.CompletedResult`



Аллокация на стеке

.net core 2.1

Span<T>

```
C# 7.2
int* block = stackalloc int[100];

Span<byte> span = size <= 128 ? stackalloc byte[size] : new byte[size];
```

ValueTask<TResult>

JIT оптимизация

Типичные заблуждения:

[AggressiveInlining] спасет всех

Generic типы инлайнятся

Компилятор умный

```
interface IChildItems
{
  Collection<IDisposable> ChildItems { get; }
}

internal static class FreeObjectUtils
{
  public void Free<T>(T instance)
    where T : IChildItems
  {
    bool needDispose = typeof(IDisposable).IsAssignableFrom(typeof(T));

    foreach (var element in instance.ChildItems)
      element.Dispose();

    if (needDispose)
      DisposableUtils.Clean(instance);
    else
      instance.ChildItems.Clear();
  }
}
```

JIT оптимизация

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    where T : IChildItems
  {


    foreach (var element in instance.ChildItems)
      element.Dispose();

    if (false)
      DisposableUtils.Clean(instance);
    else
      instance.ChildItems.Clear();
  }
}
```

JIT оптимизация

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}

internal static class FreeObjectUtils
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  public void Free<T>(T instance)
    where T : IChildItems
  {


    foreach (var element in instance.ChildItems)
      element.Dispose();




    instance.ChildItems.Clear();
  }
}
```

JIT оптимизация

```
public Dictionary(IEqualityComparer<TKey> comparer);
```

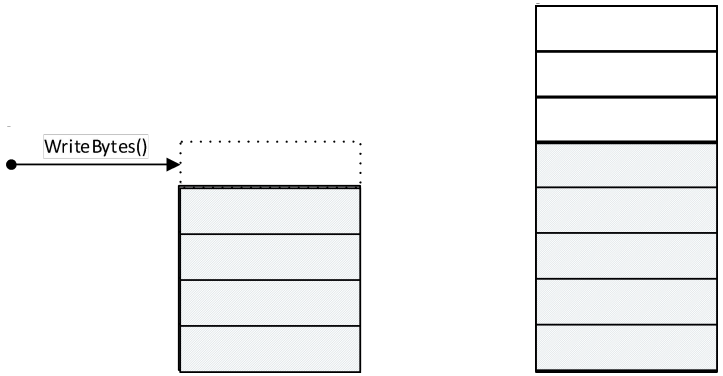
```
public struct LongEqualityComparer : IEqualityComparer<long>
{
        public static readonly IEqualityComparer<long> BoxedInstanceInt64 = new LongEqualityComparer();

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool Equals(long x, long y)
        {
            return x == y;
        }
}
```

JIT оптимизация

```
[MethodImpl(MethodImplOptions.AggressiveInlining)]
public void Clear()
{
    if (typeof(T) == typeof(int) || typeof(T) == typeof(uint) || typeof(T) == typeof(byte) ||
        typeof(T) == typeof(short) || typeof(T) == typeof(long) || typeof(T) == typeof(ulong))
    {
        _size = 0;
        _version++;
    }
    else
    {
        int size = (int)_size;

        _size = 0;
        _version++;
        if (size > 0)
            Array.Clear(_items, 0, size);
    }
}
```

MemoryStream

MemoryStream

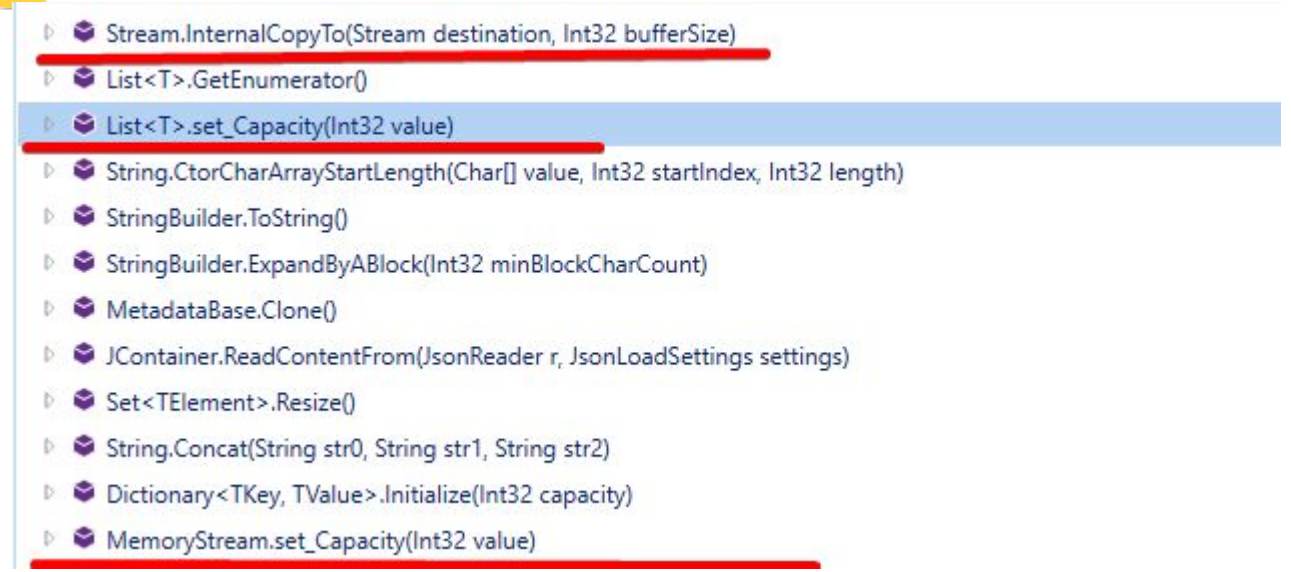


MemoryStream()	Initializes a new instance of the MemoryStream class with an expandable capacity initialized to zero.
MemoryStream(Byte[])	Initializes a new non-resizable instance of the MemoryStream class based on the specified byte array.
MemoryStream(Int32)	Initializes a new instance of the MemoryStream class with an expandable capacity initialized as specified.

MemoryStream

То же самое для:

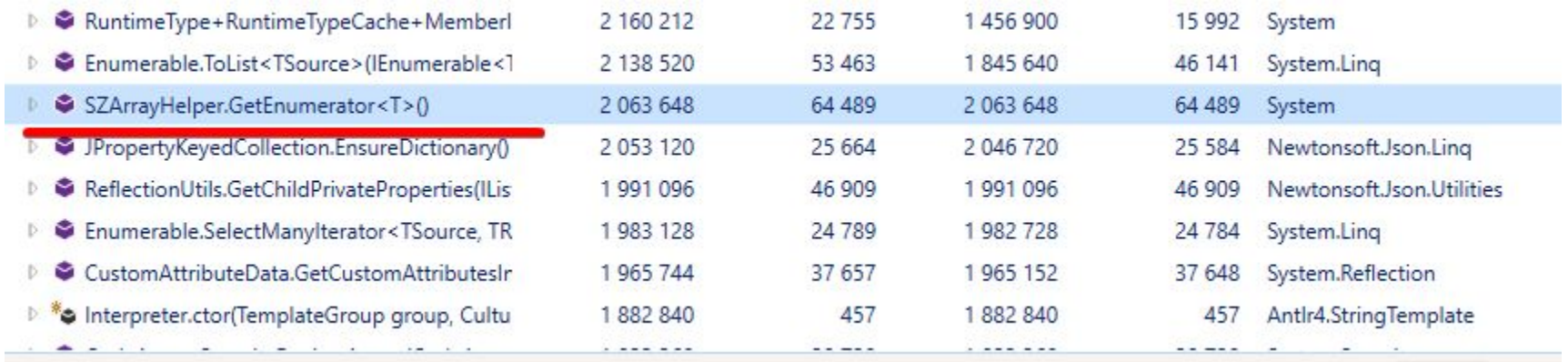
List<T>
Collection<T>
Dictionary<TKey, TValue>
и прочих коллекций



List<T>()	Initializes a new instance of the List<T> class that is empty and has the default initial capacity.
List<T>(IEnumerable<T>)	Initializes a new instance of the List<T> class that contains elements copied from the specified collection and has sufficient capacity to accommodate the number of elements copied.
List<T>(Int32)	Initializes a new instance of the List<T> class that is empty and has the specified initial capacity.

struct[] -> IList

```
int[] a = new int[10];
DoSomething(a);


public void DoSomething<T>(IList<T> list)
{
}
```



RuntimeType+RuntimeTypeCache+MemberI	2 160 212	22 755	1 456 900	15 992	System
Enumerable.ToList<TSource>(IEnumerable<T	2 138 520	53 463	1 845 640	46 141	System.Linq
SZArrayHelper.GetEnumerator<T>()	2 063 648	64 489	2 063 648	64 489	System
JPropertyKeyedCollection.EnsureDictionary()	2 053 120	25 664	2 046 720	25 584	Newtonsoft.Json.Linq
ReflectionUtils.GetChildPrivateProperties(ILis	1 991 096	46 909	1 991 096	46 909	Newtonsoft.Json.Utilities
Enumerable.SelectManyIterator<TSource, TR	1 983 128	24 789	1 982 728	24 784	System.Linq
CustomAttributeData.GetCustomAttributesIr	1 965 744	37 657	1 965 152	37 648	System.Reflection
Interpreter.ctor(TemplateGroup group, Cultu	1 882 840	457	1 882 840	457	Antlr4.StringTemplate


```
public IEnumerable<RibbonPartMetadata> FindChildren(Guid parentId)
{
      return this.AllParts.Where(part => part.ParentGuid == parentId).ToList();
}
```

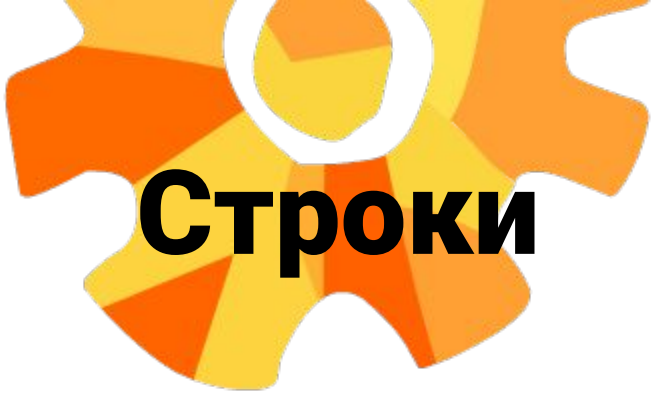
```
// [18 7 - 18 80]
    IL_000e: ldarg.0      // this
    IL_000f: call         instance class [mscorlib]System.Collections.Generic.IEnumerable`1<class WpfApp3.RibbonPartMetadata>
WpfApp3.Class2::get_AllParts()
    IL_0014: ldloc.0      // 'CS$<>8__locals0'
    IL_0015: ldftn        instance bool WpfApp3.Class2/'<>c__DisplayClass2_0'::'<FindChilds>b__0'(class WpfApp3.RibbonPartMetadata)
    IL_001b: newobj       instance void class [mscorlib]System.Func`2<class WpfApp3.RibbonPartMetadata, bool>::.ctor(object, native int)
    IL_0020: call         class [mscorlib]System.Collections.Generic.IEnumerable`1<!!0/*class WpfApp3.RibbonPartMetadata*/>
[System.Core]System.Linq.Enumerable::Where<class WpfApp3.RibbonPartMetadata>(class
[mscorlib]System.Collections.Generic.IEnumerable`1<!!0/*class WpfApp3.RibbonPartMetadata*/>, class [mscorlib]System.Func`2<!!0/*class
WpfApp3.RibbonPartMetadata*/, bool>)
    IL_0025: call         class [mscorlib]System.Collections.Generic.List`1<!!0/*class WpfApp3.RibbonPartMetadata*/>
[System.Core]System.Linq.Enumerable::ToList<class WpfApp3.RibbonPartMetadata>(class
[mscorlib]System.Collections.Generic.IEnumerable`1<!!0/*class WpfApp3.RibbonPartMetadata*/>)
    IL_002a: stloc.1      // V_1
    IL_002b: br.s         IL_002d
```


```
public IEnumerable<RibbonPartMetadata> FindChildren(Guid parentId)
{
      return this.AllParts.Where(part => part.ParentGuid == parentId).ToList();
}
```

```
public IEnumerable<RibbonPartMetadata> FindChildren(Guid parentId)
{
      var list = new List<RibbonPartMetadata>();

      foreach (RibbonPartMetadata part in this.AllParts)
      {
        if (part.ParentGuid == parentId)
        {
          list.Add(part);
        }
      }

      return list;
}
```


```
public IEnumerable<RibbonPartMetadata> FindChildren(Guid parentId)
{
      return this.AllParts.Where(part => part.ParentGuid == parentId).ToList();
}
```

```
public IEnumerable<RibbonPartMetadata> FindChildren(Guid parentId)
{
      var list = new List<RibbonPartMetadata>(this.AllPart.Count);

      foreach (RibbonPartMetadata part in this.AllParts)
      {
        if (part.ParentGuid == parentId)
        {
          list.Add(part);
        }
      }

      return list;
}
```

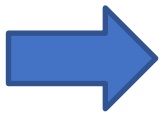


Строки

Вместо конкатенаций используй StringBuilder

Вместо string.Format используй конкатенацию

```
string first = "first";
string second = "second";
return $"{first}{second}";
```



```
string first = "first";
string second = "second";
return first + second;
```

Boxing

```
static Logger log = new Logger();
public void Info(params object[] args)

log.Info(1, 2, 3, 4, 5);
log.Info();
```

```
new object[0]
```

Как надо?

```
public static void Info();
public static void Info<T1>(T1 arg1);
…
public static void Info<T1, T2, T3>(T1 arg1, T2 arg2, T3 arg3);
```

Heap Allocation Viewer

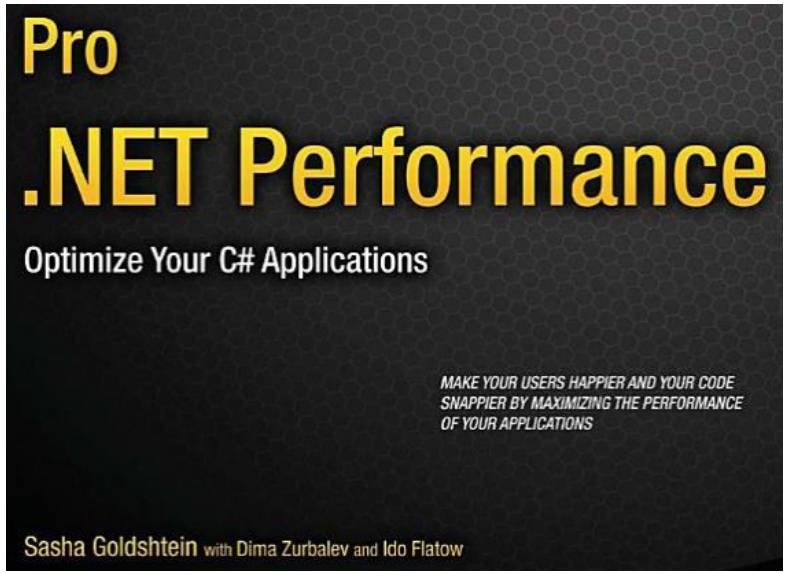
```
0 references
public class ParamsArgs
{
    1 reference
    public static void Method1(params string[] args)...

    0 references
    public void Method2()
    {
        Method1("Hello", "World");
    }
}
```

Object allocation: parameters array 'args' creation

```
var strings = new string[] { "x", "y"};
foreach (var s in strings)
{
    Task.Run(() => Console.WriteLine(s));
}
```

Delegate allocation: capture of 's' variable

Почитать?



Federico Lois
Sasha Goldstein
Андрей Акиньшин

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