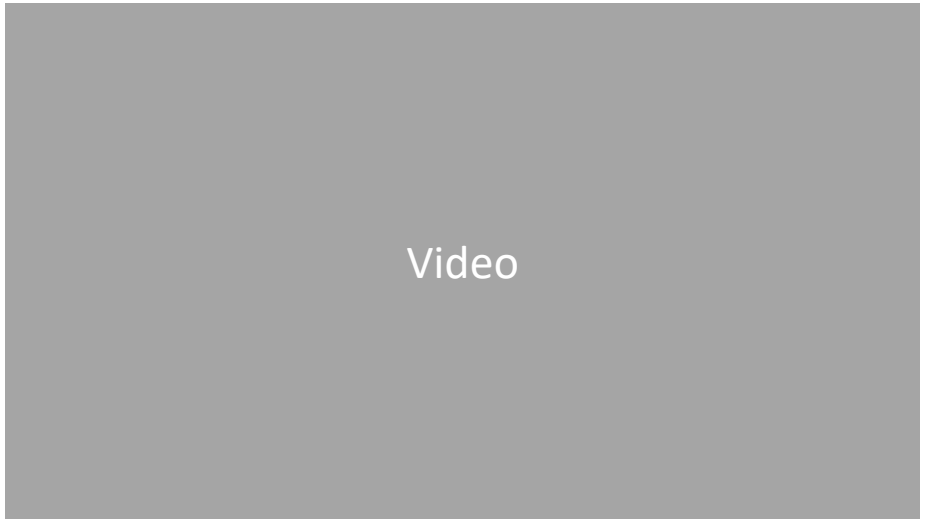
GOPAS

Novinky v .NET Internals

Robert Haken | TechEd 2021



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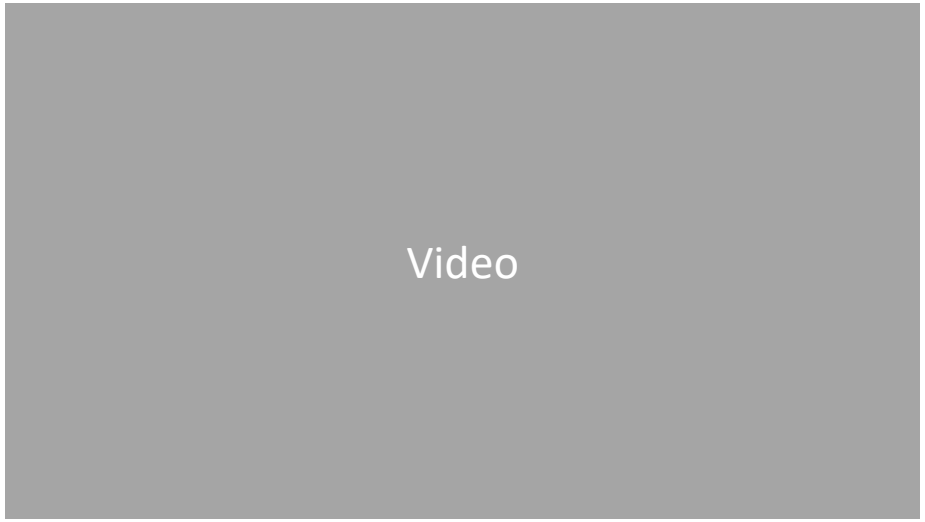
Agenda

JIT, compilation

Diagnostic CLI tools

Memory Management

Perf



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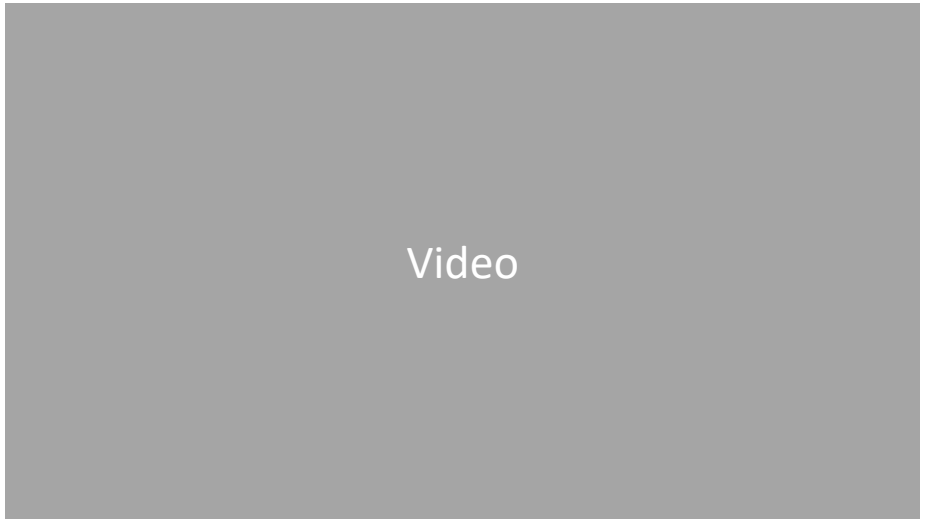
JIT, compilation, publishing



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JIT: Tiered Compilation

Tier 0 – *Quick JIT / ReadyToRun*

Tier 1 – *optimizing JIT*

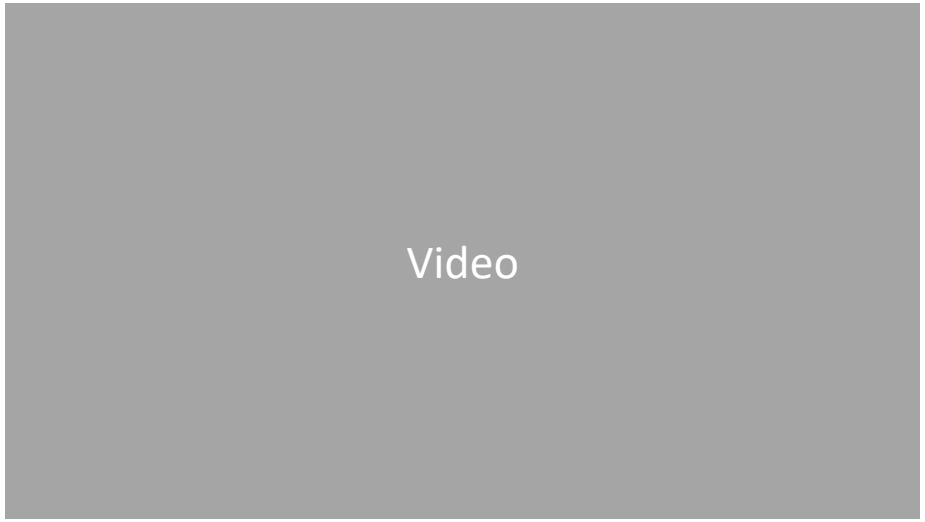
promotion

- 30+ calls, 100ms „startup timer“

.NET Core 3.0+ enabled by default

On Stack Replacement (in-place)

- while method has active stack frames!



ReadyToRun

ahead-of-time (AOT) compilation

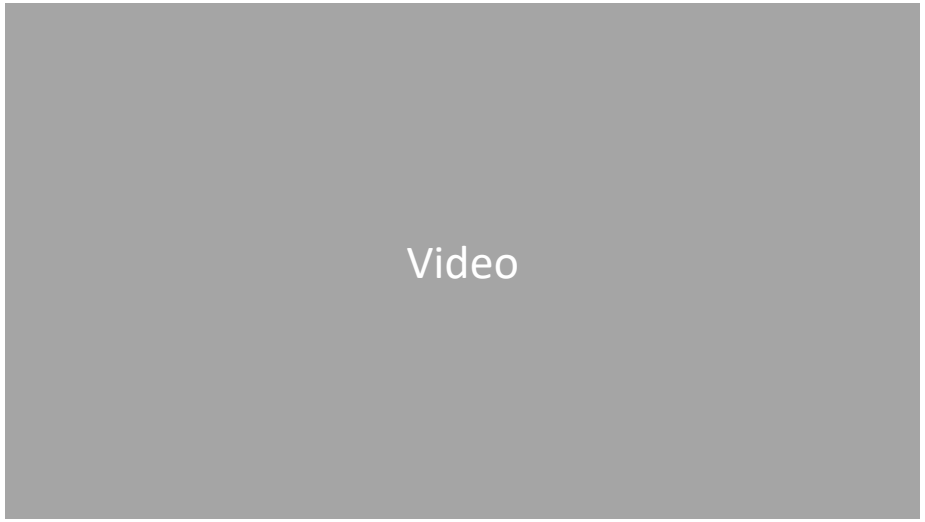
both IL + native version of the same code (bigger, slower to load)

part of publish

```
<PropertyGroup>
        <PublishReadyToRun>true</PublishReadyToRun>
</PropertyGroup>
```

enabled for .NET runtime libraries

still replaced by tiered compilation



JIT: Escape Analysis

instance used only in local variable, does not escape method

=> allocate on stack instead of heap

```
public class Calculator
{
    public int X;
    public int Y;
    public int Add()
    {
        return x + y;
    }
}

public class EscapeAnalysis
{
    private int _x;
    private int _y;
    public int UseCalculator()
    {
        Calculator calc = new Calculator();
        calc.X = _x;
        calc.Y = _y;
        return calc.Add();
    }
}
```

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App Trimming

.NET3 – Assembly-level trimming

```
<TrimMode>CopyUsed</TrimMode>
```

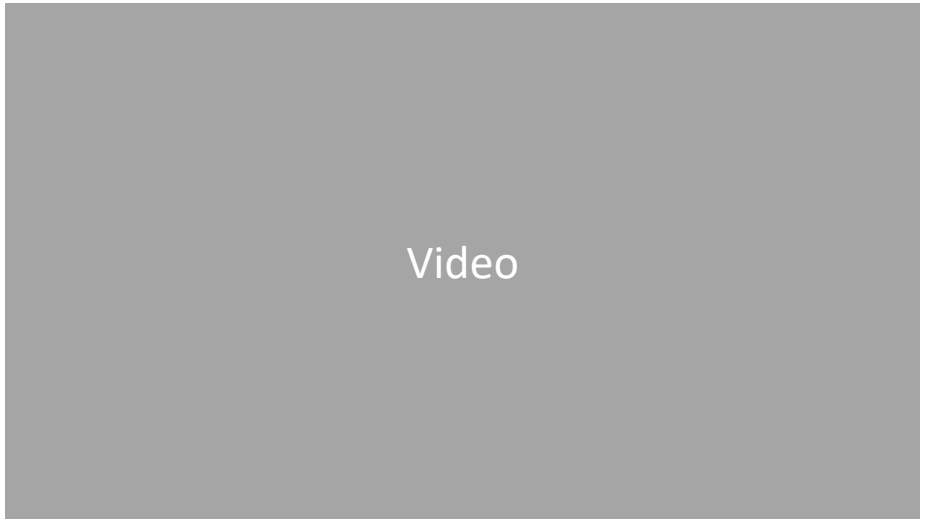
.NET5 – Member-level trimming

```
<TrimMode>Link</TrimMode>
```

removes ReadyToRun data

Blazor WASM defaults

- fw/runtime member-level trimming
- Microsoft.Extensions.* assemblies type-level
- Microsoft.AspNetCore.* hand-generated XML
- other assemblies are not trimmed



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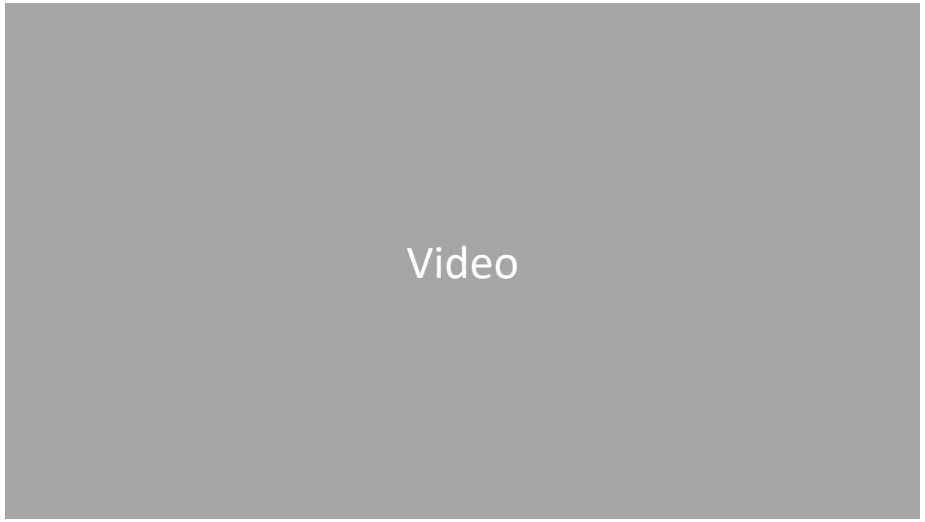
Other improvements

Profile Guided Optimization (PGO)

Loop alignment

- aligning methods to 32B boundary [NET5]
- adaptive loop alignment with NOPs [NET6]



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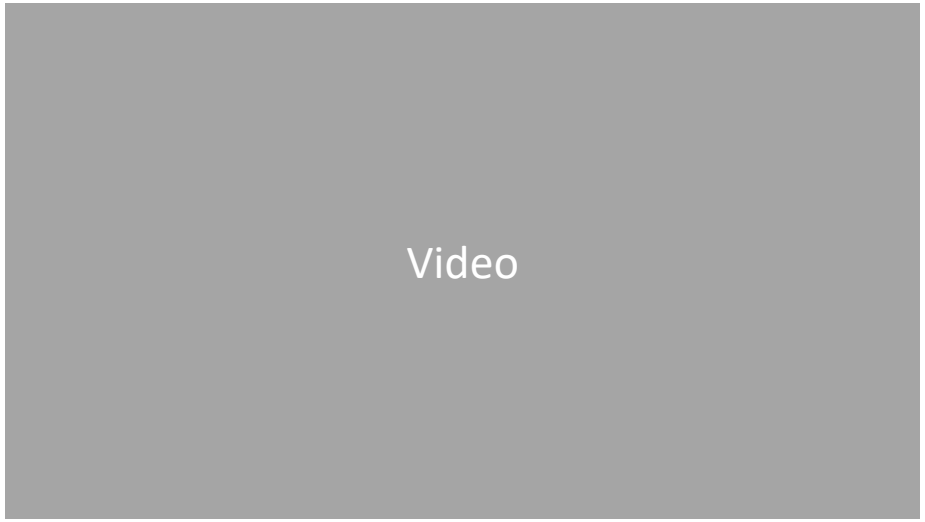
Diagnostic CLI tools



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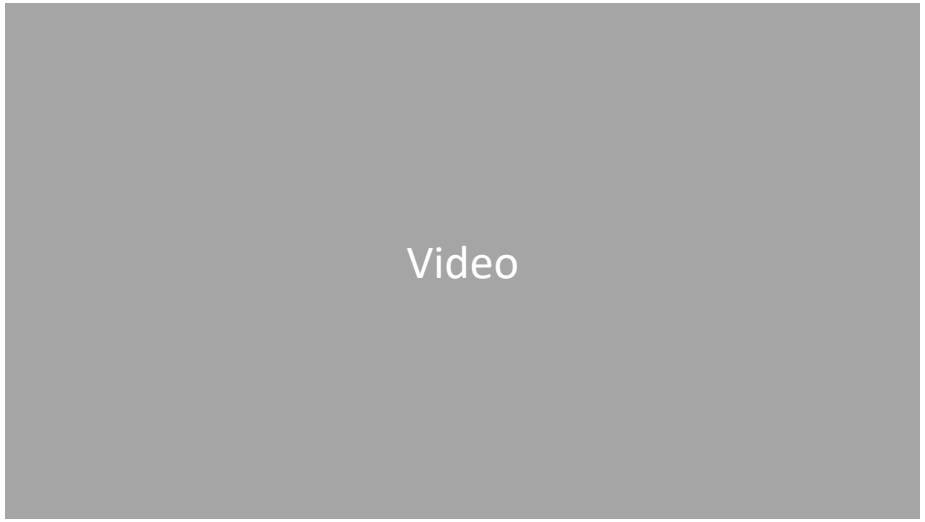
dotnet-dump

SOS.dll command-line incl. Linux

```
dotnet tool install -g dotnet-dump
dotnet-dump collect –p <pid>
dotnet-dump analyze <dumpfile>

setsymbolserver –directory <path>
                –ms
```



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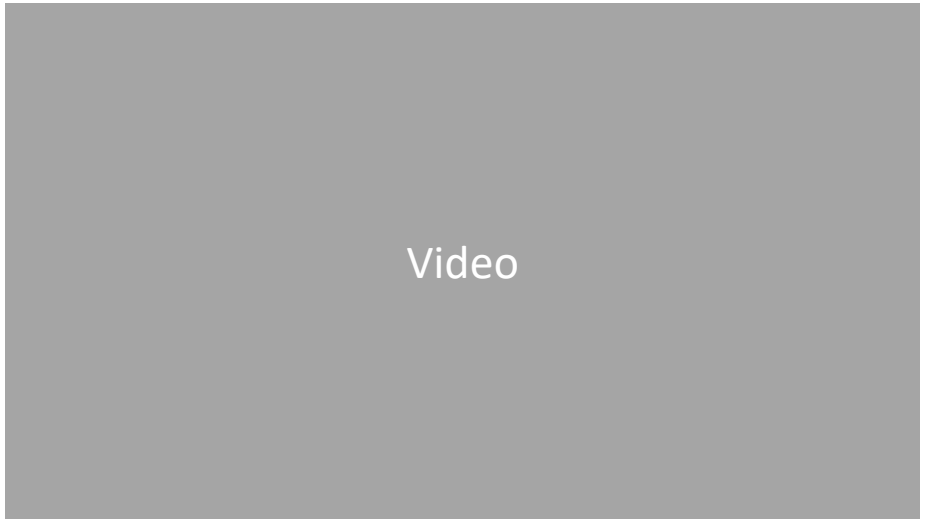
demo

dotnet-dump



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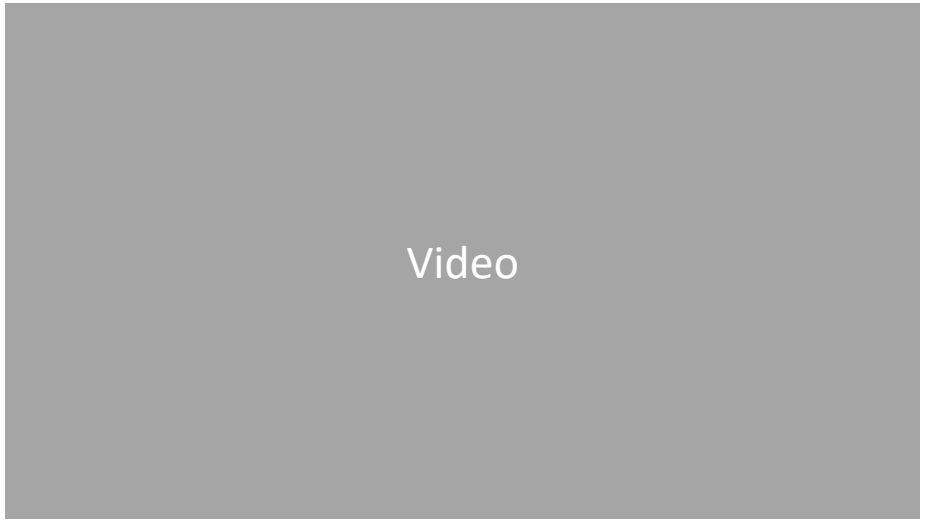
dotnet-dump [vNext]

packing (binaries, symbols)

triggers (exception, perf metrics)

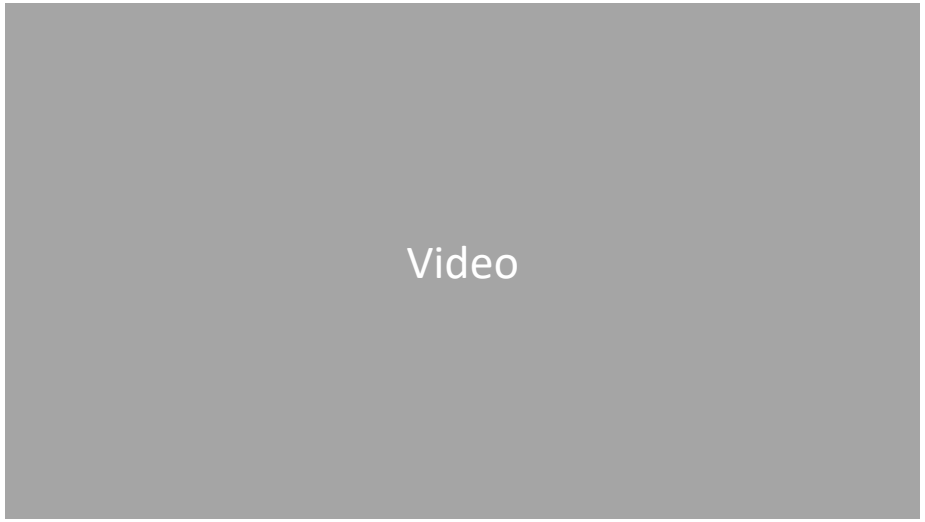
extensible commands (ála sosex, NetExt, Psscor4, ...)



dotnet-stack

„.NET Stack Printing Tool“

```
dotnet tool install -g dotnet-stack
dotnet-stack ps
dotnet-stack report -p <id>
```



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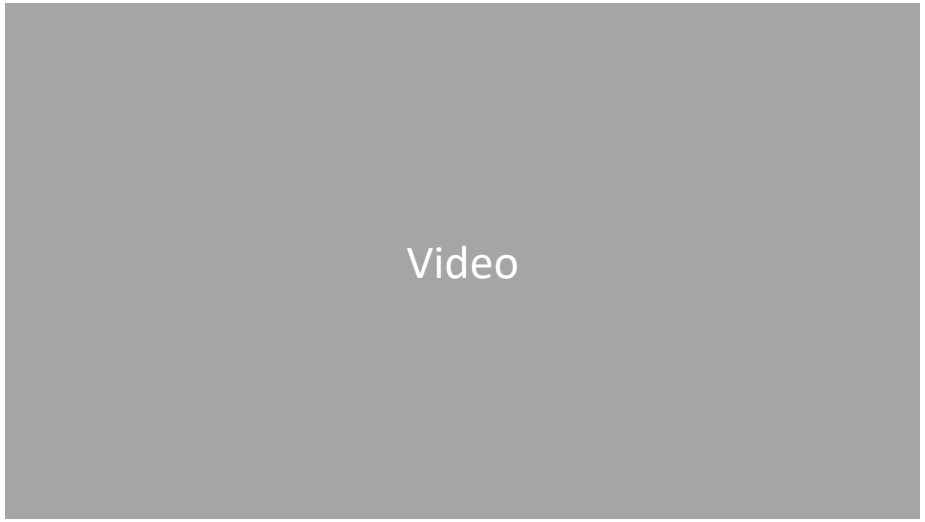
demo

dotnet-stack



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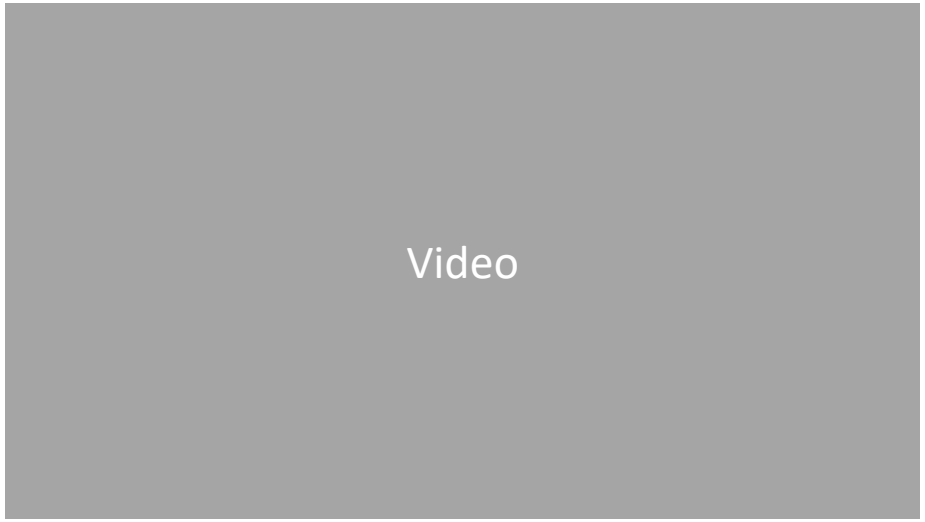
dotnet-counters

based on `EventCounter` API (x-plat)

```
dotnet tool install –g dotnet-counters
dotnet-counters list
dotnet-counters monitor –p <id> [Microsoft.AspNetCore.Hosting]
```



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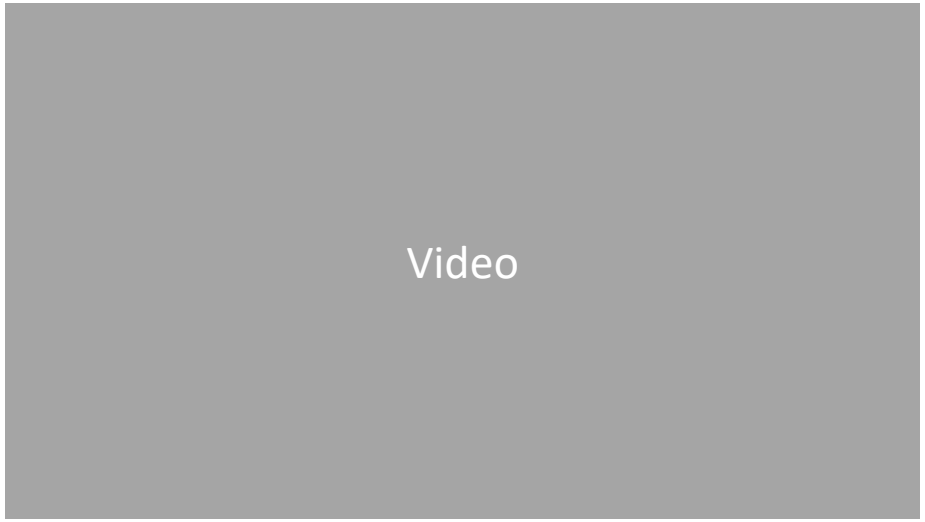
demo

dotnet-counters



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`dotnet-counters` [vNext]

profiles (named set of counters accross multiple providers)

`list -p <pid>` (process-specific list)

`view` (one-off dump of values, no wait for next counter)

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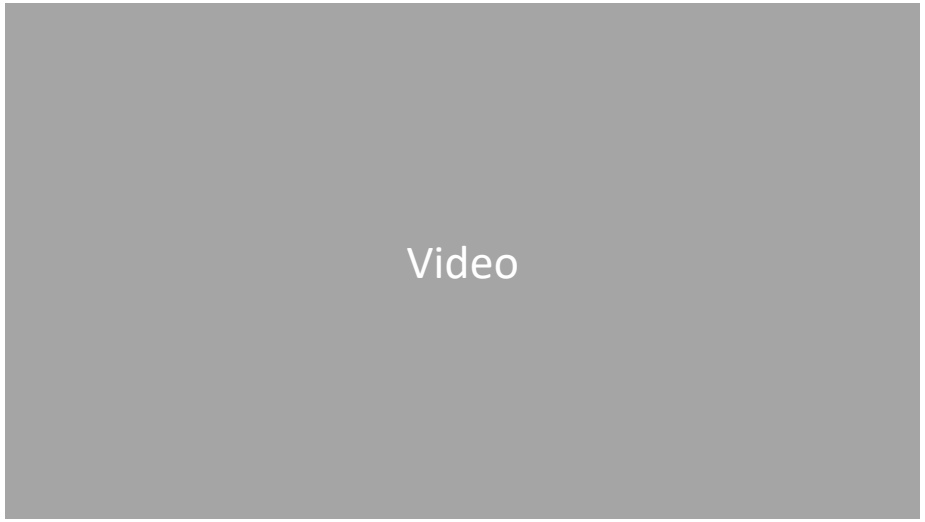
Garbage Collector



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GC: Memory-constrained scenario (containers)

NET Core 3.0+

limits taken from Linux CGroups / Windows Job objects

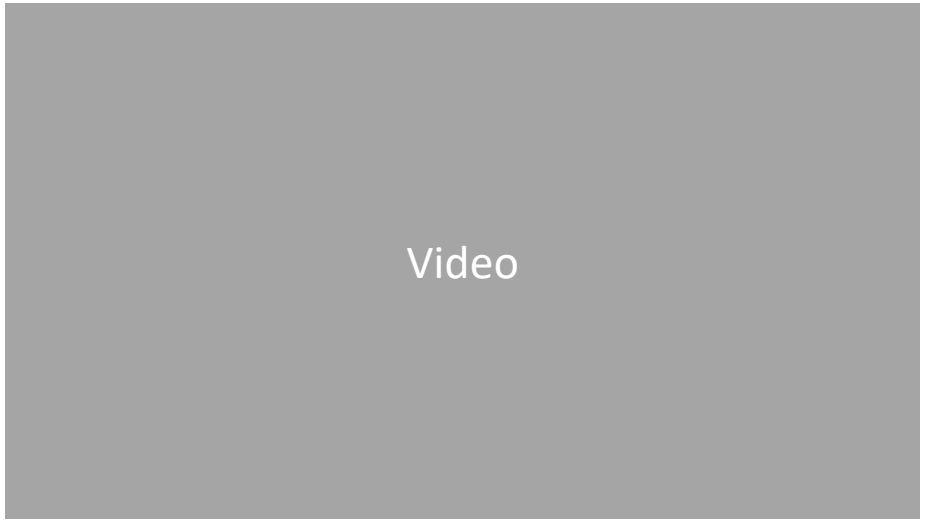
reduced minimal generation 0 GC alloc. budget (% last-level CPU cache)

default heap size in container = max(20 MB, 75% of memory limit)

minimal heap segment size 16 MB

- heap count = min(cpu_count, mem_limit /16 MB)
- Workstation GC no longer needed

LOH compaction if needed



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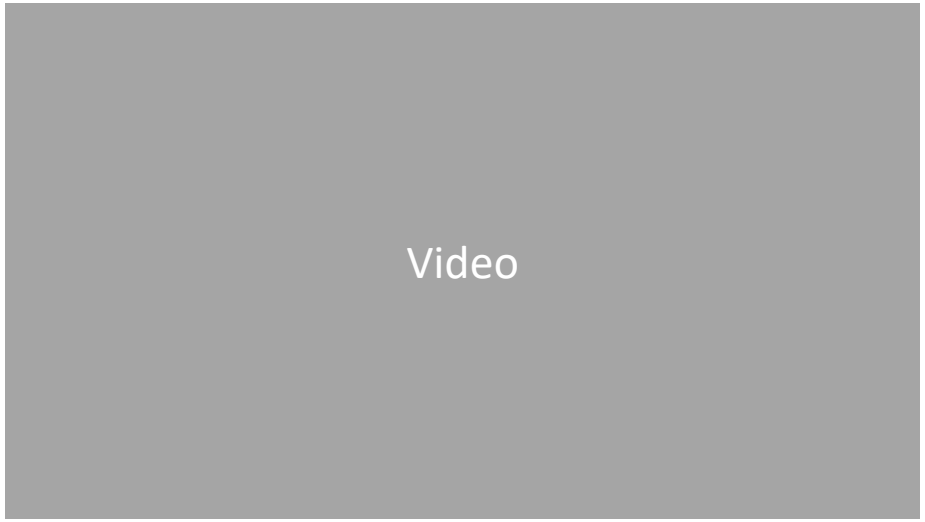
GC: Memory-constrained scenario (containers)

NET Core 3.0 configs

- `GCHeapHardLimit` – limit for GC heap (commit)
- `GCHeapHardLimitPercent`
- `GCHighMemPercent` – default is 90%



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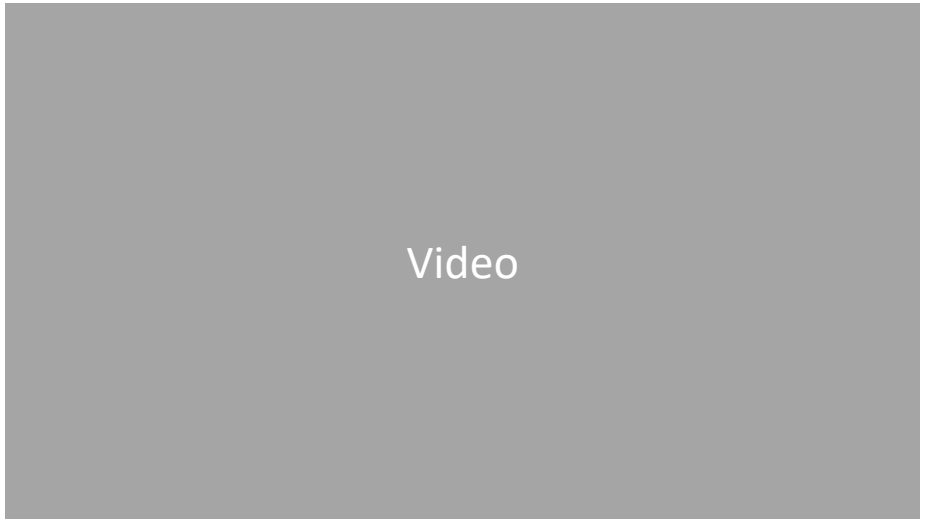
demo

ContainerResourceLimits



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Docker CPU Limits

prior: `cpu_count = Math.Round(container_cpu_limit)`

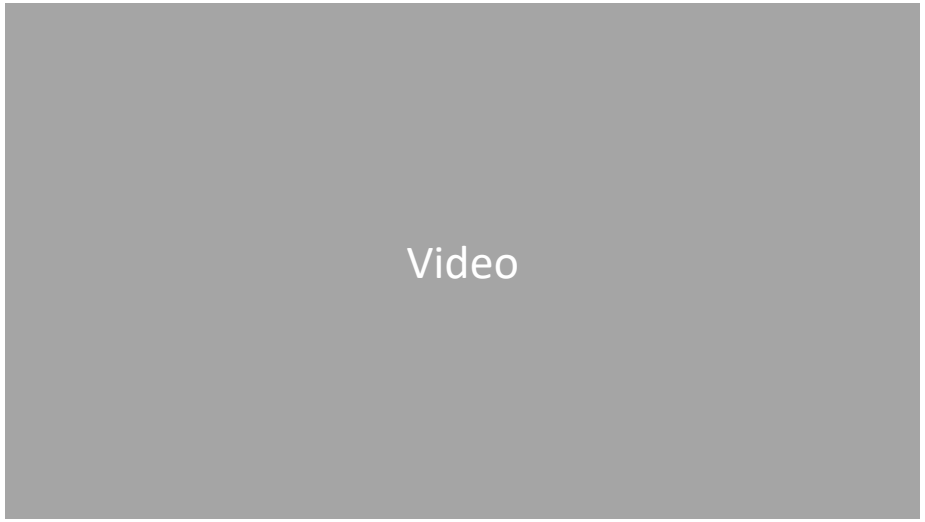
- CPU underutilization

now: `cpu_count = Math.Ceiling(container_cpu_limit)`

- no performance degradation even for 1.000001 limit (rounded to 2)

for single-core environment, Workstation GC is ALLWAYS used

- no matter you explicitly specify Server GC



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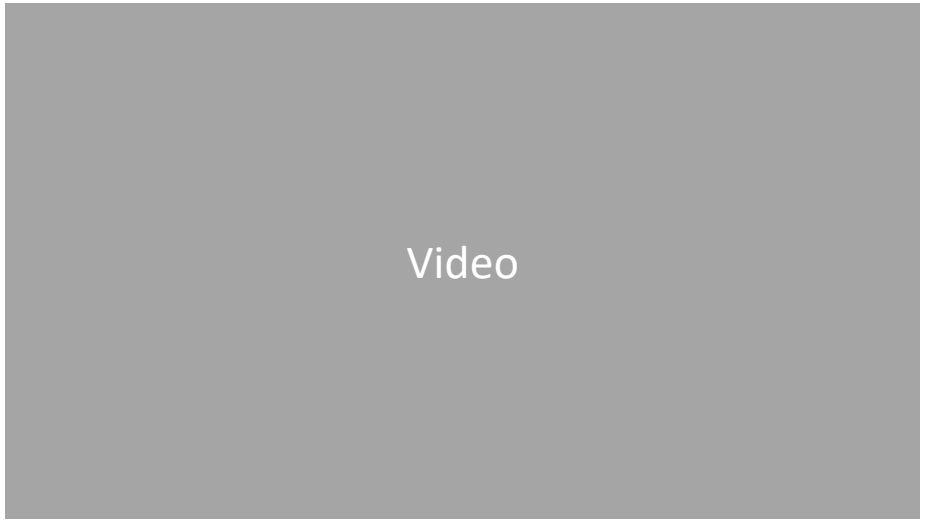
GCLOHThreshold [NET30]

default = 85 000 bytes

new config

- `GCLOHThreshold` configuration knob
- `COMPlus_GCLOHThreshold` environment variable (HEX!)

lower values ignored



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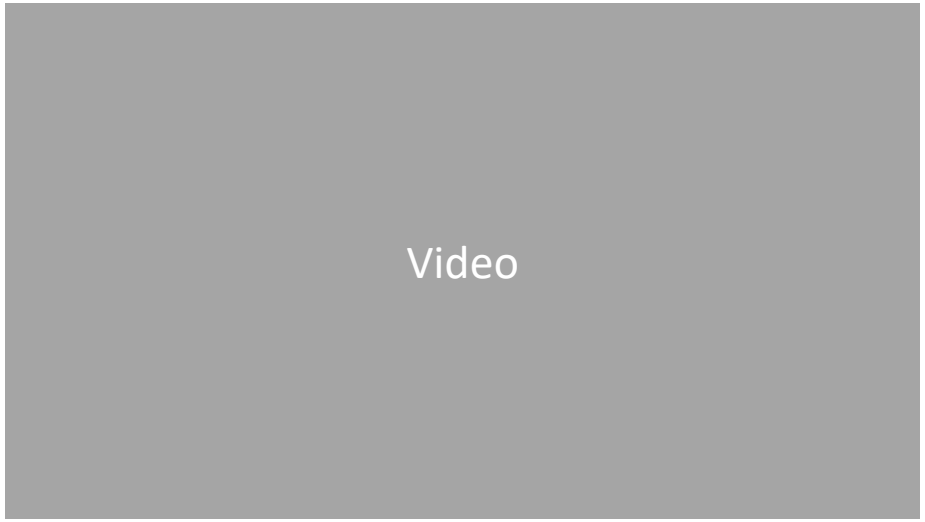
demo

LOH Threshold



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GC: Pinned Object Heap [NET5]

Scenario: Pin object when you allocate them

- `GC.AllocateArray(int length, bool pinned = false)`
- `GC.AllocateUninitializedArray()` – no zeroing
- blittable types only (no references)

own segment

swept in gen2 GCs

Video

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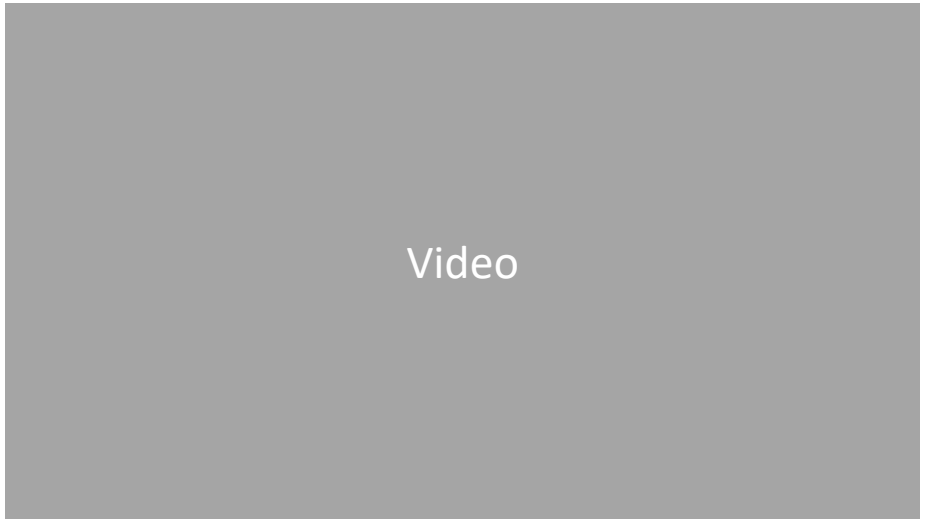
GC: Pinned Object Heap [NET5]

UOH – User Old Heap

- LOH – Large Object Heap (phys. gen3)
- POH – Pinned Object Heap (phys. gen4)

StringBuilder, Convert, Sockets, static, ...

```
COMPlus_GCHeapHardLimitPOH[Percent]
COMPlus_GCHeapHardLimitLOH[Percent]
COMPlus_GCHeapHardLimitSOH[Percent]
```



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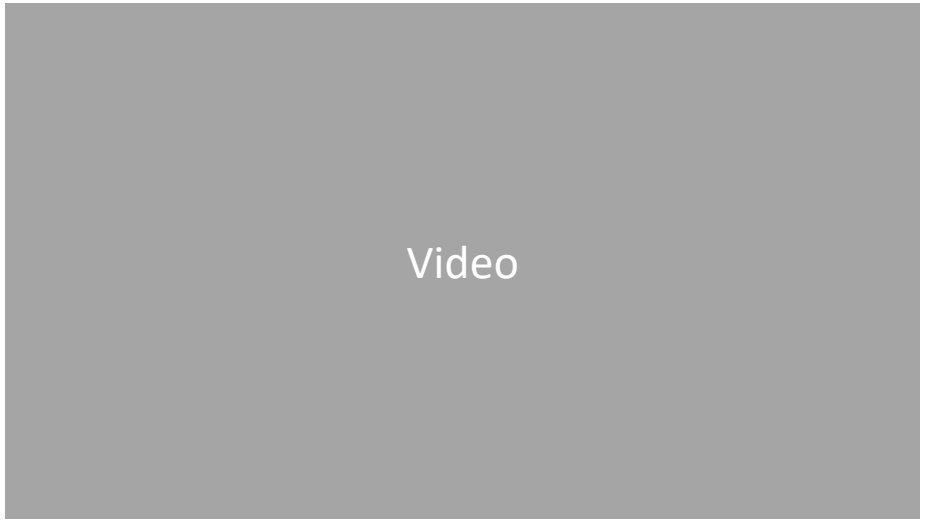
demo

Pinned Object Heap



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GC.GetGCMemoryInfo() [NET3, NET5]

metrics from last GC

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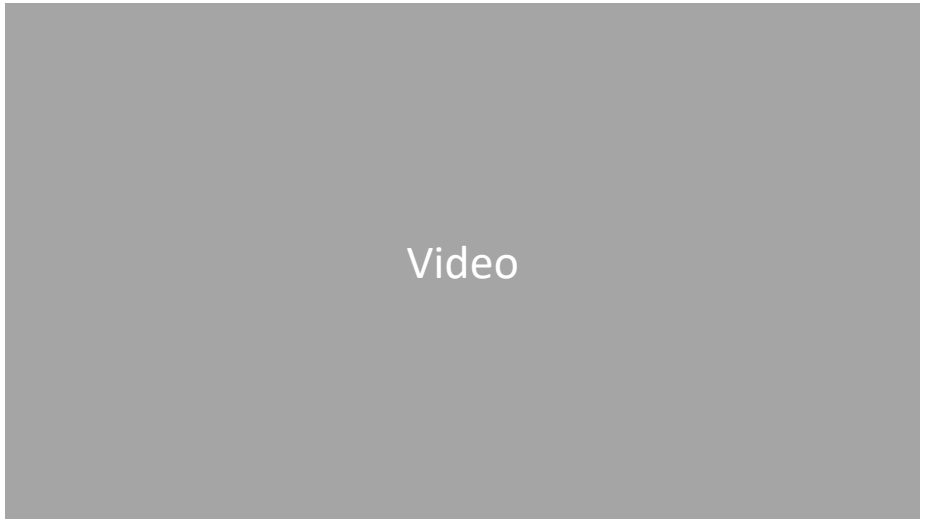
demo

GC.GetGCMemoryInfo()



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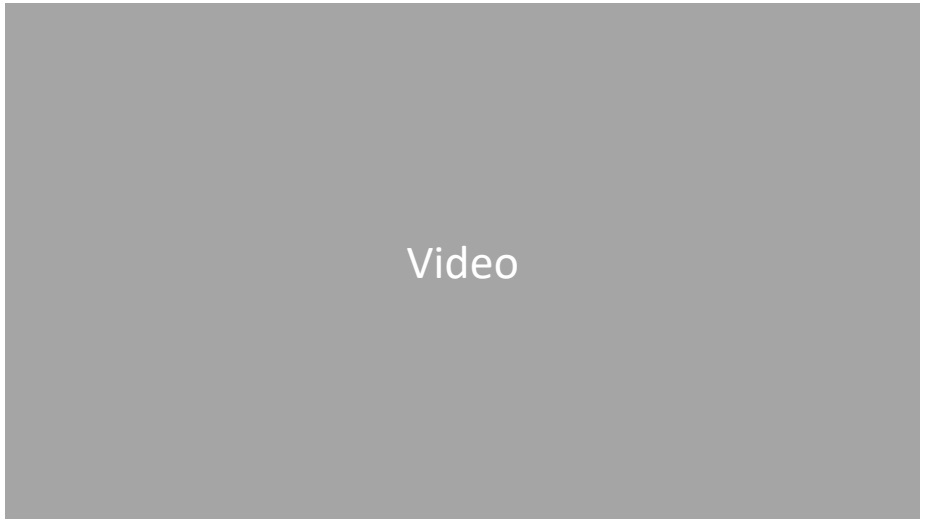
Other GC improvements in .NET5

Better decommit logic, ephemeral decommit moved out of STW

Card mark stealing

Vectorized mark list sorting (vctd. quicksort + vctd. bitonic) – AWX2+



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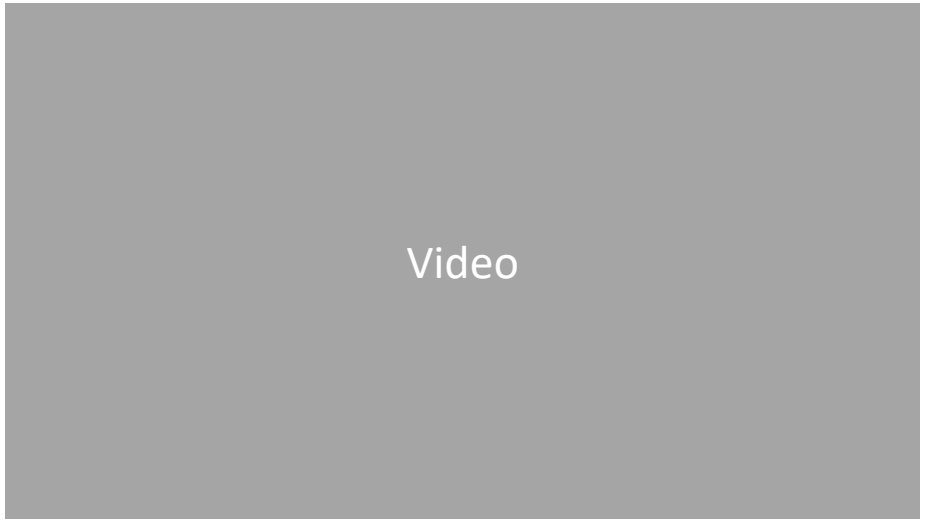
GC: Segements => Regions [NET6]

change of granularity

allows transitions of whole regions to another gen



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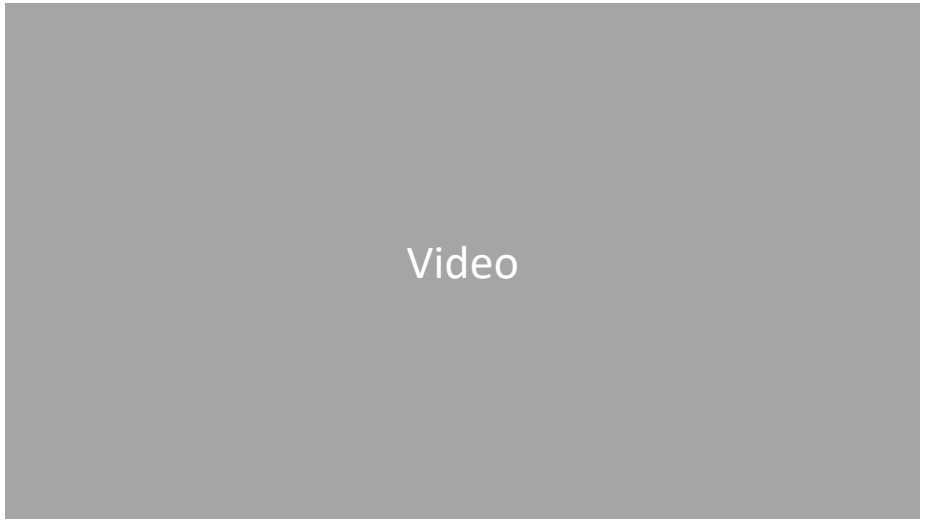
GC: Concurrent Compacting GC [NET-Future]

new flavor

Read Barrier needed (currently only Write Barrier)



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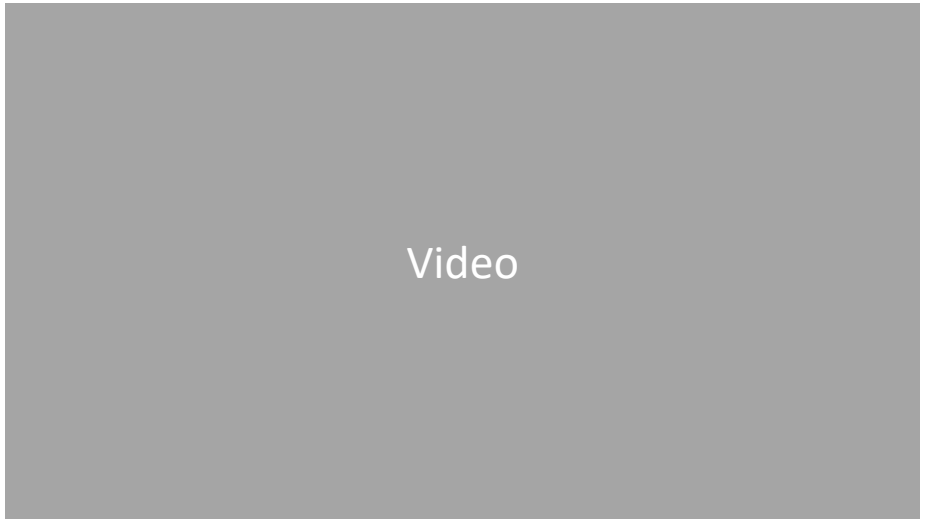

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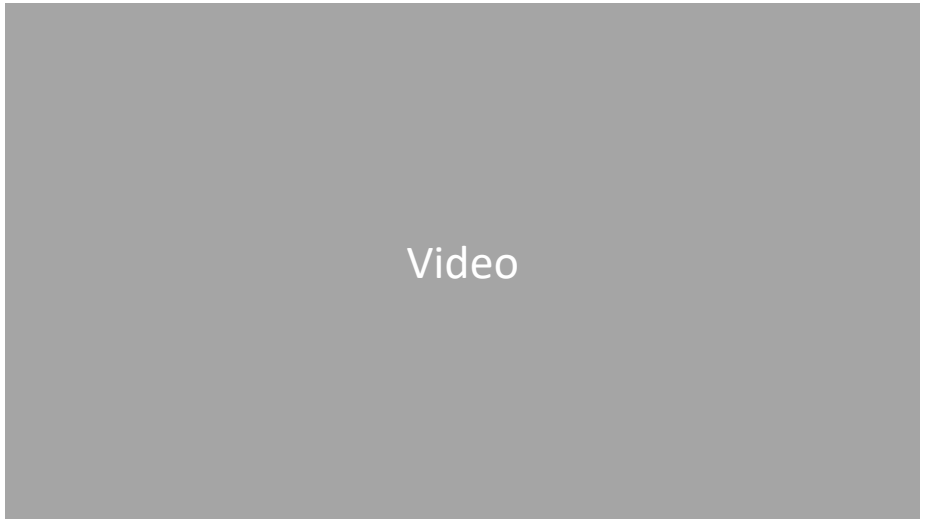
[SkipLocalsInit]

skip zeroing of stack locals

method/type/module scope

used on every assembly in netcoreapp



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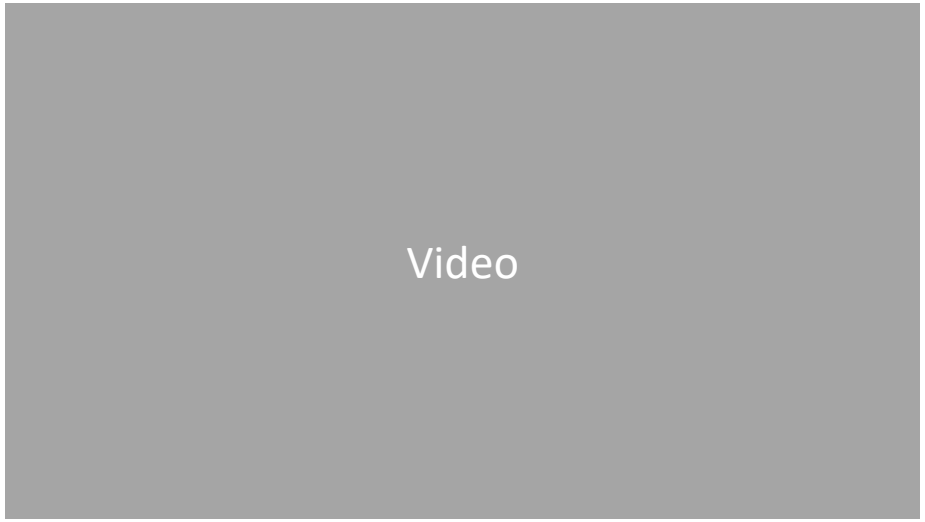
`Sort()` – no longer native

fast C# implementation

allows GC to pause whenever needed



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Other

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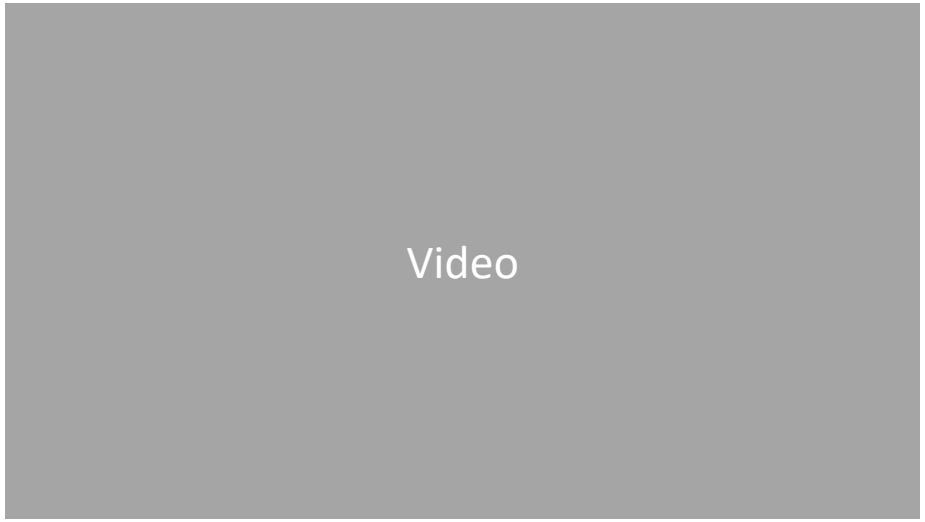
unloadable AssemblyLoadContext

replacement for AppDomains

no security, just loading isolation!

selective assembly sharing

unloading (.NET3+, GC backed)



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Děkuji Vám za pozornost

Přednášející je Vám k dispozici na chatu ještě 15 minut
po skončení přednášky.


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