Public Preview Version

.NET Memory Dump Analysis Accelerated

Version 2.0

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Prerequisites

WinDbg Commands

We use these boxes to introduce some WinDbg commands used in practice exercises

Basic .NET programming and debugging

Training Goals

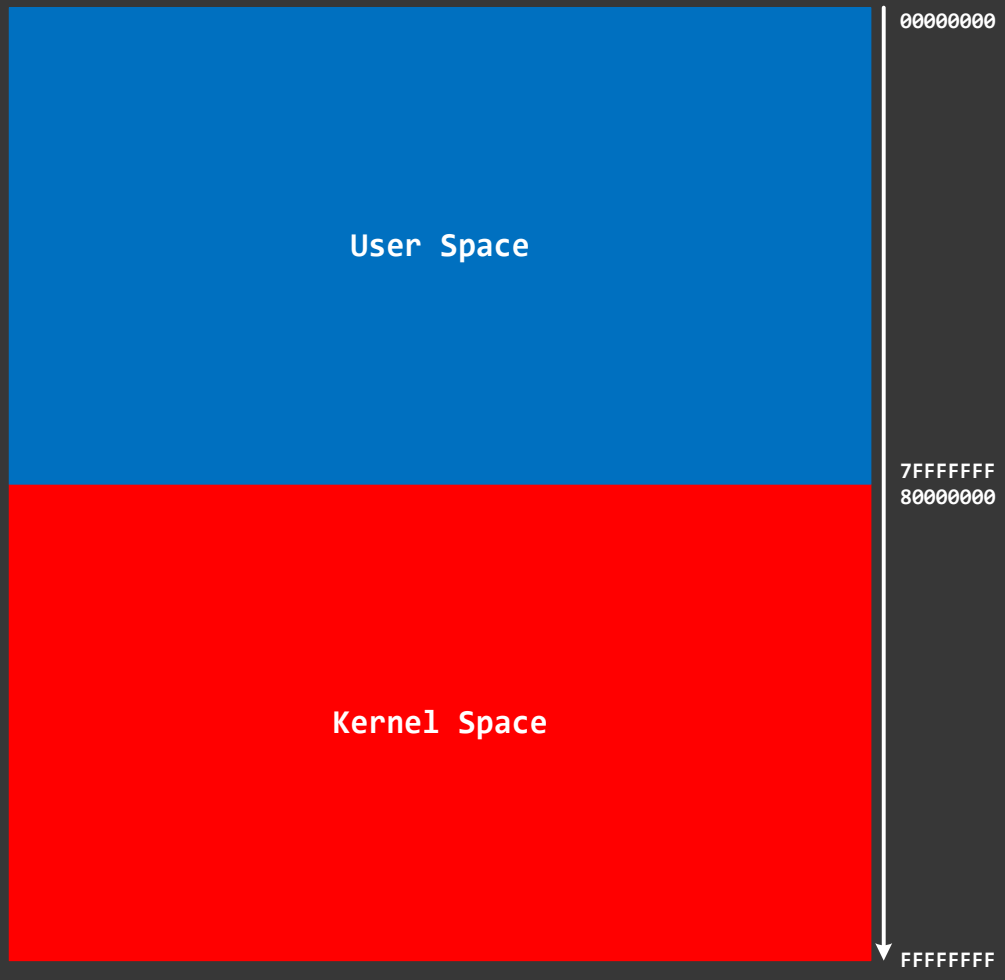
- Review fundamentals
- Learn how to analyze process dumps
- Learn necessary commands in context
- Cover CLR 2 / CLR 4 (x86 and x64)

Training Principles

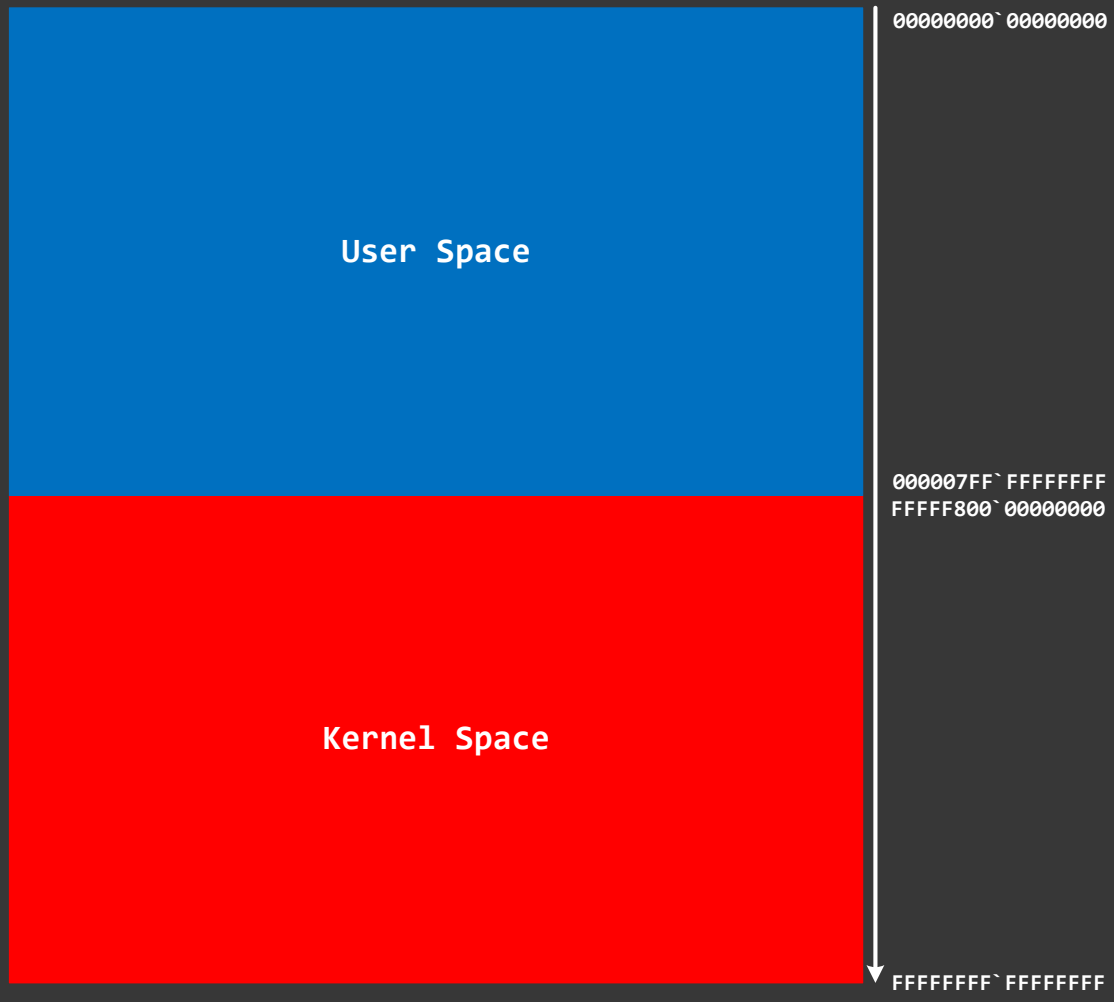
- Talk only about what I can show
- Lots of pictures
- Lots of examples
- Original content and examples

Part 1: Fundamentals

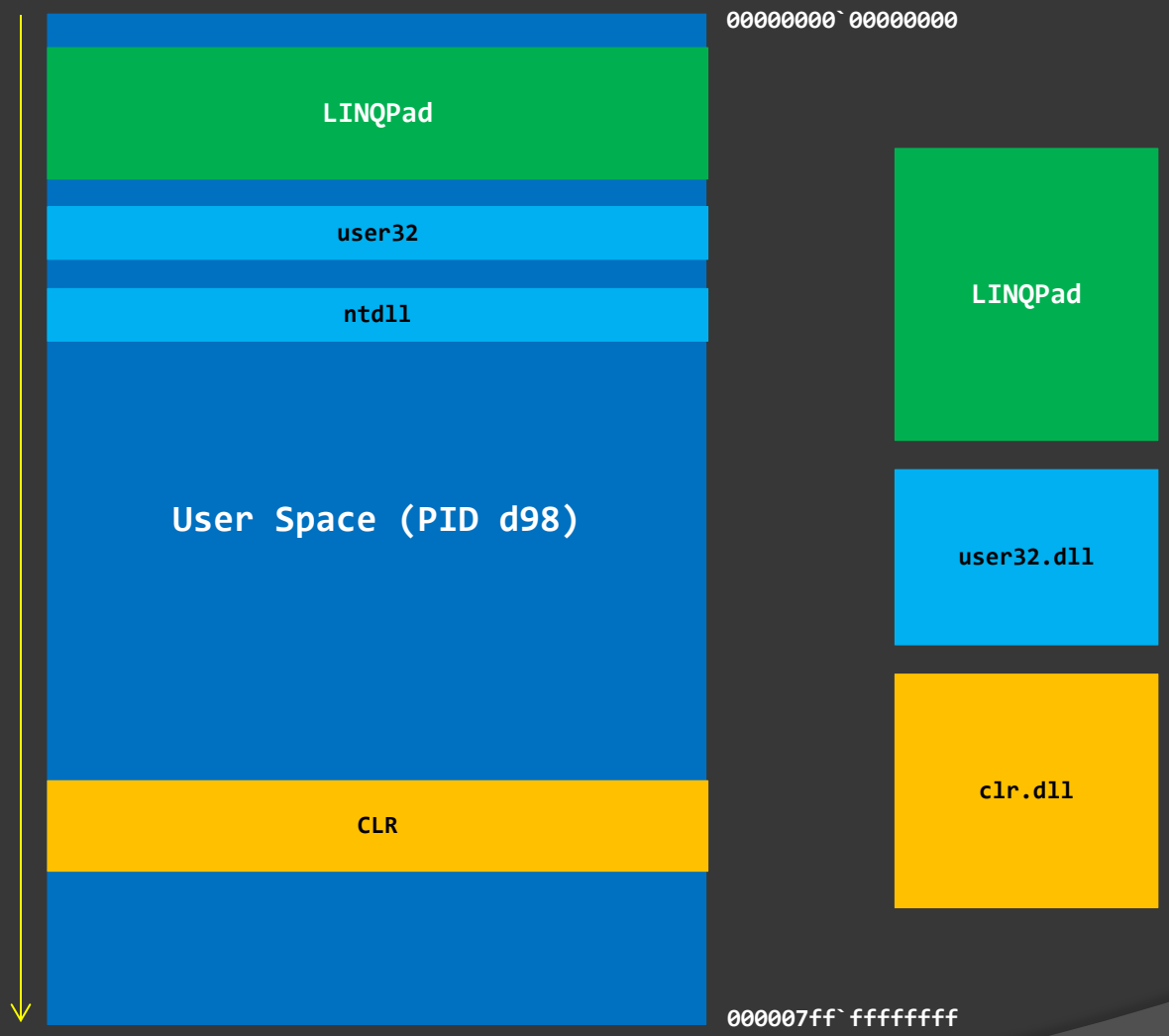
Memory Space (x86)



Memory Space (x64)



User / Managed Space



WinDbg Commands

lmv command lists all loaded modules (EXE and DLLs)

Types/Assemblies/Modules

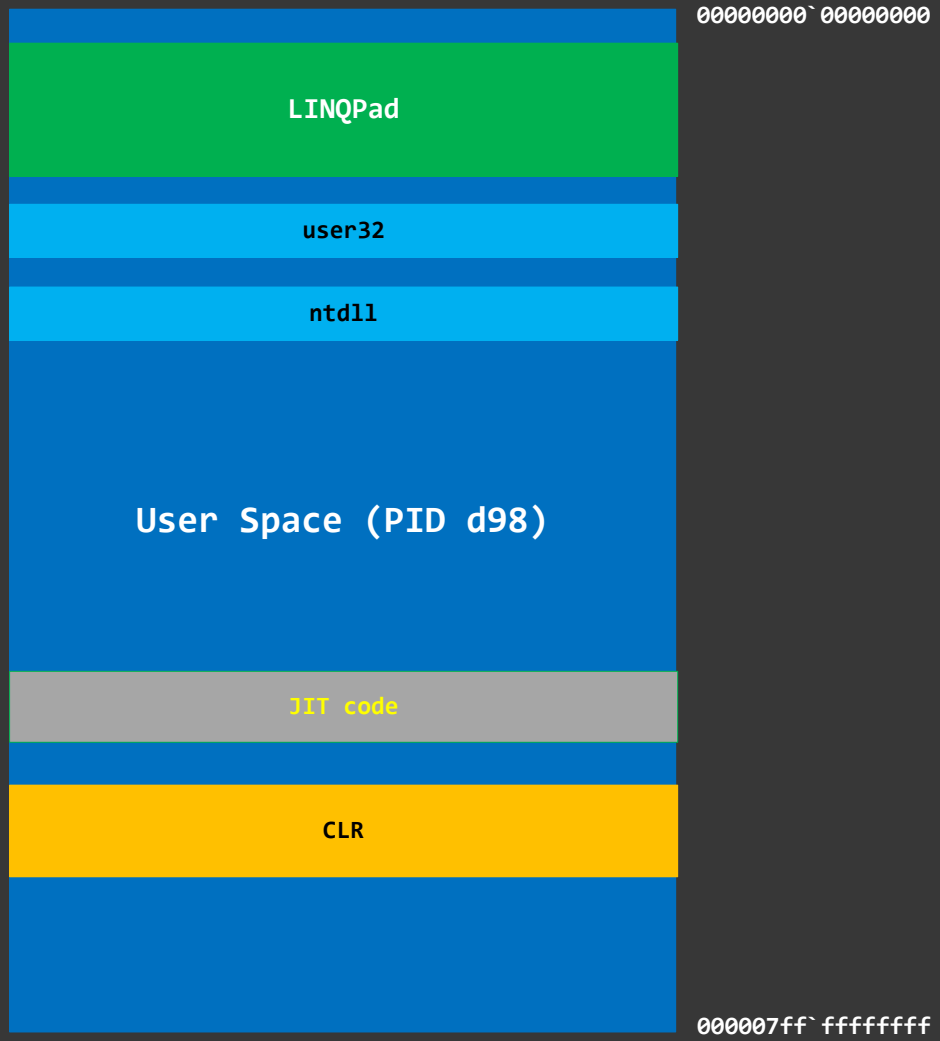
WinDbg Commands

lmv command lists all loaded modules (EXE and DLLs)

!IP2MD command shows type method and module address

!DumpModule command shows module name

Process Threads



WinDbg Commands

.load *<a path to SOS>*
Loads SOS WinDbg extension

~<n>s command switches between threads

k command shows unmanaged stack trace

!Threads command shows managed threads

!CLRStack command shows managed stack trace

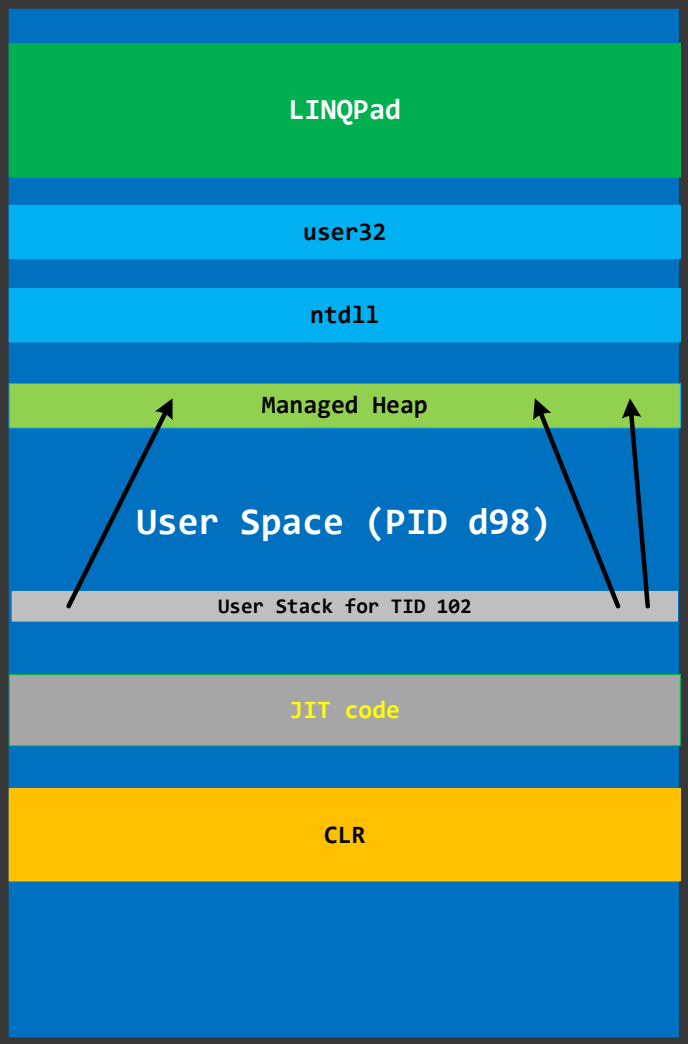
Example

```
0:000> kL
ChildEBP RetAddr
0020e95c 7720b5b4 ntdll!KiFastSystemCallRet
0020e960 68e6737a user32!NtUserWaitMessage+0xc
0020e9f4 68e66e2c System_Windows_Forms_ni+0x22737a
0020ea50 68e66c81 System_Windows_Forms_ni+0x226e2c
0020ea80 68df366d System_Windows_Forms_ni+0x226c81
0020ea98 002b31fd System_Windows_Forms_ni+0x1b366d
0020eb7c 002b1515 0x2b31fd
0020ee24 6ce421db 0x2b1515
0020ee34 6ce64a2a clr!CallDescrWorker+0x33
0020eeb0 6ce64bcc clr!CallDescrWorkerWithHandler+0x8e
0020efe8 6ce64c01 clr!MethodDesc::CallDescr+0x194
0020f004 6ce64c21 clr!MethodDesc::CallTargetWorker+0x21
0020f01c 6cf2ce82 clr!MethodDescCallSite::Call+0x1c
0020f180 6cf2cf90 clr!ClassLoader::RunMain+0x24c
0020f3e8 6cf2cda4 clr!Assembly::ExecuteMainMethod+0xc1
0020f8cc 6cf2d199 clr!SystemDomain::ExecuteMain...
0020f920 6cf2d09a clr!ExecuteEXE+0x58
0020f96c 6cfaaf00 clr!_CorExeMainInternal+0x19f
0020f9a4 6e1e55ab clr!_CorExeMain+0x4e
0020f9b0 6e187f16 mscoreei!_CorExeMain+0x38
0020f9c0 6e184de3 mscoree!ShellShim__CorExeMain+0x99
0020f9c8 77563833 mscoree!_CorExeMain_Exported+0x8
0020f9d4 77b7a9bd kernel32!BaseThreadInitThunk+0xe
0020fa14 00000000 ntdll!_RtlUserThreadStart+0x23
```

```
0:000> !IP2MD 0x2b1515
MethodDesc:   000e934c
Method Name:  LINQPad.Program.Go(...)
Class:        002c05dc
MethodTable:  000e954c
mdToken:      06000272
Module:       000e2e9c
IsJitted:     yes
CodeAddr:     002b05c0
Transparency: Critical

0:000> !DumpModule 000e2e9c
Name:       C:\LINQPad4\LINQPad.exe
Attributes: PEFile
Assembly:   00317418
[...]
```

Thread Stack Raw Data



WinDbg Commands

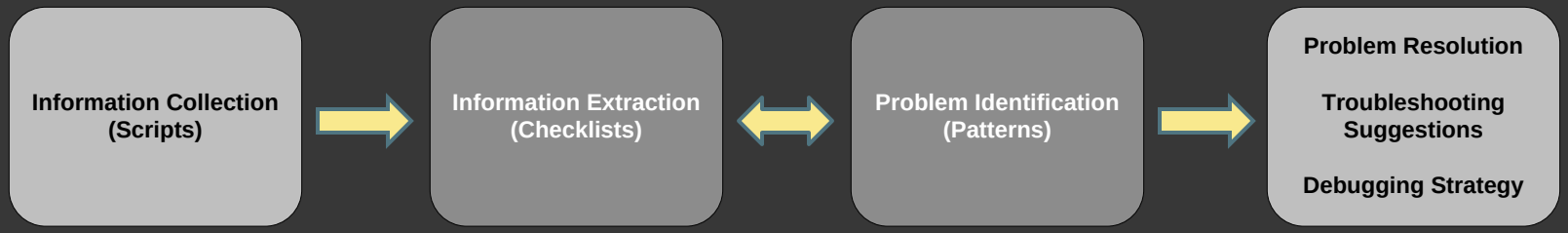
Get stack range:
!teb

Dump raw data:
dc / **dps** / **dpp** / **dpa** / **dpu**

Dump managed references:
!DumpStackObjects

Pattern-Driven Analysis

Pattern: a common recurrent identifiable problem together with a set of recommendations and possible solutions to apply in a specific context



Checklist: http://www.dumpanalysis.org/windows-memory-analysis-checklist

Patterns: http://www.dumpanalysis.org/blog/index.php/crash-dump-analysis-patterns/

.NET Patterns: http://www.dumpanalysis.org/blog/index.php/2011/04/22/net-clr-managed-space-patterns/

Part 2: Practice Exercises

Links

- Memory Dumps:

Not available in preview version

- Exercise Transcripts:

Not available in preview version

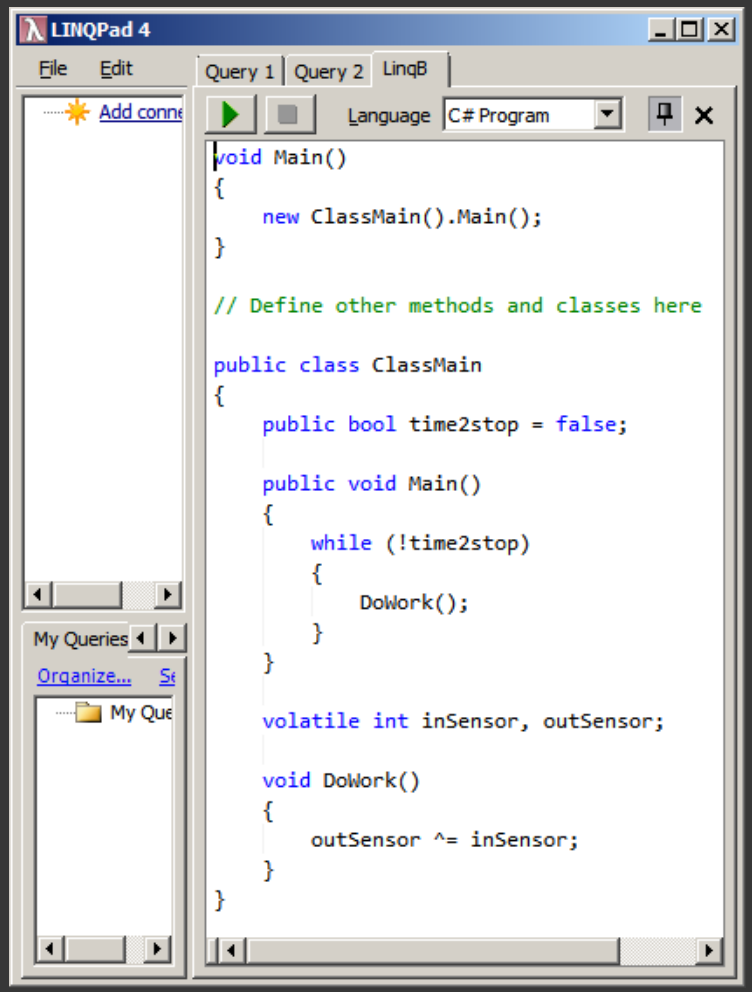
Exercise 0

- **Goal:** Install Debugging Tools for Windows and learn how to set up symbols correctly
- **Patterns:** Incorrect Stack Trace
- **Commands:** .symfix, .reload, k

Process Memory Dumps

Exercises PN1 - PN8

Modeling with LINQPad



http://www.linqpad.net/

Exercise PN1

- **Goal:** Learn how to load the correct .NET SOS WinDbg extension and analyze managed space
- **Patterns:** Stack Trace Collection; CLR Thread; Version-Specific Extension; Managed Code Exception; Managed Stack Trace
- **Commands:** .logopen, ~*k, !analyze -v, !pe, ~*e, lmv, .chain, .unload, .load, .logclose

Exercise PN2

- **Goal:** Compare CLR 2 with CLR 4. Manual stack reconstruction (*Advanced*).
- **Patterns:** Stack Trace Collection; CLR Thread; Version-Specific Extension; Managed Code Exception; Managed Stack Trace; Truncated Stack Trace; Incorrect Stack Trace (*Advanced*)
- **Commands:** .kframes, kc, dps, k L=<>

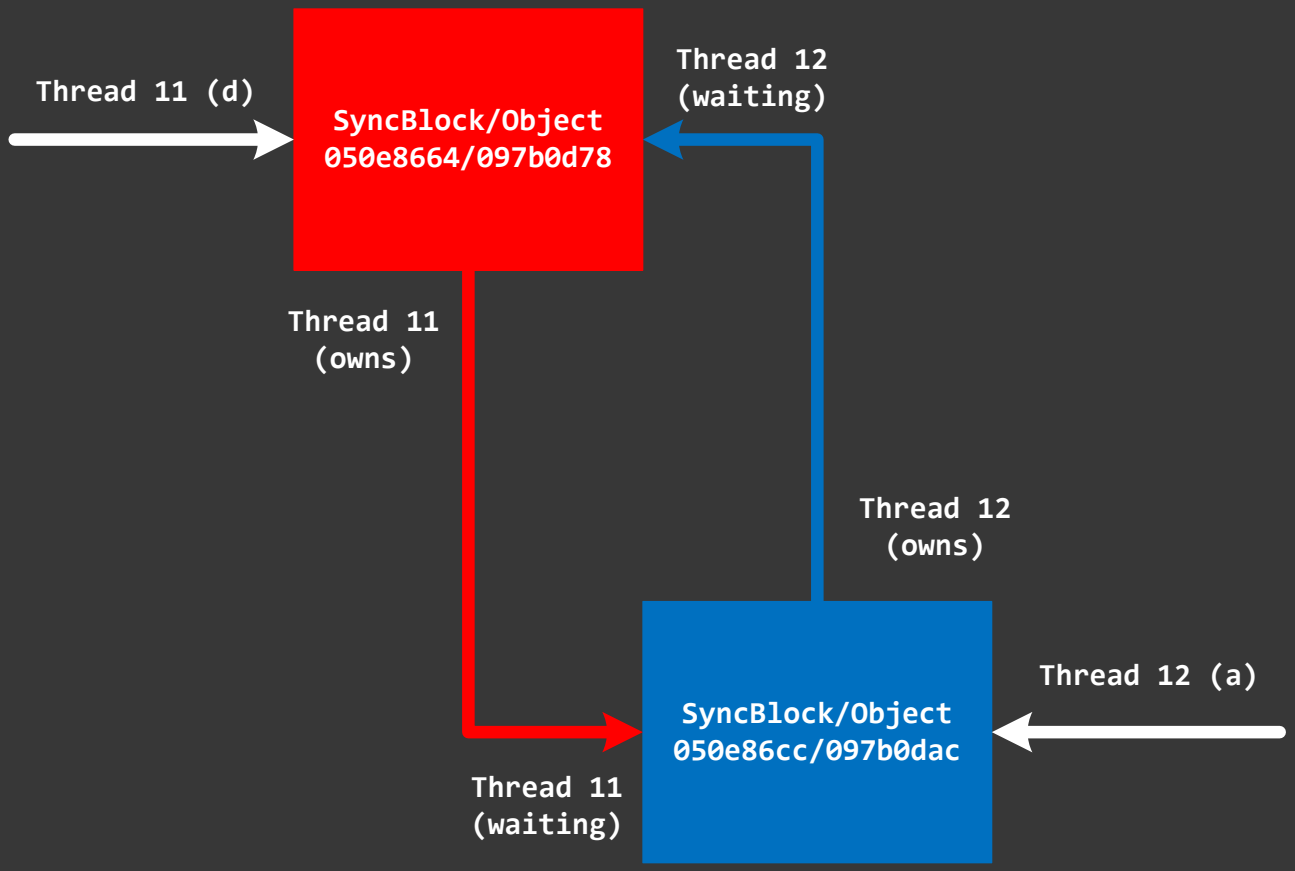
Exercise PN3

- **Goal:** Learn how to find problem assemblies, modules, classes and methods, disassemble code, analyze CPU spikes
- **Patterns:** Stack Trace Collection; CLR Thread; Version-Specific Extension; Duplicate Extension; JIT Code; Spiking Thread; Annotated Disassembly
- **Commands:** !analyze -v -hang, !CLRStack, !IP2MD, !runaway, ~<>s, ~<>k, !U, !DumpMD, !DumpClass, !DumpMT, !DumpModule, !DumpAssembly, !DumpDomain

Exercise PN4

- **Goal:** Learn how to recognize and analyze deadlocks using SOS(EX), execution residue, handled exceptions, dump object references
- **Patterns:** CLR Thread; Special Thread; Blocked Thread; Annotated Disassembly; Deadlock; Caller-n-Callee; Execution Residue; Handled Exception
- **Commands:** !Threads -special, kL, !syncblk, !DumpObject, ub, !U, dp, !dlk, !DumpStack, !DumpStackObjects, !teb, dps

Deadlock



Exercise PN5

- **Goal:** Learn how to analyze multiple managed exceptions, diagnose heap and handle leaks
- **Patterns:** CLR Thread; Managed Stack Trace Collection; Managed Code Exception; Handle Leak; Multiple Exceptions; Nested Exceptions; Annotated Disassembly; Execution Residue; Exception Thread; Hidden Exception; NULL Pointer
- **Commands:** kv, .cxr, !DumpHeap, ?, !eeheap, !GCHandles, !FinalizeQueue

Exercise PN6

- **Goal:** Learn how to recognize and analyze heap corruption
- **Patterns:** CLR Thread; Exception Thread; Invalid Pointer; Managed Heap Corruption; Execution Residue
- **Commands:** !VerifyHeap, dc

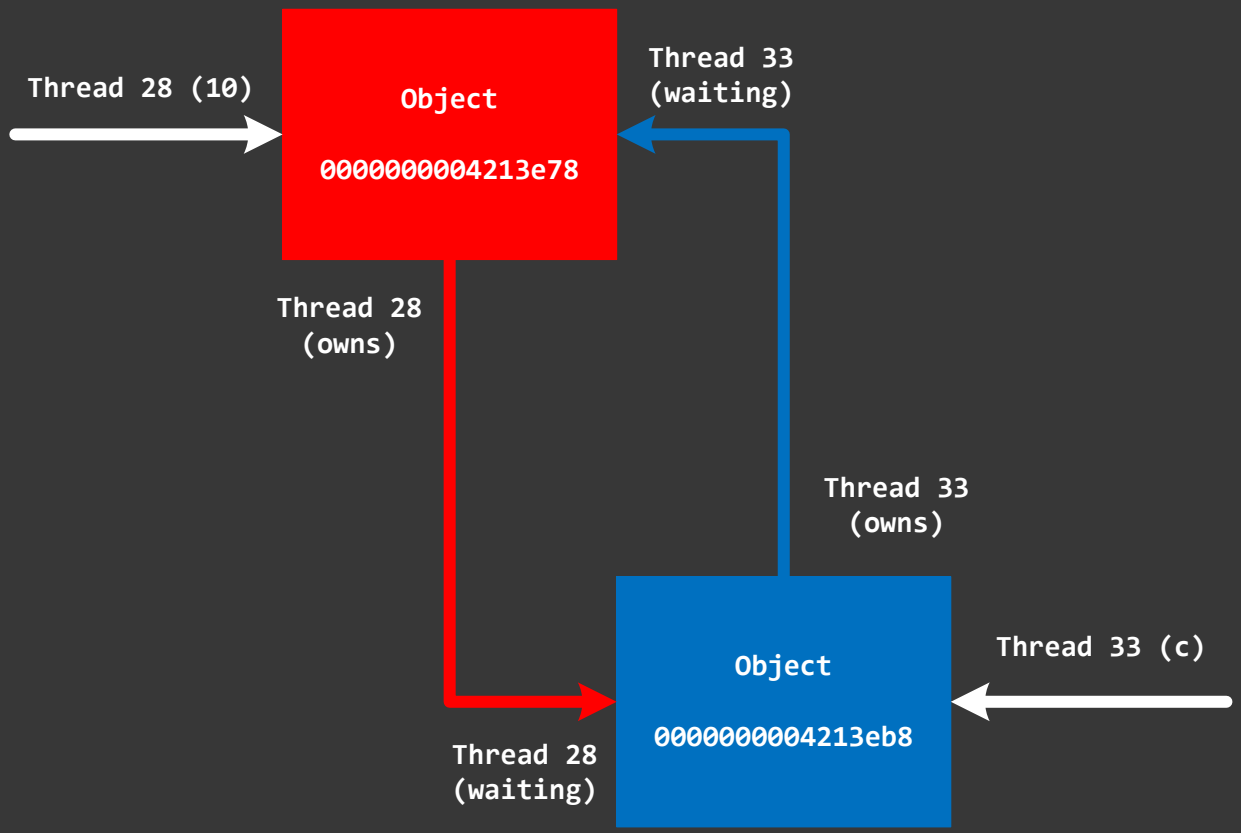
Exercise PN7 (x64)

- **Goal:** Learn how to find problem assemblies, modules, classes and methods, disassemble code, analyze CPU spikes
- **Patterns:** Stack Trace Collection; CLR Thread; Version-Specific Extension; Duplicate Extension; JIT Code; Spiking Thread; Annotated Disassembly
- **Commands:** !analyze -v -hang, !CLRStack, !IP2MD, !runaway, ~<>s, ~<>k, !U, !DumpMD, !DumpClass, !DumpMT, !DumpModule, !DumpAssembly, !DumpDomain

Exercise PN8 (x64)

- **Goal:** Learn how to recognize and analyze deadlocks using SOS(EX), execution residue, handled exceptions, dump object references
- **Patterns:** CLR Thread; Special Thread; Blocked Thread; Deadlock; Execution Residue; Handled Exception
- **Commands:** !Threads -special, kL, !syncblk, !DumpObject, ub, dp, !dlk, !DumpStack, !DumpStackObjects, !teb, dps

Deadlock (x64)



Pattern Links

CLR Thread
Managed Code Exception
Nested Exceptions
Mixed Exception
Memory Leak
JIT Code
Managed Stack Trace
Multiple Exceptions
Version-Specific Extension
Caller-n-Callee

Deadlock
Duplicate Extension
Stack Trace Collection
Dynamic Memory Corruption
Special Thread
Execution Residue
Handled Exception
Annotated Disassembly
Technology-Specific Subtrace

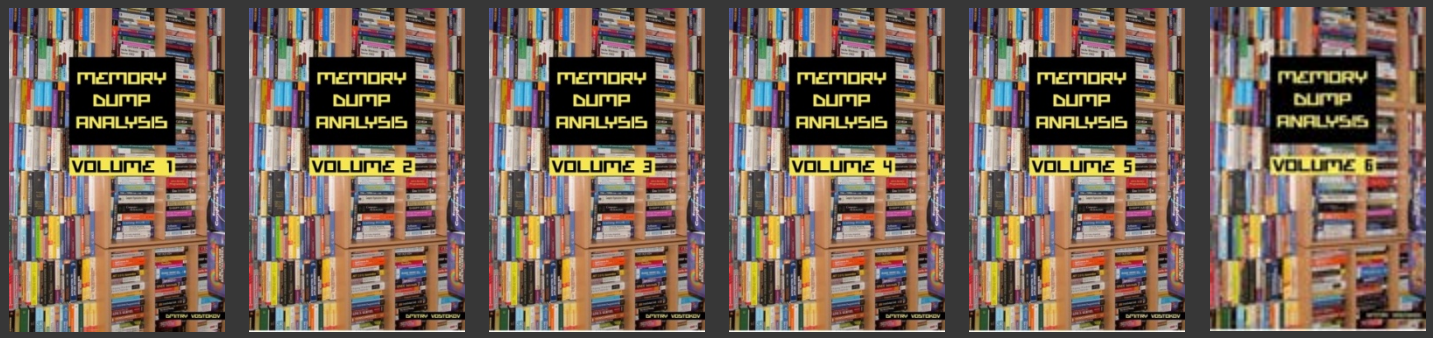
Incorrect Stack Trace Paged Out Data
NULL Pointer Handle Leak
Truncated Stack Trace Special Process
Spiking Thread Hidden Exception

SOS Checklist

- CLR module and SOS extension versions (lmv and .chain)
- Managed exceptions (~*e !pe -nested)
- Managed threads (!Threads -special)
- Managed stack traces (~*e !CLRStack)
- Managed execution residue (~*e !DumpStackObjects)
- Managed heap (!VerifyHeap, !DumpHeap -stat and !eeheap -gc)
- GC handles (!GCHandles)
- Finalizer queue (!FinalizeQueue)
- Sync blocks (!syncblk)

Resources

- WinDbg Help / WinDbg.org (quick links)
- DumpAnalysis.org
- C# 4.0 in a Nutshell
- Advanced .NET Debugging
- Debugging Microsoft .NET 2.0 Applications
- Shared Source CLI 2.0 Internals
- Accelerated Windows Memory Dump Analysis, 2nd edition
- Memory Dump Analysis Anthology, volumes 1 - 6



Q&A

Please send your feedback using the contact form on PatternDiagnostics.com

Thank you for attendance!