
## Not about what we already know…

- Be more defensive
  - /analyze (PREfast)
  - Lint
  - /RTC compiler flags VS runtime checks
    - Uninitialized variable
    - Smaller type checks (conversion to)
    - Stack frames
    - Security checks
  - ASSERT / VERIFY macros
  - Pre/Post condition checks
  - Debug builds, _SECURE_SCL
  - /GS (security buffer checking)
  - Unit tests

## Golden rules

- You are guilty until proven innocent
- Always generate debugging symbols
- The symbol server is your best friend
- All access violations are deadly
- Save a .DMP file
- Have sharp tools www.sysinternals.com and “Debugging Tools for Windows”, VS2005

## Not so obvious

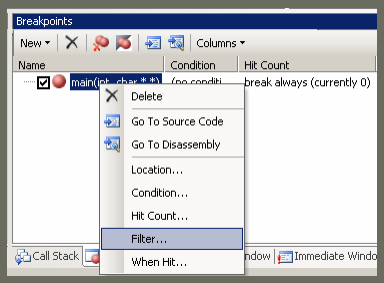
- Unoptimized can be better than DEBUG
- Remote debugging can be better than local
- Don’t use the debugger that comes with the compiler -- use the latest debugger
- Global variables can be good

## Use the latest debugger

- Use the latest debugger, but keep your build environment.
- What extra goodies are available?




VS 2005 goodies:

• Filters for breakpoints (tid, pid, machine process or thread name)
See SetThreadName in MSDN.

• Run script or print values when hit (and then stop or continue)

• Proper symbol server support

• Source server support

## Debugging nightmares

A warning to architects; how to multiply your bugs.

- All we have to do is integrate our C++ widgets, with our JScript script applets, our Java beans, and our XSL transforms, and DHTML front end, and our .NET assemblies…
- Well in theory….
- But what we get is a dangerous mess
- Be careful how many technologies you use

# How do I …

1. Debug what corrupted my ‘this’ pointer
2. Debug service startup code
3. Find what’s eating all that CPU time
4. Debug a deadlock
5. Find what corrupted my heap
6. Find the cause of leaks
7. Gather .DMP files





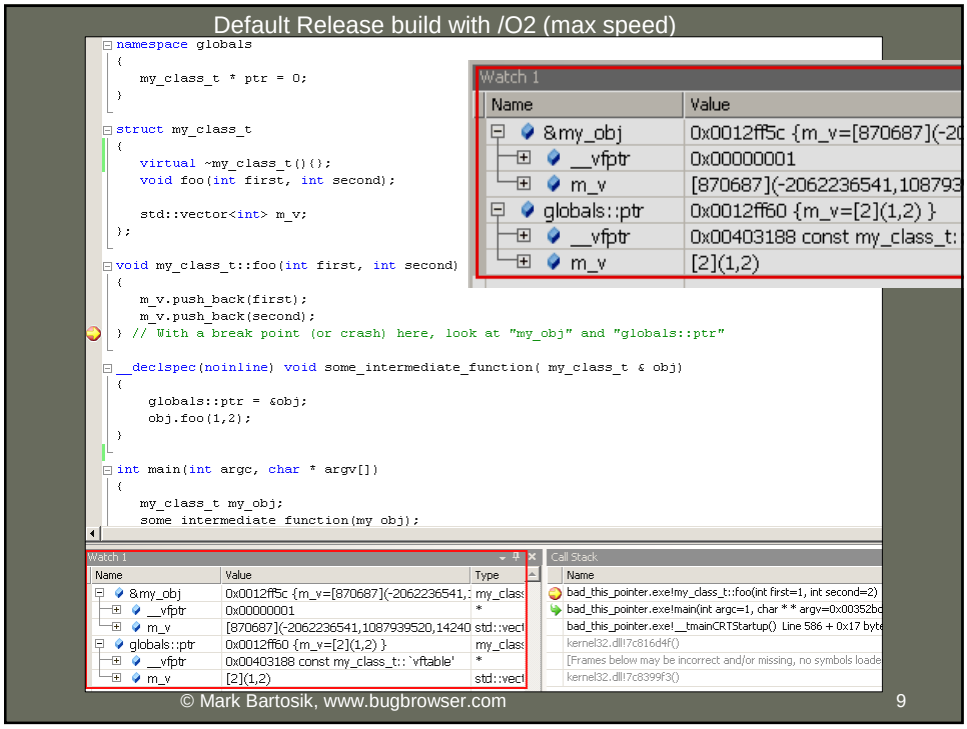
# How do I debug an invalid *this ?*

- What zapped my ‘this pointer’?
- What corrupted my object?
- Or is my debugger a liar?

```
class my_class_t
{
   void foo(int first, int second);
};
```

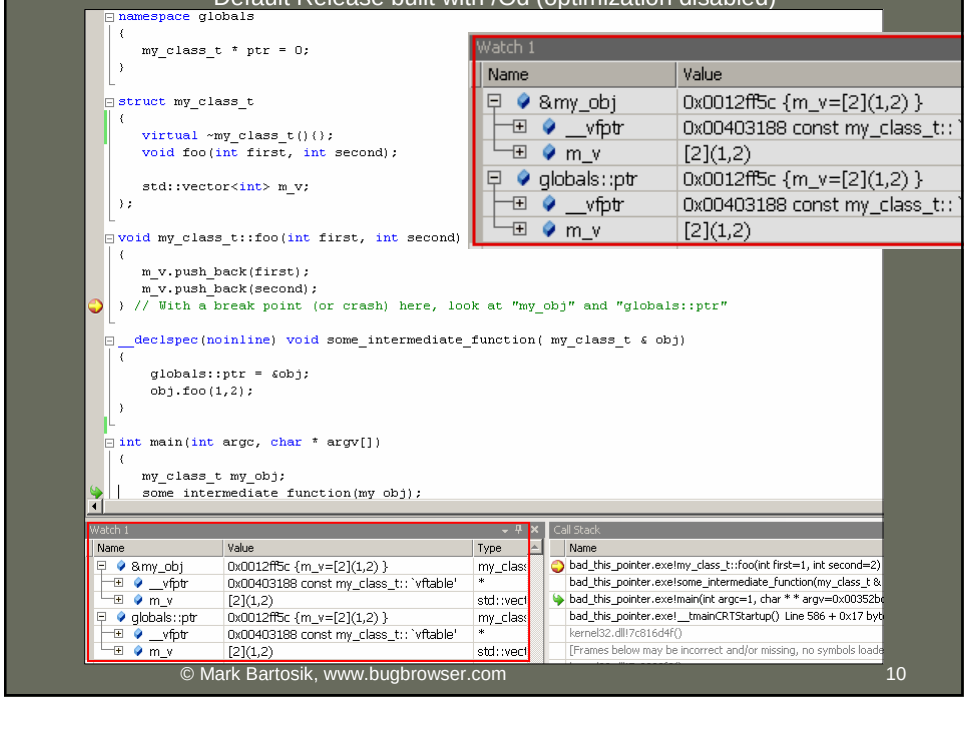
| caller | callee |
|---|---|
| `push second` | `push ebp` |
| `push first` | `mov ebp, esp` |
| **`mov ecx, this`** | **`mov esi, ecx`** |
| `call my_class_t::foo` | `xor ebx, ebx` |
| | **`mov ecx, ebx`** ← ZAP |

## Default Release build with /O2 (max speed)






## Default Release built with /Od (optimization disabled)



## How do I debug a service?

- Debug startup code in a service?

```
::MessageBox(NULL, “Service”, “Debug Me”,
             MB_SERVICE_NOTIFICATION | MB_OK );
```

You’ve got 30 seconds!
Before the service control manager terminates a non responsive process

Magic registry entry: ServicesPipeTimeout

```
symchk /ip 612 –s SRV*c:\websymbols*http://msdl.microsoft.com/download/symbols

cdb –pv –pn services.exe –c ".dump /ma c:\services.dmp; .detach; q”

cdb –z c:\services.dmp –c "x services!*timeout*; q"

cdb –pv –pn services.exe -y SRV*c:\websymbols
    -c ".symopt+ 0x400; ed services!g_dwScPipeTransactTimeout 0n60000 ; .detach; q"

NT_SYMBOL_PATH=SRV*c:\websymbols*http://msdl.microsoft.com/download/symbols
```

Alternatively call:
`SetServiceStatus` with `SERVICE_START_PENDING` and a hint of 60000 and incremented `checkpoint` value.



## Non invasive debugging

**TIP:** `-pv == Non invasive debugging`

- Only one debugger can be attached at a time, right?
- If the debugger dies the process dies, right?
- WinDbg and CDB support limited debugging without attaching as a debugger.
- Can use WinDbg in conjunction with Visual Studio
- Can probe critical applications safely
- If the application is completely frozen and the debugger cannot launch a break thread necessary for a true attach. In this case typically the *loader lock* is held.
- Does not affect timings and hide bugs.

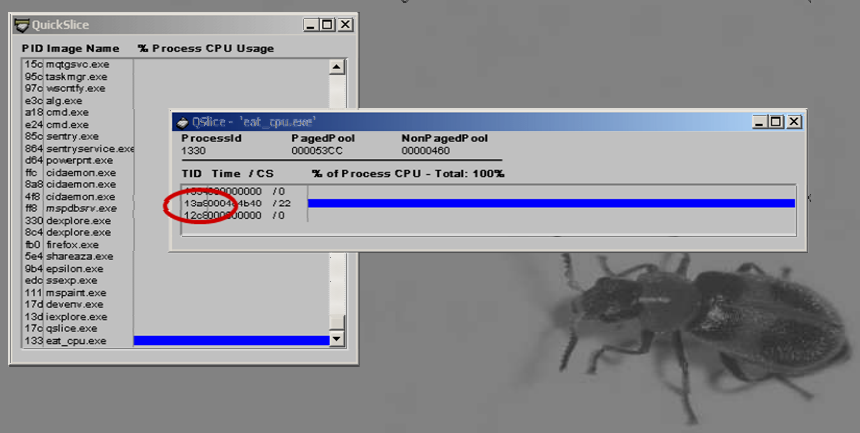
## But, it works under the Debugger!! #$%☹

- Problems
  - Program timing is affected:
    - Thread start / stop
    - Module load / unload
    - OutputDebugString
    - Exceptions (and there are many that your don't see)
  - Program heap layout is affected:
    - Debug heap in OS gets enabled only if launch under debugger
  - GUI Focus changes when breakpoint hit
- Solutions:
  - Attach instead of launch
  - Attach and detach when not required (XP and above)
  - Remote debugging
  - Non invasive WinDbg or CDB (but no break points available)

## How do I find a CPU hog?

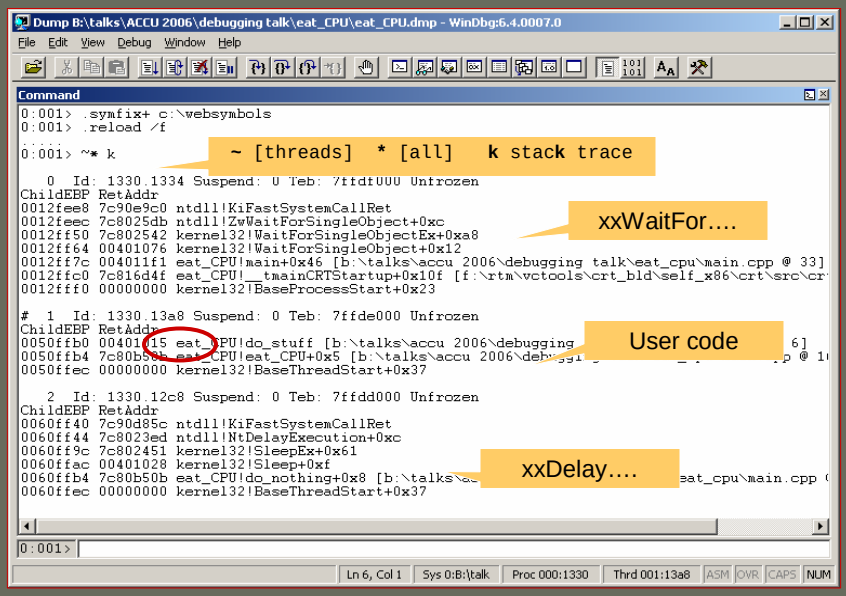
- What's eating all that CPU time?



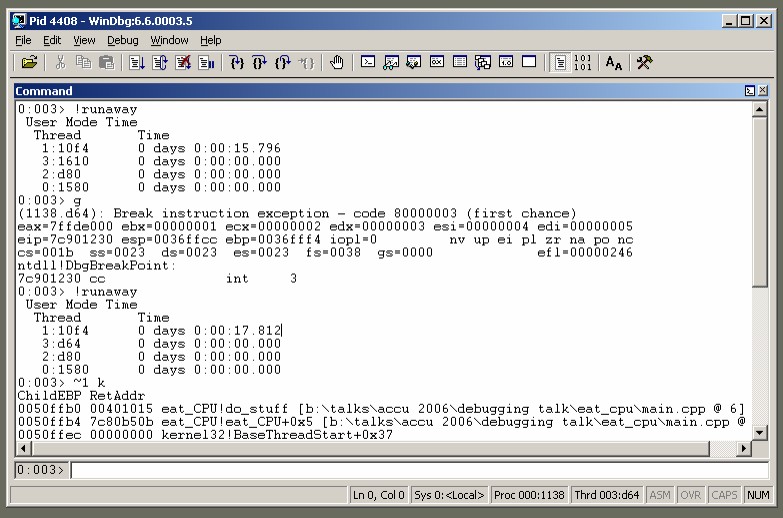
## ~* k




In VS 2005 in the command window: `>Macros.Samples.VSDebugger.DumpStacks`



## !runaway



© 2004 M. Plonsky

TID 16f4 critsec_a 00405748
TID 1214 critsec_b 00405778

# How do I debug a deadlock?

```
0:002> !locks
CritSec dead_lock!critsec_a+0 at 00405748
LockCount          1
RecursionCount     1
OwningThread       16f4
EntryCount         1
ContentionCount    1
*** Locked

CritSec dead_lock!critsec_b+0 at 00405778
LockCount          1
RecursionCount     1
OwningThread       1214
EntryCount         1
ContentionCount    1
*** Locked
```



~* k

TID 16f4 critsec_a 00405748
TID 1214 critsec_b 00405778

```
0:002> ~* kv
   0  Id: 1684.af8 Suspend: 2 Teb: 7ffdf000 Unfrozen
ChildEBP RetAddr  Args to Child
0012fee8 7c90e9c0 7c8025db  ntdll!KiFastSystemCallRet
0012feec 7c8025db 000017f4  ntdll!ZwWaitForSingleObject
0012ff50 7c802542 000017f4  kernel32!WaitForSingleObjectEx
0012ff64 004011f6 000017f4  kernel32!WaitForSingleObject
0012ff7c 0040182d 00000001  dead_lock!main
0012ffc0 7c816d4f 00000000  dead_lock!__tmainCRTStartup
0012fff0 00000000 00401976  kernel32!BaseProcessStart

   1  Id: 1684.16f4 Suspend Unfrozen
ChildEBP RetAddr  Args to Child
0050fef0 7c90e9c0 7c91901b  ntdll!KiFastSystemCallRet
0050fef4 7c91901b 000017d8  ntdll!ZwWaitForSingleObject
0050ff7c 7c90104b 00405778  ntdll!RtlpWaitForCriticalSection
0050ff84 0040109d 00405778  ntdll!RtlEnterCriticalSection
0050ff8c 00401130 4ad50ce7  dead_lock!function2
0050ffb4 7c80b50b 00000000  dead_lock!thread_a
0050ffec 00000000 004010d0  kernel32!BaseThreadStart

#  2  Id: 1684.1214 Suspend Unfrozen
ChildEBP RetAddr  Args to Child
0060fedc 7c90e9c0 7c91901b  ntdll!KiFastSystemCallRet
0060fee0 7c91901b 000017d4  ntdll!ZwWaitForSingleObject
0060ff68 7c90104b 00405748  ntdll!RtlpWaitForCriticalSection
0060ff70 00401034 00405748  ntdll!RtlEnterCriticalSection
0060ff8c 004011a0 4ae50ce7  dead_lock!function3
0060ffb4 7c80b50b 00000000  dead_lock!thread_b
0060ffec 00000000 00401140  kernel32!BaseThreadStart
```

This thread already owns **critsec_a** and is attempting to acquire **00405778**

This thread already owns **critsec_b** and is attempting to acquire **00405748**

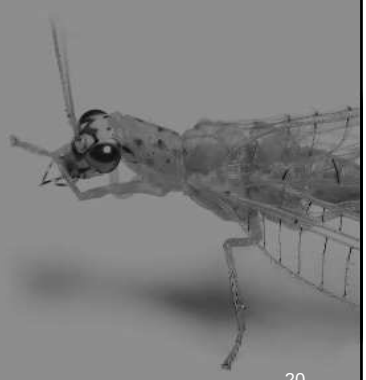
## Typical deadlock causes

1. “Upward” calls while holding a lock:
   Observer pattern / publish subscribe, or any synchronous generic callback mechanism
2. Order of locking
   thread 1: locks a, b  thread 2: locks b, a
3. Lack of RAII
4. Exception with lock acquired (even causing thread to exit)
5. Double acquire on non recursive locks
   e.g. spinlocks, and mutexs
6. Priority inversion – very rare

## How do I find memory corruptions?

- Debug build?
- Bounds checker?
- Purify?
- Debugging suit de jour?
- Application verifier, gflags
- Custom allocators
  Using `VirtualAlloc`, `VirtualProtect`, and `VirtualFree`
- Data break points
- Custom break point control
  http://www.morearty.com/code/breakpoint/



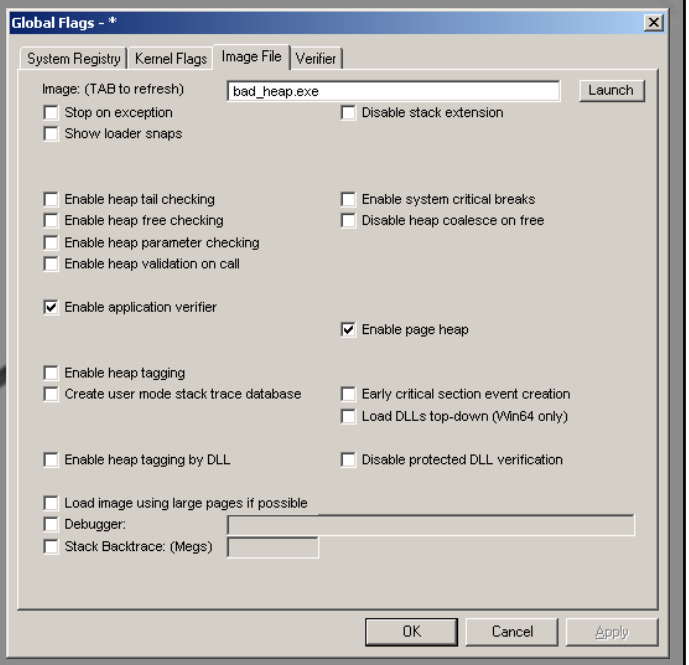
 

# gflags

Part of
Debugging Tools for Windows

Do not enable both heap tail checking and page heap



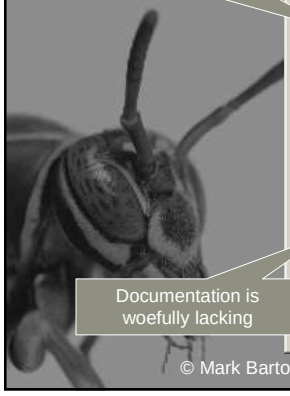


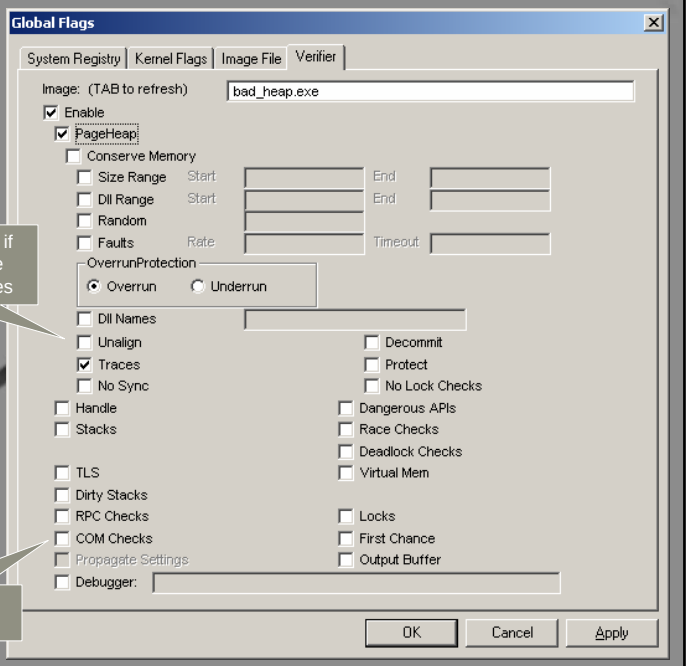

# gflags

Part of
Debugging Tools for Windows

Consider unaligned if you can, otherwise alignment is 16 bytes

Documentation is woefully lacking





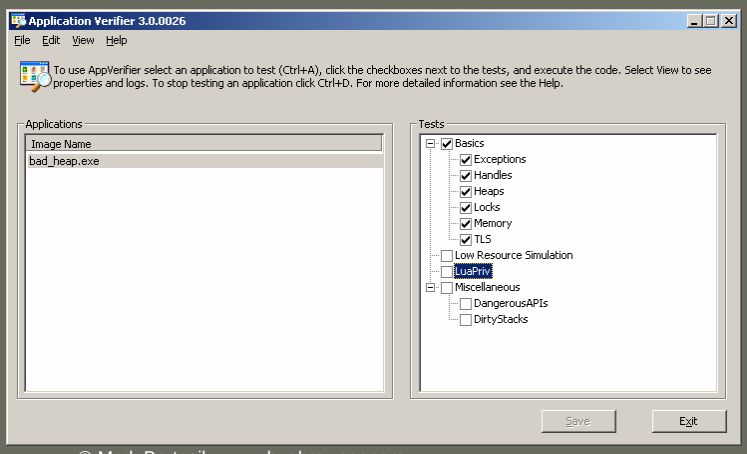
# Application Verifier

Integrated with VS 2005

OR [*exclusive or*]

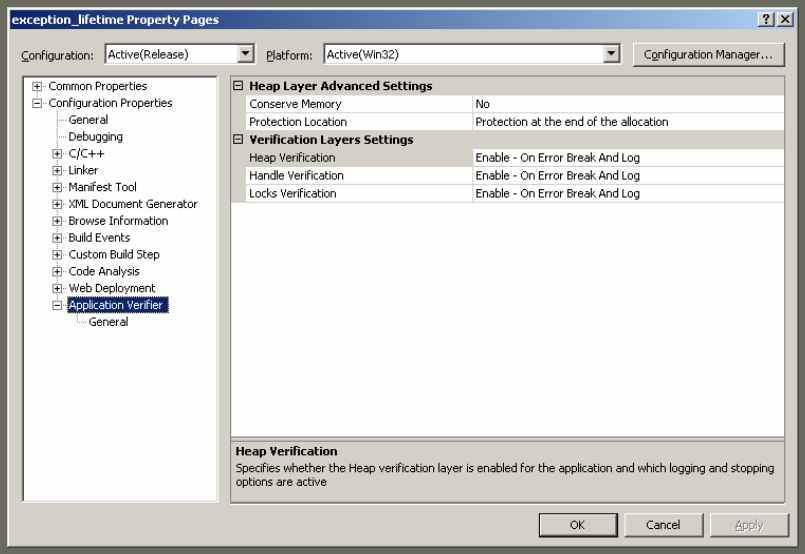
Downloadable from www.microsoft.com

(but not both MSDN Article ID: 911142)






# Application Verifier (in VS 2005)



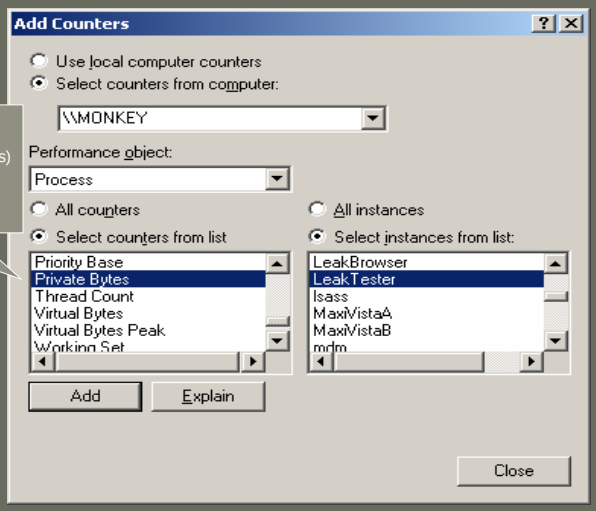
## How do I find leaks?

- Find what's leaking all my memory?
- Leak definition:
  Over time your program continues to consume more resources.
- Perfmon
  Process\Private Bytes (committed memory)
  Process\Handle Count
  Process\Virtual Bytes (address space)

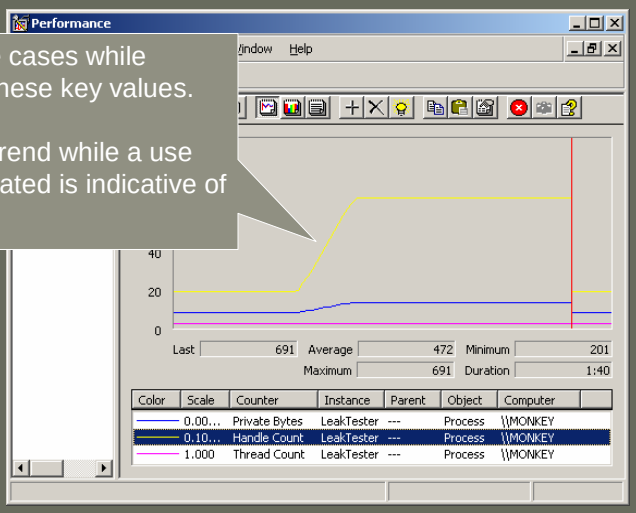


## How do I check for leaks?

Handle Count
Private Bytes (dynamic allocations)
Thread Count
Virtual Bytes (address space)



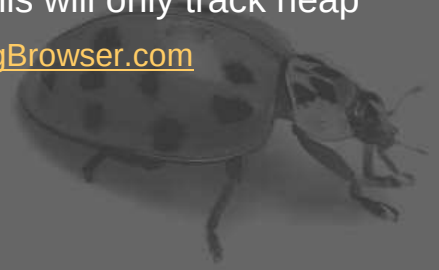
## How do I check for leaks?



## How do I find leaks?

- Memory might not be “garbage”
- Might not be practical to wait for process exit.
- Might not be practical to rebuild everything.
- Program may have many one time only “leaks”
- Microsoft’s UMDH  but this will only track heap
- Leak Browser ☺ www.BugBrowser.com

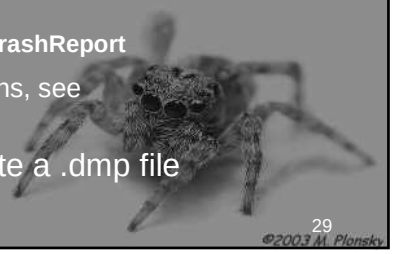


# .dmp files

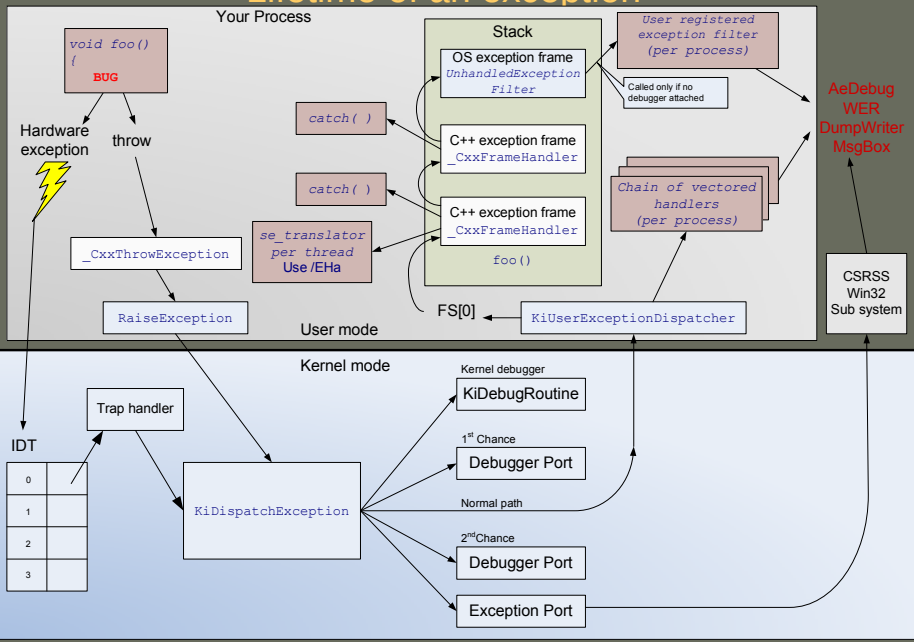
- Being able to capture an exception, a crash, or broken state in a .dmp file is the sharpest weapon against bugs.
- WinDbg, CDB, AdsPlus
  non redistributable
- Windows Error Reporting (WER)
  Requires WinQual membership, issues with configuration
- DumpWriter
  www.bugbrowser.com/dumpwriter
- CodeProject, look for CrashRpt and **XCrashReport**
- Debugging Applications, John Robins, see `SnapCurrentProcessMiniDump` API
- The trick is knowing when to create a .dmp file





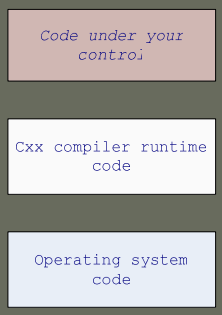


# Lifetime of an exception



## Lifetime of an exception

Key for exception lifetime



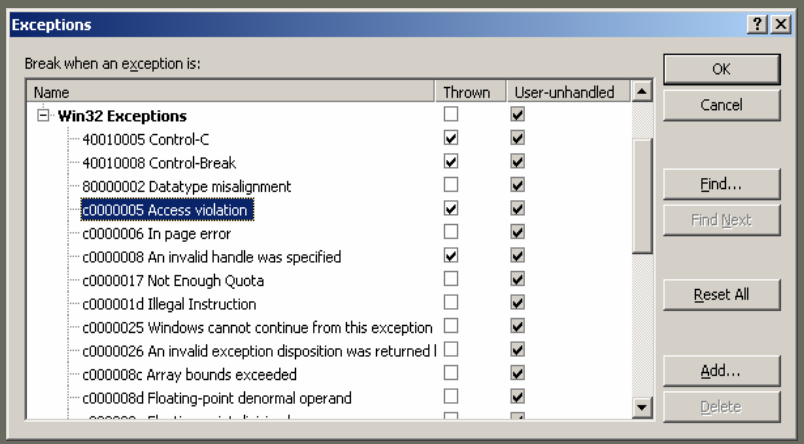

You have the following opportunities to detect a bug and create a .dmp file:

1. Assertions (instead of throw)
2. vectored exception handler
3. se_translator routine
4. __except
5. catch block
6. unhandled exception filter

 31

## Debugging exceptions

- Always trap access violations
- First column is *first chance* second column is *second chance* (unhandled)




 32

## Magic values

- Values to look for
  - 0xFDFDFDFD - No man's land
  - 0xDDDDDDDD - freed memory / deleted
  - 0xCDCDCDCD - uninitialized
  - 0xCCCCCCCC - uninitialized locals
  - 0xBAADF00D - value no longer valid
  - 0xDEADBEEF – value no longer valid
  - ???????? – uncommitted memory

## Capturing exceptions with vectored exception handlers

- Windows XP and beyond
  `_WIN32_WINNT 0x0501`
- `AddVectoredExceptionHandler`
- This installs a per process routine that is called whenever a structured exception occurs.
- There is a chain of these routines.
- It is the first place in user mode code to trap **all** exceptions. (First supported place)
- It is suitable for CONDITIONALLY creating a dump file.

## Capturing exceptions with se_translator

- The compiler provides a way to map structured exceptions (like 0xC0000005) to a C++ exception like std::runtime_error("FATAL!").
- _set_se_translator
- For VS 7.1 and greater requires /EHa, which has more overhead
- Is installed per thread **per CRT**
- Do you have control of all threads?
- Do you have multiple C++ runtimes loaded in your process?
- Can you require /EHa ?
- Good for component writers linking with **static CRT**.



## Capturing exceptions with unhandled exception filter

- Exceptions often swallowed by catch(…) before they reach the unhandled exception filter.
- Vulnerable to stack corruption, because it is called at the end of a linked list of filters which is stored on the stack.
- Per process filter installed by `SetUnhandledExceptionFilter`
- Trigger your own post mortem or leave it to Microsoft.
- The OS installs a default handler
  Default handler looks as AeDebug registry key, runs debugger if configured.
  Win2K: MessageBox or DrWtsn32
  XP, 2003: if no debugger is installed (or Drwtsn32) loads faultrep.dll and calls ReportFault

## Capturing exceptions with catch blocks

- Use catch ( std::exception & e ) for recovery
- catch (…) is evil, but necessary because not all C++ exceptions are rooted in std::exception.
- catch (…) is evil, because it stops unhandled exception filter from activating.
- Use catch (…) for recovery only if you have already trapped fatal exceptions and triggered post a mortem dmp.
- Catch blocks are not good places to trigger a dump because the stack is unwound and destructors have run, possibly destroying evidence.



## Capturing exceptions with __try , __except

- Cannot mix try and __try in the same function
- Cannot use __try in functions that require object unwinding
- GetExceptionInformation is treated as a keyword
- A catch(…) lower in the callstack can swallow exceptions
- Can provide for more localized control, e.g. per thread, per function becomes messy
- Can be messy

Example code:

```
LONG WINAPI MyExceptionFilter(EXCEPTION_POINTERS* ExceptionInfo)
{
   // Decide whether to create a .dmp file}
   .
   .
}

void c_plus_plus_function();

void wrapper_around_c_plus_plus_function()
{
   __try
   {
      c_plus_plus_function();
   }
   __except( MyExceptionFilter( GetExceptionInformation() ) )
   {}
}
```

## Capturing post mortem files programmatically

- Implement a vectored exception handler,
  not simple, catches almost everything.
- Implement an unhandled exception filter, easy but does not catch everything.
- Implement an se_translator function
  easy but not suitable for all projects.
- Implement an exception filter with __except, can be messy, scoped, easy for per thread, does not catch everything.
- Implement catch(…),
  not recommended.
- Whatever the mechanism used to intercept exceptions, we need a process to create the dumpfile (doing this in-proc is not recommended).
- A typical implementation will `CreateProcess` with a command line of "`dumpcapture-program –p` *`pid`*".



## Capturing post mortem files

- PER MACHINE configuration. Controlled by machine administrator.
  The OS installed unhandled exception filter looks at the AeDebug registry key will automatically launch the debugger registered by this key. This is done by an internal kernel32 function called `UnhandledExceptionFilter`.

  HKEY_LOCAL_MACHINE\Software\Microsoft\Windows NT\CurrentVersion\AeDebug
  Values are Auto (DWORD set to 1)
  and Debugger (String command line for debugger)
  - `drwtsn32 -p %ld` (will use WER instead under XP and later)
  - `pathto\ntsd -p %ld -e %ld -g -c ".dump /ma /u c:\TEMP\new.dmp; q"`
  - `pathto\cdb -p %ld -e %ld -g -c ".dump /ma /u c:\TEMP\new.dmp; q"`
  - `pathto\windbg -p %ld -e %ld -g -c ".dump /ma /u c:\TEMP\new.dmp; q"`
  - `pathto\dumpwriter -p %ld -e %ld`

- PER APPLICATION configuration. Controlled by application developer.
  - Call `CreateProcess` or `system` or similar to launch a process like those above. This can be done from within your chosen exception interception routine, you can control where dump file is written and how much information is included. This gives the developer much finer grain control.
  - Call `ReportFault`. This reports to Microsoft via WER (XP and above).

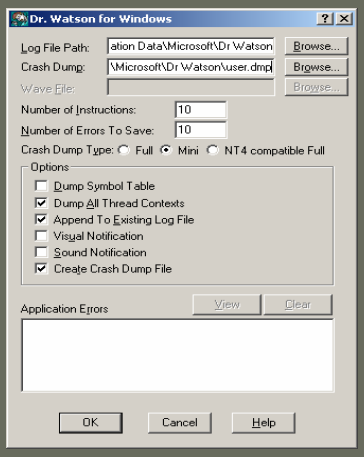
## Configuring DrWtsn32
## Dr. Watson

**DrWatson has retired!**
(Still used on NT4 and 2000)

DrWtsn32 /?
to configure

DrWtsn32 –p pid
To create a dump file,
and add to the logs,
but only ONE dump file is created.
Not recommended.

DrWtsn32 –i
To install a post mortem debugger.
Not recommended






## Configuring DumpWriter
http://www.bugbrowser.com/dumpwriter

- Dumpwriter /?
- Can configure solely via command line
- Can configure with a per installation XML file
- Can configure with a per application XML file
- Can configure with xpath within an XML file
- See HTML documentation
- Open source

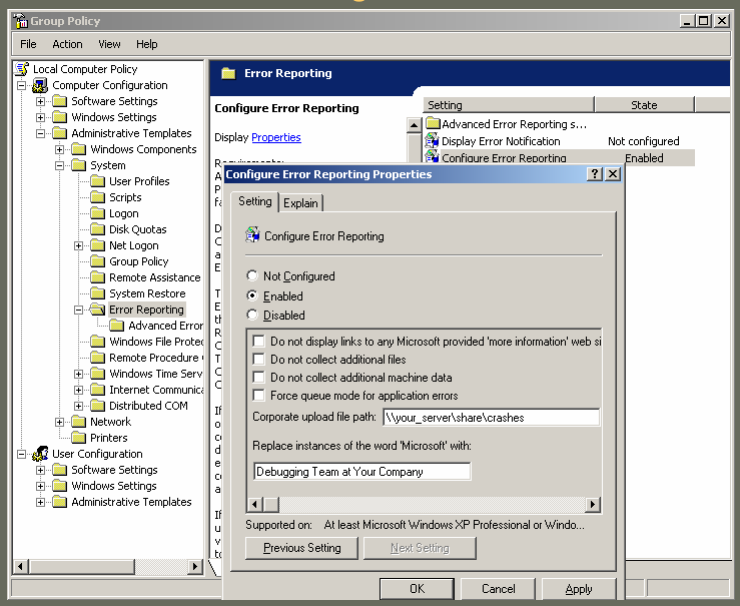
## Using WER

https://winqual.microsoft.com must use IE

- WER is configured via Group Policy editor `GPEDIT.MSC`
  Path in GPEDIT is \Computer Configuration\Administrative Templates\System\Error Reporting
  - Enable / disable.
  - Enable a corporate upload path (UNC path)
    This can be a network path for your test lab, or a local path.
  - Cannot redirect to a different web address ☹
- Basic requirements
  - Class 3 Verisign code signing certificate ($500).
  - Free once you have the Verisign cert.
    (billing is only for other WinQual services, not WER)
  - Sign the legal agreement (privacy of user data etc.)
  - You submit your products' released modules to Microsoft to create a mapping.
    (1 business day to process, 1 week to be reflected on web site planned to reduce 24 hours).
- You can download .cab files with the .dmp files and a little more info.
- Currently have to have 3 crash reports per bucket to display crash reports (a bucket is a crash at a unique RVA in a module).
  (Hope to use stripped symbols to allow buckets to use function names rather than RVA)

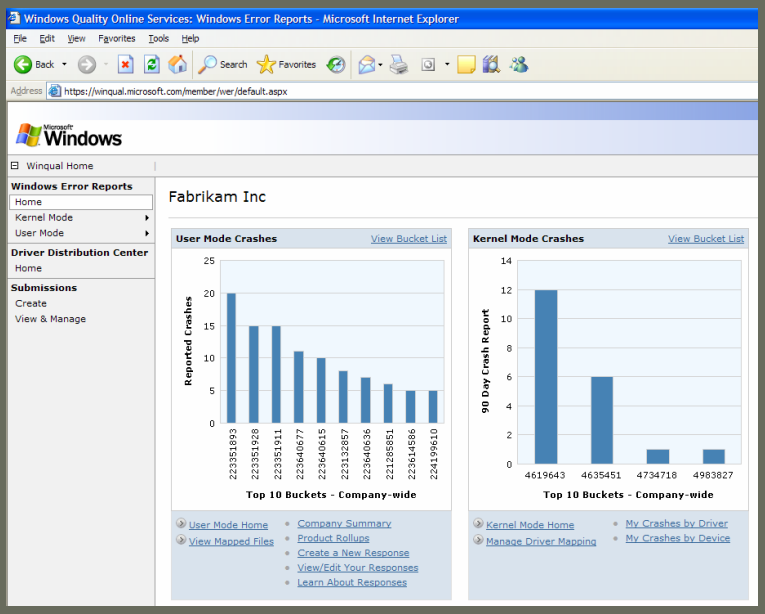
## Using WER



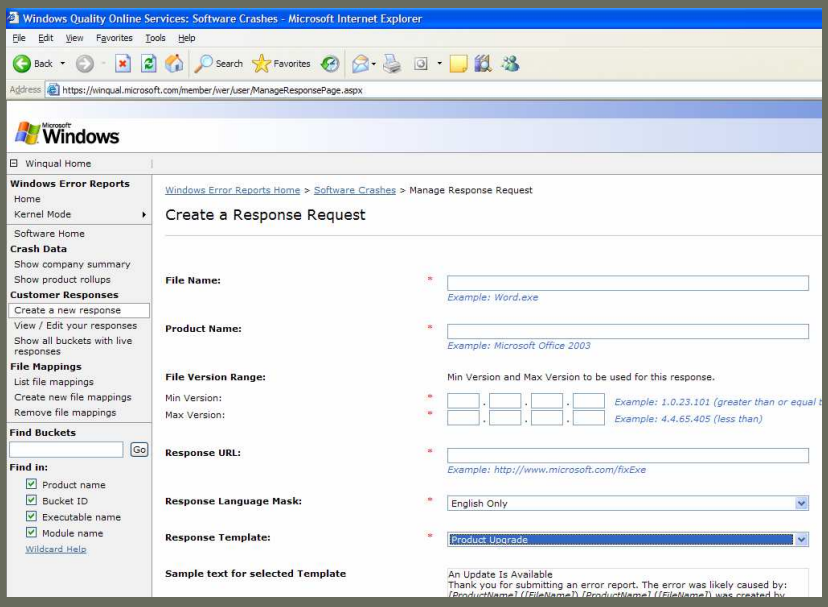
 

## Using WER






## Using WER

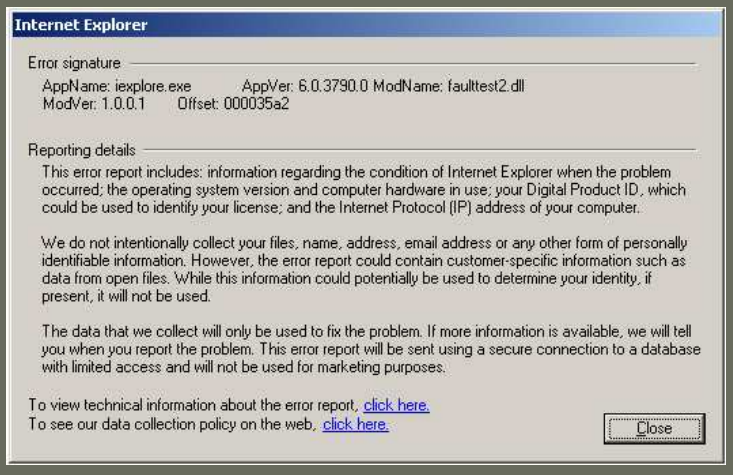


## Using WER (example crash)

- WER will report Shell detected hangs “Application not responding”
- WER will report unhandled exceptions




## Using WER (example crash)



## Using WER
## (example crash)

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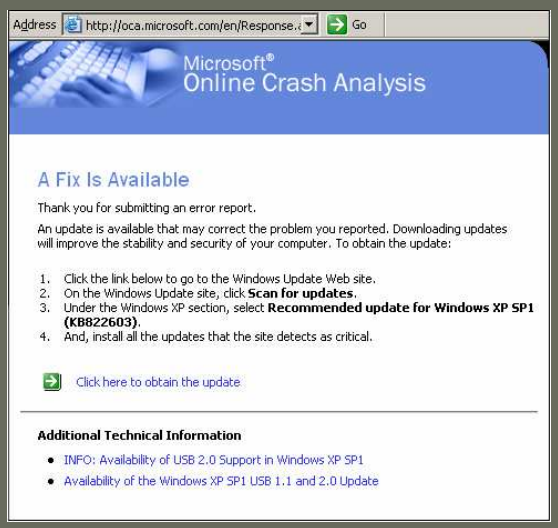
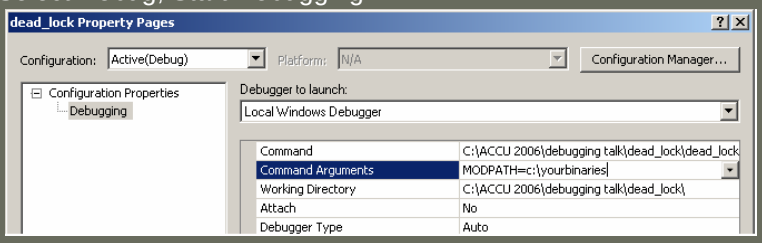


## Reading .dmp files with VS 2005

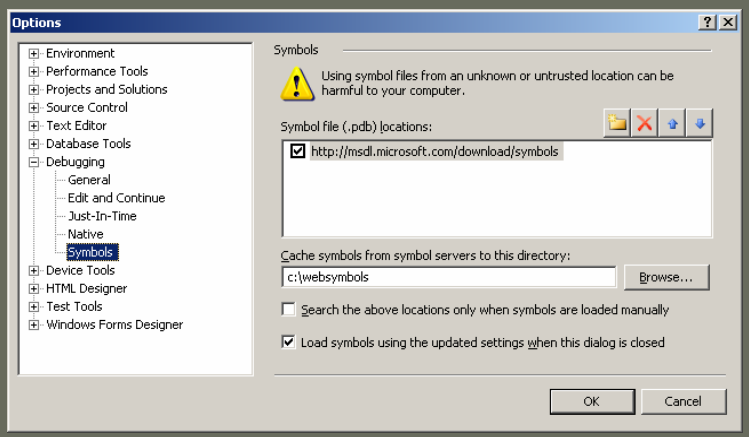
- View the dump file in both WinDbg and Visual Studio.
- VS 2005:
  - Open the .dmp file using File, Open, Project/Solution
  - Set `MODPATH` to point to where binaries are
  - Set symbol path to include Microsoft symbol server
  - Select Debug, Start Debugging






## Reading .dmp files with VS 2005

- Always include the Microsoft symbol server on the path (Menu option: Tools, Options)
- Or set `_NT_SYMBOL_PATH` environment variable to include `SRV*c:\websymbols*http://msdl.microsoft.com/download/symbols`



## Reading .dmp files with WinDebug

- First download the latest Debugging Tools for Windows package.
  It is updated about twice a year, plus beta releases, currently at v6.6.
- Set the symbol path:

  .sympath
  *or from the menu*
  File, Symbol File Path…
- Make sure the Microsoft symbol server is on the path:

  Add SRV*c:\websymbols*http://msdl.microsoft.com/download/symbols
  *or use*
  .symfix+ c:\websymbols
- Make sure that path to the binary images is set

  .exepath+ c:\where_your_binaries_are

  *or from the menu*

  File, Image File Path…
- File, Open Crash Dump… (older versions also Debug, Go)



## Summary notes (this slide not on ACCU CD)

- Always build with symbols, and archive symbols with .exe (and to your symbol server)
- Use Microsoft symbol server, for large projects maybe setup your own symbol server.
- Use source server (integrate it with your build, read more in Debugging Tools for Windows help file)
- Sign up for WER is you can, if not use dumpwriter from www.bugbrowser.com
- Unoptimized builds really help debugging
- Capture a .DMP file if you can, either using WER (can confirm local path), or dumpwriter or similar or windbg or your debugger
- Use VS 2005 debugger (and WinDbg – but Windbg is not user friendly)
- How to debug high CPU usage
- How to debug deadlocks
- How to debug memory overwrites
- Globals are handy for debugging (but bad for design usually)
- Enable trap on Access Violation in the exceptions dialog of Visual Studio.
- Several ways to trap an exception to generate a .dmp file (best is vectored exception handler)

# Links and references

**Links**

- Latest slides, DumpWriter, Leak Browser: www.bugbrowser.com
- Insect photos thanks to: www.mplonsky.com
- WinDbg help: news://microsoft.pubic.windbg
- Debugging Tools for Windows: http://www.microsoft.com/whdc/devtools/debugging/default.mspx
- Programmed breakpoint control: http://www.morearty.com/code/breakpoint
- Windows Error Reporting (WER):
  - http://winqual.microsoft.com (must use IE for this site)
  - http://microsoft.sitestream.com/PDC05/FUN/FUN313.zip
  - http://microsoft.sitestream.com/PDC05/FUN/FUN313_files/Botto_files/FUN313_Hardester.ppt
- Code Project:
  - http://www.codeproject.com/debug/postmortemdebug_standalone1.asp
  - http://www.codeproject.com/debug/crash_report.asp
  - http://www.codeproject.com/debug/XCrashReportPt1.asp

**Books**

- Debugging Applications for Microsoft .NET and Microsoft Windows, ISBN:0735615365
  (I disagree with a lot of advice in this book – like recommendations not to use STL and even some debugging aspects, nevertheless it presents useful techniques)
- Microsoft Windows Internals, ISBN:0735619174 (currently 4th Edition)
- How Debuggers Work, ISBN 0-471-14966-8