Multi-Monitor real time rendering in engines without native support

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- AMD Eyefinity Technology (2013).

Overview

- Supported technologies
- How multi-monitor rendering works
- Commercial engines and their problems
- Problems that appear in real-time rendering
- Solutions
- Quick overview of what a process really is
- Fixing the problems
- See it in action
- Conclusions
- Questions

Supported technologies

- AMD Eyefinity technology
- Matrox Tripple2Go technology
- nVidia Surround technology

- Supported display modes: minimum 3 displays in
  - Landscape
  - Portrait
  - Matrix

- Supported Operating Systems
  - Microsoft Windows
  - Linux
  - MacOS (only for Matrox solution)

How multi-monitor rendering works

- Enabled via driver
- Seen as one big screen
- Offers hardware acceleration in all rending modes

Commercial engines and their problems

Most commercial engines have problems:

Mass Effect (2007). Video game developed by Bioware. Published by Electronic Arts.

Problems that appear in real-time rendering

- Understanding the engine
- Behaviors

Anamorphic behavior

Tomb Raider : The Angel of Darkness (2003). Video game. Developed by Core Design. Published by Eidos Interactive

Problems that appear in real-time rendering

Pillarbox behavior

Stretch behavior

Tomb Raider : The Angel of Darkness (2003). Video game. Developed by Core Design. Published by Eidos Interactive

Problems that appear in real-time rendering

Vertical – (minus) behavior

Horizontal + (plus) behavior

Tomb Raider : The Angel of Darkness (2003). Video game. Developed by Core Design. Published by Eidos Interactive

Problems that appear in real-time rendering

- Problems:
  - Resolution Support
  - Aspect Ratio
    - Aspect Ratio = Horizontal Resolution / Vertical Resolution
  - Field of View
    - Tan (HorFOV / 2) / Tan (VertFOV / 2) = Aspect Ratio
  - Interface centering (wrong scale and position)

    - typedef struct _RECT {
      LONG left;
      LONG top;
      LONG right;
      LONG bottom;
      } RECT, *PRECT;

Solutions

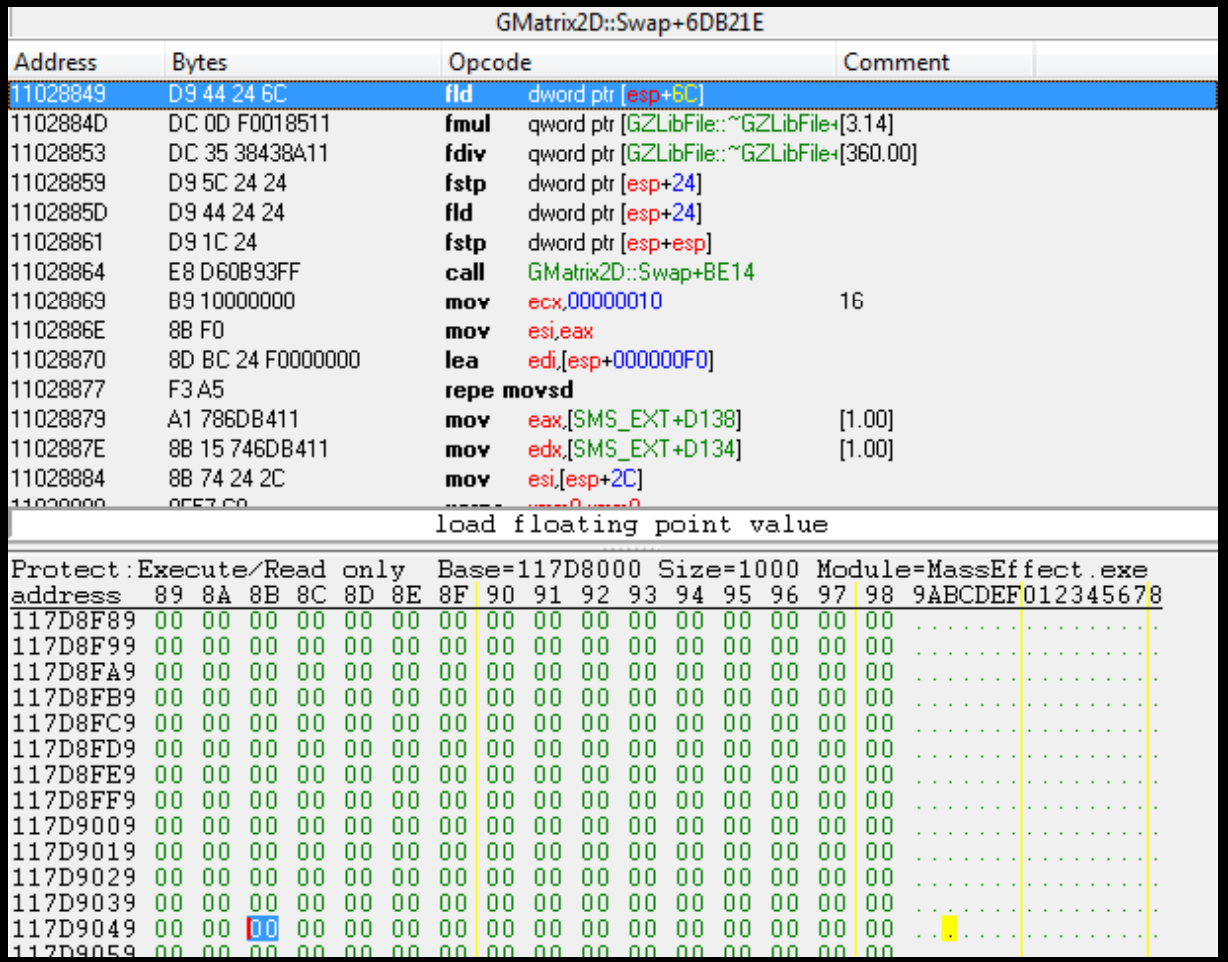
- Code injection techniques
  - Working on any application that runs on the CPU
- Intercepting draw calls
  - Valuable for changing shader programs that run on the GPU

Quick overview of what a process really is

- The x86 Assembly Language
- Contiguous memory allocation
  - Physical Address = Base register address + Logical address/Virtual address
- Why is the stack and heap important

Quick overview of what a process really is

- Memory representation and layout



GMatrix2D::Swap+6DB21E

Address	Bytes	Opcode		Comment
11028849	D9 44 24 6C	**fld**	dword ptr [esp+6C]	
1102884D	DC 0D F0018511	**fmul**	qword ptr [GZLibFile::~GZLibFile+	[3.14]
11028853	DC 35 38438A11	**fdiv**	qword ptr [GZLibFile::~GZLibFile+	[360.00]
11028859	D9 5C 24 24	**fstp**	dword ptr [esp+24]	
1102885D	D9 44 24 24	**fld**	dword ptr [esp+24]	
11028861	D9 1C 24	**fstp**	dword ptr [esp+esp]	
11028864	E8 D60B93FF	**call**	GMatrix2D::Swap+BE14	
11028869	B9 10000000	**mov**	ecx,00000010	16
1102886E	8B F0	**mov**	esi,eax	
11028870	8D BC 24 F0000000	**lea**	edi,[esp+000000F0]	
11028877	F3 A5	**repe movsd**		
11028879	A1 786DB411	**mov**	eax,[SMS_EXT+D138]	[1.00]
1102887E	8B 15 746DB411	**mov**	edx,[SMS_EXT+D134]	[1.00]
11028884	8B 74 24 2C	**mov**	esi,[esp+2C]	

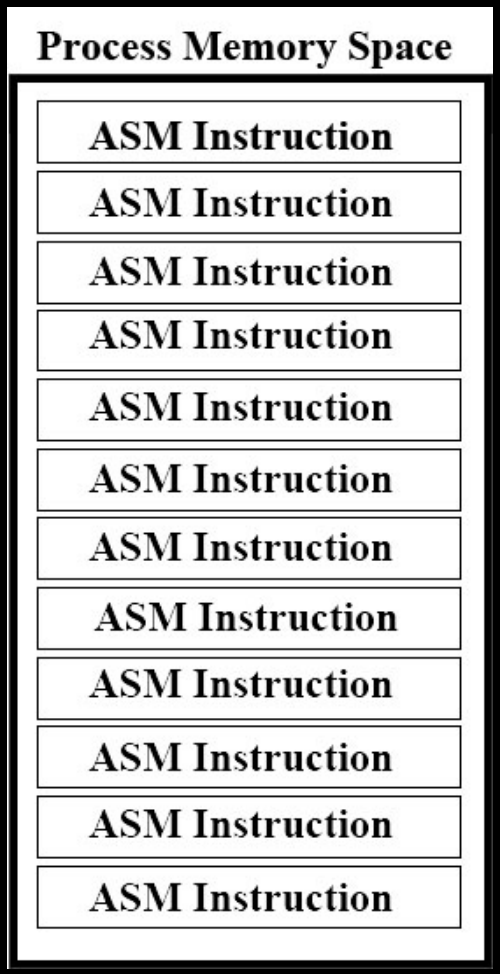
load floating point value

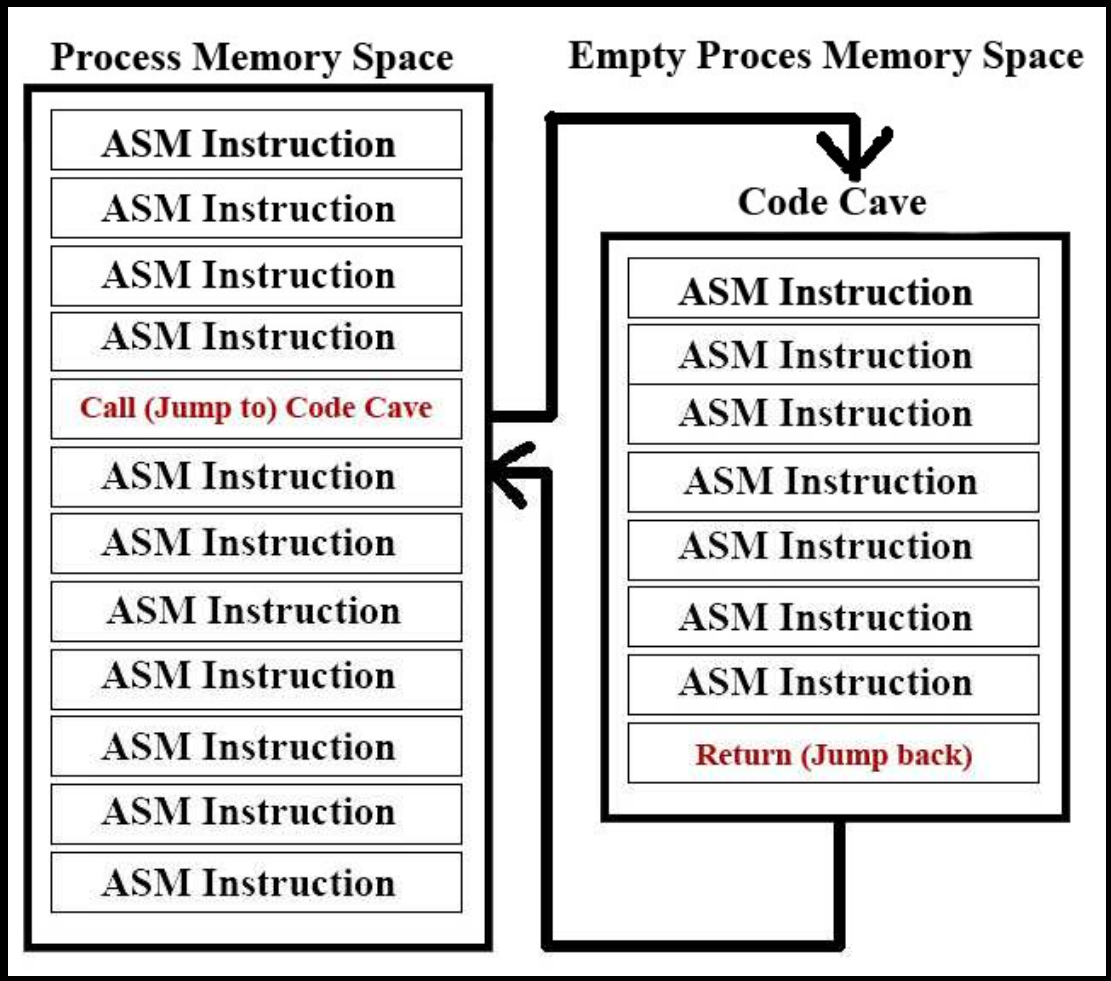
Protect:Execute/Read only Base=117D8000 Size=1000 Module=MassEffect.exe

address	89	8A	8B	8C	8D	8E	8F	90	91	92	93	94	95	96	97	98	9ABCDEF012345678
117D8F89	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D8F99	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D8FA9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D8FB9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D8FC9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D8FD9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D8FE9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D8FF9	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D9009	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D9019	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D9029	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D9039	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....
117D9049	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	....

Fixing the problems

- Code Injection using “Code caves”





Fixing the problems

- Use of debuggers, disassembles and assemblers
  - Software breakpoints for variables
  - Hardware breakpoints to discover the ASM instructions accessing a memory location
  - Finding pointers to dynamic allocated memory locations
- Understanding of the assembly code.

Fixing the problems

- Create a “fix” by hooking the process
- Allocate memory in the target process memory space
- Write all necessary “code caves” in the process memory space
- The new “values” can be calculated either in the program or directly in the ASM “code cave”
- Under Linux this can be done using “ptrace utility”
- Under Ms Windows this can be done using “WINAPI”

See it in action

Doom 3 BFG Edition (under Linux)

Doom 3 BFG (2012). Video Game. Developed by id Software. Published by Bathesda Softworks

See it in action

- Mass Effect (under Windows)

Mass Effect (2007). Video game developed by Bioware. Published by Electronic Arts.

Conclusions

- Advantages:
  - Works on multiple machines sharing the same process binary executable
  - Independent of hardware type
  - Relatively easy to implement
- Disadvantages:
  - Highly dependent on the ASM instructions layout
  - Requires programming in ASM
  - Improvement can be done by using “signature scanning” methods
  - Need permission to write in process memory space

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Questions

Any questions ?

The source code for Doom 3 BFG fix can be found at :
https://github.com/helifax/TrippleScreen_Doom3BFG_LINUX

THANK YOU !