SAND2016-2370PE

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```
; Attributes: bp-based frame

; int __cdecl _tmainCRTStartup()
__tmainCRTStartup proc near

var_2C= dword ptr -2Ch
var_28= dword ptr -28h
nested= dword ptr -24h
```

```
ELSE (* Near absolute call *)
    IF OperandSize = 64
        THEN
            tempRIP ← DEST; (* DEST
            IF stack not large enough
                THEN #SS(0); FI;
            Push(RIP);
            RIP ← tempRIP;
    FI;
```

```
6854 7369 6920 2073 756a 7473 6120 6420
6d75 2062 6574 7478 6620 6c69 2c65 6220
7475 4920 6e20 6565 6564 2064 6f73 656d
7420 7865 2074 6f73 7420 6168 2074 2049
6f63 6c75 2064 6174 656b 6120 7320 7263
6565 736e 6f68 2074 666f 7320 6d6f 2065
7573 6570 2072 7773 6565 2074 6f6c 6b6f
6e69 2067 6962 616e 7972 202e 6649 7920
756f 6720 746f 6220 726f 6465 6520 6f6e
6775 2068 6f74 6620 6769 7275 2065 756f
2074 6877 7461 7420 6968 2073 6173 7379
202c 6f79 2075 6873 756f 646c 6520 6d2d
6961 206c 656d 6120 2074 7473 6167 6e69
4065 6173 646e 6169 672e 766f 002e
```

Debugging Demonstration

Sherry Gaines

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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But first….

A BIT ABOUT SANDIA AND MY GROUP

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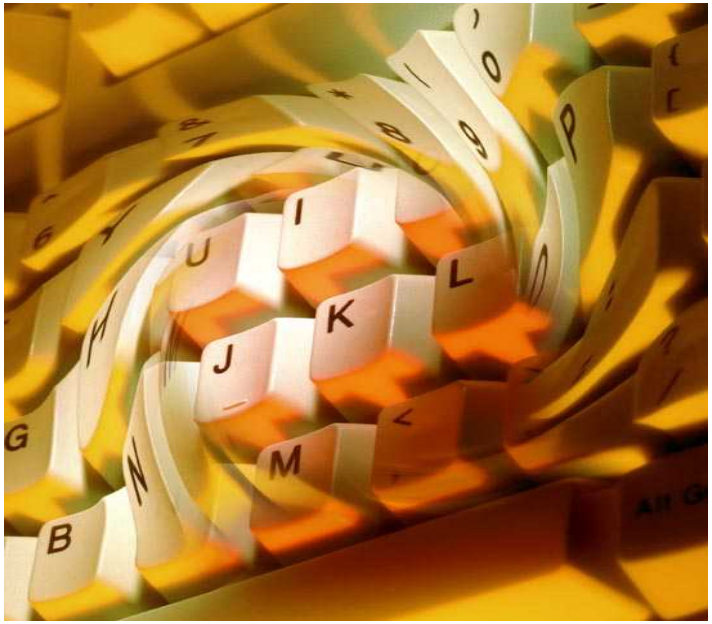
Advanced Software Engineering

Advanced Software Engineering (ASE) Organization 9520

- Vision
  - We are the recognized provider of secure intelligent technology solutions.
- Mission
  - We develop solutions for National Security Missions, providing technologies that are leveraged by Mission Support.



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Advanced Software Engineering

Core Competencies

- Algorithmic Research
- Technology Assessments - Application & Infrastructure Security
- Business Modeling & Analysis, including Requirements Engineering
- Custom Software & Application R&D
- Cyber Modeling & Simulation Architecture Systems
- Cyber Security R&D (encryption, large scale simulations, other…)
- Trusted Systems R&D
- Data Science & Analytics Services (Predictive Analytics)
- Integration Frameworks
- Engineering R&D Solutions into Production Environments
- Satellite Ground System & Data Management Software Systems
- Safeguards & Security Information Systems
- Native Mobile Application Software & Infrastructure (iOS, Surface, Android)
- Emerging Technology Applications

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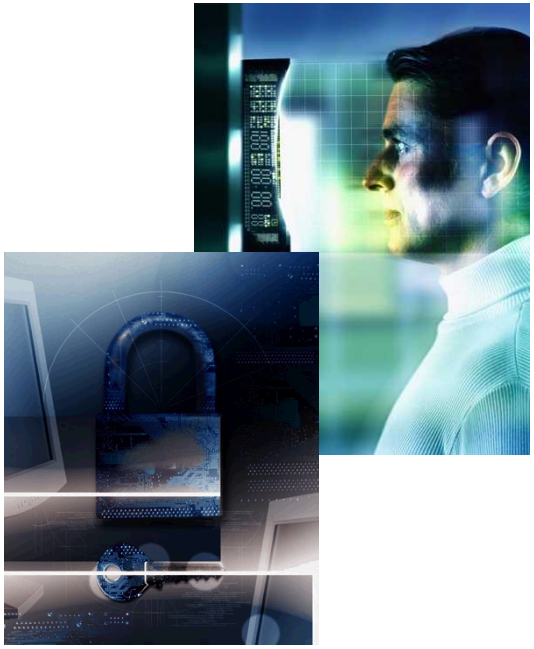
Enabling our customers by providing technology solutions that improve their productivity and deliver a substantive return on investment.

- Transforming prototype systems into reliable and maintainable solutions.
- Automating processes to allow for reliable solutions and redirecting personnel from administrative to substantive activities.
- Developing solutions that incorporates the necessary engineering controls and interfaces to ensure the safety and security of the laboratories.



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Cyber Analysis R&D Solutions

Information security-related research and development as well as providing security expertise in support of the many phases in the software engineering lifecycle.

- Cyber Modeling & Simulation Architecture Security Services
- Large-Scale Emulytics™
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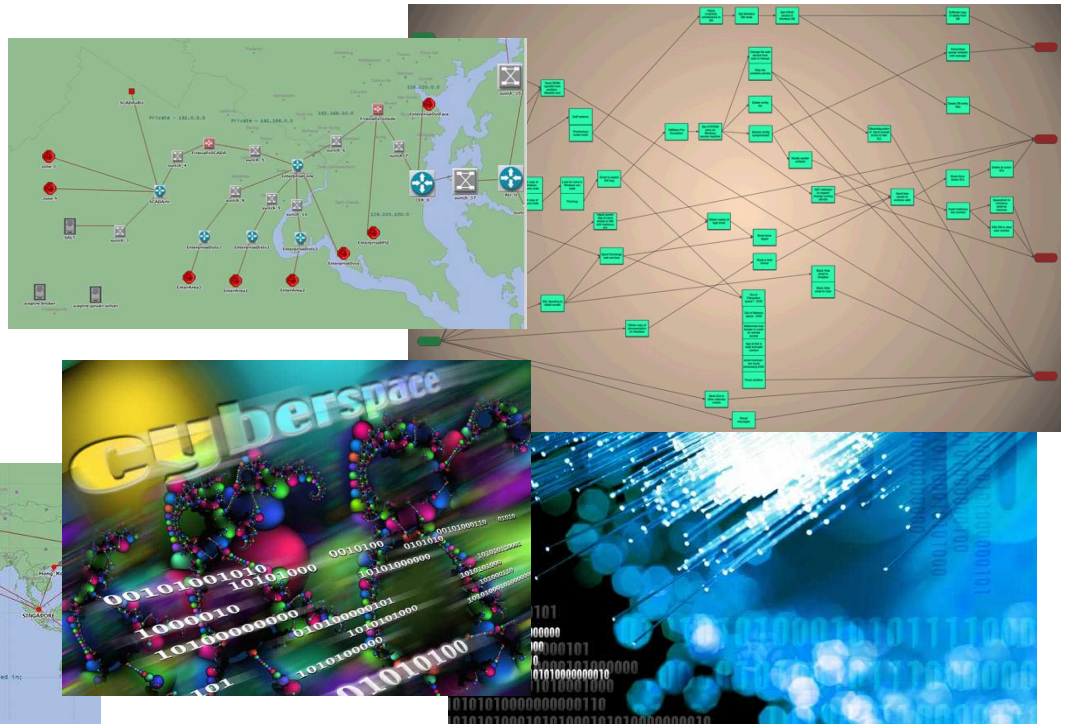
- Cyber Technical Assessments
- Cyber Security Research



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Now onto debugging….

WHY DO I CARE?

Usually…. pointers

https://xkcd.com/138/

* 37prime.com

https://xkcd.com/371/

Which of these are pointers?

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1. char * superSweetChar;
2. char superSweetChars[42];
3. char lonelySweetChar;
4. UINT64 addressOfThing;
5. PUINT64 addressOfThing2;
6. int thisNeatFunction(int, char);
7. int (*thisOtherNeatFunction)(int, char);

What do we use pointers for?

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- Pointing to dynamically allocated data
- Referencing data within structures
- Typically for pointing to beginning of strings
- Pointing to start of arrays
- ….

Why do our programs crash?

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- What about using pointers incorrectly makes our programs crash?

- Usually Operating System memory layout and protections!
  - Programs cannot read into each others memory
    - Unless specifically allowed
  - Programs cannot read address 0!
    - NULL == 0
  - User mode programs cannot read kernel mode memory
    - With new hardware features, the reverse is true in some cases as well
  - Page Tables!
    - Control what application can access what memory

Pointer problems cause vulnerabilities!

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- Buffer overflow
- Heap overflow
- Stack smashing
- Double free
- Use after free
- Data corruption
- Data leakage
- Unintended code flows

That's scary!

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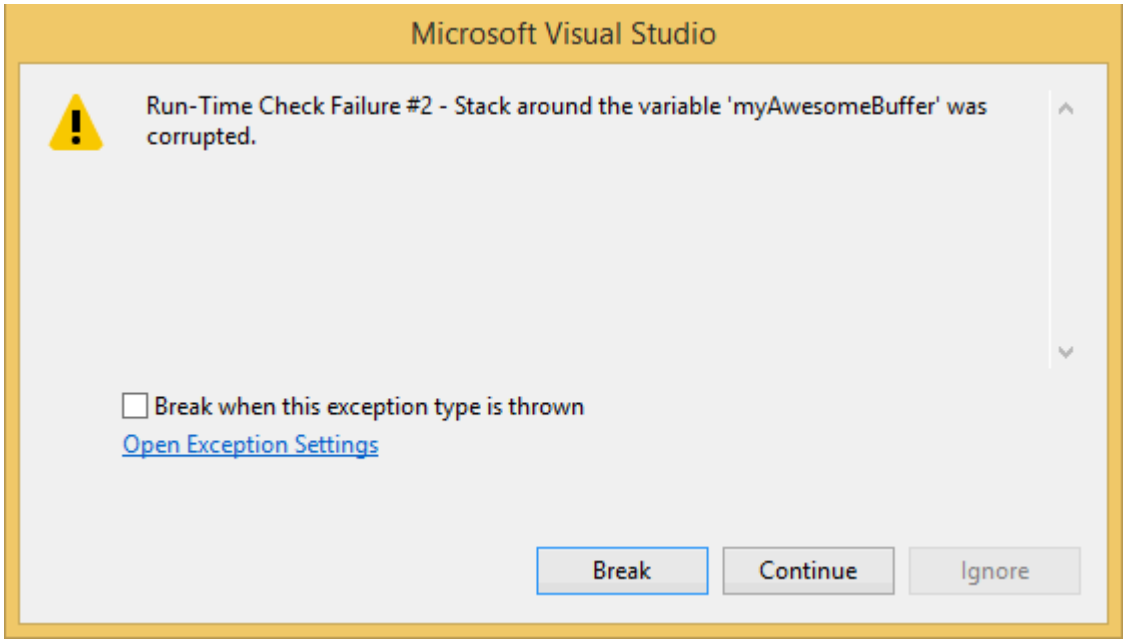
- However, there are mitigations to what can be accomplished by an attacker via pointer issues
  - DEP/NX
  - ASLR
  - Memory manager improvements

Example!

- Lets take a simple program that has a buffer overflow vulnerability via the stack
  - DebuggingStackOverflow.cpp



Tips and Tricks

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- RSP is the stack pointer
- RIP is the instruction pointer
- Stacks grow DOWN (contrary to how they are usually drawn)
- Heaps grow UP (ish)

Questions?

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```
/*
DebuggingDemo.cpp : Defines the entry point for the console application.

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criminal liability under U.S. laws.
*/

#include "stdafx.h"

#define FUDGE_FACTOR 102
#define ARRAY_LEN 25
#define CHAR_IN_MY_BUFFER 'A'


bool bufferOverflowsAreBad(const char putThisCharInMyBuffer);


int _tmain(int argc, _TCHAR* argv[])
{
bufferOverflowsAreBad(CHAR_IN_MY_BUFFER);
return 0;
}

bool bufferOverflowsAreBad(const char putThisCharInMyBuffer)
{
unsigned int i = 0;
char myAwesomeBuffer[ARRAY_LEN];
for (i = 0; i < ARRAY_LEN + FUDGE_FACTOR; i++)
{
myAwesomeBuffer[i] = putThisCharInMyBuffer;
}
return true;
}
```