Writing Metasploit Plugins

from vulnerability to exploit

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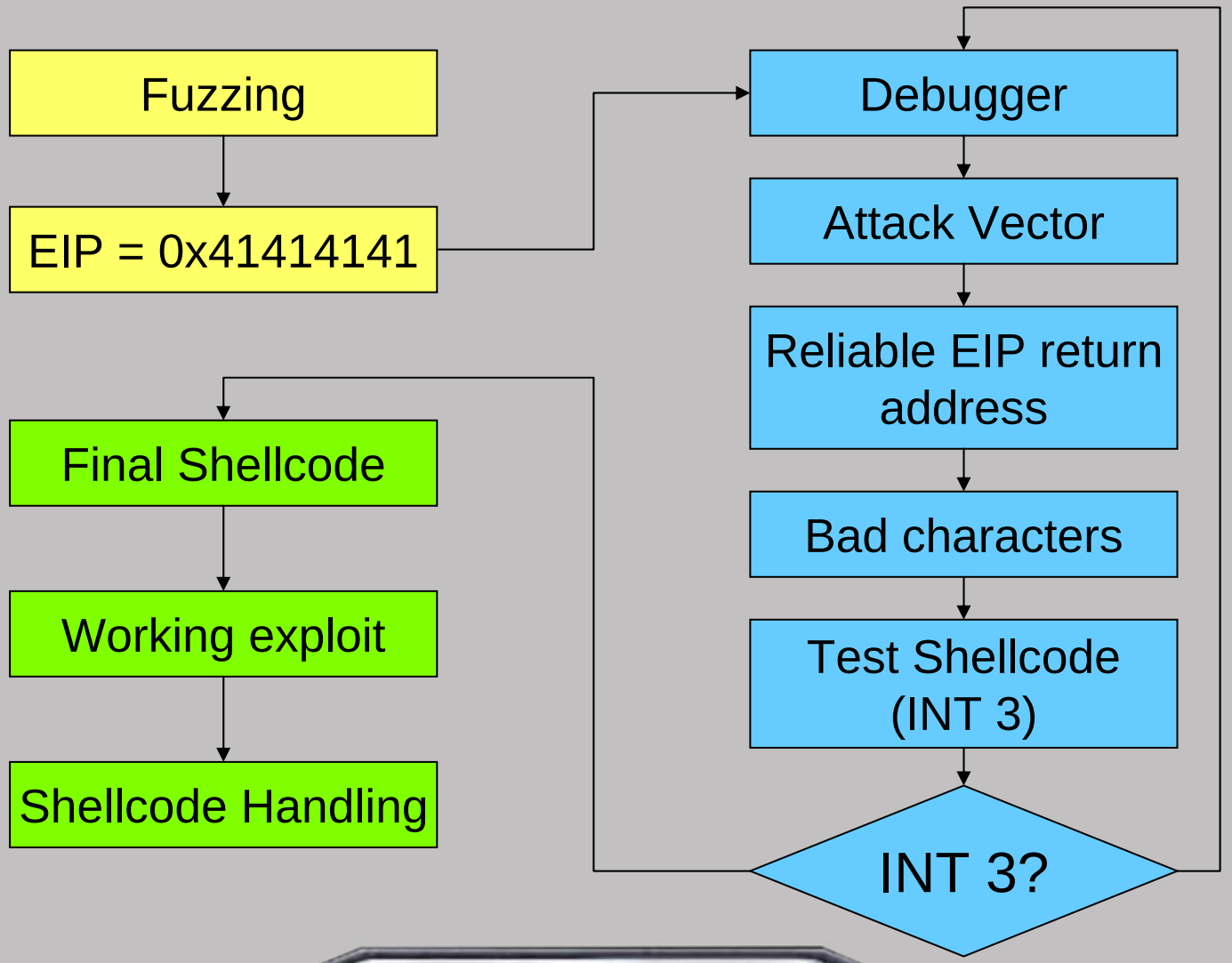
who am i

```
# who am i
16:08  up  4:26, 1 user, load averages: 0.28 0.40 0.33
USER     TTY      FROM              LOGIN@  IDLE WHAT
saumil   console  -                 11:43    0:05 bash
```

- Saumil Shah - “krafty”
  - ceo, net-square solutions
  - saumil@saumil.net
  - author: “Web Hacking - Attacks and Defense”

From Vulnerability to Exploit



The CPU's registers

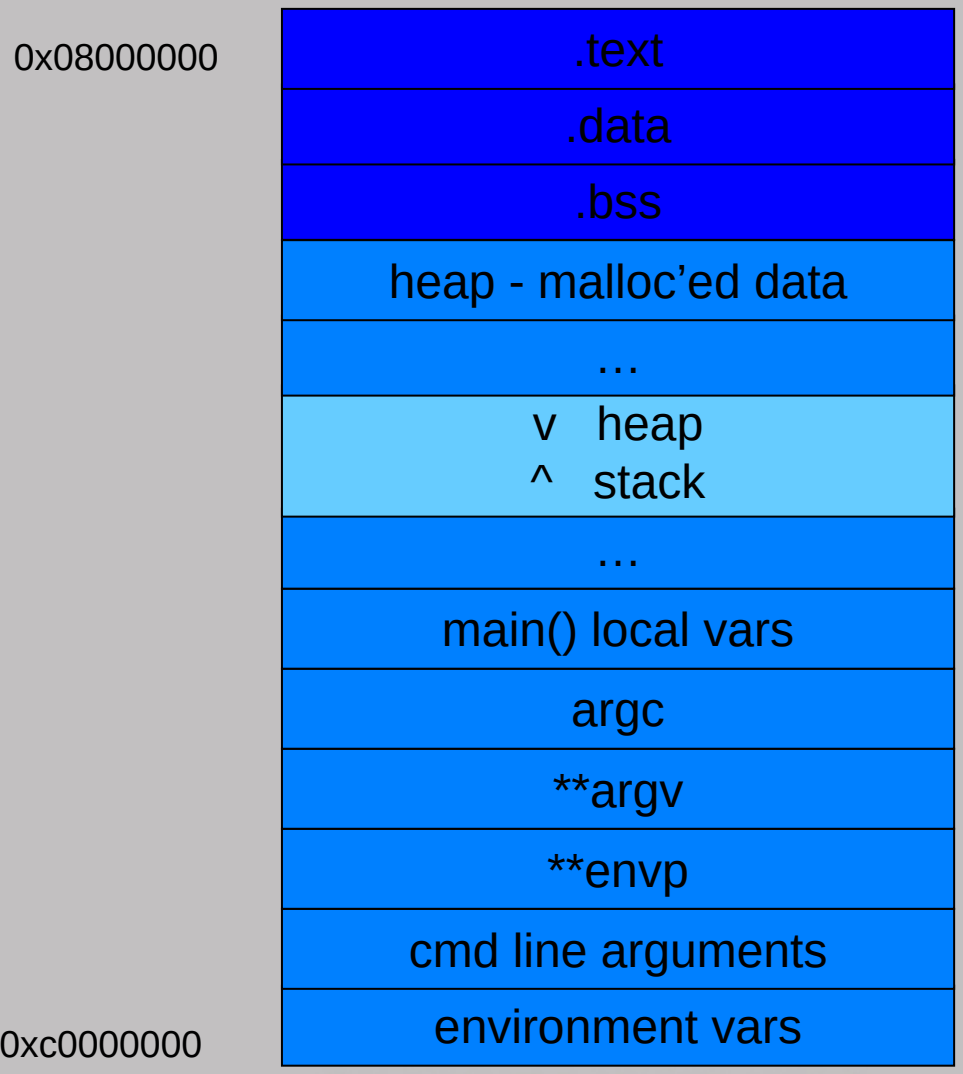
- The Intel 32-bit x86 registers:

EAX	ESP
accumulator	stack pointer
EBX	EBP
base	base pointer
ECX	ESI
counter	source index
EDX	EDI
data	destination index

EIP

instruction pointer

The Process Memory Map



Stack Overflows

- Error condition when a larger chunk of data is attempted to be written into a smaller container (local var on the stack).

```
char buffer[128];
strcpy(buffer, argv[1]);
```

- What will happen if “argv[1]” is more than 128 bytes?

Overflowing victim1.c

- It's easy, have an input of more than 128 characters

```
$ ./victim1 AAAAAAAAAAAAAAAA……AAAAAAAAA
Segmentation fault (core dumped)
$
```

- Post-mortem of victim1

```
$ gdb
(gdb) target core core
Core was generated by `./victim1 AAAAAAA……AAAA'.
Program terminated with signal 11, Segmentation
fault.
#0  0x41414141 in ?? ()
(gdb)
```

Post mortem debugging

- Register dump after a stack overflow:

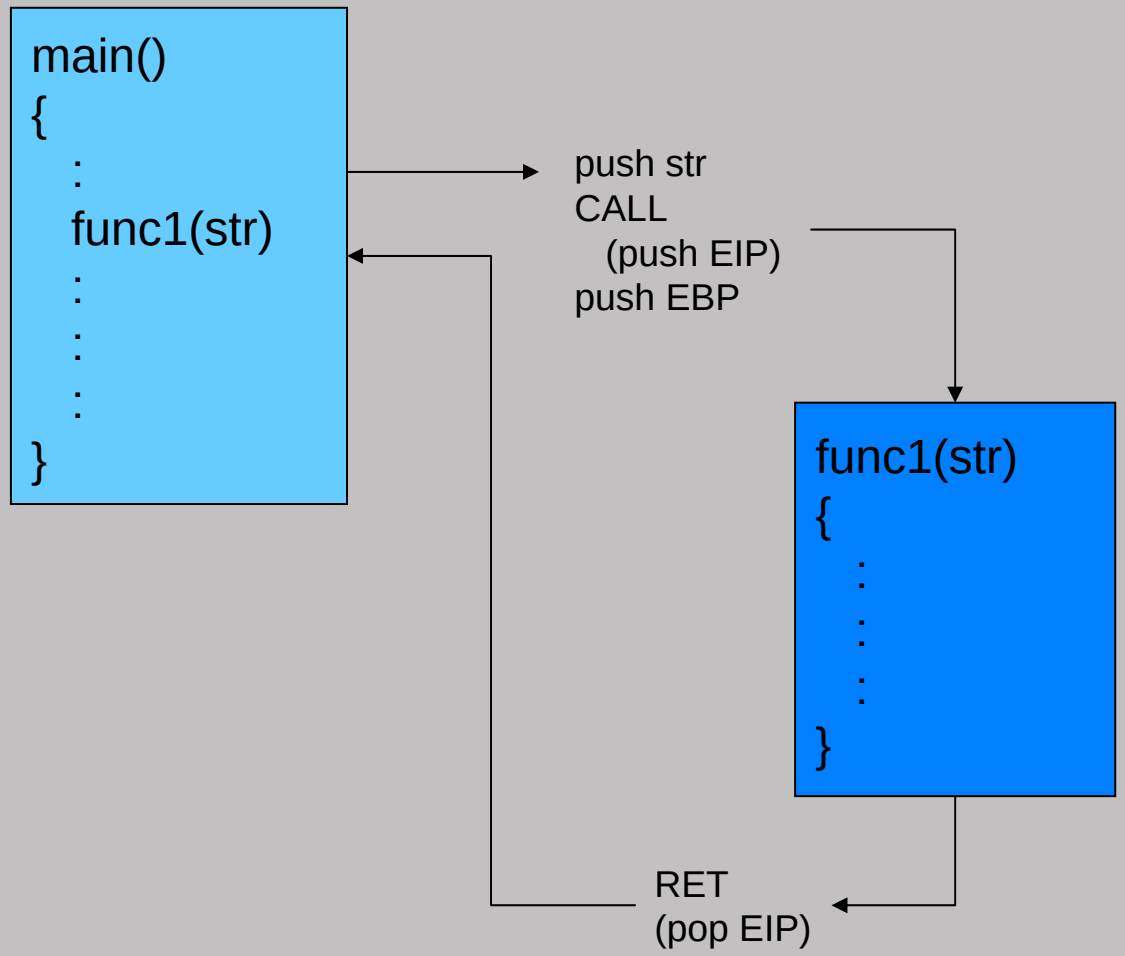
```
(gdb) info registers
esp            0xbffffb24       -1073743068
ebp            0x41414141       1094795585
esi            0x4000ae60       1073786464
edi            0xbffffb74       -1073742988
eip            0x41414141       1094795585
```

- EIP's value is "0x41414141", i.e. "AAAA"
- EIP got overwritten with bytes from the overflowed buffer.

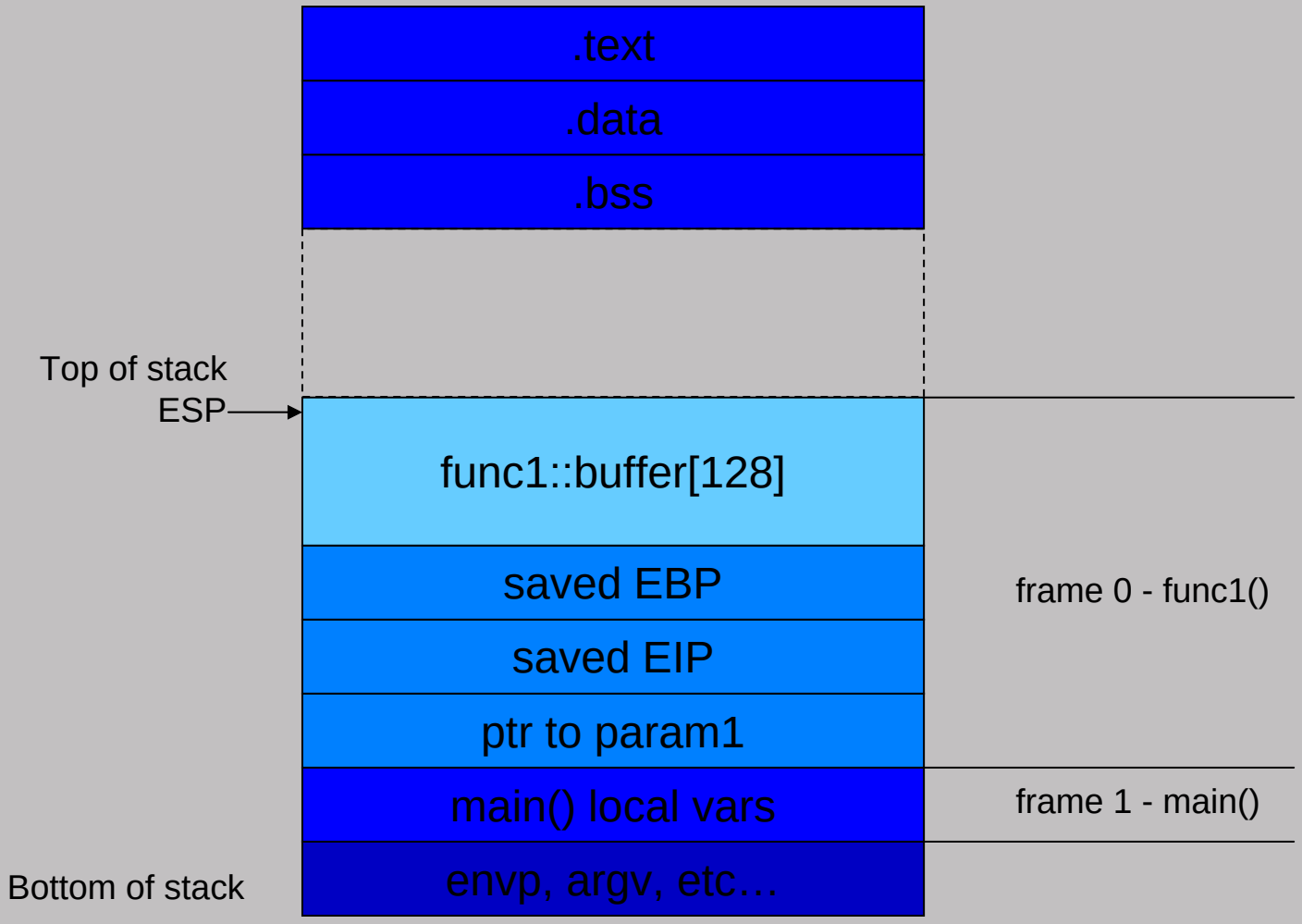
Calling a function

- When a function is called, the following are pushed onto the stack:
  - function parameters
  - saved value of registers such as EBP and EIP
- When the function returns, EIP is popped off from the stack, which resumes the normal course of program execution

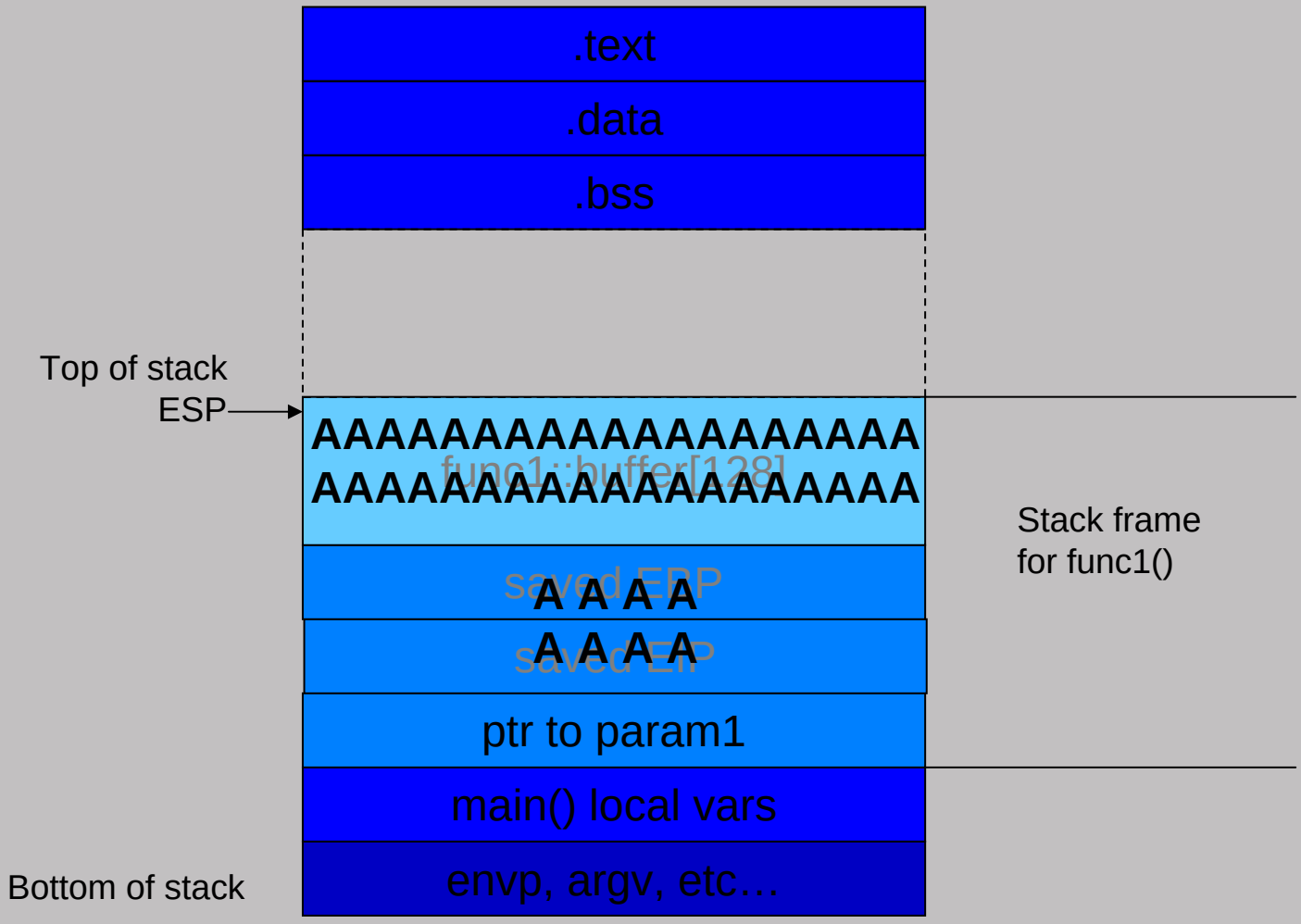
Calling a function



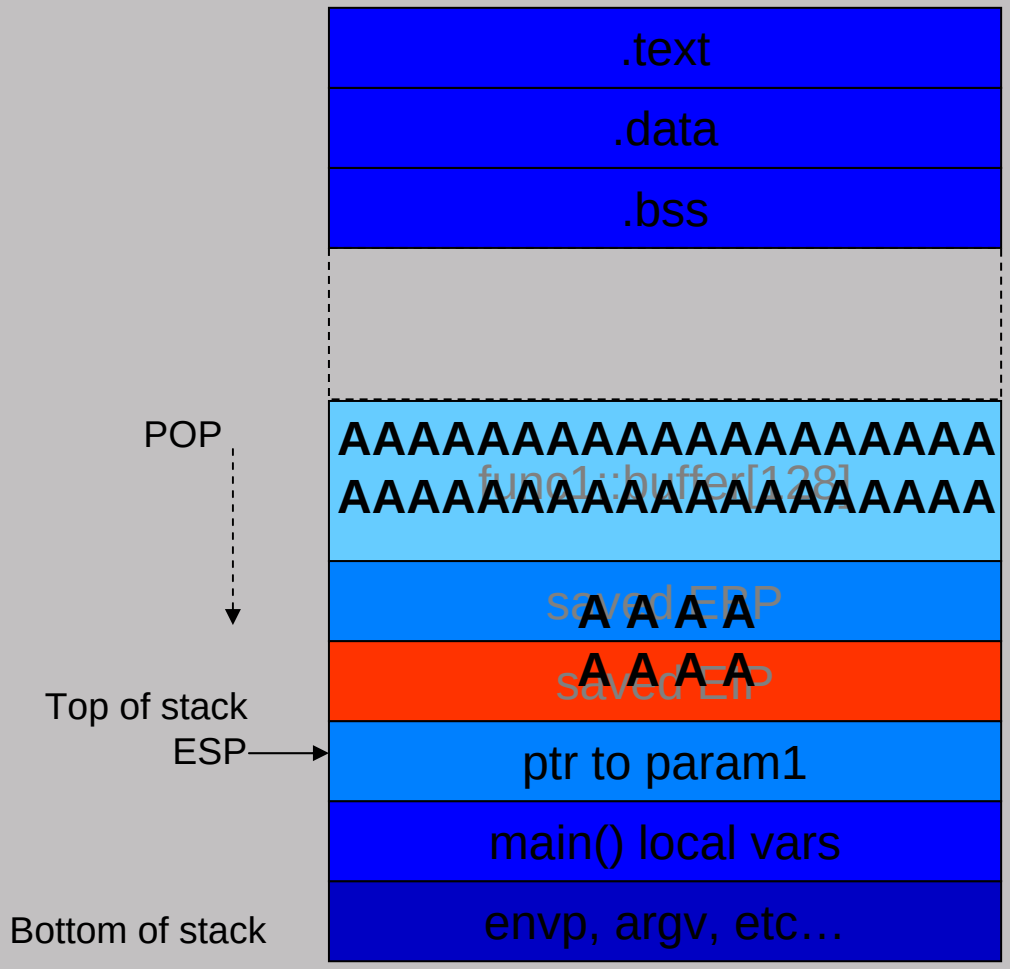
victim's Memory Map - before



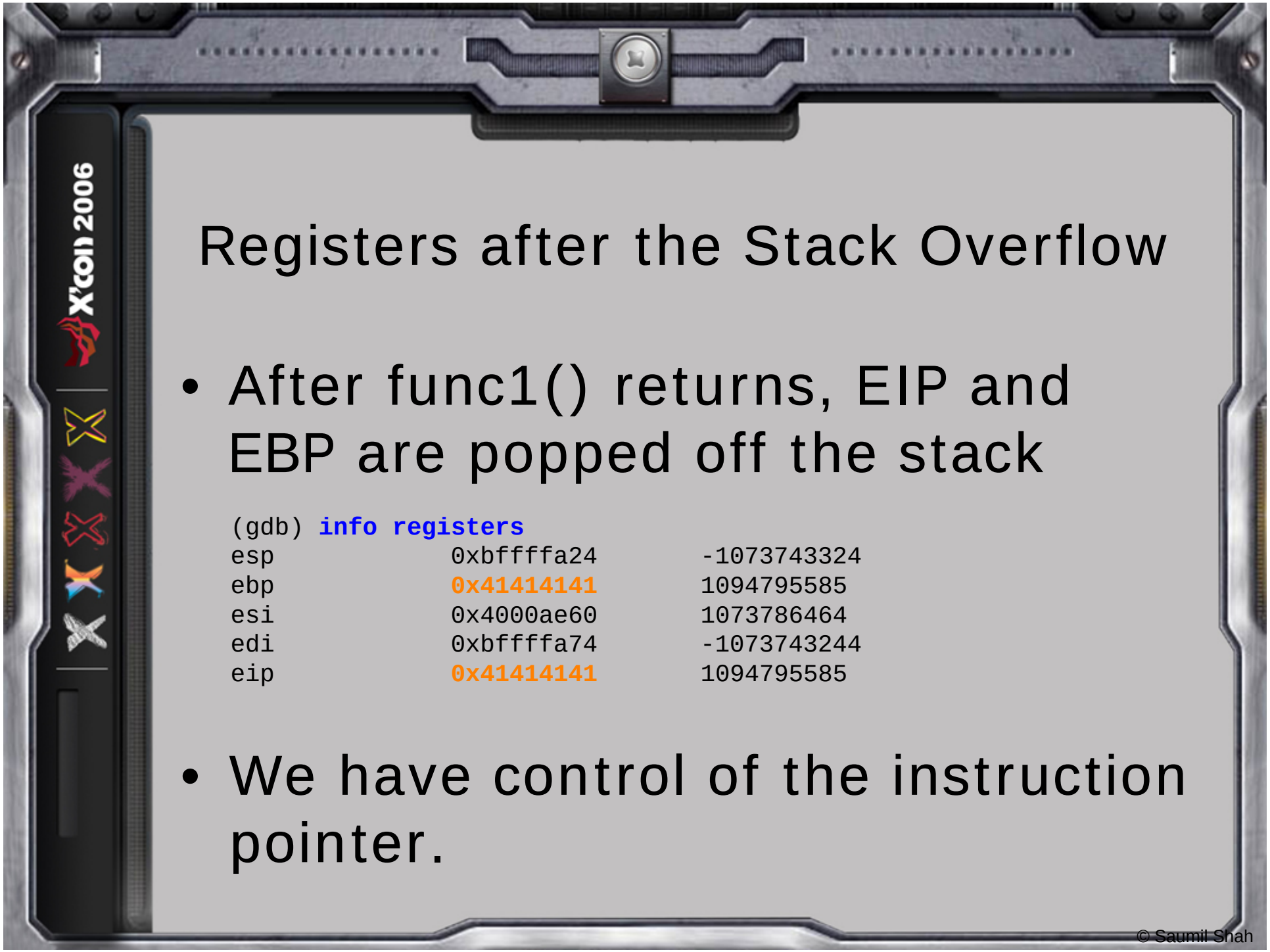
victim's Memory Map - after



The Stack Overflowed



when func1 returns
EIP will be popped
EIP = 0x41414141
("AAAA")



Registers after the Stack Overflow

- After func1() returns, EIP and EBP are popped off the stack

```
(gdb) info registers
esp            0xbffffa24       -1073743324
ebp            0x41414141       1094795585
esi            0x4000ae60       1073786464
edi            0xbffffa74       -1073743244
eip            0x41414141       1094795585
```

- We have control of the instruction pointer.

Controlling EIP

- Vulnerabilities may lead to EIP control.
- We can set the instruction pointer to go to wherever we want...
- ...the question is, “where do we want to go?”
- Can we inject our own code, and make EIP jump to it?
- And, where do we inject our code?

Introducing Metasploit

- An advanced open-source exploit research and development framework.
- http://metasploit.com
- Current stable version: 2.6
  - Written in Perl, runs on Unix and Win32 (cygwin)
  - 160+ exploits, 77 payloads, 13 encoders
- Brand new 3.0 beta1
  - Complete rewrite in Ruby

Introducing Metasploit

- Generate shellcode.
- Shellcode encoding.
- Shellcode handlers.
- Scanning binaries for specific instructions:
  - e.g. POP/POP/RET, JMP ESI, etc.
- Ability to add custom exploits, shellcode, encoders.
- ...and lots more.

EIP = 0x41414141

- How do we determine which 4 bytes go into EIP?
- Use a cyclic pattern as input:

```
Aa0Aa1Aa2Aa3Aa4Aa5Aa6Aa7Aa8Aa9Ab0Ab1Ab2Ab3Ab4Ab5Ab6Ab7Ab8Ab9Ac0Ac1
Ac2Ac3Ac4Ac5Ac6Ac7Ac8Ac9Ad0Ad1Ad2Ad3Ad4Ad5Ad6Ad7Ad8Ad9Ae0Ae1Ae2Ae3
Ae4Ae5Ae6Ae7Ae8Ae9Af0Af1Af2Af3Af4Af5Af6Af7Af8Af9Ag0Ag1Ag2Ag3Ag4Ag5
Ag6Ag7Ag8Ag9Ah0Ah1Ah2Ah3Ah4Ah5.....
```

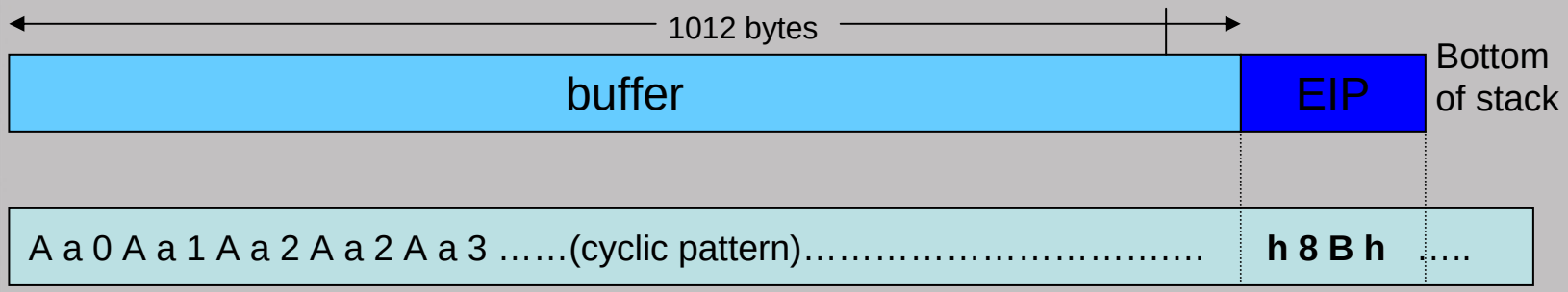
- Metasploit's Pex::Text::PatternOffset()
- Generate patterns, find substring.

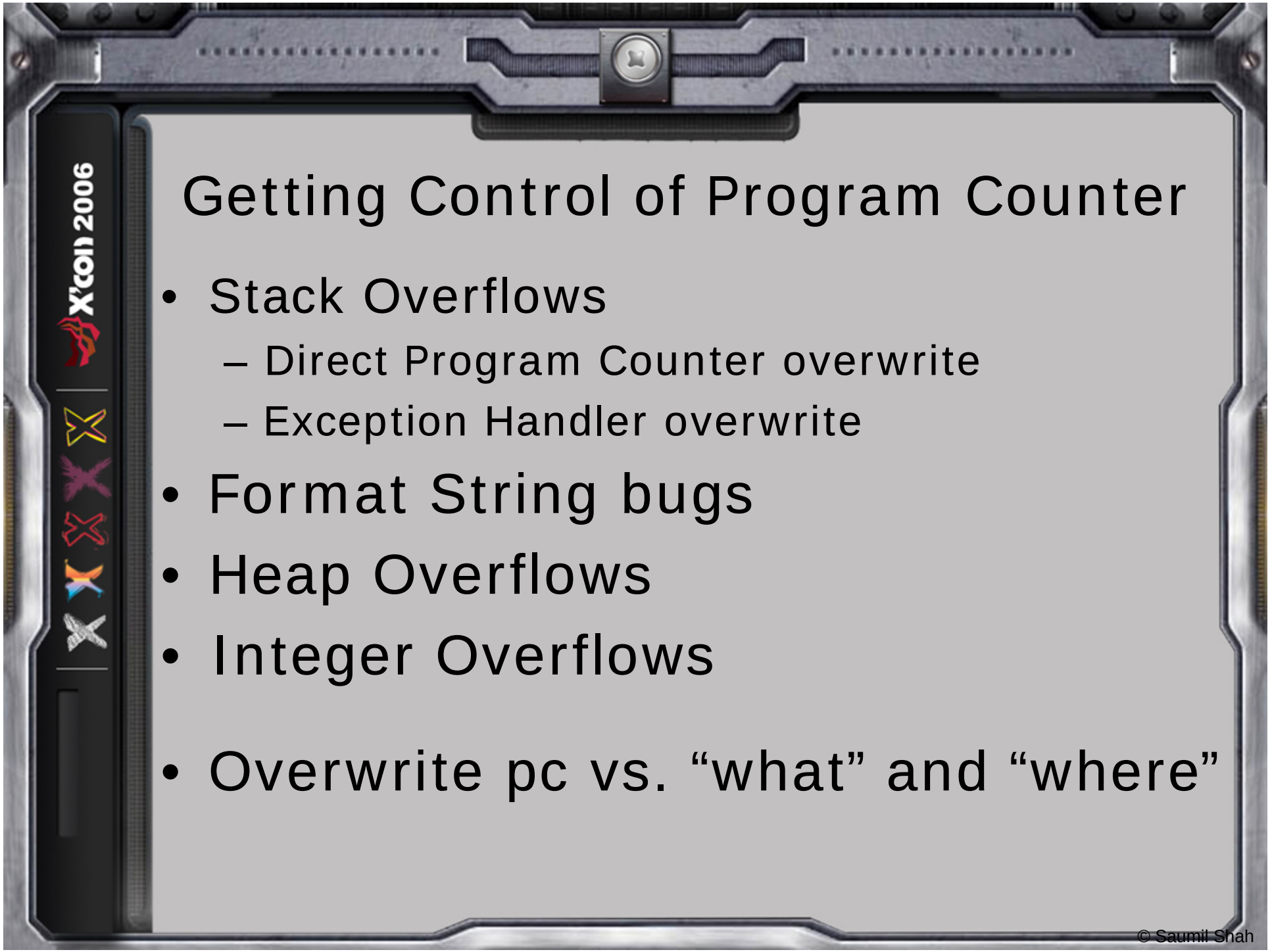
Distance to EIP

- Use Metasploit's patternOffset.pl

```
krafty:~/metasploit$ perl sdk/patternOffset.pl 0x68423768 2000
1012
```

- Based on what EIP gets overwritten with, we can find the "distance to EIP" with this pattern.





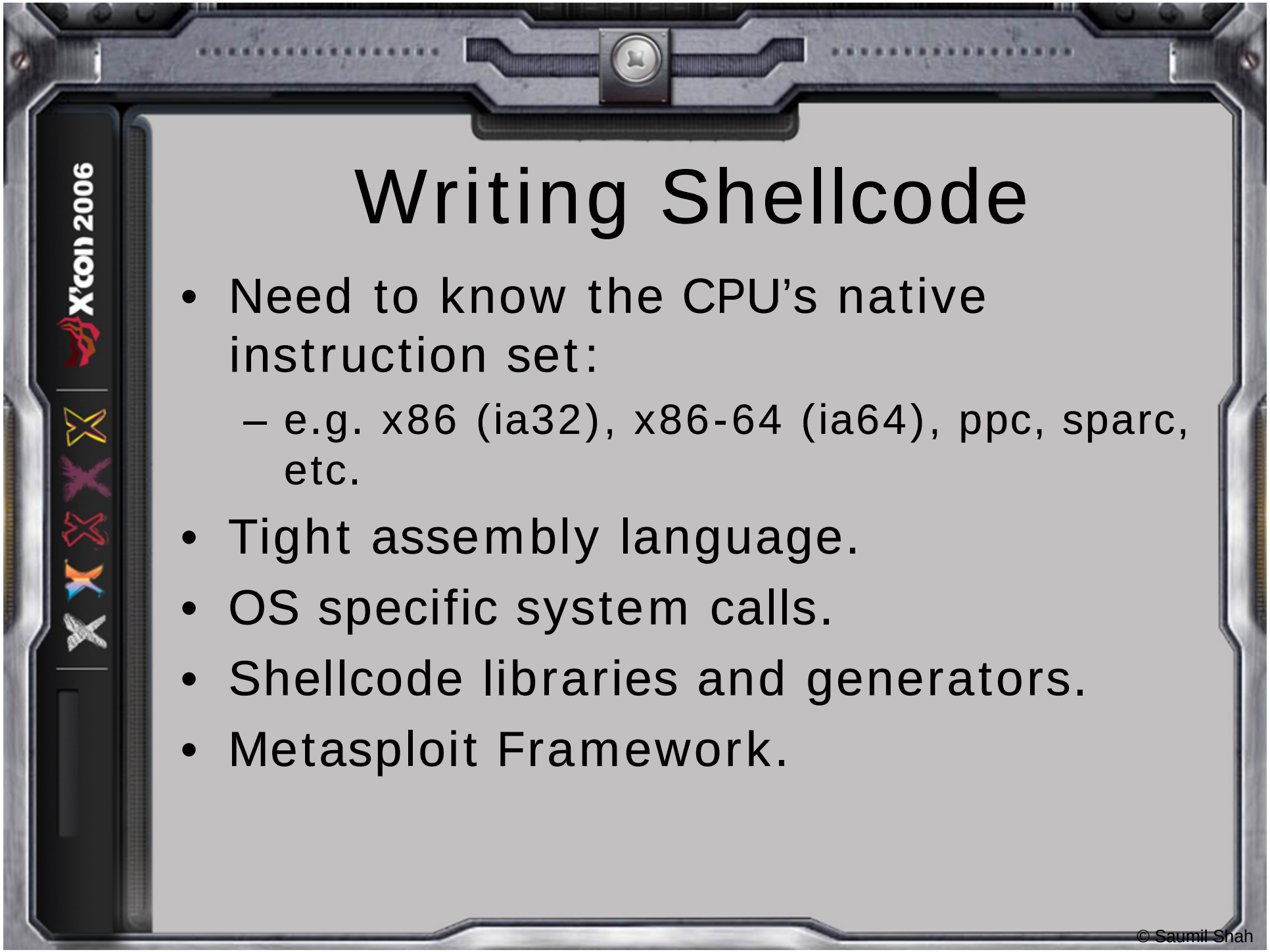
Getting Control of Program Counter

- Stack Overflows
  - Direct Program Counter overwrite
  - Exception Handler overwrite
- Format String bugs
- Heap Overflows
- Integer Overflows

- Overwrite pc vs. “what” and “where”

Enter Shellcode

- Code assembled in the CPU's native instruction set.
- Injected as a part of the buffer that is overflowed.
- Most typical function of the injected code is to "spawn a shell" - ergo "shellcode".
- A buffer containing shellcode is termed as "payload".

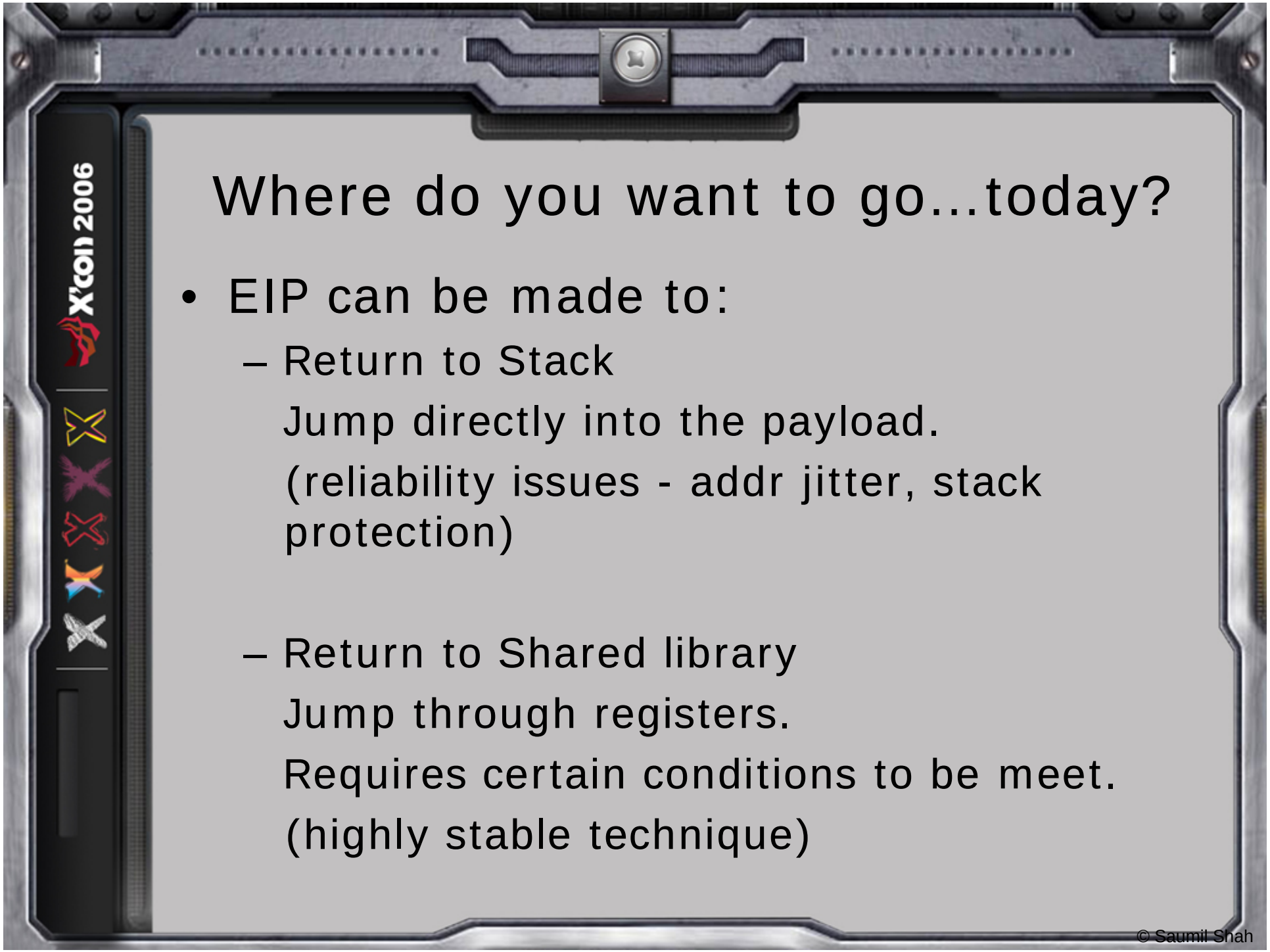


Writing Shellcode

- Need to know the CPU's native instruction set:
  - e.g. x86 (ia32), x86-64 (ia64), ppc, sparc, etc.
- Tight assembly language.
- OS specific system calls.
- Shellcode libraries and generators.
- Metasploit Framework.

Injecting the shellcode

- Easiest way is to pack it in the buffer overflow data itself.
- Place it somewhere in the payload data.
- Need to figure out where it will reside in the memory of the target process.



Where do you want to go...today?

- EIP can be made to:
  - Return to Stack

    Jump directly into the payload.

    (reliability issues - addr jitter, stack protection)

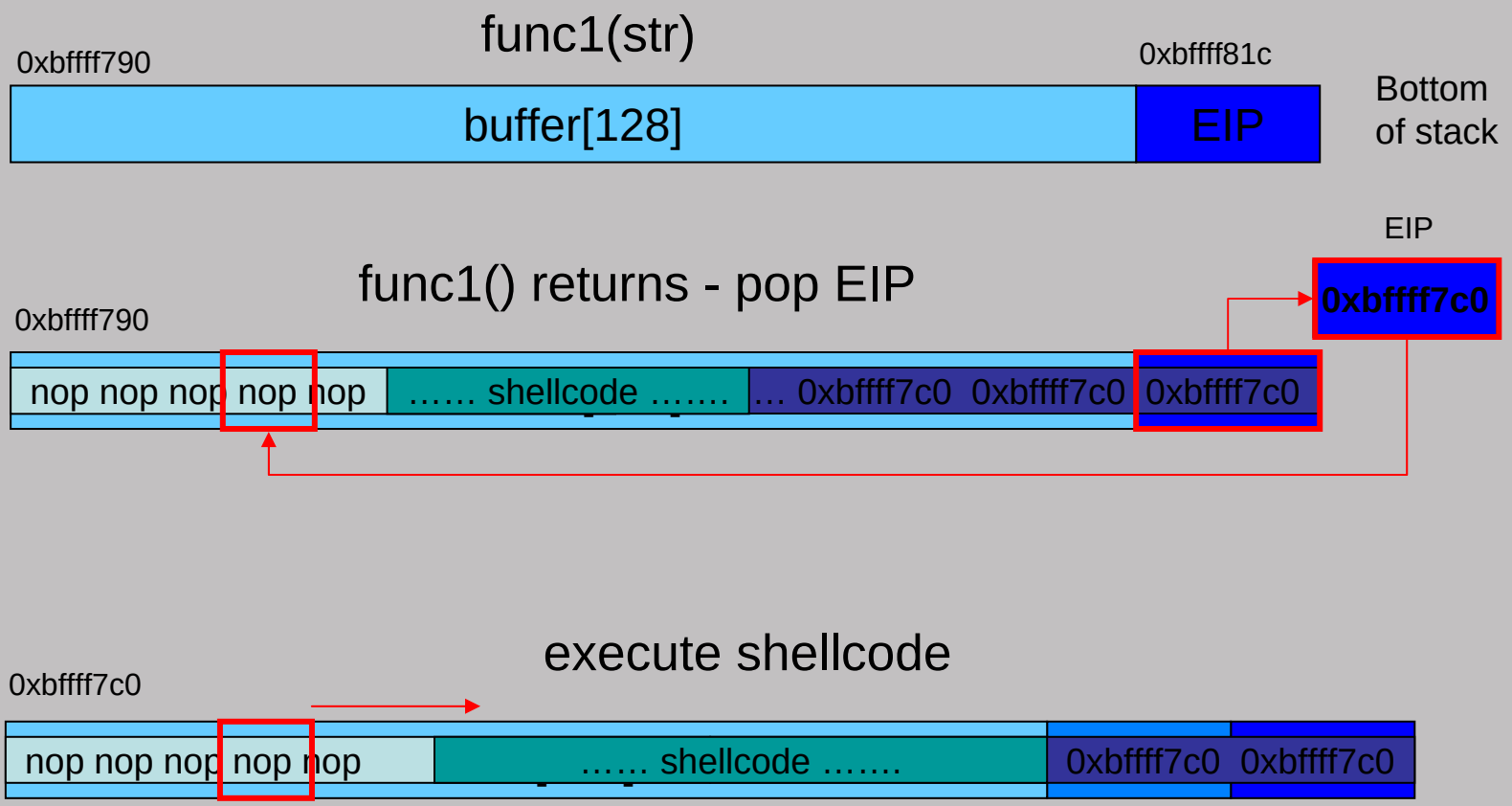
  - Return to Shared library

    Jump through registers.

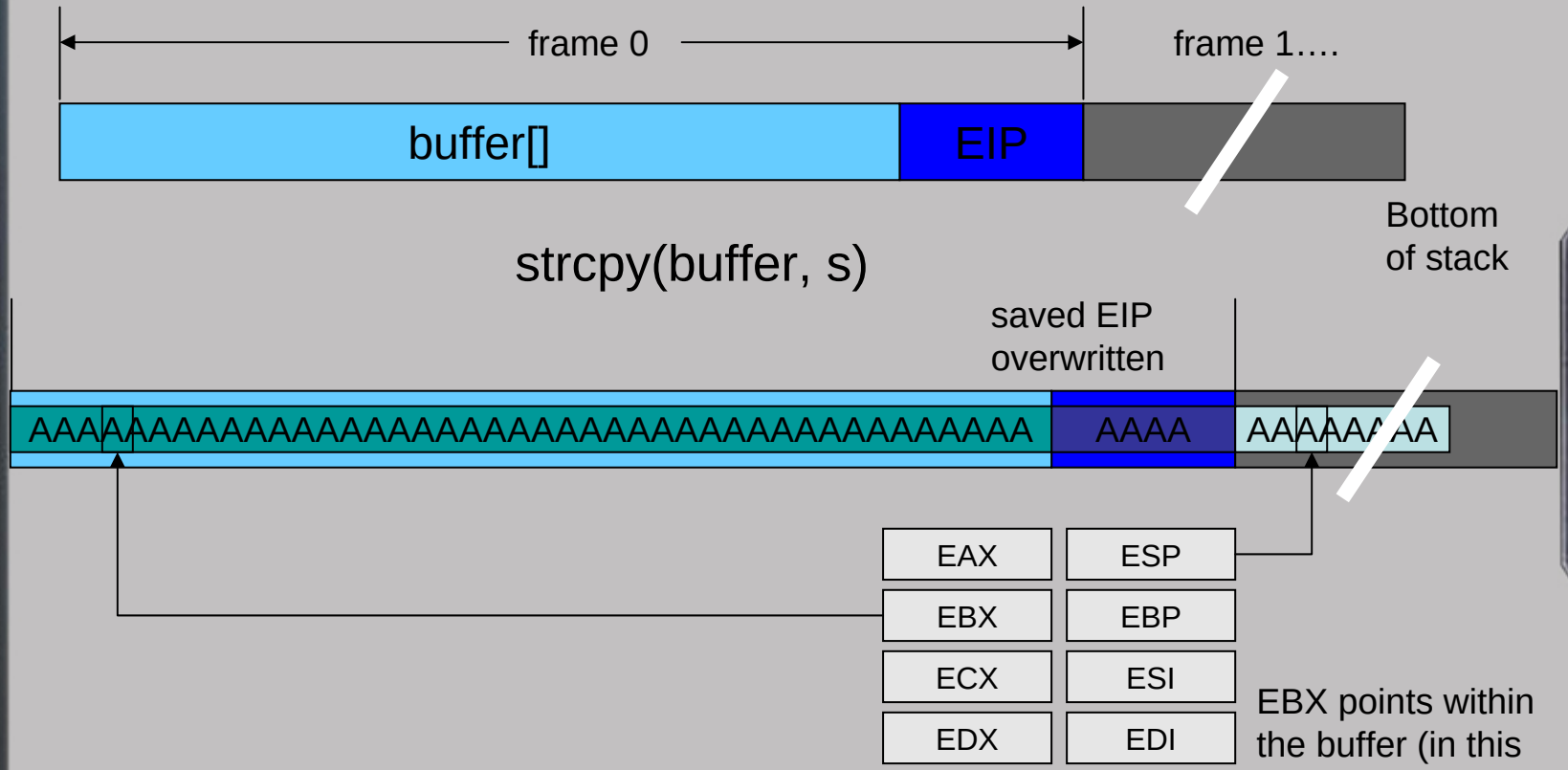
    Requires certain conditions to be meet.

    (highly stable technique)

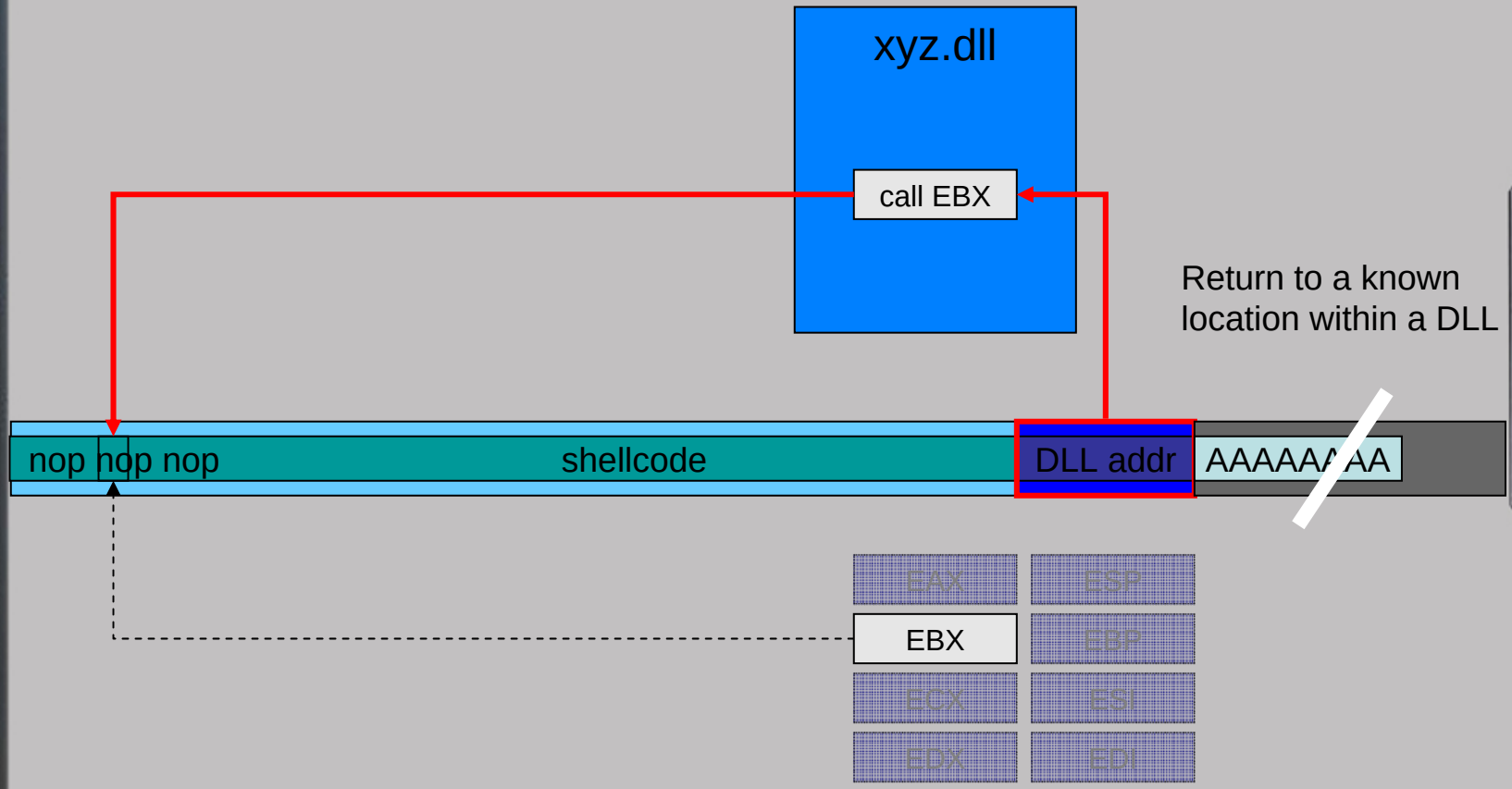
Return to Stack



Jump through Register

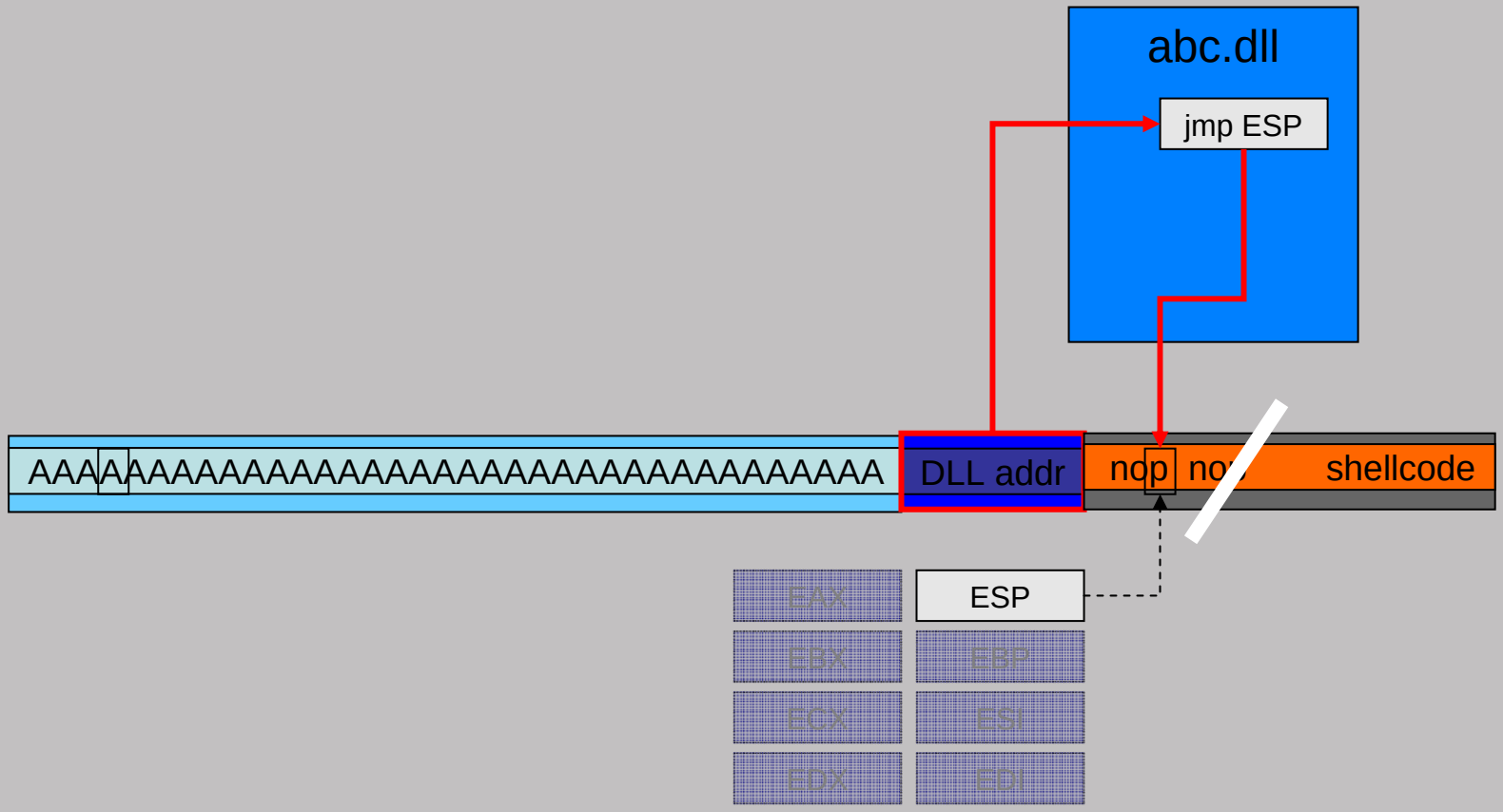


Jump through Register

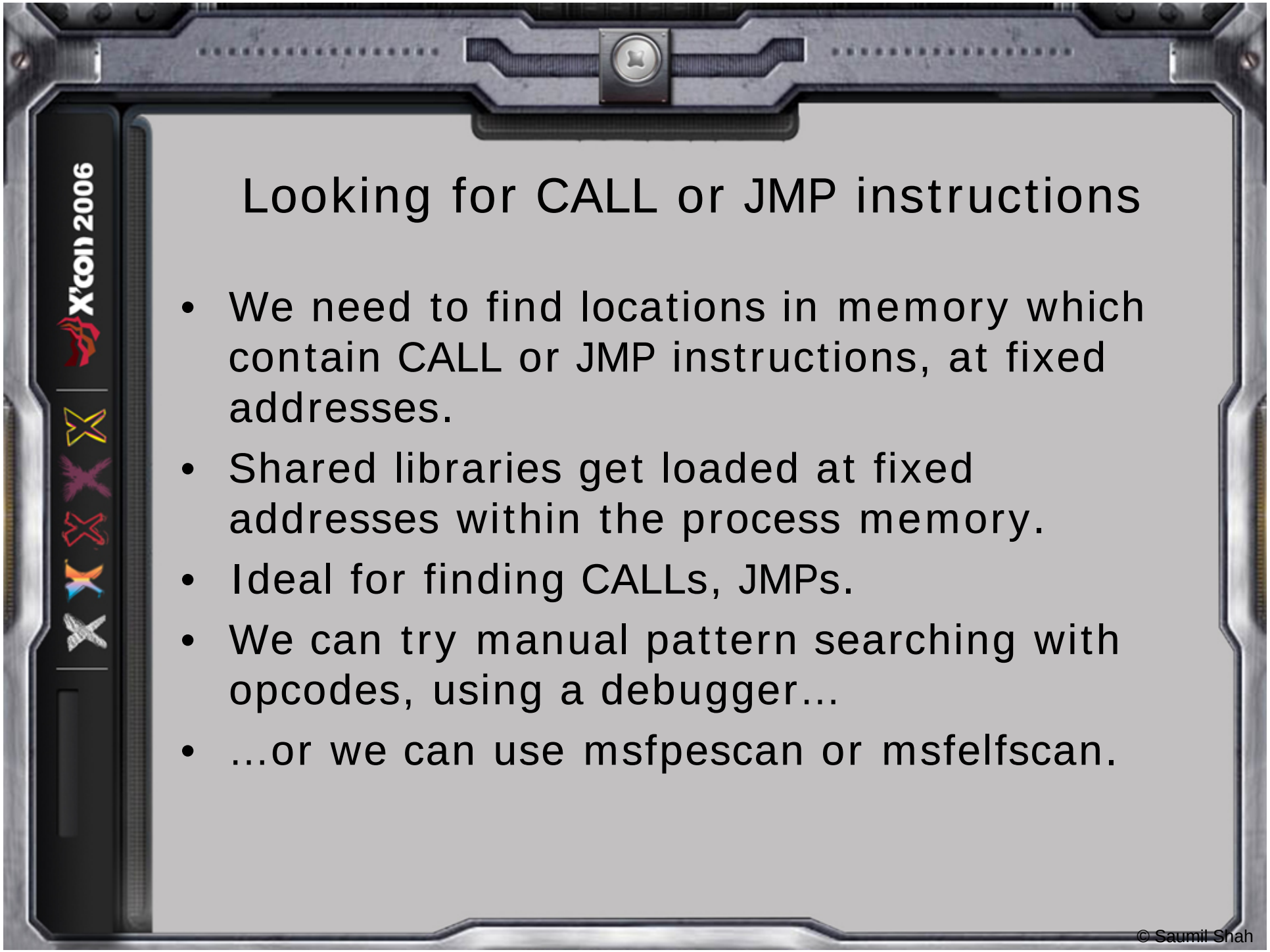


shellcode at the beginning of the buffer

Jump through Register



shellcode at the end of the buffer



Looking for CALL or JMP instructions

- We need to find locations in memory which contain CALL or JMP instructions, at fixed addresses.
- Shared libraries get loaded at fixed addresses within the process memory.
- Ideal for finding CALLs, JMPs.
- We can try manual pattern searching with opcodes, using a debugger...
- ...or we can use msfpescan or msfelfscan.

msfpescan, msfelfscan

- Utilities to scan binaries (executables or shared libraries).
- Support for ELF and PE binaries.
- Uses metasploit's built-in disassemblers.
- Can find CALLs, JMPs, or POP/POP/RET instruction sets.
- Can be used to find instruction groups specified by regular expressions.

msfpescan'ning Windows DLLs

- If we need to search for a jump to ESI:

```
~/framework$ ./msfpescan -f windlls/USER32.DLL -j esi
0x77e11c46    call esi
0x77e121b7    call esi
0x77e121c5    call esi
0x77e1222a    call esi
:         :    :     :
0x77e6ca97    jmp esi
```

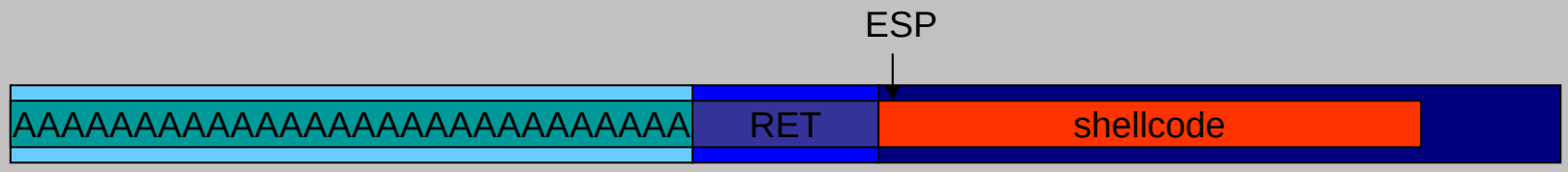
- We can point EIP to any of these values...
- ...and it will then execute a JMP/CALL ESI

Candidate binaries

- First, search the executing binary itself.
  - Independent of Kernel, Service Packs, libs.
- Second, search shared libraries or DLLs included with the software itself. (e.g. in_mp3.dll for Winamp)
- Last, search default shared libraries that get included from the OS:
  - e.g. KERNEL32.DLL, libc.so, etc.
  - Makes the exploit OS kernel, SP specific.

Case Study - peercast HTTP overflow

- 1000 byte payload.
- first 780 bytes can be AAAA's.
- Bytes 781-784 shall contain an address which will go into EIP.
- Bytes 785 onwards contain shellcode.



A little about shellcode

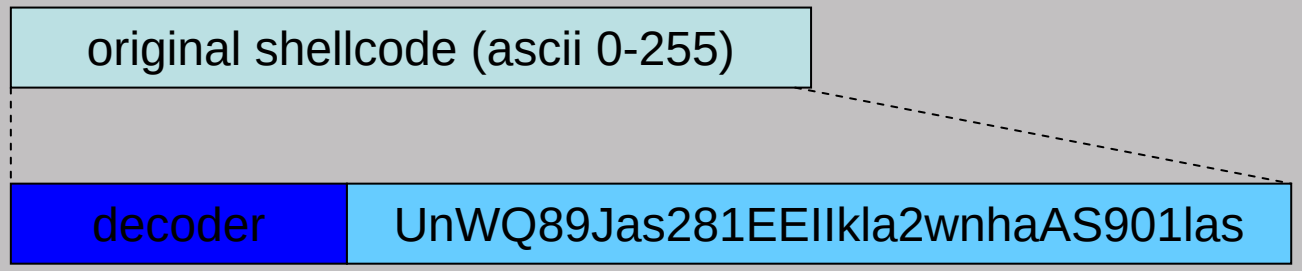
- Types of shellcode:
  - Bind shell
  - Exec command
  - Reverse shell
  - Staged shell, etc.
- Advanced techniques:
  - Meterpreter
  - Uploading and running DLLs “in-process”
  - ...etc.

Payload Encoders

- Payload encoders create encoded shellcode, which meets certain criteria.
- e.g. Alpha2 generates resultant shellcode which is only alphanumeric.
- Allows us to bypass any protocol parsing mechanisms / byte filters.
- An extra “decoder” is added to the beginning of the shellcode.
  - size may increase.

Payload Encoders

- Example: Alpha2 encoding



- Transforms raw payload into alphanumeric only shellcode.
- Decoder decodes the payload “in-memory”.

Payload Encoders

- Metasploit offers many types of encoders.
- Work around protocol parsing
  - e.g. avoid CR, LF, NULL
  - toupper(), tolower(), etc.
- Defeat IDS
  - Polymorphic Shellcode
  - Shikata Ga Nai

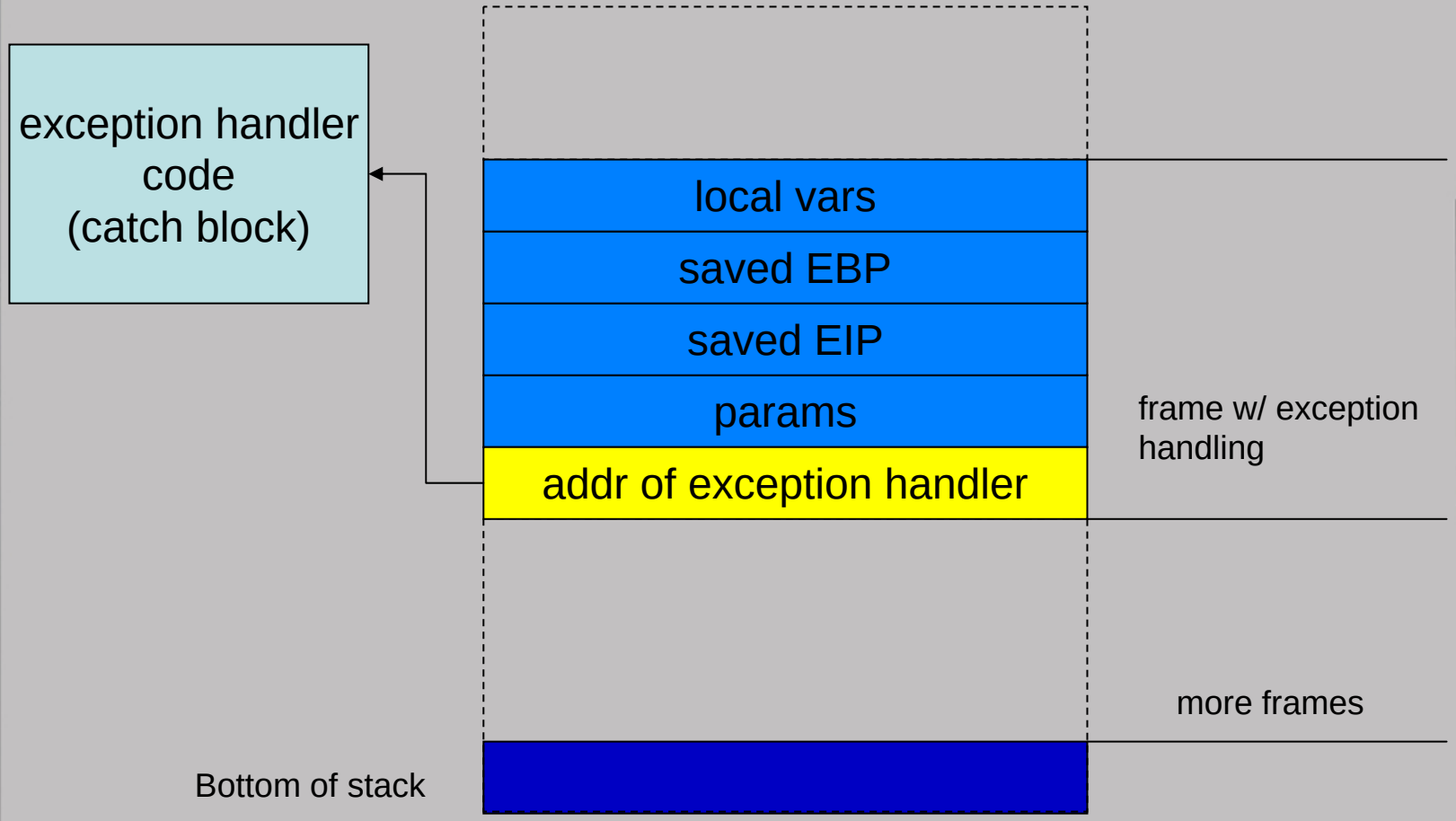
Exploiting Exception Handling

- Try / catch block

```
try {
   :        code that may throw
   :        an exception.
}
catch {
   :        attempt to recover from
   :        the exception gracefully.
}
```

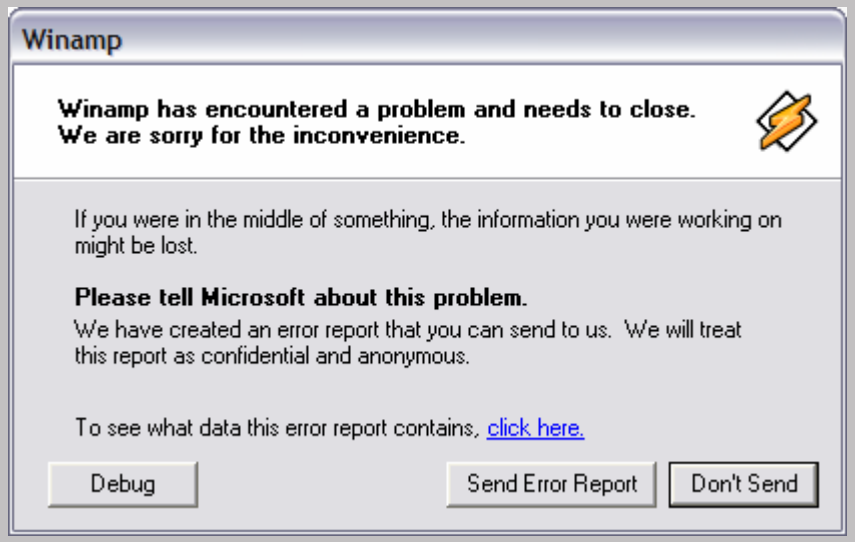
- Pointer to the exception handling code also saved on the stack, for each code block.

Exception handling ... implementation

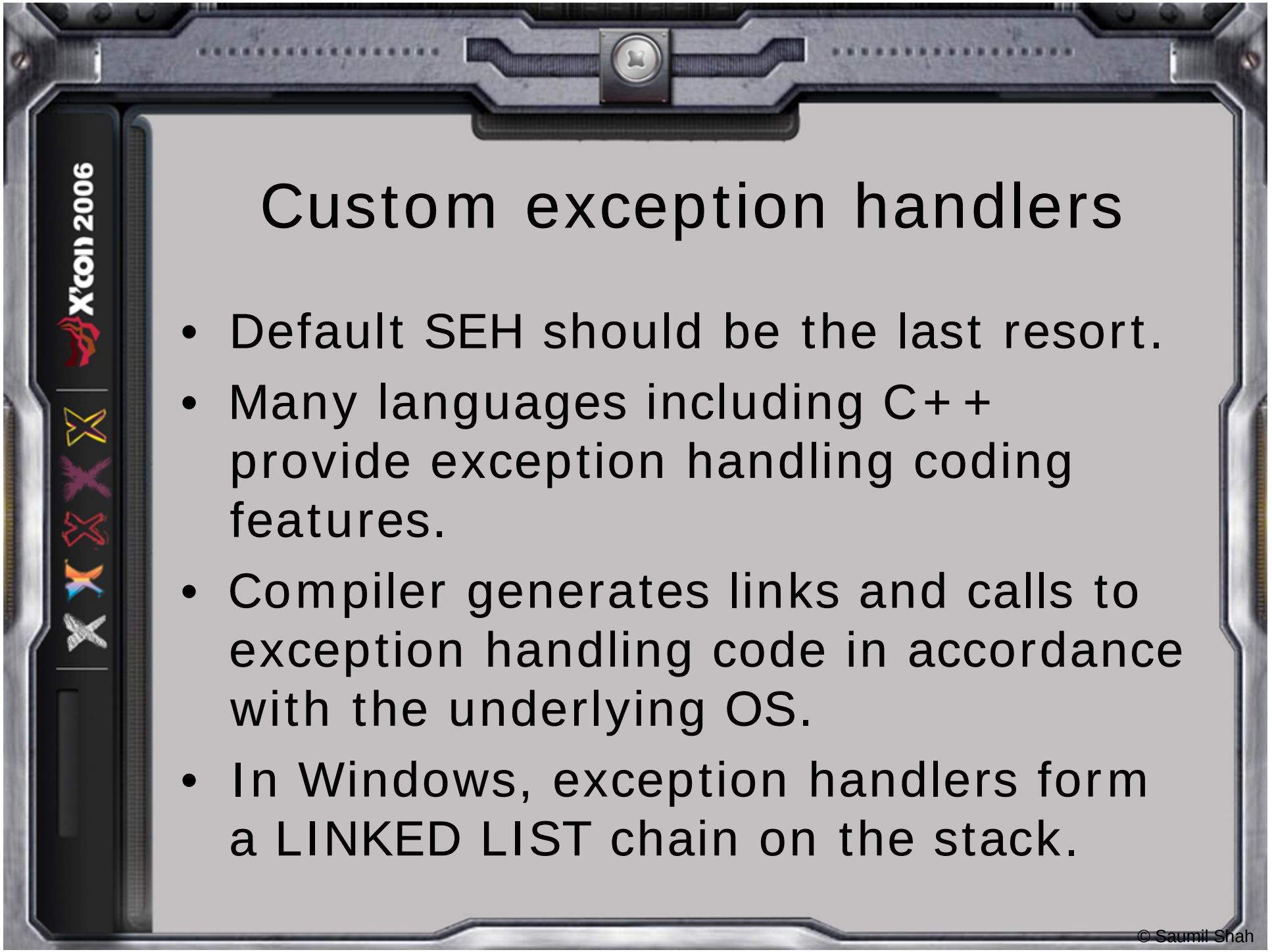


Windows SEH

- SEH - Structured Exception Handler
- Windows pops up a dialog box:



- Default handler kicking in.

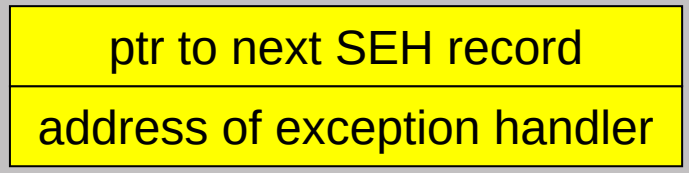


Custom exception handlers

- Default SEH should be the last resort.
- Many languages including C++ provide exception handling coding features.
- Compiler generates links and calls to exception handling code in accordance with the underlying OS.
- In Windows, exception handlers form a LINKED LIST chain on the stack.

SEH Record

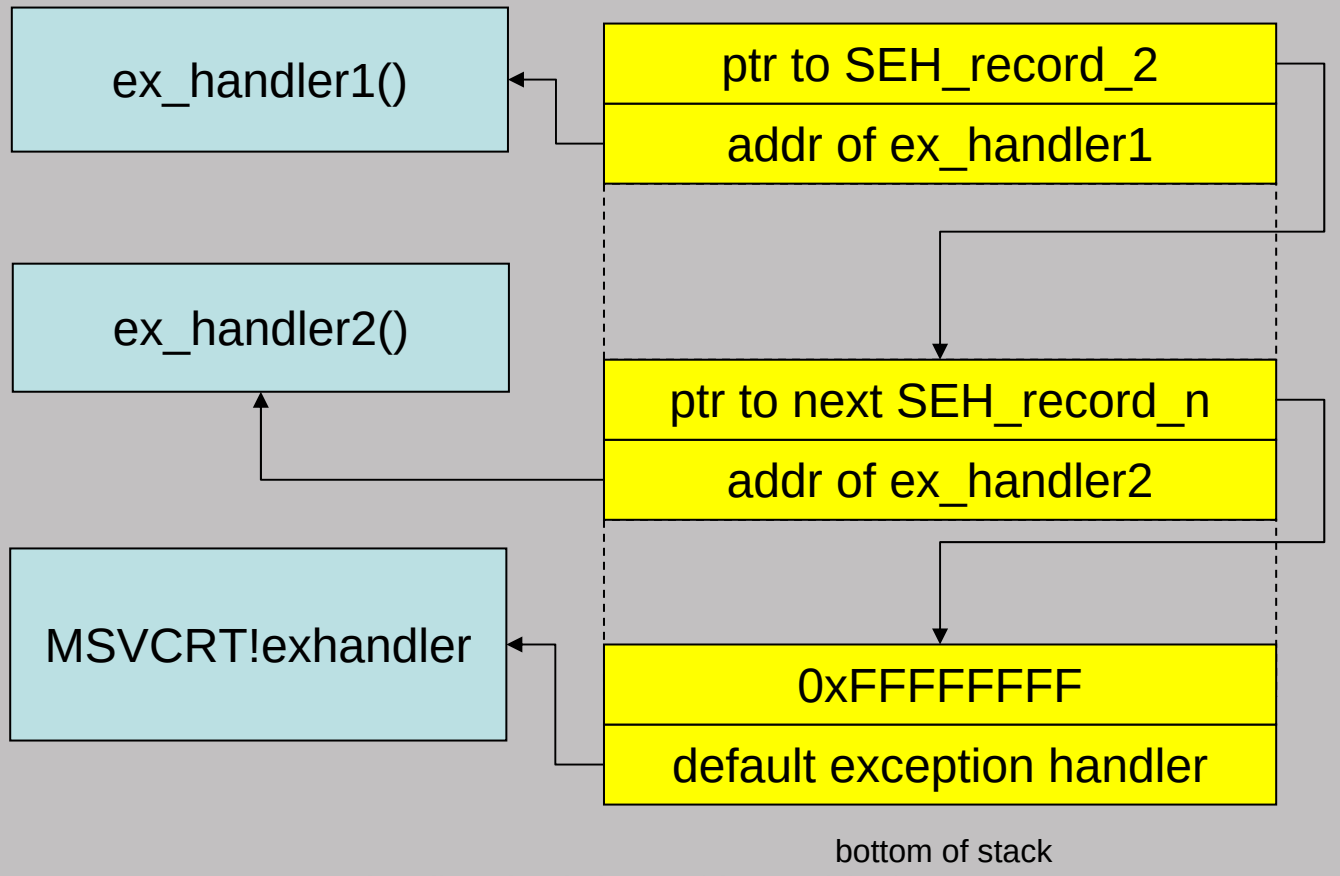
- Each SEH record is of 8 bytes



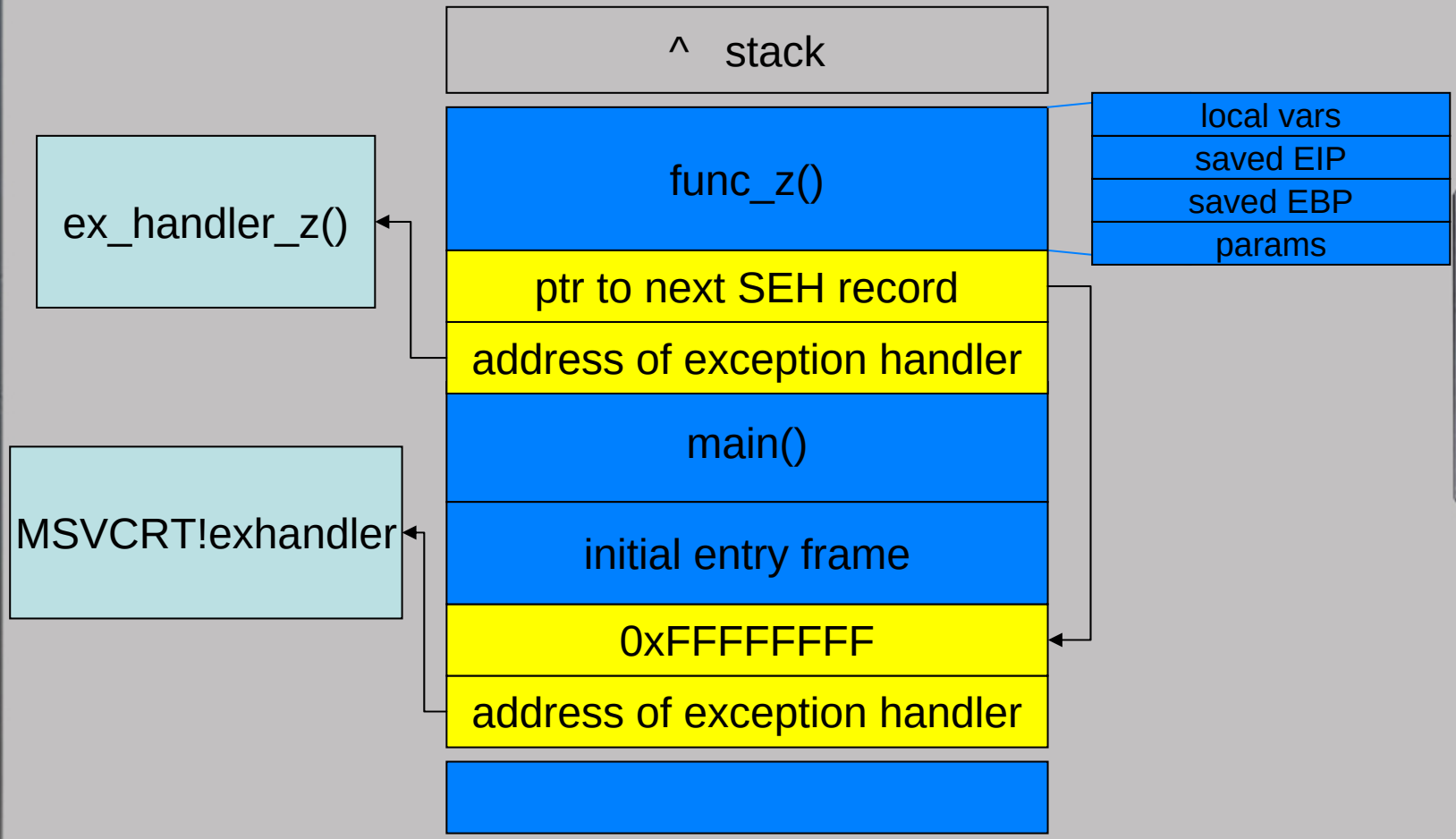
- These SEH records are found on the stack.
- In sequence with the functions being called, interspersed among function (block) frames.
- WinDBG command - !exchain

SEH Chain

- Each SEH record is of 8 bytes



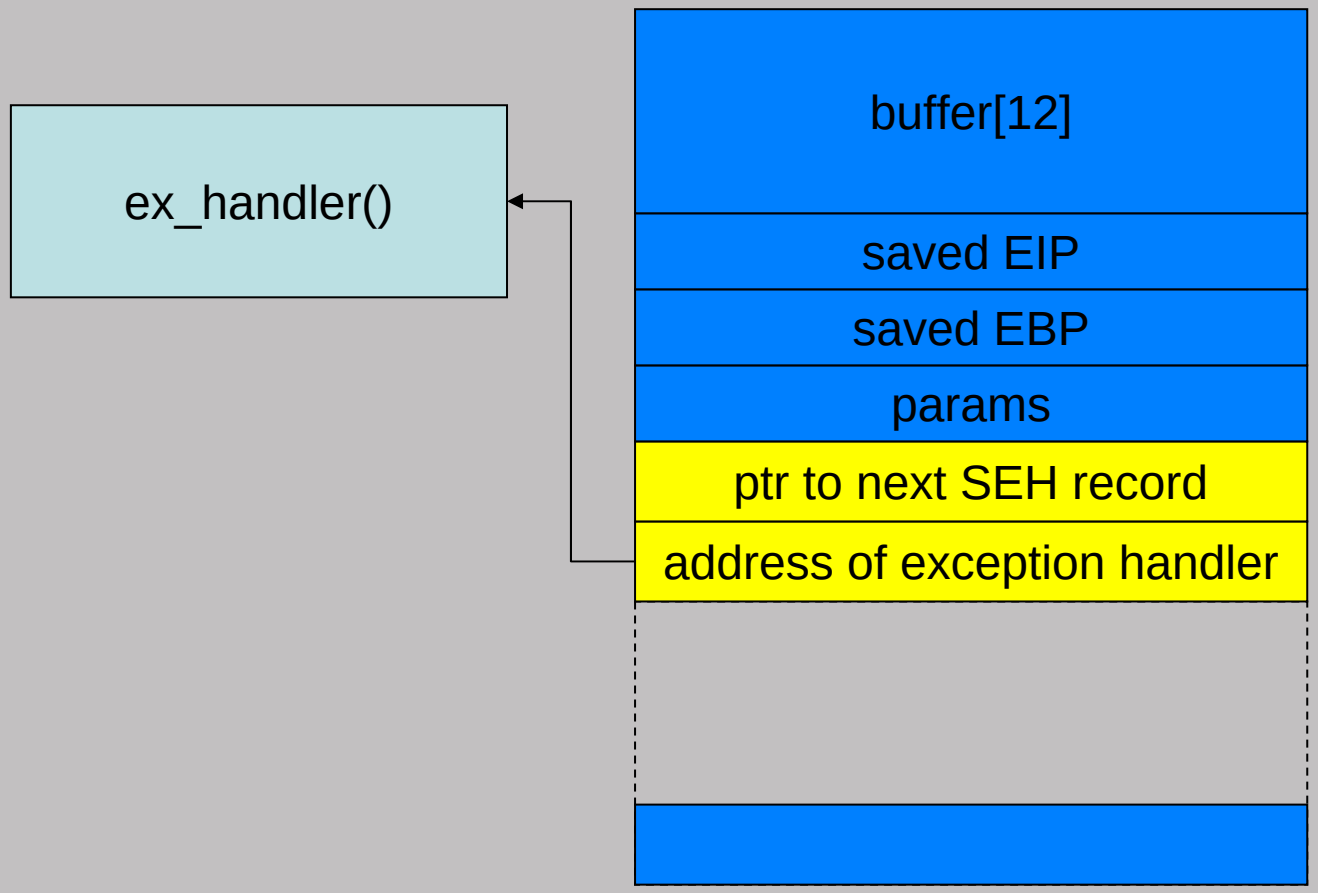
SEH on the stack



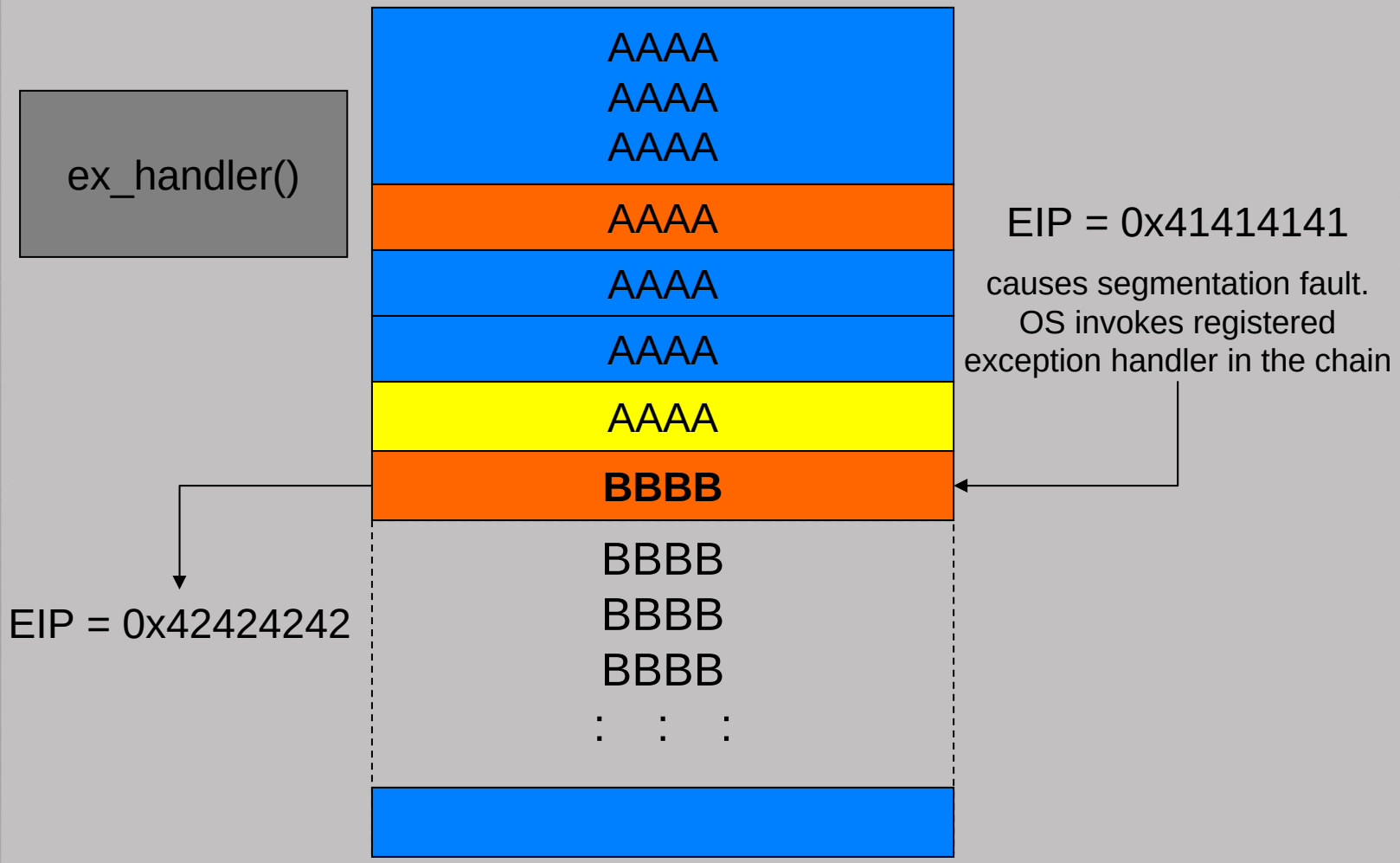
Yet another way of getting EIP

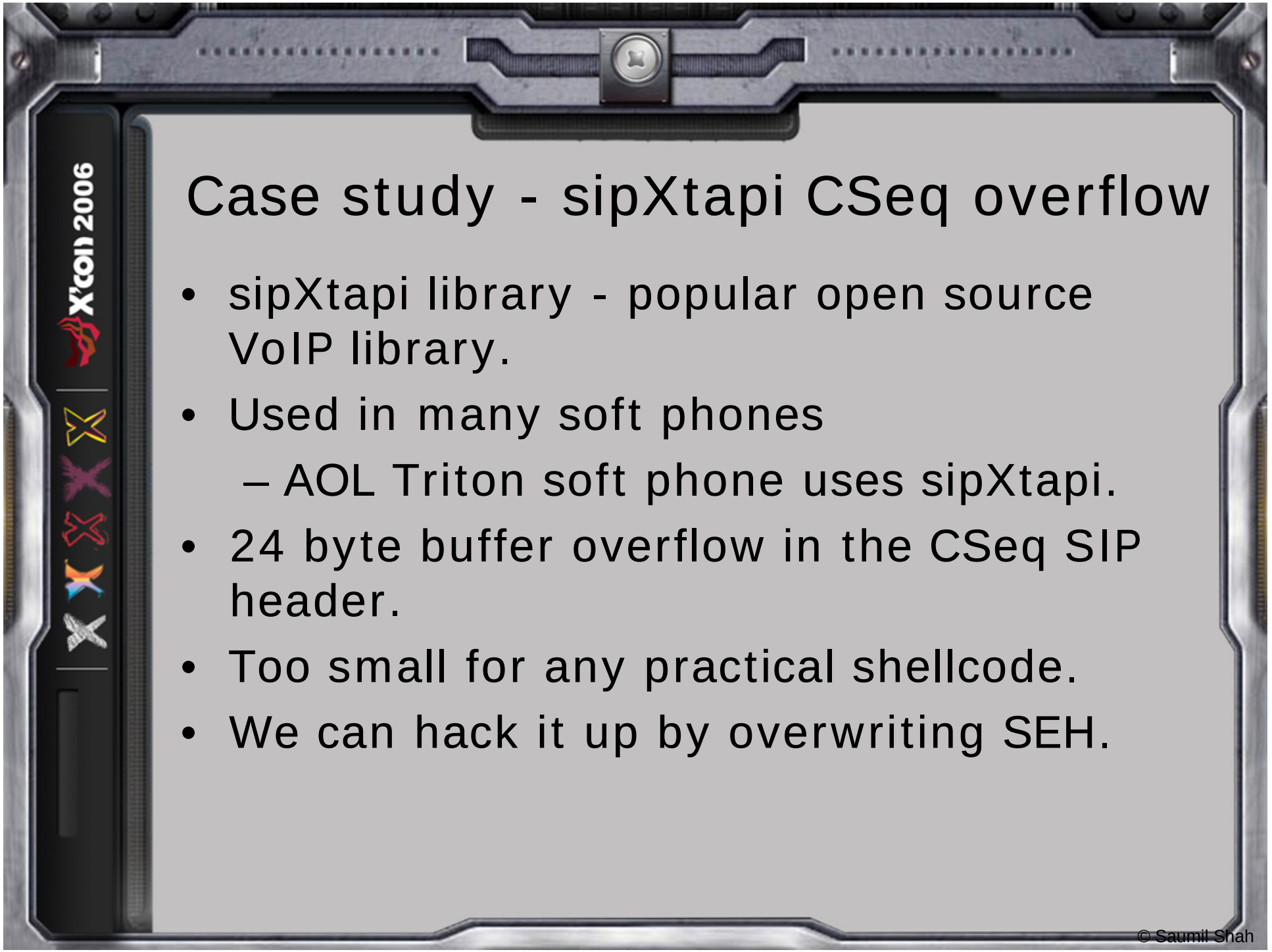
- Overwrite one of the addresses of the registered exception handlers...
- ...and, make the process throw an exception!
- If no custom exception handlers are registered, overwrite the default SEH.
- Might have to travel way down the stack...
- ...but in doing so, you get a long buffer!

Overwriting SEH



Overwriting SEH





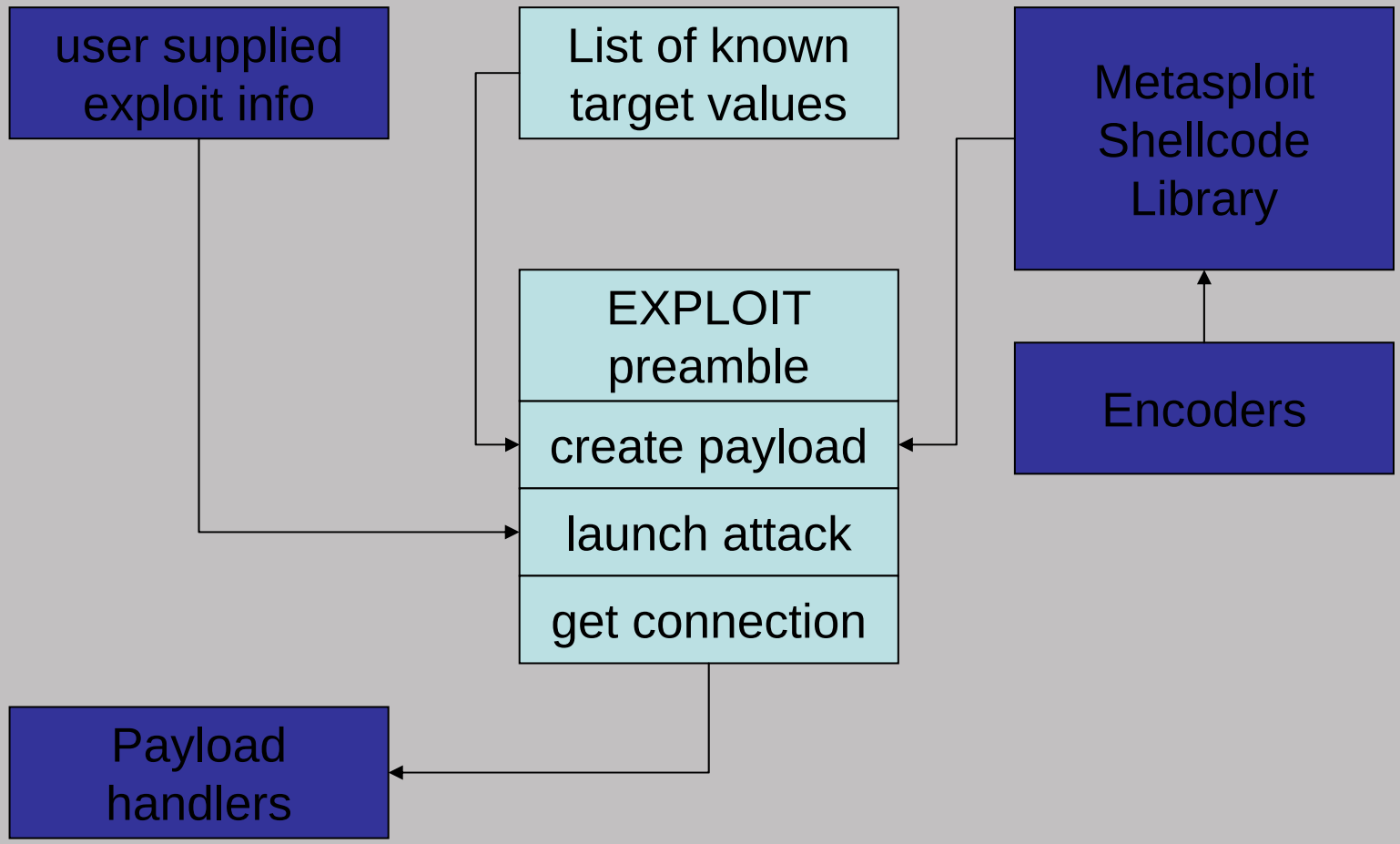
Case study - sipXtapi CSeq overflow

- sipXtapi library - popular open source VoIP library.
- Used in many soft phones
  - AOL Triton soft phone uses sipXtapi.
- 24 byte buffer overflow in the CSeq SIP header.
- Too small for any practical shellcode.
- We can hack it up by overwriting SEH.

Writing Metasploit exploit modules

- Integration within the Metasploit framework.
- Multiple target support.
- Dynamic payload selection.
- Dynamic payload encoding.
- Built-in payload handlers.
- Can use advanced payloads.
- ...a highly portable, flexible and rugged exploit!

How Metasploit runs an exploit



Writing a Metasploit exploit

- Perl module (2.6), Ruby module (3.0)
- Pre-existing data structures
  - %info, %advanced
- Constructor
  - sub new {...}
- Exploit code
  - sub Exploit {...}

Structure of the exploit perl module

```
package Msf::Exploit::name;
use base “Msf::Exploit”;
use strict;
use Pex::Text;

my $advanced = { };
```

```
my $info = { };
```

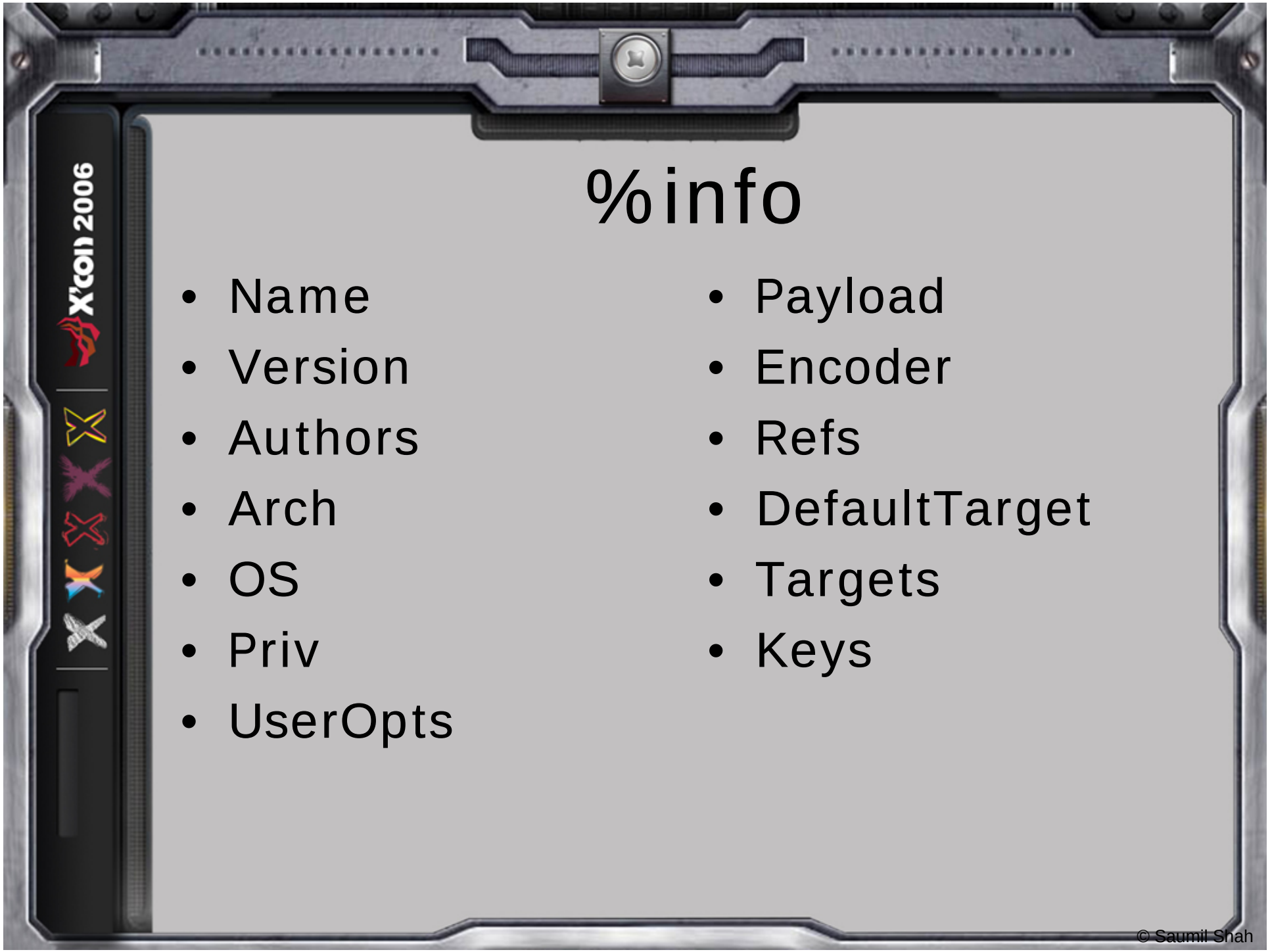
information block

```
sub new {

}
```

constructor
return an instance of our exploit

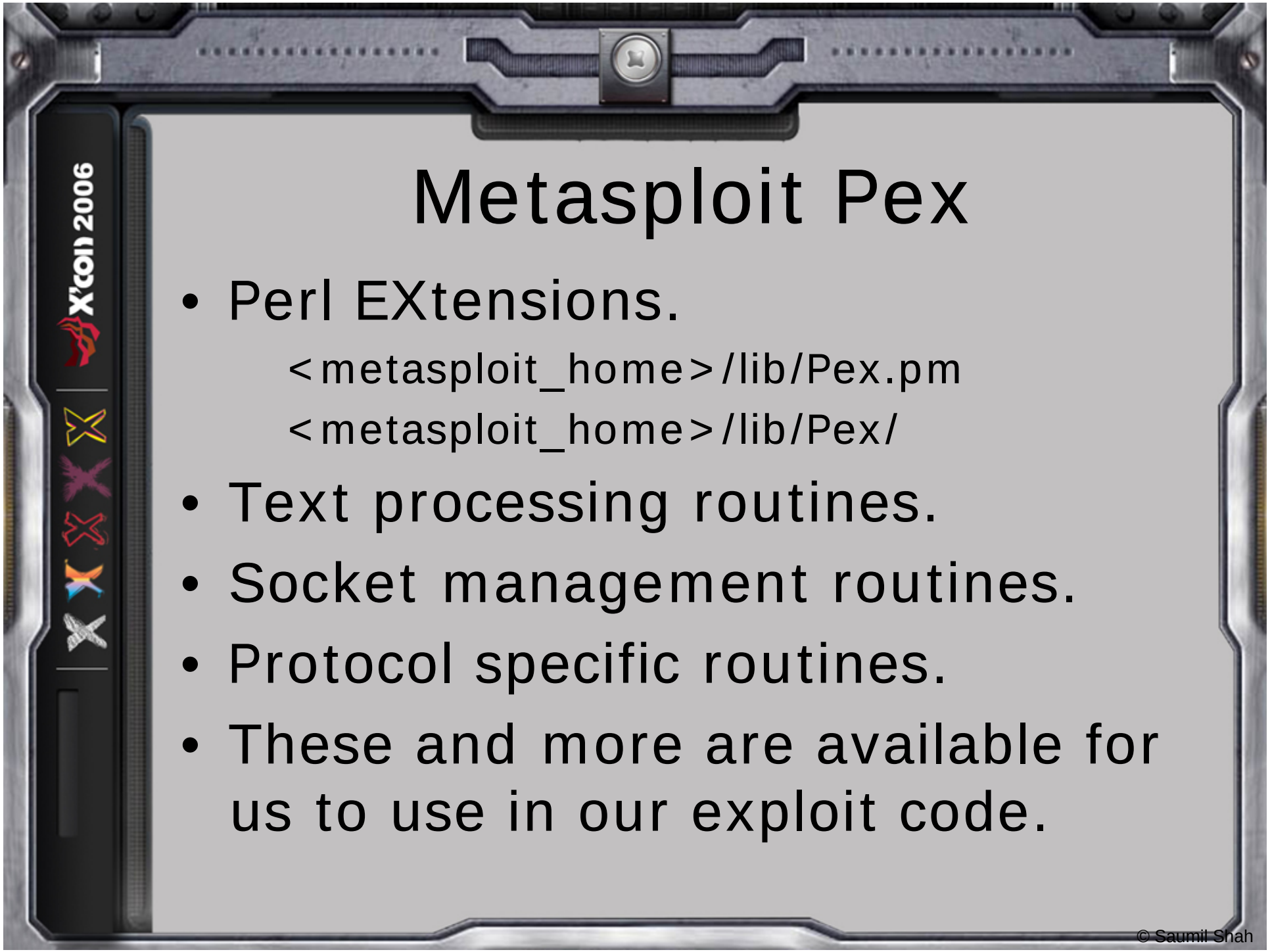
```
sub Exploit {

}
```

exploit block



%info

- Name
- Version
- Authors
- Arch
- OS
- Priv
- UserOpts
- Payload
- Encoder
- Refs
- DefaultTarget
- Targets
- Keys

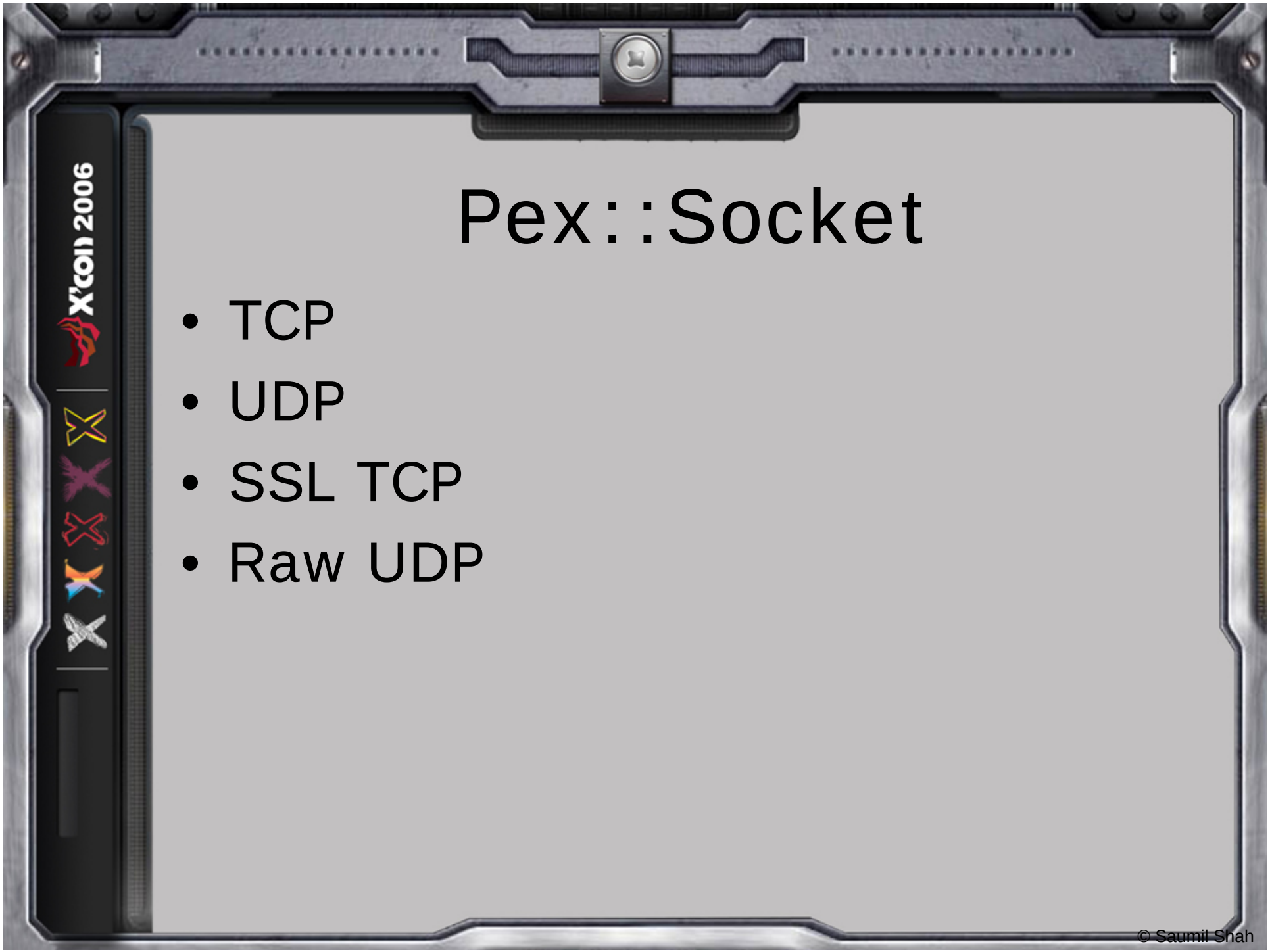


Metasploit Pex

- Perl EXtensions.
  - <metasploit_home>/lib/Pex.pm
  - <metasploit_home>/lib/Pex/
- Text processing routines.
- Socket management routines.
- Protocol specific routines.
- These and more are available for us to use in our exploit code.

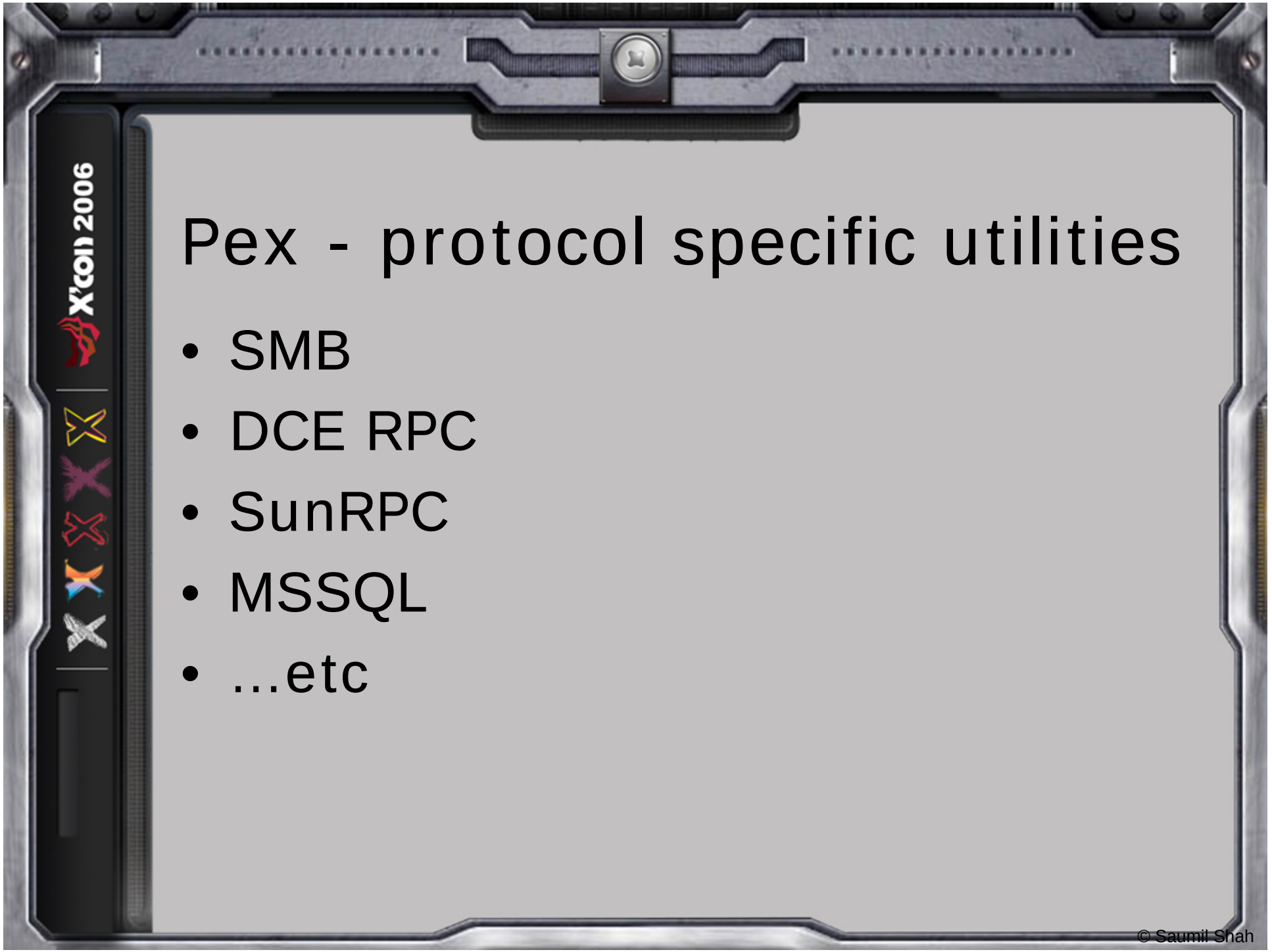
Pex::Text

- Encoding and Decoding (e.g. Base64)
- Pattern Generation
- Random text generation (to defeat IDS)
- Padding
- ...etc



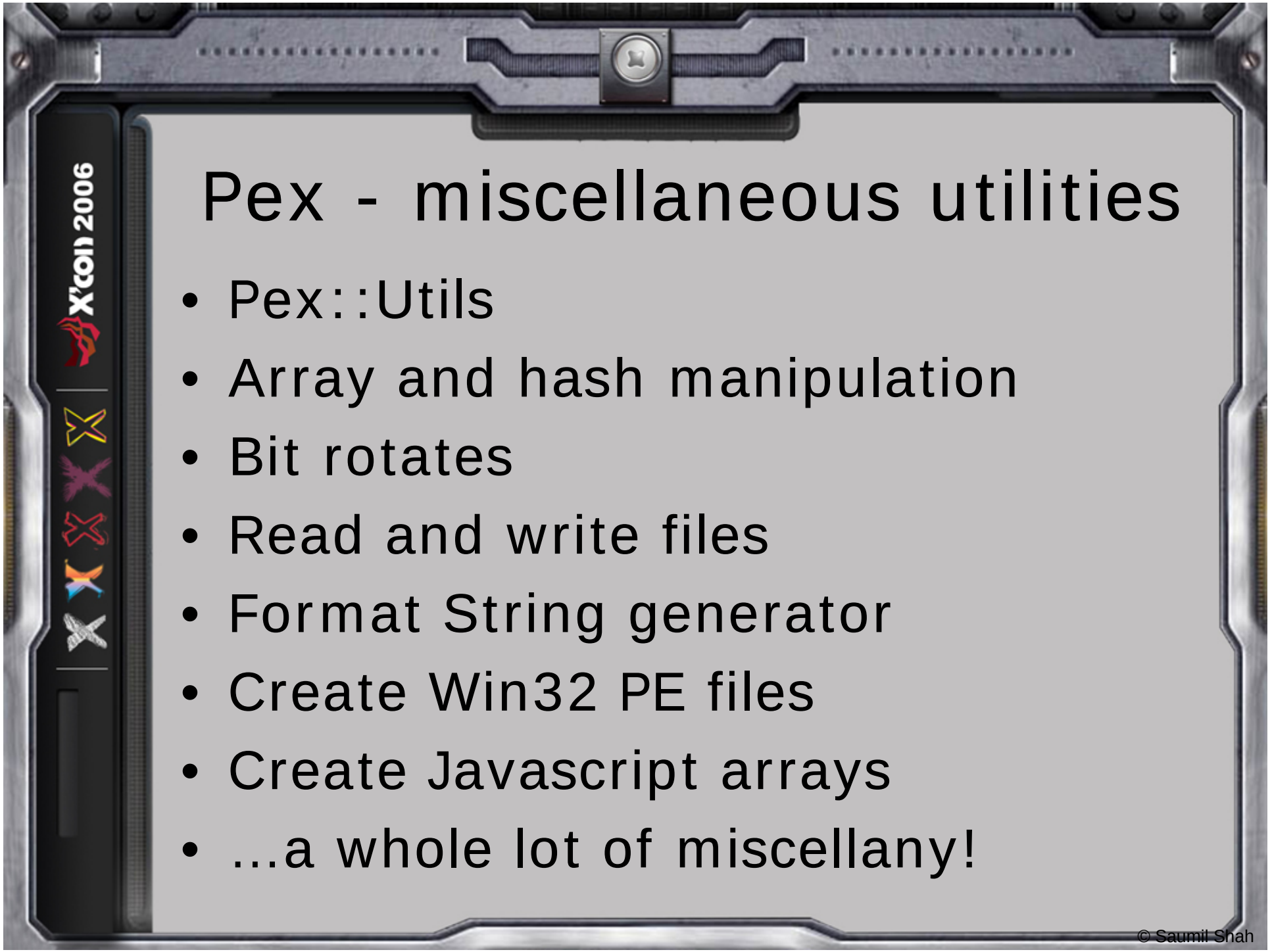
Pex::Socket

- TCP
- UDP
- SSL TCP
- Raw UDP



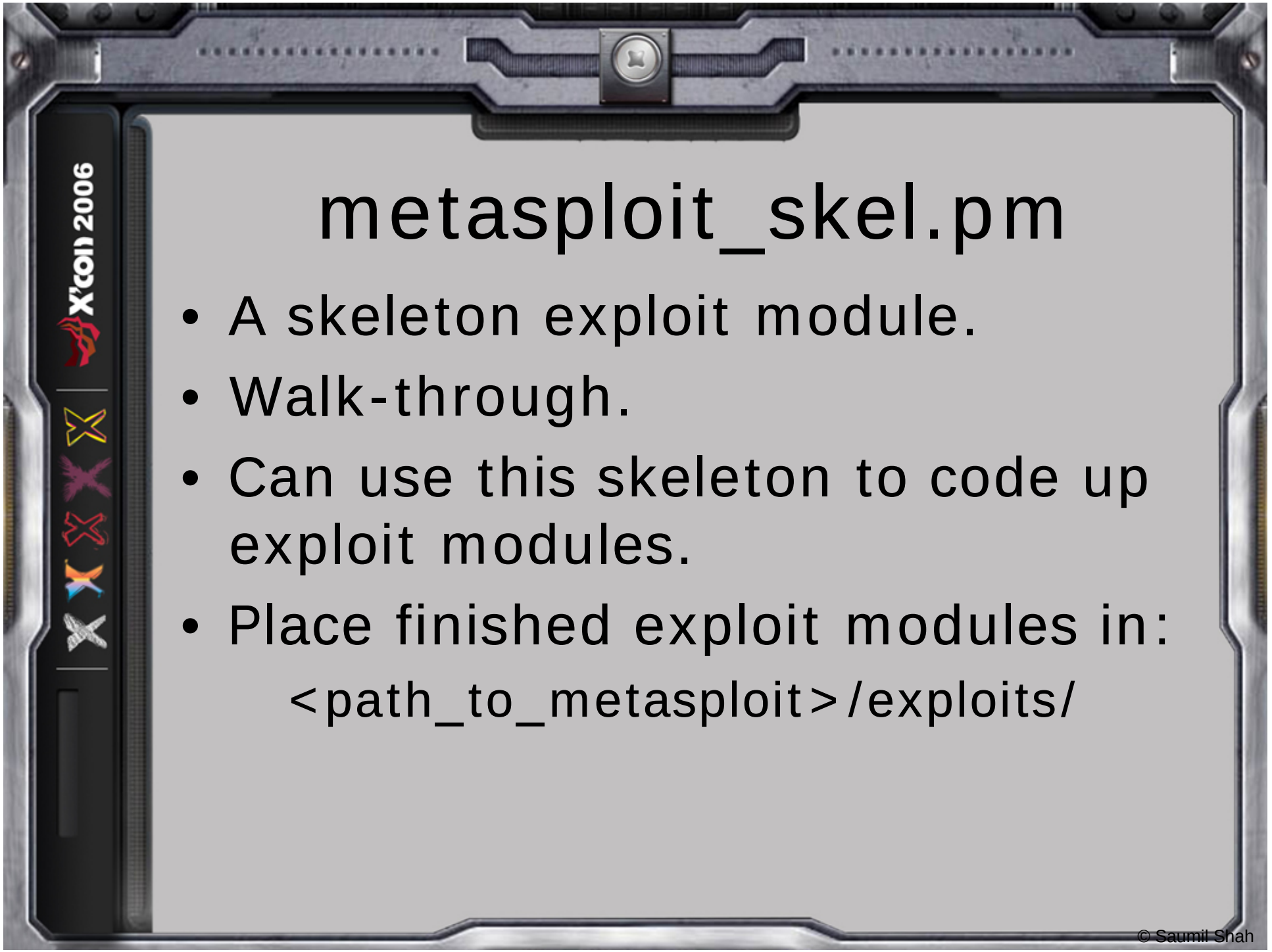
Pex - protocol specific utilities

- SMB
- DCE RPC
- SunRPC
- MSSQL
- ...etc



Pex - miscellaneous utilities

- Pex::Utils
- Array and hash manipulation
- Bit rotates
- Read and write files
- Format String generator
- Create Win32 PE files
- Create Javascript arrays
- ...a whole lot of miscellany!



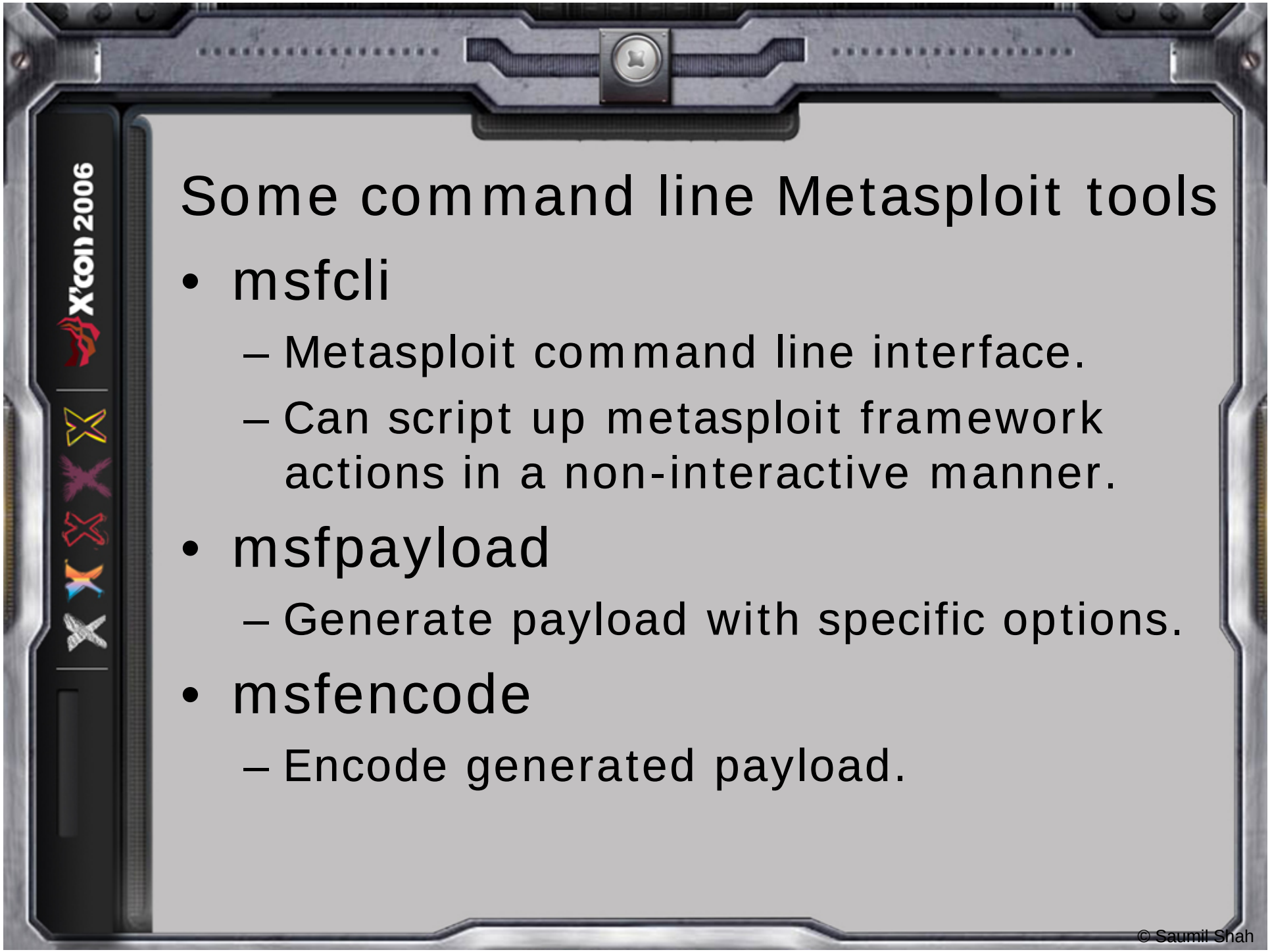
metasploit_skel.pm

- A skeleton exploit module.
- Walk-through.
- Can use this skeleton to code up exploit modules.
- Place finished exploit modules in:

  <path_to_metasploit>/exploits/

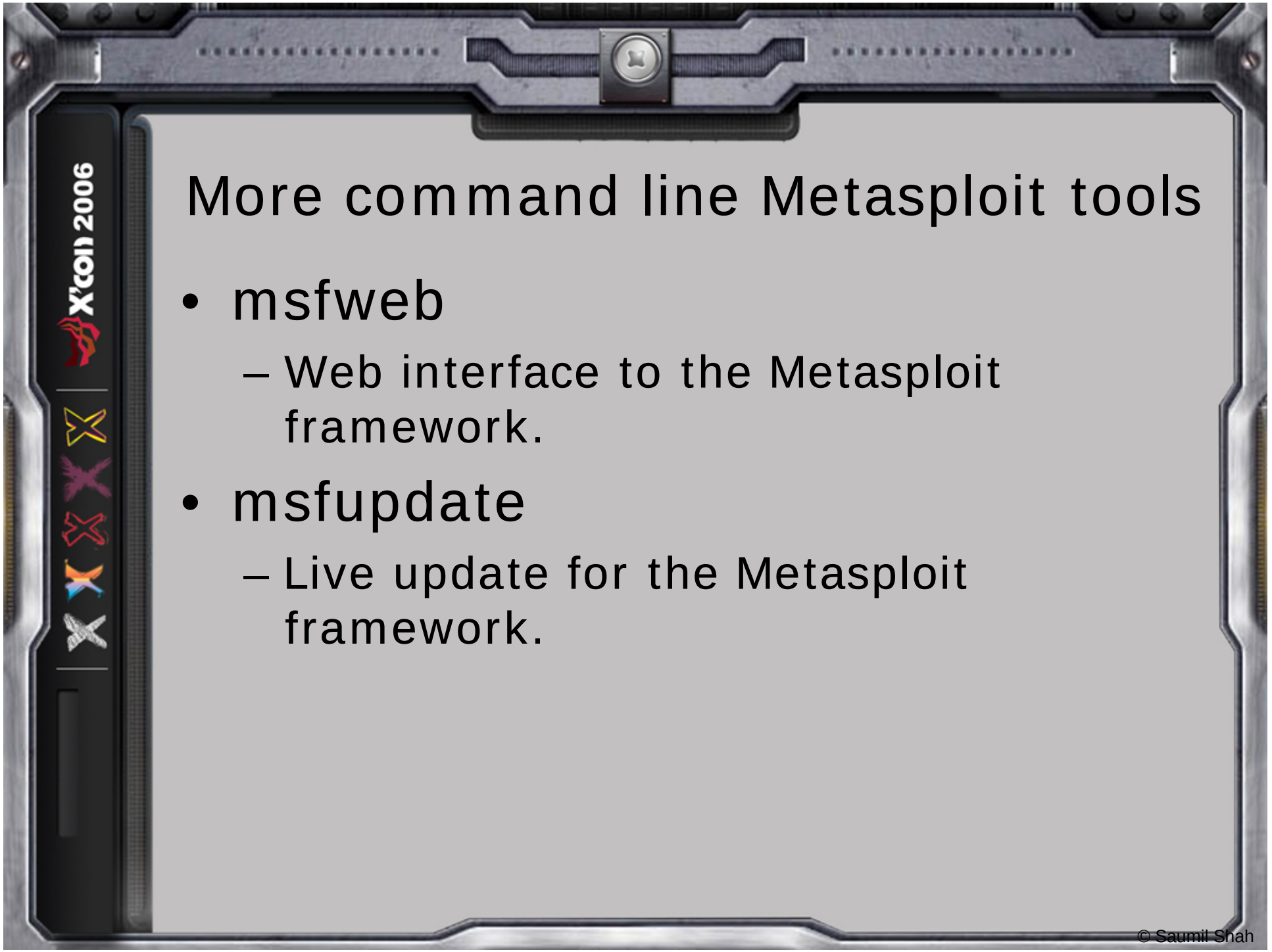
Finished examples

- my_peercast.pm
- my_sipxtapi.pm



Some command line Metasploit tools

- msfcli
  - Metasploit command line interface.
  - Can script up metasploit framework actions in a non-interactive manner.
- msfpayload
  - Generate payload with specific options.
- msfencode
  - Encode generated payload.



More command line Metasploit tools

- msfweb
  - Web interface to the Metasploit framework.
- msfupdate
  - Live update for the Metasploit framework.

New in Version 3.0

- msfd
  - Metasploit daemon, allows for client-server operation of Metasploit.
- msfopcode
  - command line interface to Metasploit's online opcode database.
- msfwx
  - a GUI interface using wxruby.

New in Version 3.0

- New payloads, new encoders.
- Ruby extension - Rex (similar to Pex)
- NASM shell.
- Back end Database support.
- ...whole lot of goodies here and there.

Thank You!

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