Safe C API—Concise solution of buffer overflow

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Agenda

- Brief introduction of buffer overflow
- The difference between standard C API and Safe C API
- How does Safe C avoid buffer issue
- Cautions
- Summary

Buffer overflow

What is buffer overflow

- More data is put into a holding area than it can handle.

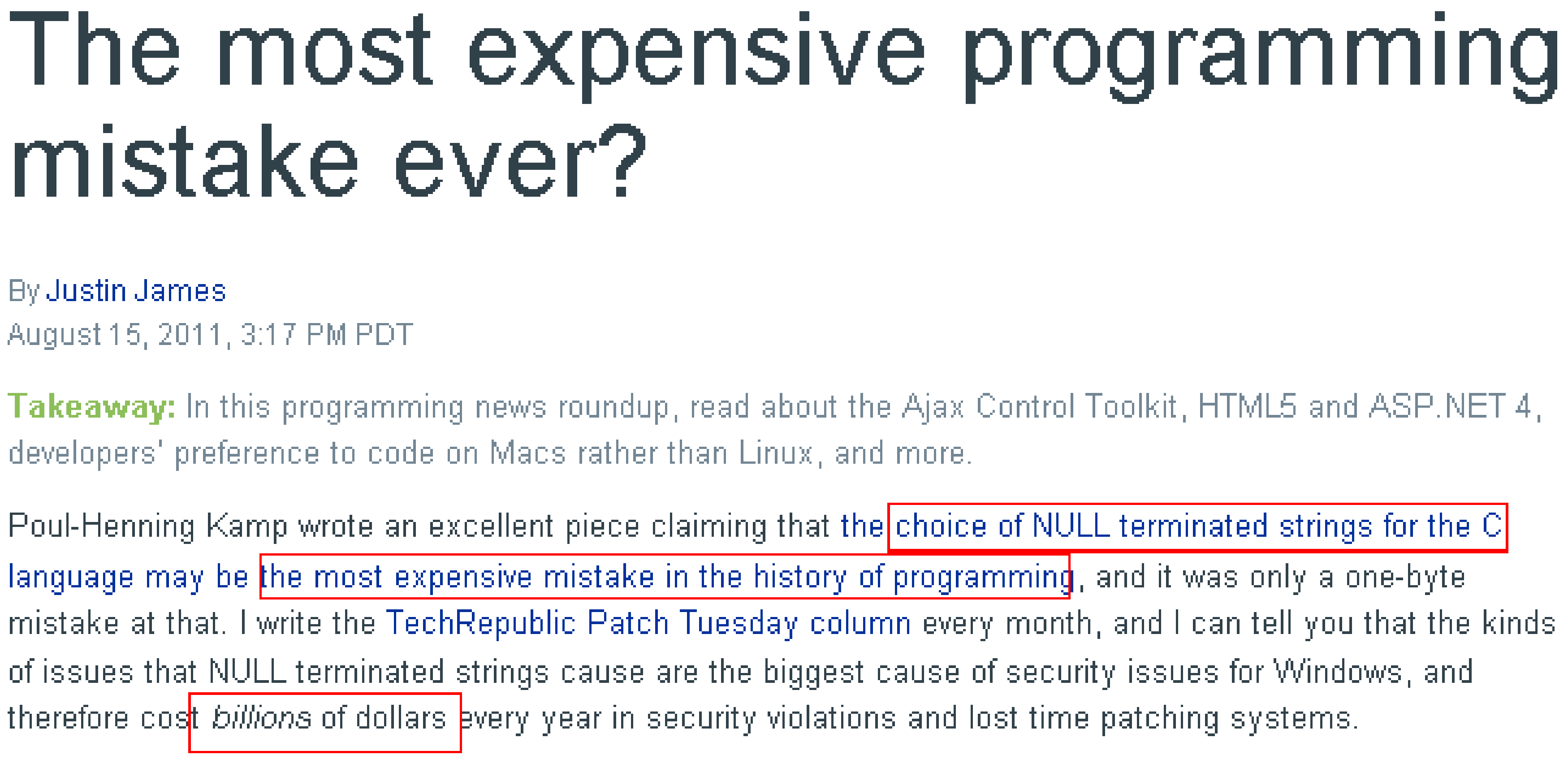
What’s the result of buffer overflow

- Programs can act in strange ways.
- Programs can fail completely.
- Programs can proceed without any noticeable difference in execution.

Notorious attack

Attack	Date	Damage
Morris Worm	1988-11	Over 6000 server crash Unix sendmail、Finger、rsh/rexec
Code Red worm	2001-7	IIS 4.0 and 5.0 allowing the worm to execute arbitrary code and infect the machine. It affected almost 1,500,000 system.
Slammer Worm	2003-1	Microsoft SQL Server 2000 a computer worm that caused a denial of service on some Internet hosts and dramatically slowed down general Internet traffic. Infect 359,000
Sun Solaris telnet daemon	2007-2	This may allow a remote attacker to trivially bypass the telnet and login authentication mechanisms.
Ubuntu Perl-Compatible Regular Expression (PCRE) library	2010-4	it could still be injected deliberated in malware to create backdoor entrances into a network

The cost of buffer error



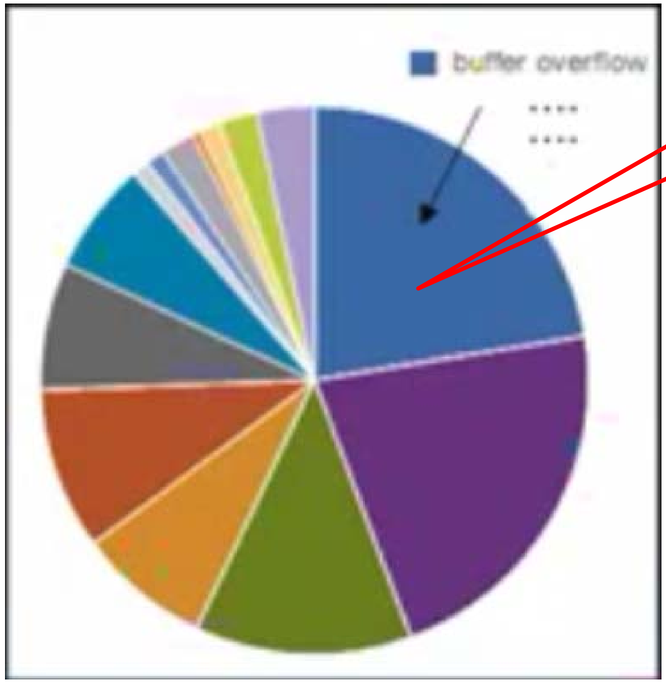
The most expensive programming mistake ever?

By Justin James
August 15, 2011, 3:17 PM PDT

Takeaway: In this programming news roundup, read about the Ajax Control Toolkit, HTML5 and ASP.NET 4, developers' preference to code on Macs rather than Linux, and more.

Poul-Henning Kamp wrote an excellent piece claiming that the choice of NULL terminated strings for the C language may be the most expensive mistake in the history of programming, and it was only a one-byte mistake at that. I write the TechRepublic Patch Tuesday column every month, and I can tell you that the kinds of issues that NULL terminated strings cause are the biggest cause of security issues for Windows, and therefore cost *billions* of dollars every year in security violations and lost time patching systems.

Buffer overflow bug



Buffer overflow

How to avoid it?

CPU/OS

- AMD Ehanced Virus Protection / Intel Excute Disable Bit (EDB)
- OS Data Execution Protection(NX)

Compiler

- MS: /GS /DYNAMICBASE /NXCOMPAT
- Linux: FORTIFY_SOURCE StackGuard StackShield ProPolice

Use different languages, like Java, C#

Write the right code

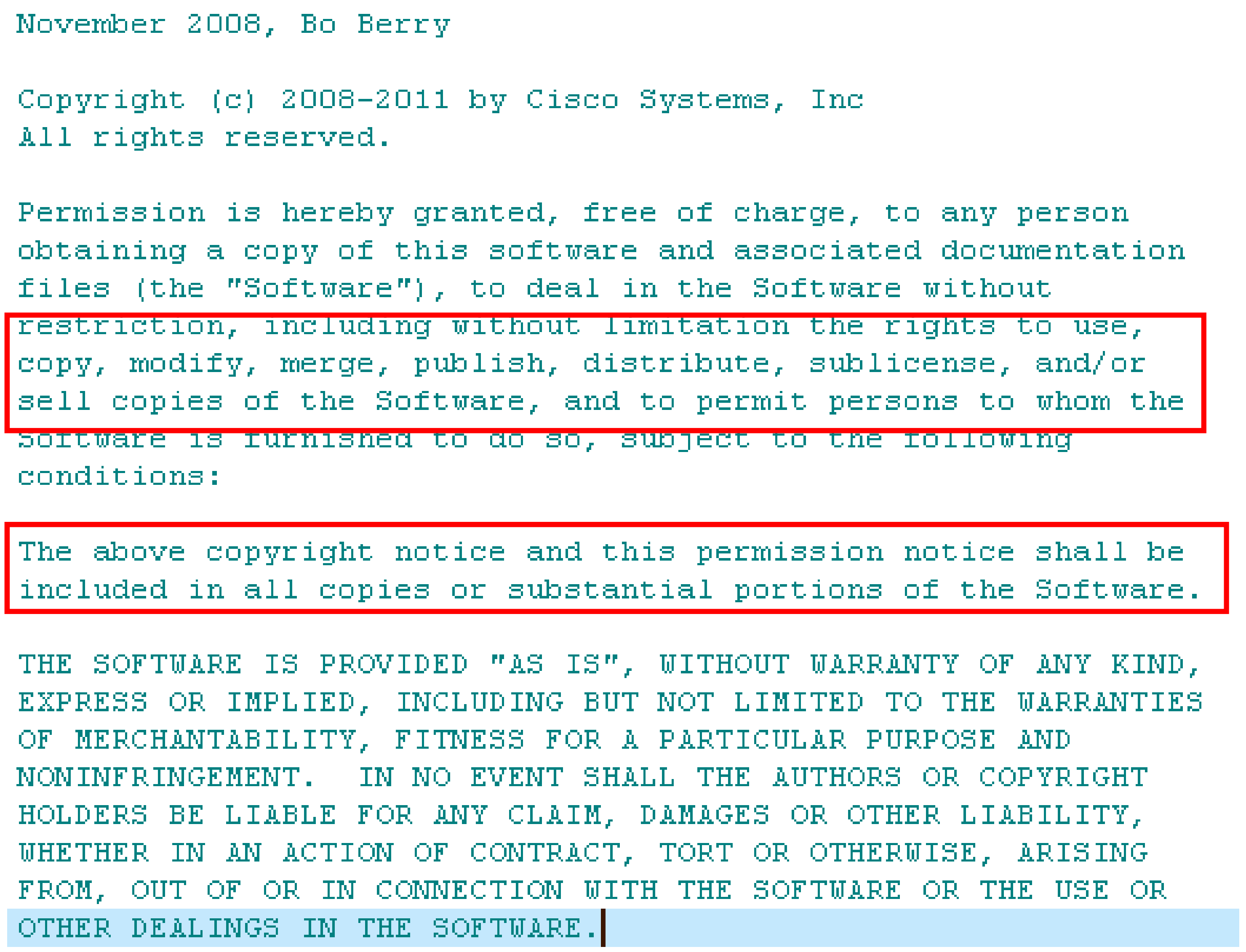
- Use safe library

  C++ STL

  C Safe C Library

  http://sourceforge.net/projects/safeclib

Safe C License



November 2008, Bo Berry

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Overview the difference

Sample safe C replacement to traditional standard C lib function

C Standard	Safe C Standard
char *strcpy (dest, src)	errno_t strcpy_s (dest, dmax, src)

Error codes to indicate specific failure

_s postfix for all safe functions

Max destination buffer size to prevent overflow

The standard C API

Strong points

Convenient to use.

Performance is a little better than Safe C API

Weak points

No input validation, easy to cause buffer issue.

Some APIs have no return value to check whether there is an issue happened.

The Safe C API

Strong points

Input validation to avoid buffer issue, like overflow, un-terminated string etc.

Have return value to check whether there is an issue during calling.

Weak points

Performance is a little poorer than standard API.

Write more codes to check the return value.

Why Safe C?

Guard against overflowing a buffer

Do not unexpectedly truncate string

Do not produce un-terminated string

Return value to show whether there is error happened

Provide unified Runtime-constraint handler

string API List

Standard C API	Safe C API
strcpy	strcpy_s
strcat	strcat_s
strcmp	strcmp_s
stricmp	strcasecmp_s
strcmp	strcmp_s
strcspn	strcspn_s
strncat	strncat_s
strncpy	strncpy_s
strlen/strnlen	strnlen_s
strpbrk	strpbrk_s
strspn	strspn_s
strstr	strstr_s
strtok	strtok_s
strchr	strfirstchar_s
strrchr	strlastchar_s

How does string API to avoid buffer issue

strcpy_s

The difference to copy string

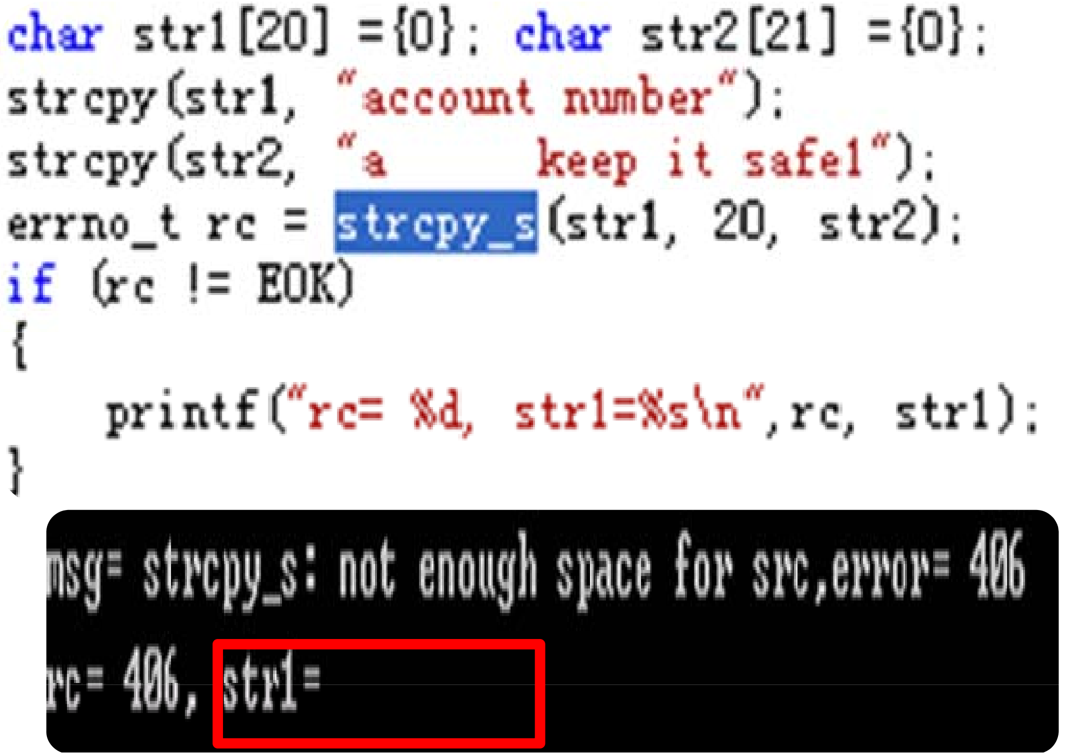
- Standard C

```
char str1[20] = {0};
char str2[20] ={”Just a test”};
strcpy(str1,   “a string“  );
```

- Safe C

```
errno_t rc =strcpy_s(str1, 20, str2);
if (  rc != EOK)   {/* copy failed */ }
else               {/* copy success */ }
```

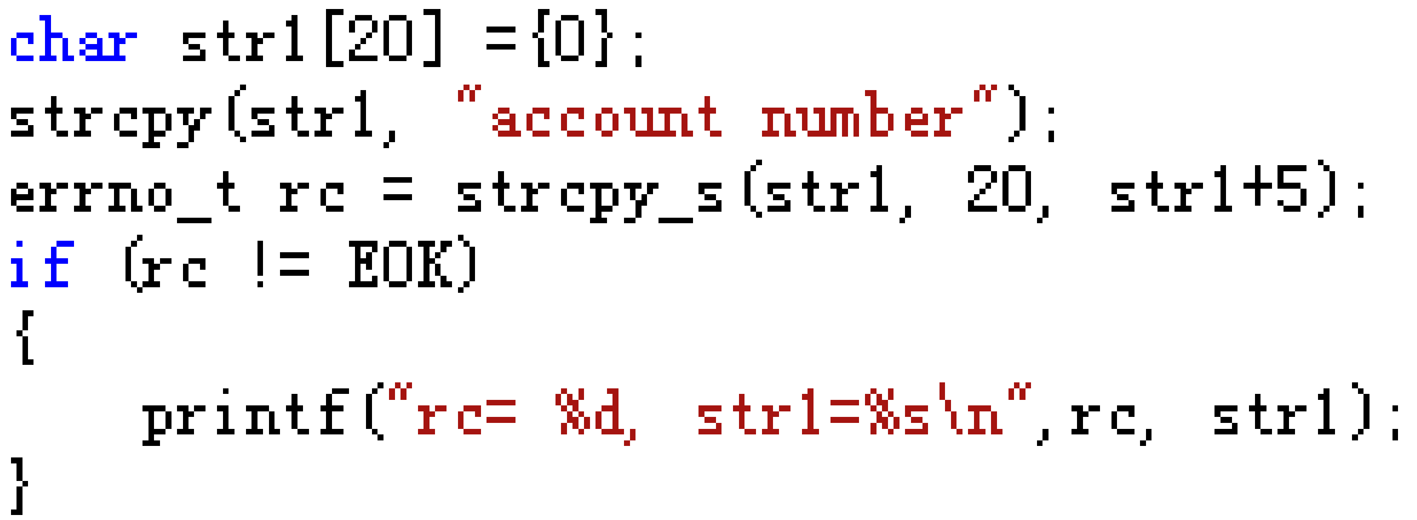
How does strcpy_s avoid buffer


```
char str1[20] ={0}; char str2[21] ={0};
strcpy(str1, "account number");
strcpy(str2, "a      keep it safe1");
errno_t rc = strcpy_s(str1, 20, str2);
if (rc != EOK)
{
    printf("rc= %d, str1=%s\n",rc, str1);
}
```

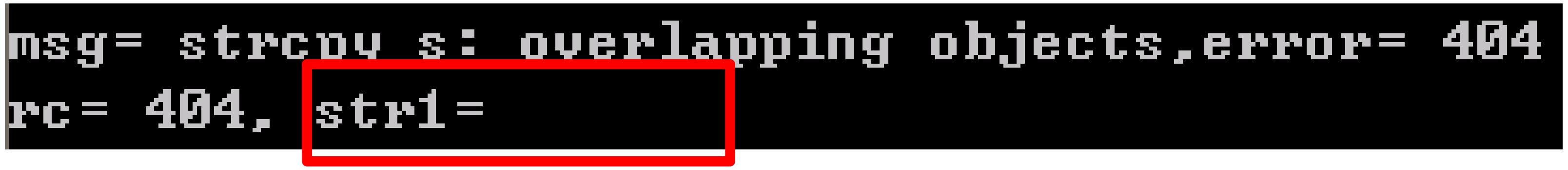
```
msg= strcpy_s: not enough space for src,error= 406
rc= 406, str1=
```

If Safe C check the buffer is not enough to contain the string(including the end char '\0'), it will empty the dest string.

How does strcpy_s avoid buffer issue --overlap



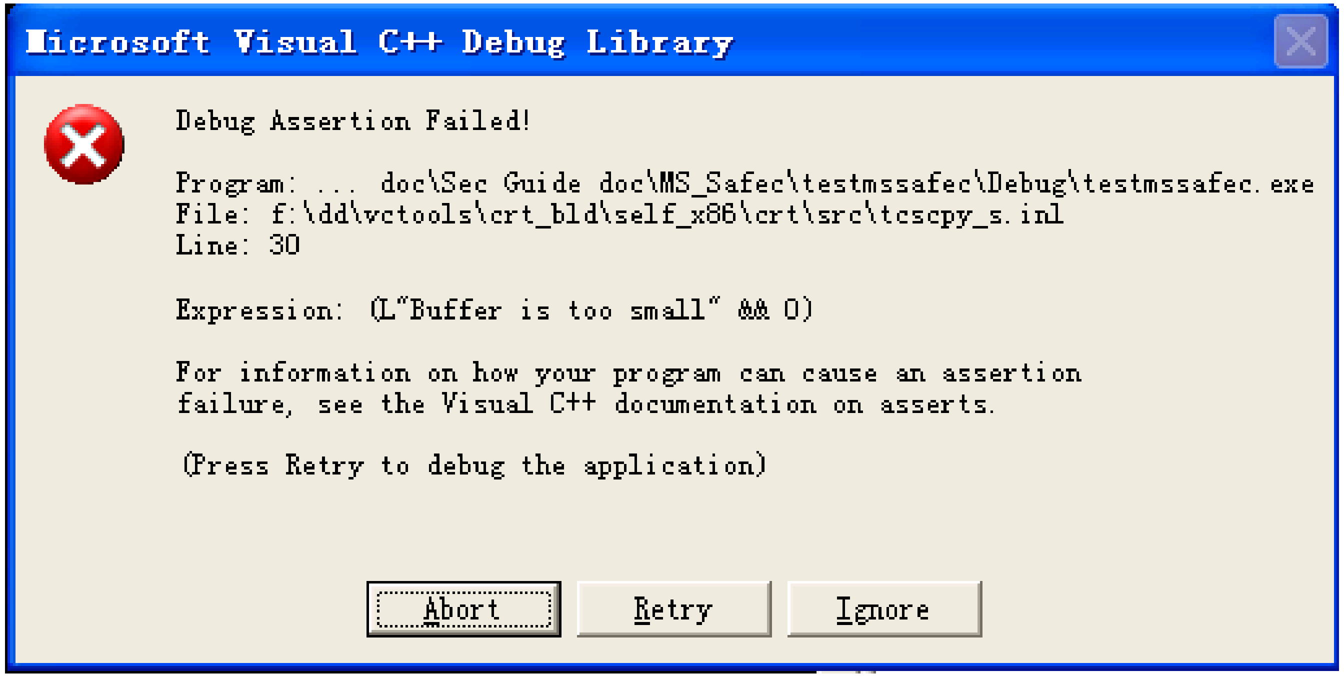
```
char str1[20] ={0};
strcpy(str1, "account number");
errno_t rc = strcpy_s(str1, 20, str1+5);
if (rc != EOK)
{
    printf("rc= %d, str1=%s\n",rc, str1);
}
```



```
msg= strcpy_s: overlapping objects,error= 404
rc= 404, str1=
```

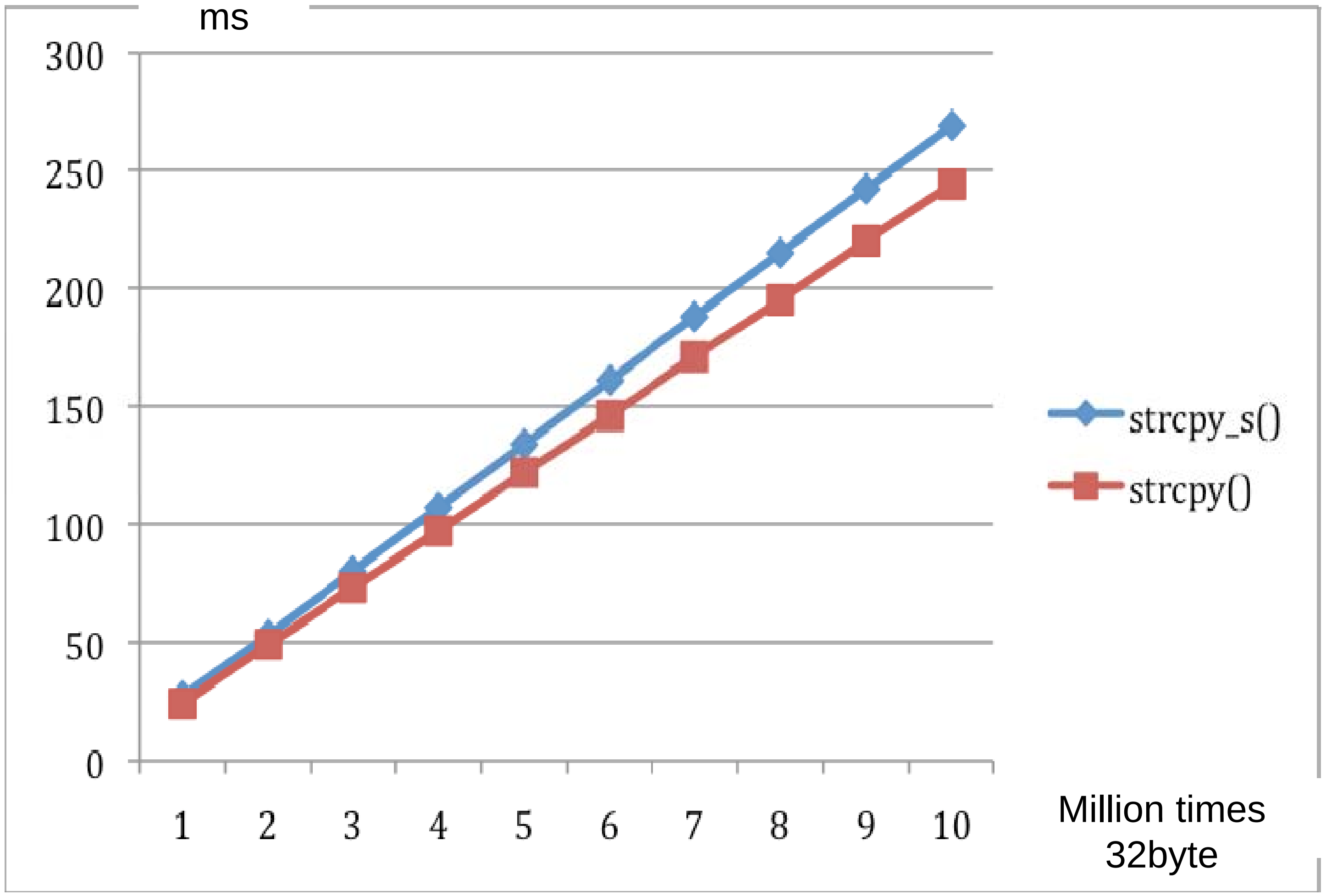
If Safe C check the buffer is overlapped, it will empty the dest string.

strcpy_s of MS


Microsoft Visual C++ Debug Library

```
Debug Assertion Failed!

Program: ... doc\Sec Guide doc\MS_Safec\testmssafec\Debug\testmssafec.exe
File: f:\dd\vctools\crt_bld\self_x86\crt\src\tcscpy_s.inl
Line: 30

Expression: (L"Buffer is too small" && 0)

For information on how your program can cause an assertion
failure, see the Visual C++ documentation on asserts.

(Press Retry to debug the application)
```

strcpy/strcpy_s Performance



How does string API avoid buffer issue

Which API will cause to set dest to empty?

- strcpy_s strncpy_s strcat_s strncat_s
- strcpyfld_s strcpyfldin_s strcpyfldout_s

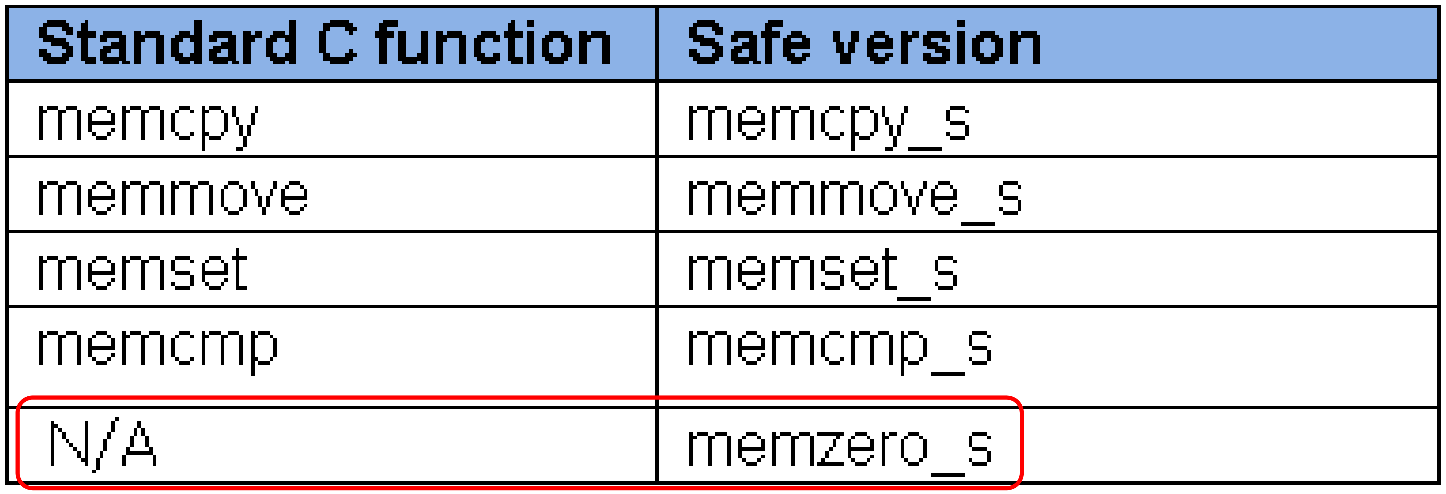
What kinds of error will set dest to empty?

ESOVRLP	Buffer overlap
ESUNTERM	unterminated string Like: dest[dmax-1] is not '\0'
ESNOSPC	not enough space

What is the default action?

- The default will only set the first byte to '\0'
- if want all bytes were set to '\0', please define SAFE_LIB_STR_NULL_SLACK.
- Or redefine the error handler.

Memory API list



Standard C function	Safe version
memcpy	memcpy_s
memmove	memmove_s
memset	memset_s
memcmp	memcmp_s
N/A	memzero_s

How does memory API avoid buffer issue

Which API will cause to set dest content to 0?

- memmove_s
- memcpy_s

What kinds of error will cause to set dest to 0?

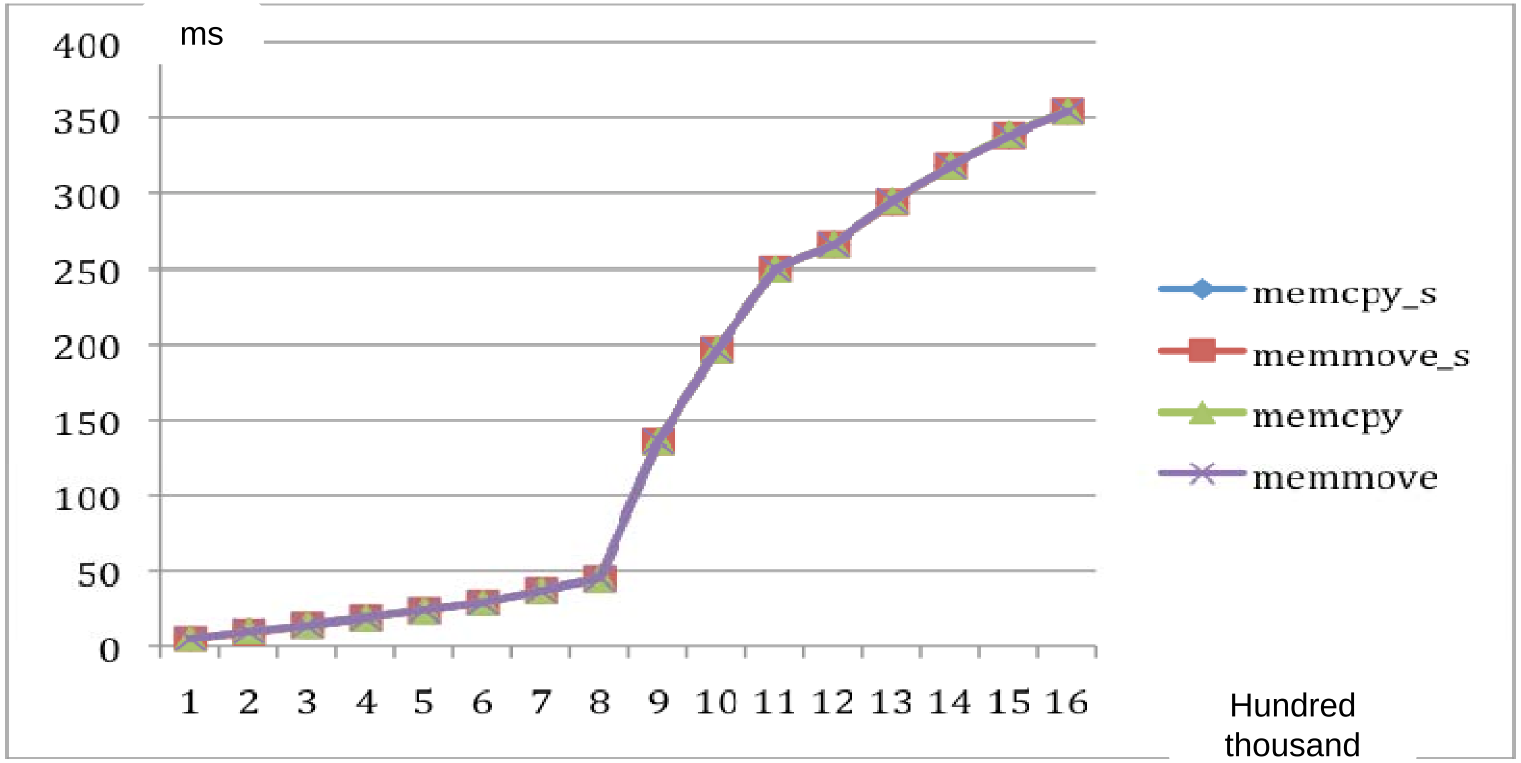
ESZEROL	smax is 0
ESNULLP	src is NULL
ESLEMAX	smax exceeds dmax
ESOVRLP	Memory overlap

What is the default action?

- the default will set all bytes to 0

Memory API- Performance

For Safe C memcpy_s and memmove_s are same. They call the same API.



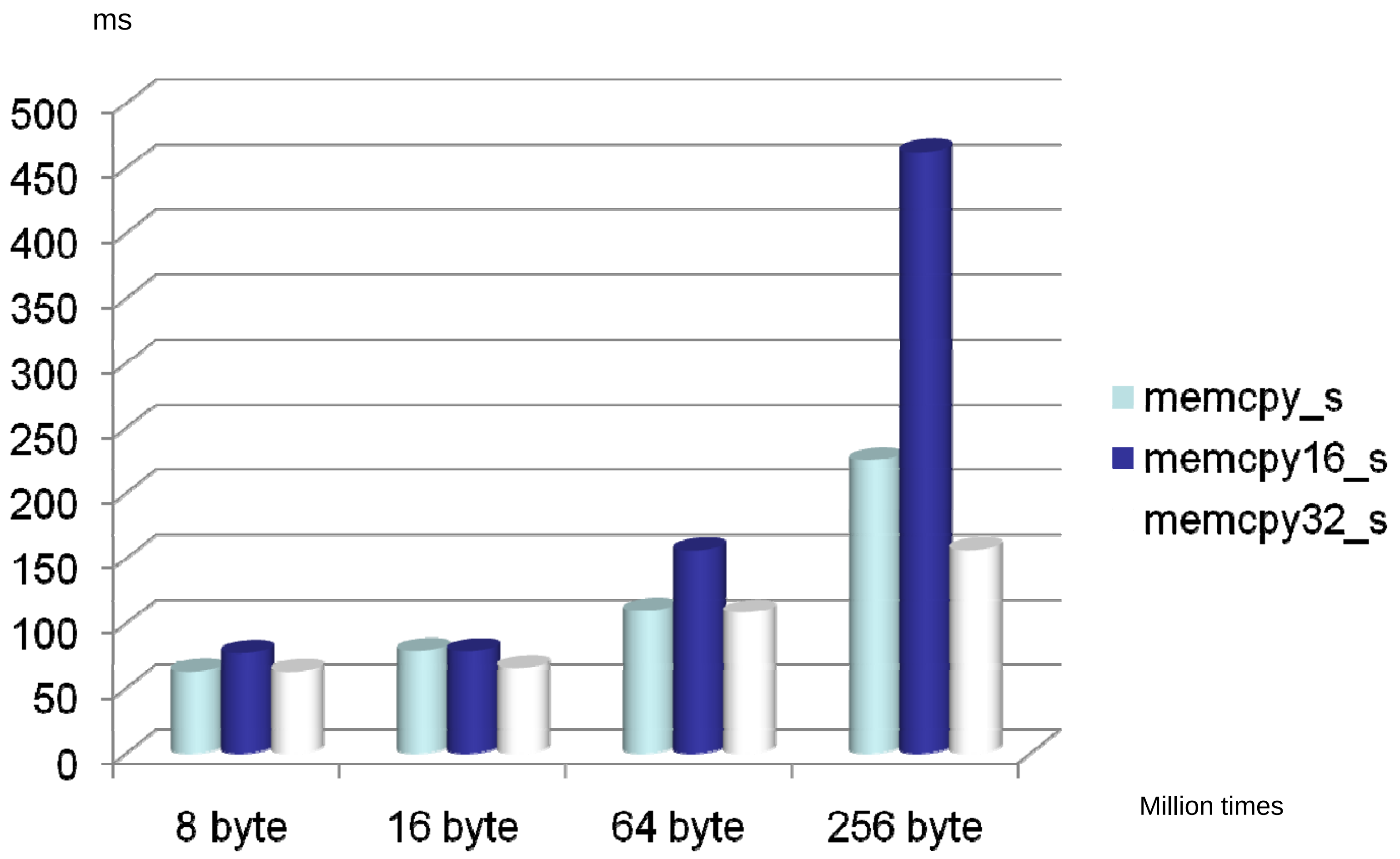
memcpy_s, memmove_s vs memcpy, memmove

Memory API

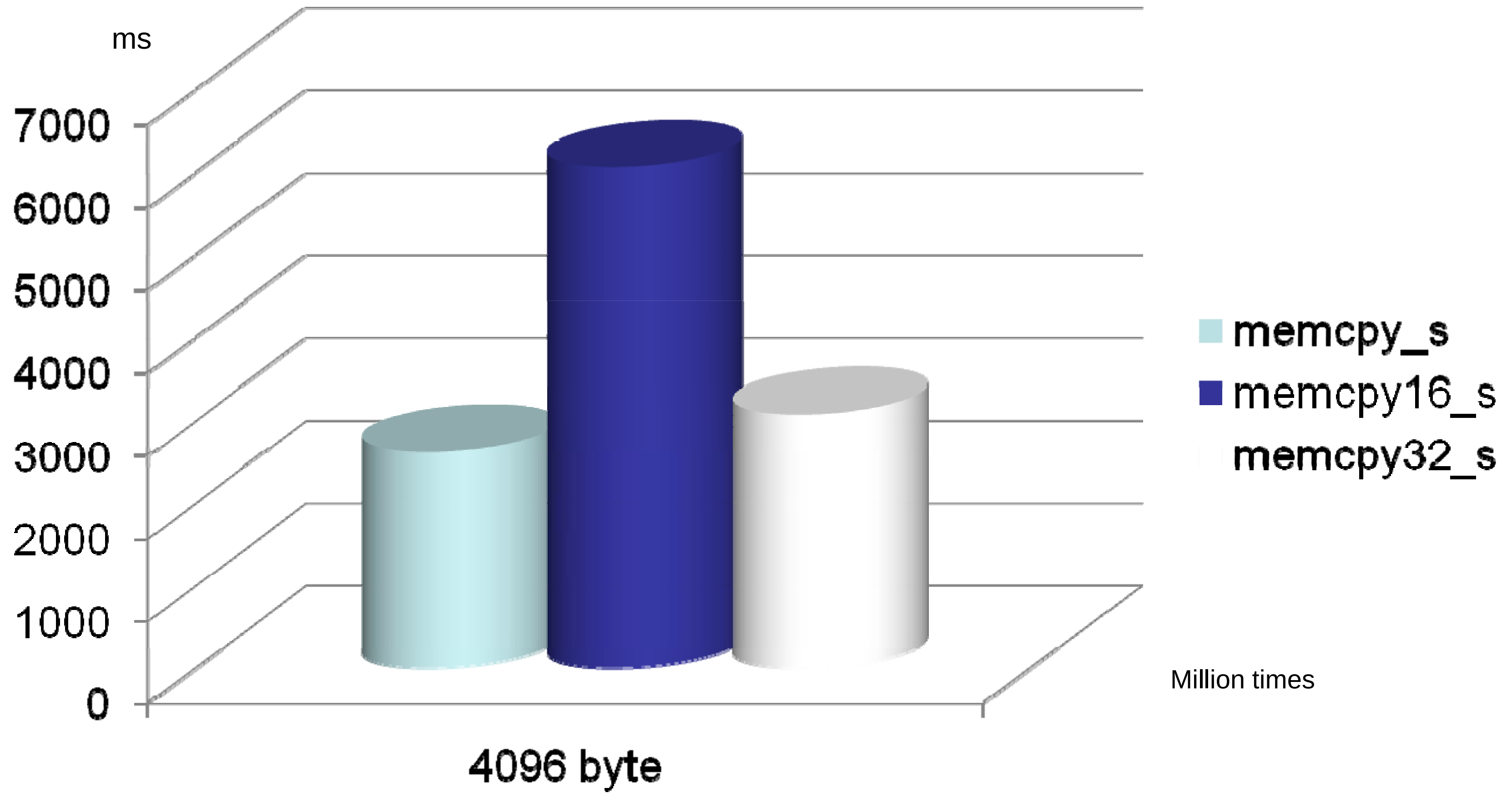
There are 3 APIs were provided by safe C for every standard API

Void *	Uint16 *	Uint32 *
memcpy_s	memcpy16_s	memcpy32_s
memmove_s	memmove16_s	memmove32_s
memset_s	memset16_s	memset32_s
memzero_s	memzero16_s	memzero32_s

Memory API- Performance test result I



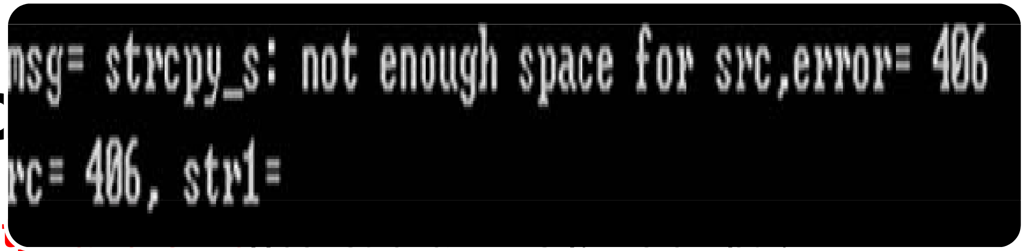
Memory API- Performance test result II



Error handler

The default handler

Simple error message to console



```
msg= strcpy_s: not enough space for src,error= 406
rc= 406, str1=
```

How to use your c

typedef void (***safe_lib_constraint**
errno_t error);

safe_lib_constraint_handler_t **safe_lib_set_constraint_handler**(

safe_lib_constraint_handler_t handler)

What kinds of platforms can use

Windows

MAC

Linux

Solaris

AIX

How to use it on Solaris?

The type in safe_types.h has conflict with inttypes.h

- int8_t int16_t int32_t uchar_t uint8_t uint16_t uint32_t ushort
- ulong ulonglong rsize_t

- **safe_types.h**
- #ifdef SOLARIS
- #include <inttypes.h>
- #else
- #endif

Safe C Caution I --- about case

The API name with case means insensitive

- strcasestr_s
- strcasecmp_s

Safe C Caution II– memset_s

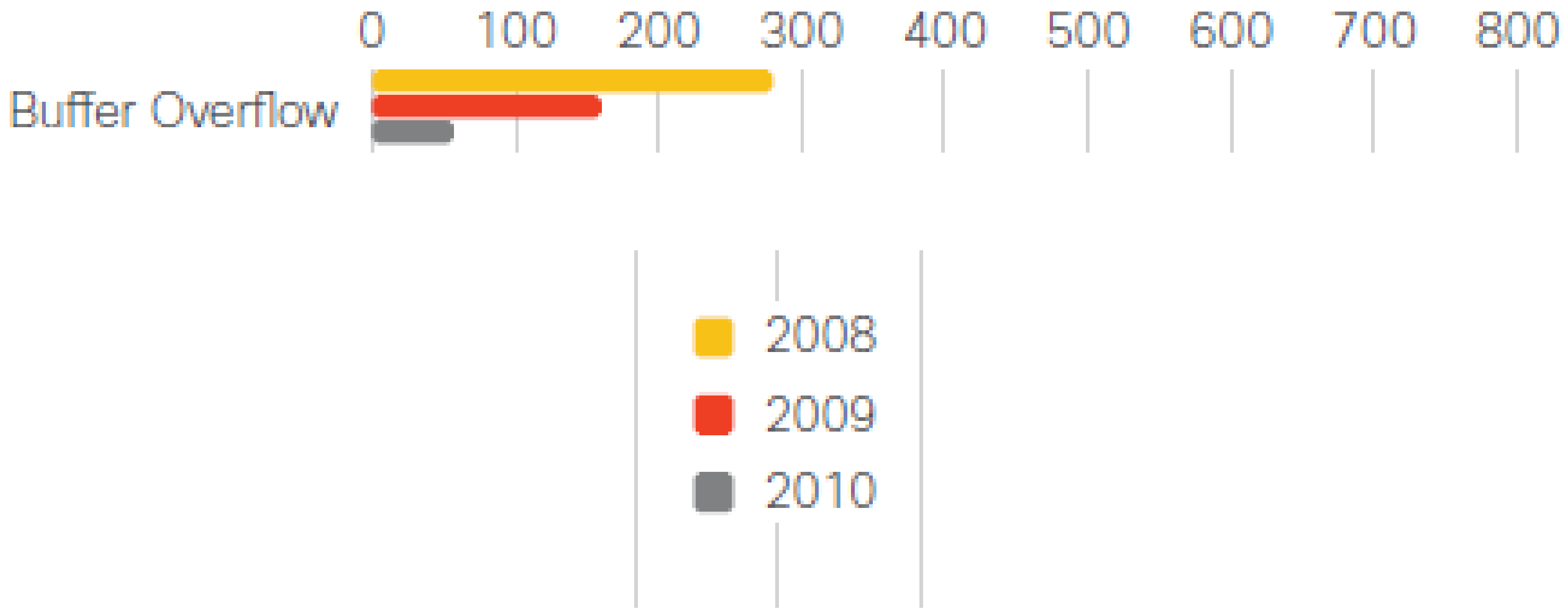
```
errno_t memset_s (void *dest, rsize_t len uint8_t value
        void*   memset(void *s int c , size_t n );
```

Use memzero_s to set memory to 0.

Safe C Caution III

Safe is based on the **correct** size of destination buffer.

The result of using Safe C



Summary & Conclusion