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Minds in Motion

Improving Embedded Software Using Lint with Code Composer Studio™ (CCStudio) IDE

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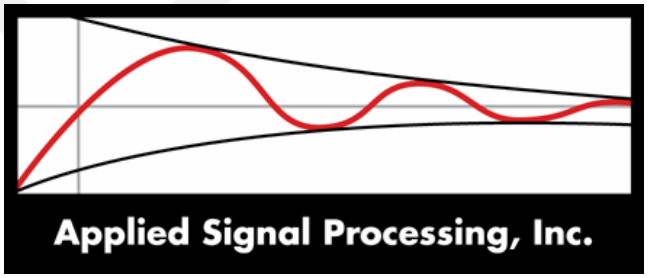

Applied Signal Processing, Inc.

- Statement: Improving Embedded Software Using Lint with CCStudio.
- Education
  - BS-EE, CS UW-Madison 84
  - MS-EE UW-Madison 87
  - Math Minor, ABD EE UW-Madison
- Experience
  - Active Noise and Vibration Control (Automotive, Aerospace)
  - Acoustic Projects
  - File System Projects
- Bias
  - “Ancient”
  - TI Third Party (always looking for work!)
  - No affiliation with PC-Lint other than satisfied customer.

Target Audience

- DSP software developers
- Microcontroller software developers
- Software managers
- Project managers

Session Topics

- C Language Challenges - Why you need Lint*
- What Lint can do for you
- How to integrate Lint into CCStudio IDE
- How to configure Lint for your HW/Application
- Examples where Lint saved the day

*C++ is similar but not covered by this talk

Software Challenges

- A Byte is not necessarily 8 bits
- Various size of pointers, floats, doubles, long long, etc…
- Access to hardware registers (r/w, volatile, cregister, various width)
- Variables in ROM/Flash rather than RAM blocks with different performance characteristics
- Libraries with different development standards/styles

Table 5–1. TMS320C55x C/C++ Data Types

Type	Size	Representation	Minimum Value	Maximum Value
char, signed char	16 bits	ASCII	–32 768	32 767
unsigned char	16 bits	ASCII	0	65 535
short, signed short	16 bits	2s complement	–32 768	32 767
unsigned short	16 bits	Binary	0	65 535
int, signed int	16 bits	2s complement	–32 768	32 767
unsigned int	16 bits	Binary	0	65 535
long, signed long	32 bits	2s complement	–2 147 483 648	2 147 483 647
unsigned long	32 bits	Binary	0	4 294 967 295
long long	40 bits	2s complement	–549 755 813 888	549 755 813 887
unsigned long long	40 bits	Binary	0	1 099 511 627 775
enum	16 bits	2s complement	–32 768	32 767
float	32 bits	IEEE 32-bit	1.175 494e–38	3.40 282 346e+38
double	32 bits	IEEE 32-bit	1.175 494e–38	3.40 282 346e+38
long double	32 bits	IEEE 32-bit	1.175 494e–38	3.40 282 346e+38
pointers (data) small memory mode large memory mode	 16 bits 23 bits	Binary	0	 0xFFFF 0x7FFFFF
pointers (function)	24 bits	Binary	0	0xFFFFFF

What can Lint do? (for you)

- Static analysis tool
- Lint is a C preprocessor. Checks C/C++ source code and find bugs, glitches, inconsistencies, non-portable constructs, redundant code, and much more.
- Lint can look across multiple modules and enjoys an added perspective
- Does not replace compiler/linker
- Does not perform run time analysis

Integrating Lint to CCStudio

- Unit Lint command
- `Lint-nt.exe –u HW_options.lnt module0.c`
- Global Lint command
- `Lint-nt.exe HW_options.lnt *.lob`
- Modify HW_Options.lnt for processor
- Modify ApplicationSpecific.lnt for project

HW_options.lnt

- Data Types
  - -sb8, -si4 // C67xx
  - -sb16, -si1 // C54xx
  - -s32, -si1 // C3x, C4x
- Compiler specific predefined macros
  - _TMS320C6X, _LITTLE_ENDIAN
- Reserved keywords
  - inline
  - warn
  - Cregister
- Command line defines
  - _DEBUG
  - CHIP_6713
- Include Directories
- Message formatting and suppression
- Libraries can have different (less stringent) lint policy

ApplicationSpecific.Int

- Command line defines
- Application specific include paths
- Suppress messages about linker defined symbols
  - esym(526,_STACK_SIZE)
- Suppress messages about specific functions
  - esym(528,cos)
- Suppress messages about application variables and functions
  - esym(552,assert_line)

Lint Inline

- Possible to suppress specific messages within a module
- Suppress within a function or block of code
- Suppress for a line of code
  - **ASSERT**(0**==CheckFreeDiskSpace**());
    //lint!e666

Review

- Lint is a static analysis tool
- Easy to integrate unit and global Lint checks within CCStudio
- Initial flood of messages can be handled by correct option configuration
- Review of messages will probably stimulate coding changes
- Get rid of the false-positives detections
- Next: Subtle Coding Bugs

Real Life Examples

- Mixed size
- Operator precedence
- Structure initialization
- Overflow of shift
- Global wrap-up

Mixed sizes.

```
int function3(Uint32 a, int b)
{
    int ret_value;

   ret_value=a;
    return(ret_value);
}   //  function3().
```

"Module1.c", line 59: warning: Info 712: Loss of precision (assignment) (unsigned long to int)

Operator Precedence

```
#if (0)
    ret_value=a<<shift+1;   // Implies a<<(shift+1)
  #else
    ret_value=(a<<shift)+1;   // Desired.
  #endif
```

"Module1.c", line 73: warning: Info 701: Shift left of signed quantity (int)

"Module1.c", line 73: warning: Warning 504: Unusual shift operation (right side unparenthesized)

Structure Initialization

```
DMA_Config my_dma_config=
{
    0,0,0,0,0
};
```

"module2.c", line 21: warning: Info 785: Too few initializers for aggregate 'my_dma_config'

Overflow in shift constant

```
/*!
    Macro for building Q values from non-negative values of floating point x less than
     2^(15-Q).
*/
#if (0)
   #define QCONST16_POS(x,q) ( (Int16)(+0.5f+(x)*( 1<<(q))) )
#else
   #define QCONST16_POS(x,q) (Int16)min(32767,+0.5f+(x)*(1U<<(q)))
#endif

Int16 one_12=QCONST16_POS(1.0,12);
Int16 one_15=QCONST16_POS(1.0,15);
```

"Module0.c", line 41: warning: Warning 648: Overflow in computing constant for operation: 'shift left'

Global Wrapup

- "Module1.c", line 20: warning: Error 15: Symbol 'x_array' redeclared (size,precision) (line 39, file main.c)
- Info 765: external 'one_12' (line 40, file Module0.c) could be made static
- Info 714: Symbol 'one_12' (line 40, file Module0.c) not referenced
- Info 765: external 'one_15' (line 41, file Module0.c) could be made static
- Info 714: Symbol 'one_15' (line 41, file Module0.c) not referenced
- Info 765: external 'function2(unsigned long, int)' (line 16, file Module1.c) could be made static
- Info 714: Symbol 'function2(unsigned long, int)' (line 16, file Module1.c) not referenced

Summary

- Easy to integrate into CCStudio
- Option files can manage messages
- Incredibly inexpensive relative to cost of finding a single bug
- Regular use improves software coding quality
- Topics not covered
  - C++
  - Strong Types (Q math, enumerations)
  - Dynamic checks
  - ASSERT(), VERIFY()

References

- "Writing Solid Code", Steve Maguire, Microsoft Press.
- "Debugging Applications", John Robbins, Microsoft Press.
- PC-Lint for C/C++, Gimpel Software.
- "The C Programming Language", Kernighan and Ritchie, Prentice Hall Software Series.

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