CSE 30: Computer Organization and Systems Programming

Lecture 4: Overflow
Memory organization

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Announcements

• Fill out the partner form provided on Piazza by the end of the day

• Quiz is available on TED, complete by 11:30pm tonight
Overflow

- Overflow occurs when an addition or subtraction results in a value which cannot be represented using the number of bits available.
- For signed numbers overflow occurs if
  - On adding two positive numbers, the result is negative, or
  - On adding two negative numbers, the result is positive
Handling Overflow

• Overflow is a problem in modern day programs

• Hardware can detect when overflow occurs

• Software may or may not check for it
  – C and Java don’t!
How To Detect Overflow?

Q: In 2’s complement representation, overflow occurs on addition if there is a carry out of the most significant bit (sign bit).

A. True
B. False

In the above example carry 1, but there was no overflow.
How To Detect Overflow

Signed (2's Comp)

• Contention: On addition, an overflow occurs if and only if the carry into the sign bit differs from the carry out from the sign bit.

Example:

\[ \begin{array}{c|c}
A & B \\
\hline
0 & 0 \\
1 & 1 \\
\end{array} \begin{array}{c|c}
A + B \\
\hline
0 & 0 \\
1 & 1 \\
\end{array} \]

\[ \text{Overflow} = \text{Cin} \oplus \text{Cout} \]

\[ \text{Cin = 0} / \text{Cin = 1} \]

\[ \text{Cout = 0} / \text{Cout = 1} \]

(1) Add 2 positive nos. → result is -ve
MSB \[ \Rightarrow \text{Cin} \]
\[ 0 \]
\[ 0 \]
\[ 0 \]
\[ \Rightarrow \text{Cin = 1} \]
\[ \text{Cout = 0} \]

(2) Add 2 negative nos. → result is +ve
\[ 0 \]
\[ 0 \]
\[ 1 \]
\[ \Rightarrow \text{Cin = 0} \]
\[ \text{Cout = 1} \]
Will $0111_2 + 0101_2$ result in overflow?

A. Yes

B. No

C. It depends

- Unsigned $7 + 5 = 12 < 15$ (no overflow)
- Signed (2's comp) $7 + 5 = 12 > \frac{15}{2}$ (overflow)

Max positive number than can be represented in 4 bits using 2's comp
Will \(011111111011_2 + 111111101101_2\) result in overflow (assume 2’s comp)?

A. Yes

\(\textbf{B. No}\) (Adding a positive & negative no. will never result in over flow)

C. It depends
Programmer’s model of the computer

Stored program model

Registers (4 bytes in ARM)

bus

specify address

read/write data

Program + data (in binary format)

Memory (Main memory)

Processor
Memory Organization

• Sequence of cells in a linear arrangement
• Each cell stores 8 bits (a byte)
• ARM is byte addressable: Each cell has a memory address

Address

0x00

0x01

Can store 1 byte of information (8 bits)
A typical memory hierarchy

- small expensive $/bit fast
- big cheap $/bit slow

• so then where is my program and data??
Units of Memory

1KB
1MB
1GB
1TB
1PB
1EX
Memory Organization

• If N bits are used to represent memory addresses in a computer, we say it has an N-bit address space

• ARM is a 32-bit architecture

  1. 32 bit address space
  2. 32 bit registers
  3. 32 bit instructions
Memory

PI Q: How much memory can be supported on a 32-bit machine?

A. 2GB  
B. 4GB  
C. 8GB  
D. 16GB