



Computer Systems and Networks

ECPE 170 – Jeff Shafer – University of the Pacific

Endianness

Lab Schedule

Activities

➤ This Week

- Lab 9 – Network Programming

➤ Next Week

- Start MIPS Assembly Programming
(lecture for 1+ day)

Assignments Due

➤ Lab 9

- Due by Apr 4th 5:00am

Endianness

- **In typical computer memory, each address (location) stores one byte**
- If we have a one-byte integer, how is that stored in memory?
- If we have a two-byte integer, how is that stored in memory?
- If we have a four-byte integer, how is that stored in memory?

Endianness = Byte Ordering

Endianness Example

- 32-bit hexadecimal number
0x12345678
- Composed of 4 bytes:
0x12 0x34 0x56 0x78
(MSB) (LSB)
- Two possible arrangements:

Address	"Option A"	"Option B"
0	0x12	0x78
1	0x34	0x56
2	0x56	0x34
3	0x78	0x12

Endianness Example

- 32-bit hexadecimal number
0x12345678
- Composed of 4 bytes:
0x12 0x34 0x56 0x78
(MSB) (LSB)
- Two possible arrangements:
 - **Big Endian**
 - **Little Endian**

Address	Big Endian	Little Endian
0	0x12 (MSB)	0x78 (LSB)
1	0x34	0x56
2	0x56	0x34
3	0x78	0x12

Endianness

- **How is DEADBEEF₁₆ stored in little and big endian formats at address 21C₁₆?**
 - Little endian
 - 21C₁₆=EF₁₆
 - 21D₁₆=BE₁₆
 - 21E₁₆=AD₁₆
 - 21F₁₆=DE₁₆
 - Big endian
 - 21C₁₆=DE₁₆
 - 21D₁₆=AD₁₆
 - 21E₁₆=BE₁₆
 - 21F₁₆=EF₁₆

Big Endian –vs– Little Endian

Big-Endian CPU

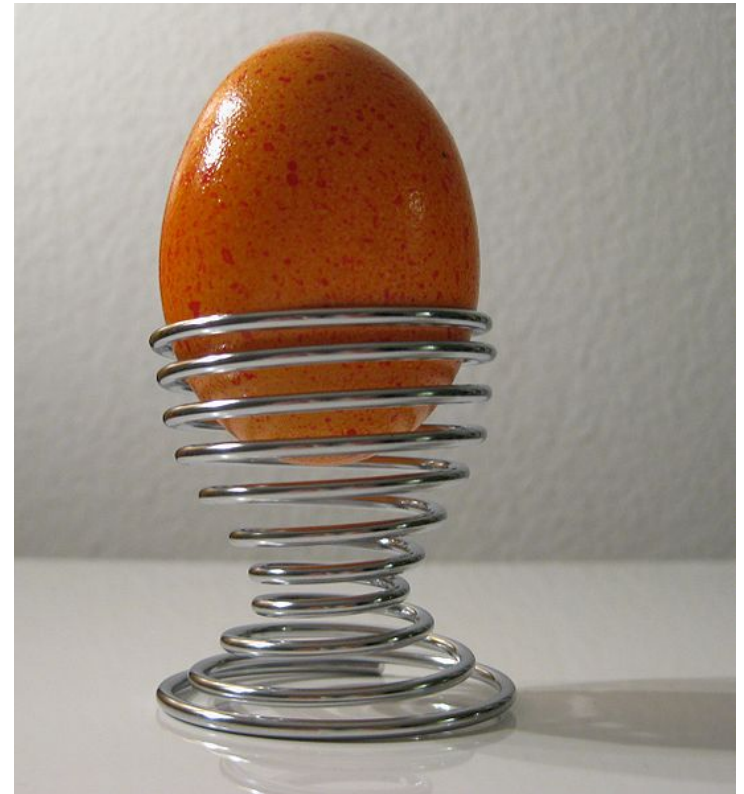
- **Most significant byte (MSB) comes first** (stored in lower memory address)
- Examples
 - Motorola 68000
 - Java virtual machine
 - IBM PowerPC (by default, can also be little endian)

Little-Endian CPU

- **Least significant byte (LSB) comes first** (stored in lower memory addresses)
- Examples
 - Intel x86/x86-64
 - DEC Alpha
 - ARM (by default, also can be big endian)

Etymology of “Endiann”

- Origin in 1980s
- Reference to Swift's *Gulliver's Travels*, in which the Lilliputians were divided into two camps:
 - Those who ate their eggs by opening the ‘big’ end
 - Those who ate them by opening the ‘little’ end
- In other words,
a trivial distinction



Do I Care?

- **When do I need to care that some computers are big-endian and others are little endian?**
 - What happens if I open big-endian data on a little-endian computer?

- Endianness must be considered whenever you are **sharing data** between different computer systems
 - Reading/writing data files to disk
 - Reading/writing data files to network

Best Practices

- **Pick one format and stick with it!**
 - Example: Data sent over the network will always be in *big-endian* format regardless of who sends it
 - *Networks are big-endian “by tradition”*
 - Example: Data written to disk will always be in *little-endian* format regardless of who writes it

- **Convert between data storage/transfer format and internal representation as needed**
 - Example: Little-endian machines convert to big-endian before sending data onto the network (and convert back upon receiving data from the network)

Examples in Industry

Little-Endian Format	Big-Endian Format	Variable or Bi-Endian Format
BMP (Windows* & OS/2)	PSD (Adobe Photoshop*)	DXF (AutoCAD*)
GIF	IMG (GEM Raster*)	PS (Postscript*, 8 bit interpreted text, no Endian issue)
FLI (Autodesk Animator*)	JPEG, JPG	POV (Persistence of Visionraytracer*)
PCX (PC Paintbrush*)	MacPaint	RIFF (WAV & AVI*)
QTM (MAC Quicktime*)	SGI (Silicon Graphics*)	TIFF
RTF (Rich Text Format)	Sun Raster	XWD (X Window Dump*)
	WPG (WordPerfect*)	
Bus Protocols	Network Protocols	Bus Protocols
Infiniband	TCP/IP	GMII (8 bit wide bus, no Endian issue)
PCI Express	UDP	
PCI-32/PCI-64		
USB		

Table 2- Common file formats