CMSC 131

Object-Oriented Programming I

Computer Organization

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This material is based on material provided by Ben Bederson, Bonnie Dorr, Fawzi Emad, David Mount, Jan Plane

Computer Organization

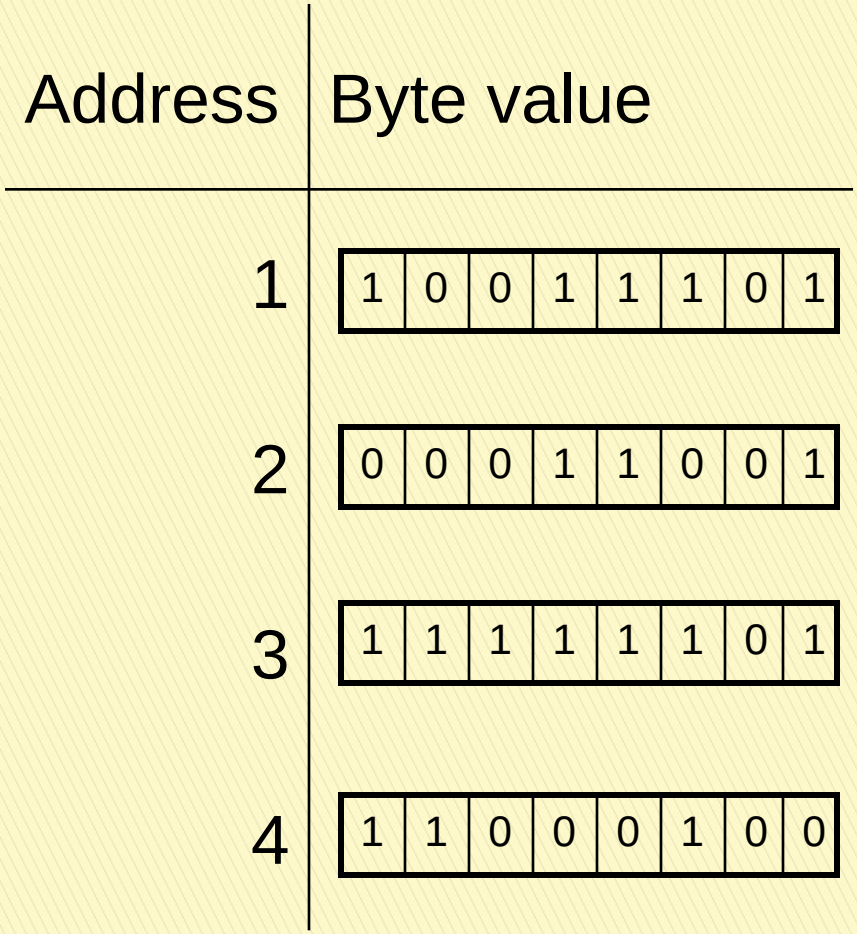
- Hardware: physical parts of computer
  - Monitor, mouse, keyboard
  - Chips, boards
  - Cables, cards
  - etc.
- Software: non-physical (“logical”) parts of computer
  - Programs = instructions for computer to perform

Hardware Overview

- **CPU** → central processing unit "brain"
  - Executes the "instructions" in programs
- **Main memory** → random-access memory = "RAM"
  - Stores data that CPU accesses, including instructions
  - FAST, but temporary; wiped out when computer is shut off!
- **Secondary memory**→ Hard disks, CDs, DVDs, flash memory, etc.
  - Stores data that can be loaded into main memory
  - SLOWER, but permanent
- **I/O devices**
  - How you communicate with your machine
  - Keyboard, monitor, mouse, speakers, etc.
- **Networking equipment**
  - How others communicate with your machine
  - Networking "cards", cables, etc.

Main Memory

- Computer data consists of off and on pieces (often written as 0's and 1's)
- bit: A single cell in main memory that can hold either a 0 or 1
- *byte*: A sequence of 8 bits
- word: Unit of memory (often a sequence of 4 bytes)
- Main memory: table of bytes indexed by "addresses"



How Many Different Values in a…

- Bit?
  2
- Two bits?
  4 = 2 x *2*
- Byte?
  256 = 2 x *2* x *2* x *2* x *2* x *2* x *2* x *2* = 2^8
- Word?
  4,294,967,296 = 2^{32}
- In general k bits can represent 2^k *values*

Other Standard Terminology

Prefixes for bit and byte multiples						
Decimal			Binary			
Value	SI		Value	IEC		JEDEC
1000	k	kilo-	1024	Ki	kibi-	K kilo-
1000^2	M	mega-	1024^2	Mi	mebi-	M mega-
1000^3	G	giga-	1024^3	Gi	gibi-	G giga-
1000^4	T	tera-	1024^4	Ti	tebi-	
1000^5	P	peta-	1024^5	Pi	pebi-	
1000^6	E	exa-	1024^6	Ei	exbi-	
1000^7	Z	zetta-	1024^7	Zi	zebi-	
1000^8	Y	yotta-	1024^8	Yi	yobi-	

One kilobyte is approximately one kibibyte which is approximately 1000 bytes.

$2^{10} = 1024$

$2^{20} = 1024^2$

$2^{30} = 1024^3$

How Are Characters, Etc., Represented?

Via *encoding schemes*

Example: ASCII (American Standard Code for Information Interchange)

- Standard for encoding character values as bytes
- In ASCII:
  - ‘A’ 01000001
  - ‘a’ 01100001
  - ‘,’ 00101100
  - etc.

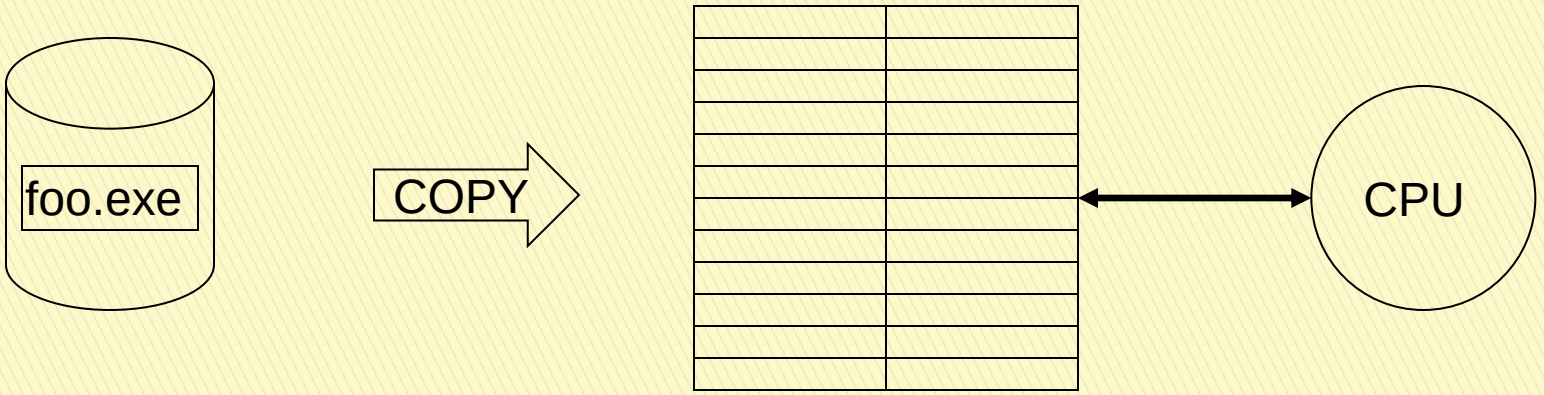
Other Character Encodings

- International support?
  - Unicode
- Most common variation: UTF-8
  - Backwards compatible with ASCII

Software Overview

- **Two levels →** Operating System and Application
- **Operating system→** manages computer's resources; typically runs as soon as computer is turned on. Typical responsibilities:
  - *Process management* →Determines when, how programs will run on CPU time
  - *Memory management*
  - *I/O, window system*
  - *Network control*
  - *Security*
- **Applications →** programs users interact directly with; usually are explicitly run. Examples:
  - *Word processors*
  - *Games*
  - *Spreadsheets*
  - *Music software*
  - *Java Programs*
  - *Etc*

How Programs Are Executed



Program “foo” initially stored in secondary storage

Program copied into main memory

CPU executes program instruction-by-instruction

Programming Languages

- Used to write programs that run on computers
- Generations of programming languages
  - 1st (1GL): machine code
  - 2nd (2GL): assembly code
  - 3rd (3GL): procedural languages
  - 4th (4GL): application-specific languages
  - 5th (5GL): constraint languages

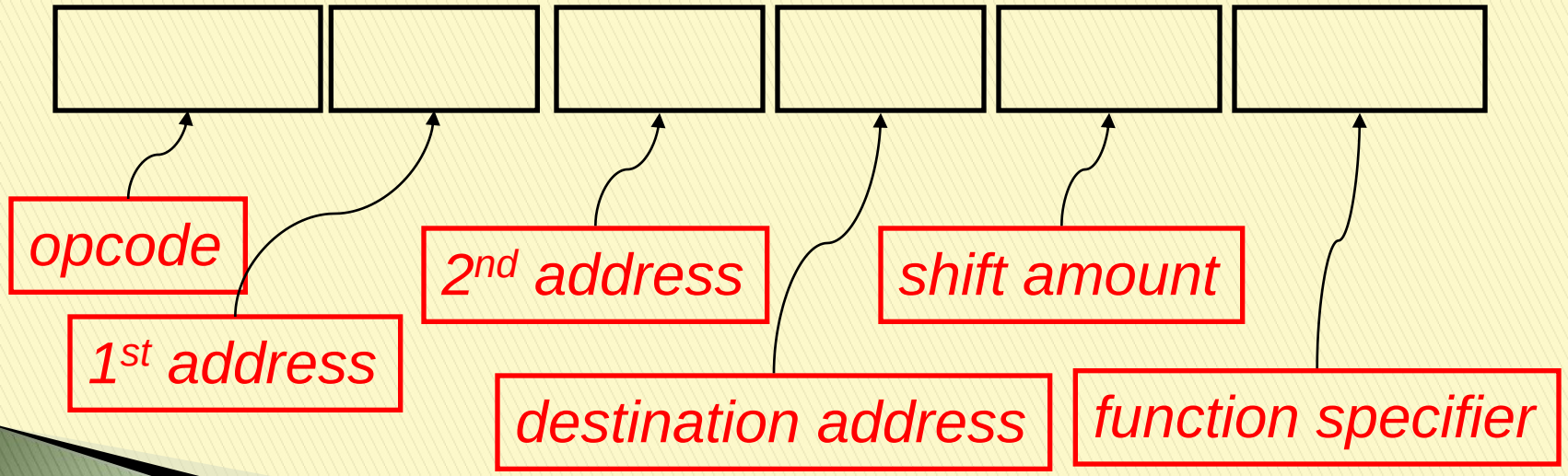
1st Generation: Machine Code

- Recall: computer data is 0's and 1's
- In machine code, so are programs!
  - Program → sequence of instructions
  - Machine code → instructions consist of 0's and 1's
- Next slide → example machine code instruction from MIPS (= "Microprocessor without interlocked pipeline stages") architecture
  - Popular in mid-, late 90s
  - Instructions are 4 bytes long

Example MIPS Instruction

- "Add data in addresses 1, 2, store result in address 6":
  00000000001000100011000000100000
- ???

  000000 00001 00010 00110 00000 100000



2nd Generation: Assembly

- Problem with 1GLs: Who can remember those opcodes, addresses, etc., as 0's, 1's?
- Solution (1950s): *assembly language*
  - Use *mnemonics* → descriptive character strings for opcodes
  - Let programmers give descriptive names to addresses
- MIPS example revisited:

```
add $1, $2, $6
```

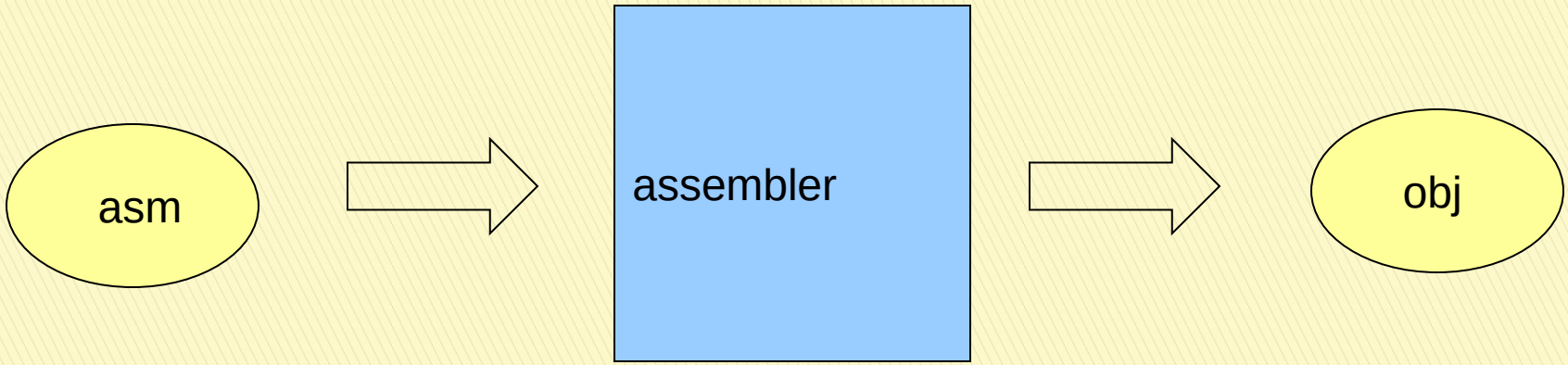
instead of

```
00000000001000100011000000100000
```

for "add contents of addresses 1, 2, store result in 6"

Assemblers

- Computers still only work on machine code (1GL)
- Assembly language is not machine code
- *Assemblers* are programs that convert assembly language to machine code (“object code”)



3rd Generation: Procedural Languages

- Problems with 2GLs
  - *Platform dependency*
    - Different kinds (*architectures*) of computers use different instruction formats

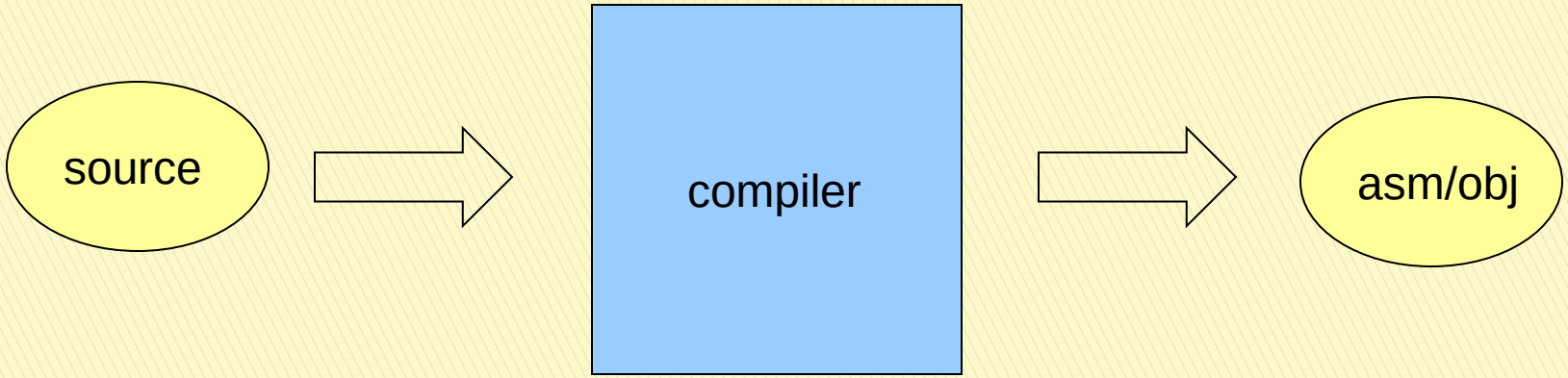
      E.g. x86, Pentium, 68K, MIPS, SPARC, etc.
    - 1GL / 2GL programs written for one kind of machine will not work on another
  - *Low level* → programs difficult to understand
- Solution (60s → now): *procedural languages*

3rd Generation: Procedural Languages

- Procedural languages
- Higher-level, “universal” constructs
- Examples:
  - 1950's → early 60s : Fortran, Cobol
  - 1958 → Lisp, invented for AI, still used!
  - late 60's → Algol, first language that "looks" modern
  - 70's → Pascal (like Algol, but simpler), used for teaching
  - 80's → C became popular (although it was "invented" in 70's)
    C++ "C with classes , object oriented”
  - 90's → Java, Fully object oriented
  - 00's → C# (Microsoft's answer to java)
- List of computer programming languages
  - http://en.wikipedia.org/wiki/List_of_programming_languages

Compilers

- Computers can only execute machine code
- *Compilers* are programs for translating 3GL programs ("source code") into assembler / machine code



Interpreters

- Another way to execute 3GL programs
  - Interpreters take source code as input
  - Interpreters execute source directly
  - Much slower than compiled programs
- *Debuggers* are based on interpreters
  - Debuggers support step-by-step execution of source code
  - Internal behavior of program can be closely inspected
- Common interpreter?

Object-Oriented Terminology

- Procedural-oriented languages
  - Programming centers around "actions" (verbs)
- Object Oriented Languages
  - Centered on objects (nouns)
- Object
  - Principal entities that are manipulated by the program (nouns)
- Class
  - A "blueprint"/recipe that defines the structure for one or more objects
- Method
  - java term for a "function", a "procedure" or a "subroutine"
  - this is the code that does something (verbs)
- Why we prefer the object-oriented approach?
  - One big reason: recycling
- System Example