BU Summer Challenge
Computer Science

Computer Systems
Computer Systems

- “Abstractions that enable humans to use computers efficiently.”
- Systems simplify the use of certain features(s) of the computers.
- Systems provide ways to perform complicated tasks, based on simpler ones.
- Systems also ensure that such use is fast and reliable.
- Operating Systems use built-in simple hardware instructions to enable/perform complicated tasks efficiently.
Computer Architecture

- Central Processing Unit (CPU)
- Hard Drive / Hard Disk / Memory Disk
- RAM / Main Memory
- Input/Output Devices (Keyboard, Wireless Adapters...
Computer Architecture

- Process = a running program.
- Programs are stored on hard disk.
- Programs are moved into RAM when they run.
- Process = program code + data (variables) in memory
Program Memory

0xBFFFFFFF
- Stack
  Used for storing function arguments and local variables

0xB0000000
- Unused Memory

0xA0000000
- Heap
  Dynamic Memory - malloc()

0x90000000
- .bss
  Uninitialized Data

0x80000000
- .data
  Initialized Data

0x80480000
- .text
  Program code
Operating Systems
Operating Systems

- Windows (7, 8, 10), Mac OS X (Sierra, El Capitan, Yosemite), Android, iOS. Linux (Ubuntu, Fedora)

- An operating system is a large collection of programs that sit between hardware and user programs.

- Operating Systems is like an infrastructure for other programs.

- Operating Systems must be very reliable and efficient.
What do Operating Systems do?

- Program loading/running.
- Process Scheduling.
- Inter-Process Communication.
- Process Synchronization.
- Memory (RAM) Management.
- Disk Management.
- Device Management (drivers).
Database Systems
Why Do We Need Database Systems?

- Think of Facebook.
- Tons of users = tons of data.
- Fast access to any portion of the data.
- Many users connecting at once.
- New data is added frequently.
Why Do We Need Database Systems?

- Simplest database is a file or a spreadsheet.
- Searching for data in a file requires you to read all the file (takes time).
- Changing and deleting data requires you to read all the file.
- What if certain data elements have relations with one another?
Database Systems Features

- Manage storing and moving data from hard drives to RAM.
- Create and maintain indexes to locate location of data quickly.
- Allow specifying relationships between data elements.
- Provide ways to express and ensure integrity constraints on data.
- Support backup, replication, and distribution of data.
Database Systems Features

● Database systems are really complicated!

● Implement specific programming languages and easy to use libraries for efficient usage of data.

● Implement complicated low-level file systems and storage management.

● Implement distributed protocols for ensuring consistency between copies/replicas of the same database, or for distributing large data between many databases.
Database Systems Features

- Relational Table (SQL) based: MySQL, MS SQL Server, Postgres.
- Key-Value Store: Big Table, Amazon Dyno.
- Column-Based: HBase.
- Graph-Based: Neo4j.
- Document-Object based: MongoDB.
Web Servers and Frameworks
What are Web Servers/Frameworks?

- Collection of software that runs on Computers.
- These software are what makes a computer become a server.
- Intermediate layer between the hardware/network and the code of the server.
- Match URL to functions in the server code (routes), handles part of the encoding of parameters and results, provide ways to interact with databases, etc.
- Have to be really fast to support many connections quickly.
Networks
How Do Networks Work?

Network Layers

- **Physical**: Transmitting bits (row data) over a connection. Cables + Network Card/Chip.

- **Data**: Moves data between physically between adjacent computers. Detects and corrects errors from physical layer.

- **Network**: Sending data in packets and routing.
How Do Networks Work?

Network Layers

- **Transport**: Reliable data transfer between any computers in a network.

- **Session**: Manages continuous interactions (keeps a connection open).

- **Presentation**: Changes data from/to usable form. Compression, encryption, encoding.

- **Application**: Provides easy ways for applications to communicate. Email, File Transfer.
7 Layers of OSI Model

DATA

Application Layer

Presentation Layer

Session Layer

Transport Layer

Network Layer

Datalink Layer

Physical Layer

SENDER

DATA

Application Layer

Presentation Layer

Session Layer

Transport Layer

Network Layer

Datalink Layer

Physical Layer

RECEIVER
Distributed Systems
Big Data

- Big Data: Data that is too big to fit on a single powerful computer.

- Big Data: Data that is too big for processing on a single powerful computer.

- How to handle big data?
  split it among many many computers (cluster), divide up the work, combine results.
Byzantine General Problem!

Coordinated Attack Leading to Victory

Uncoordinated Attack Leading to Defeat
Byzantine General Problem!
Distributed Systems

- Implement protocols that allow many computers to work together on large data.
- Reliable communications.
- Crash-detection and recovery.
- Malicious (evil) computers.
- Leader election, consensus, consistency.
- Distributed file system.
Distributed Systems

- Popular Distributed Systems: Hadoop, Spark!
- Extremely hot topic and in demand.