CMSC 132: OBJECT-ORIENTED PROGRAMMING II

Networking

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Networking

- **Internet**
  - Designed with multiple layers of abstraction
  - Underlying medium is unreliable, packet oriented
  - Packet-Switching
    - https://www.youtube.com/watch?v=vSlcoQowe9I

Internet (IP) Address

- **Unique address for machine on internet**
  - Get from ISP when connecting to internet
  - Allows network to find your machine
- **Internet Protocols IPV4, IPV6**
  - Define how data is sent between computers over packet-switched network
- **(IPV4) Internet Protocol Version 4**
  - 32-bit unsigned integer ⇒ 128.8.128.8
  - Domain name ⇒ cs.umd.edu
  - **localhost** ⇒ **127.0.0.1**
- **(IPV6) Internet Protocol Version 6**
  - 128-bit address
  - Designed to replace IPV4
  - Addresses exhaustion of addresses associated with IPV4 (now we have 2^128)
  - Format: http://msdn.microsoft.com/en-us/library/aa921042.aspx

IP Address (DNS)

- Domain Name System (DNS)
  - Protocol for translating domain names to IP addresses
    - Example: cs.umd.edu → 128.8.128.44
  - Multiple DNS servers on internet
  - DNS server may need to query other DNS servers
    - edu DNS server queries umd.edu server to find cs.umd.edu

Ports

- Abstraction to identify (refine) destination
  - Provide multiple destinations at single IP address
- Format
  - Unsigned 16-bit integer (0 to 65,535)
  - Ports **0** to **4096** often reserved & restricted
- Many ports pre-assigned to important services
  - 21 ftp (file transfer)
  - 23 telnet (remote terminal)
  - 25 SMTP (email)
  - **80** http (web)
  - Others
    - http://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers

Uniform Resource Locators (URLs)

- **Represent web resources**
  - Web pages
  - Arbitrary files
  - …
- **Examples**
  - http://www.cs.umd.edu/index.html
  - ftp://www.cs.umd.edu/pub/doc/csd_policies.pdf
  - https://login.yahoo.com/
  - file://dir/my.txt

Uniform Resource Identifier (URIs)

- Consists of
  - Scheme
    - http:
    - https: (secure http)
    - mailto:
    - ldap:
    - tel:
  - IP address (or domain name)
  - Port (optional, 80 if not specified)
    - http://www.cs.umd.edu:80/
  - Reference to anchor (optional)
  - Query terms
- URL (Uniform Resource Locator) → specific type of URI; reference to a web resource

Internet Connections

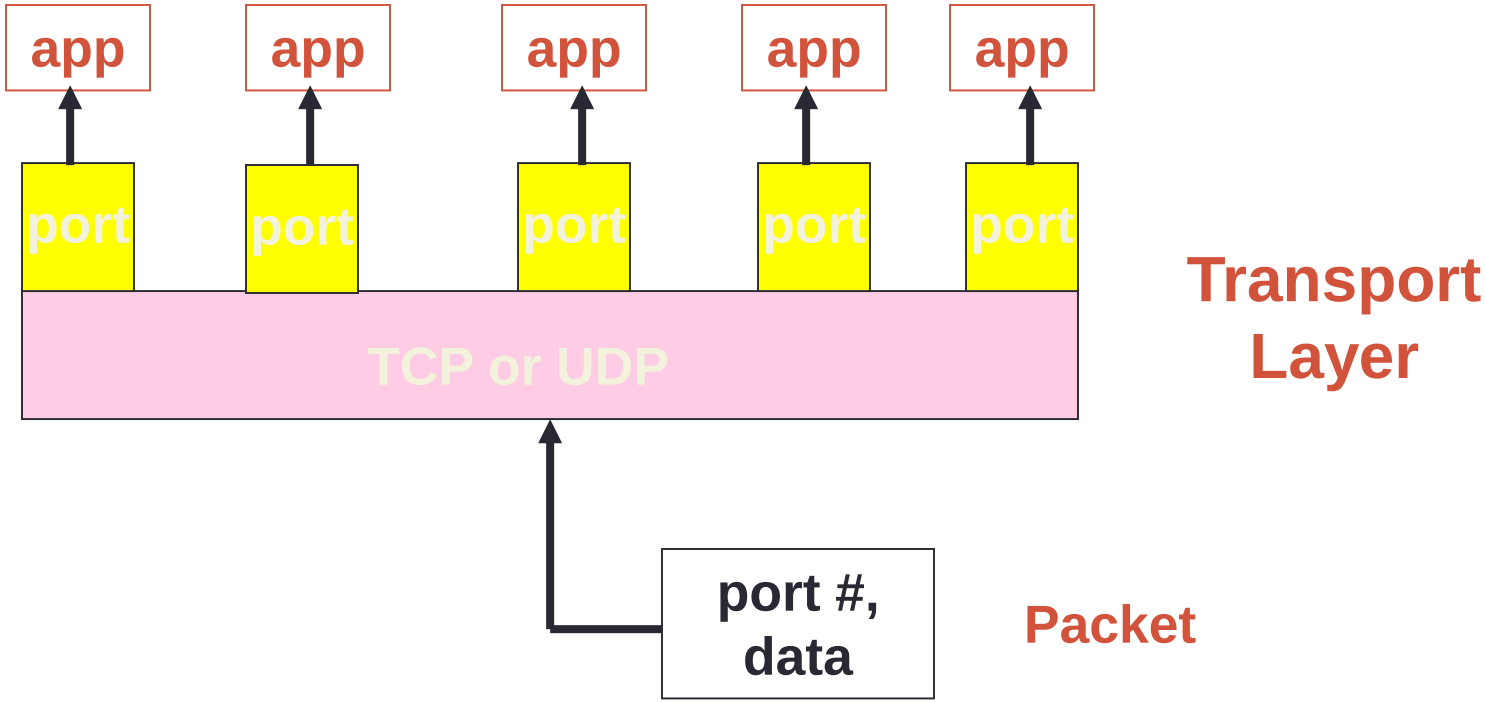
- Two types of connections: **TCP** and **UDP**
- **TCP**
  - Connection oriented
  - Provides illusion of reliable connection
    - Extra messages between sender / recipient
    - Resend packets if necessary
  - Reliable but more overhead for small messages
  - Application can treat as reliable connection
    - Despite unreliability of underlying IP (network)
  - **Examples:** ftp, ssh, http
  - **Vast majority of internet traffic is TCP**
- **UDP**
  - More like sending a postcard
  - Might get lost with no notification
  - Useful is some specialized cases
    - Messages are small
    - if a packet is lost, would rather just lose it than delay receipt of next packet

Sockets

- Application-level abstraction
  - Represents network connection
  - Implemented in software
  - Supports both UDP and TCP protocols
- History
  - Introduced in Berkley UNIX in 1980s
  - Networking API

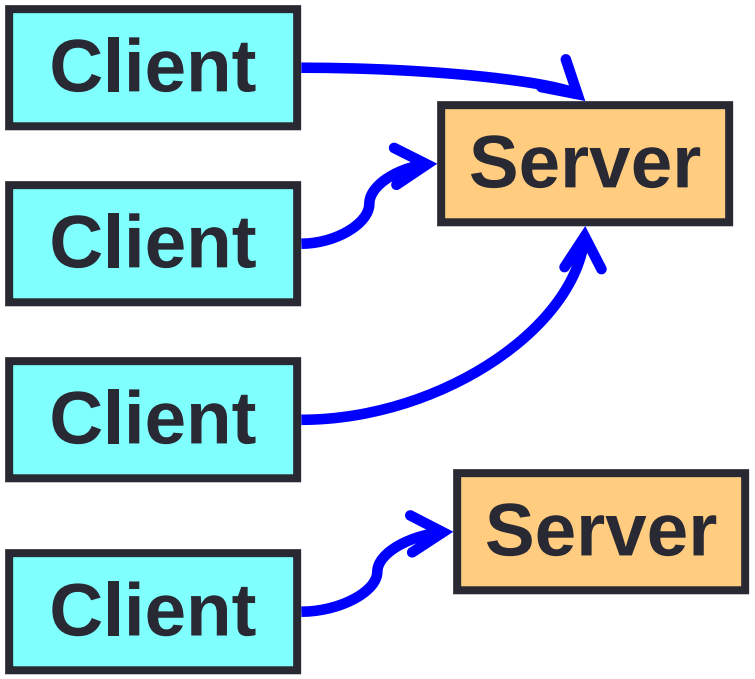
Sockets

- Socket is bound to port number
  - Receives data packet
  - Relays to specific port



Client / Server Model

- Relationship between two computer programs
- Client
  - Initiates communication
  - Requests services
- Server
  - Receives communication
  - Provides services
- Other models
  - Master / worker
  - Peer-to-peer (P2P)



Server Programming

- Two approaches
  - Loop
    - Handles multiple connections in order
    - Limits on amount of network traffic
    - Not resilient in face of slow / stopped clients
  - Multithreading
    - Allows multiple simultaneous connections

Simple Server Programming (Loop)

- Basic steps
  1. Determine server location → port & IP address
  2. Creates server socket to listen for connections
  3. Loop

```
while (true) {
    Accept network connection from client
    Read data from client (request)
    Write data to client (response)
    Close network connection to client
}
```

Client Programming

- Basic steps
  1. Determine server location – IP address & port
  2. Open network connection to server
  3. Write data to server (request)
  4. Read data from server (response)
  5. Close network connection
  6. Stop client

Java Networking Classes

- **IP addresses**
  - InetAddress
- **Packets**
  - DatagramPacket
- **Sockets**
  - Socket ⇒ TCP client sockets
  - ServerSocket ⇒ TCP server sockets
  - DatagramSocket ⇒ UDP sockets (server or client)
  - Sockets transfer data via Java I/O streams
- **URL Connection Classes**
  - High-level description of network service
  - Access resource named by URL
  - Examples
    - URLConnection ⇒ Reads resource
    - HttpURLConnection ⇒ Handles web page
    - JarURLConnection ⇒ Manipulates Java Archive

Java Networking Examples

- TCP Client/Server: See tcpServerClient package
- Toy Web Server: See toyWebServer package
- Network I/O: See networkIO package