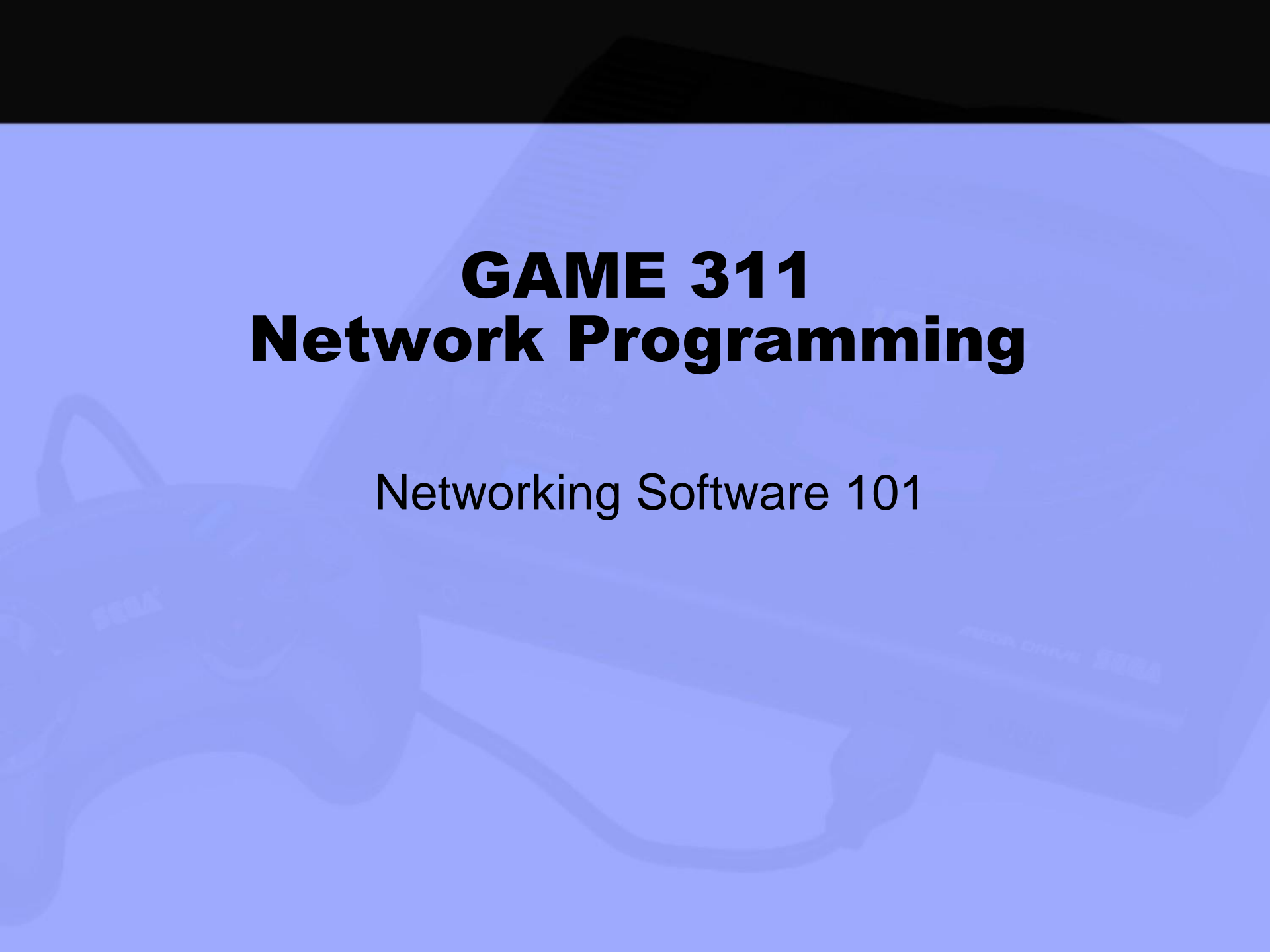


GAME 311

Network Programming

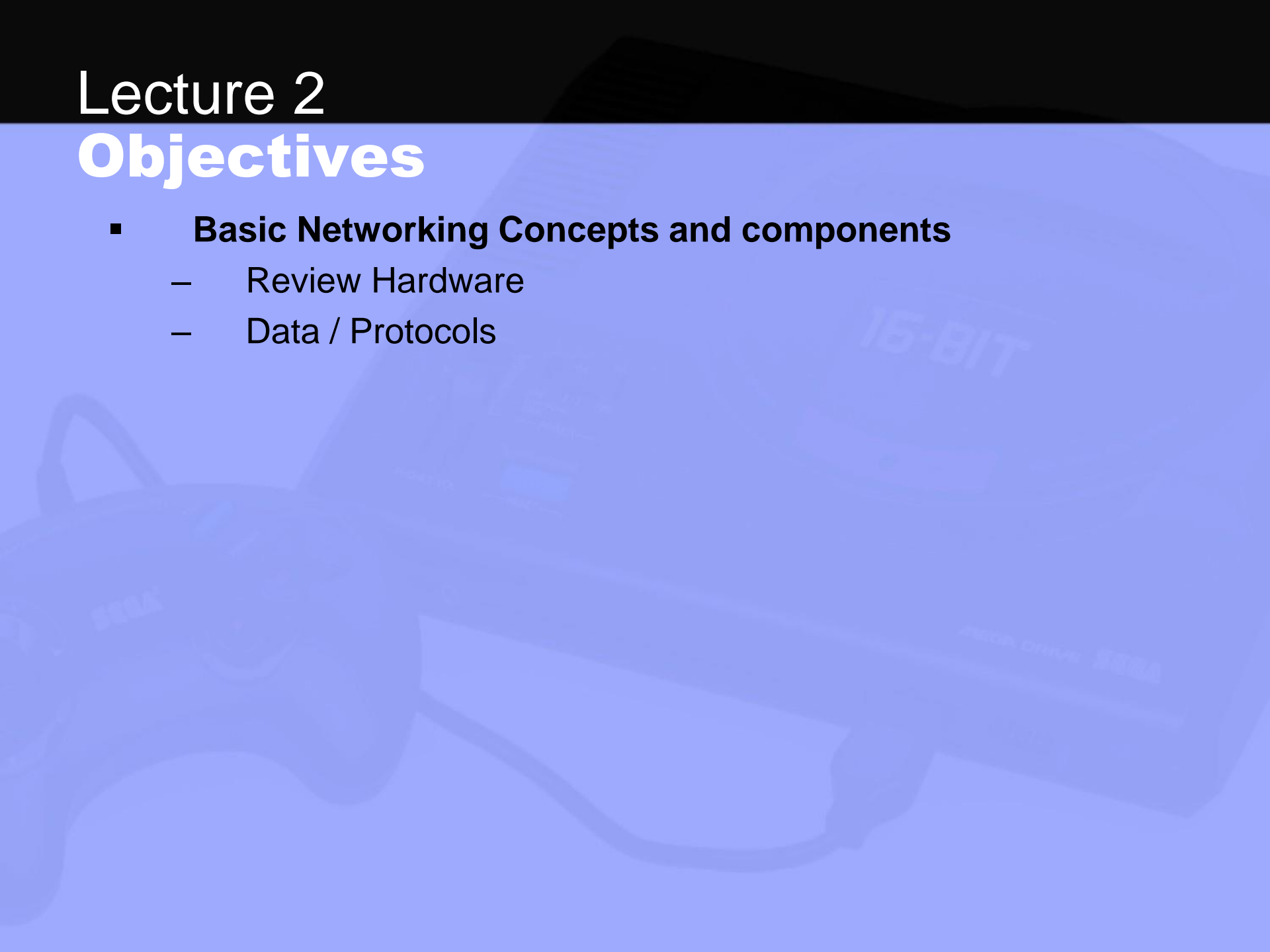
Networking Software 101



Lecture 2

Objectives

- **Basic Networking Concepts and components**
 - Review Hardware
 - Data / Protocols



Networking 101

- Concept of transferring data
- Communicating from one electronic device to another
- Can be short or long distanced.
- Requirements:
 - Hardware
 - Software
 - Collection of important information:

Who?	What?	Where?	How?	When?
Is sending data	To send	To send it to	To send the data	To send it (usually immediately)

Hardware Review

- Requirements for Networking:
 - Two Devices
 - Mediums for transmission:
 - Cables and cords used for the signal to be sent along.
 - Network card
- Additional Hardware:
 - Routing Devices
 - Modem
 - Wireless NIC, Access Point, repeater

MAC Address

- Stands for **Media Access Control** Address.
- Is a **unique identifier** issued to each piece of networking hardware.
 - A PC with a NIC, a router, a phone and a PS4 would each have their own unique MAC address.
 - **12 Hex values** grouped by 2
 - **A3::F0::12::27::48::9B**
 - First 3 sections identify the manufacturer
 - Also known as the physical address
 - This is used in conjunction with IP addresses to direct messages to a correct destination target.
 - Process known as ARP discussed later.
 - First addresses associated with networking before protocols.



IP Address

- Internet Protocol Address
 - Looks something like 192.168.0.1.
 - Used to identify a specific device for network communication.
 - Like the address of a house it is a way to identify where to send information to.
 - Was created as a organization protocol as MAC addresses had no consistency within a network using multiple brands of equipment.
- IP addresses can be either internal to a network or globally on the internet.

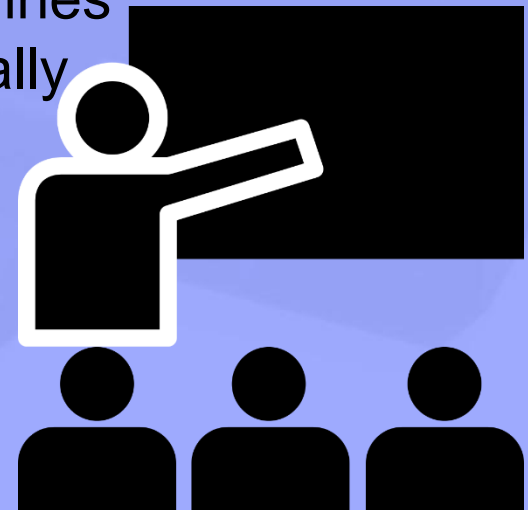


IP's

- There are now **2 different types of IP** in use:
- **IPv4**: IP's are a set of **4 8bit binary values**
 - Are **unique to each device connected** to a network.
 - Range value for each decimal separated value is **0-255** (256 / 8Bits)
 - Binary is $1111\ 1111 = 255$
- **IPv6**: IP's are **8 sets of 4 hexadecimal** values resulting in a **128 bit** address.
 - This theoretically resolves any concerns about running out of IP addresses.
 - Possibility of (2^{128}) addresses

IPv4 Classes

- IP's in **IPv4** have Classes (5 different types)
 - IP classes have a distinct usage of the **first 4 bits** to determine which class type it is.
 - **Class A** addresses begin with **0xxx**, or **1 to 126** decimal.
 - **Class B** addresses begin with **10xx**, or **128 to 191** decimal.
 - **Class C** addresses begin with **110x**, or **192 to 223** decimal.
 - **Class D** addresses begin with **1110**, or **224 to 239** decimal.
 - **Class E** addresses begin with **1111**, or **240 to 254** decimal.
 - Based on which class an IP belongs to defines how many IP's it will have to distribute locally within it's network.
 - **127.0.0.1** is reserved as the local host IP address and is never assigned.
 - When used it will act as the local computer



IP “Class” Breakdowns

IP CLASSES - WITH THEIR START AND END ADDRESSES

Class	Leading bits	Size of <i>network number</i> bit field	Size of <i>rest</i> bit field	Number of networks	Addresses per network	Total addresses in class	Start address	End address
Class A	0	8	24	128 (27)	16,777,216 (224)	2,147,483,648 (231)	0.0.0.0	127.255.255.255
Class B	10	16	16	16,384 (214)	65,536 (216)	1,073,741,824 (230)	128.0.0.0	191.255.255.255
Class C	110	24	8	2,097,152 (221)	256 (28)	536,870,912 (229)	192.0.0.0	223.255.255.255
Class D (multicast)	1110	not defined	not defined	not defined	not defined	268,435,456 (228)	224.0.0.0	239.255.255.255
Class E (reserved)	1111	not defined	not defined	not defined	not defined	268,435,456 (228)	240.0.0.0	255.255.255.255

- https://www.paessler.com/info/ip_address_basics_ii

NAT

- NAT (Network Address Translation) defines the way the router takes in a connection from an external source and re-routes it to clients within the network.
 - This process typically consumes multiple public IP's, one for each device connected.
 - routes the public IP's assigned into LAN private IP's through a single device managing connections.
- When NAT receives traffic from a CLIENT of the internal network it gets an IP and PORT for both the CLIENT and it's destination recipient.
 - The NAT then creates what's known as a socket keeping track of this pairing of data for communication.



PAT

- PAT (Port Address Translation) is the process in which a router takes in a single IP from a service provider and divides it into a subset of internal IP's for use on the local network.
 - External IP is communicated through the use of the WAN connection on a router.
 - Redistributed amongst the clients connected to the internal network through the remaining physical ports or wireless connections.
 - Only 1 IP is used for all outbound connections assigning a different port to each client connected.
- Routers keep track of the individual IP's of devices connected and route traffic from and to them by rewriting the header packets of data being sent from the CLIENTS to use the single IP provided by the ISP.

PAT CONTINUED


- PAT is required as there are a **limited amount of public IP addresses** which can be distributed around the world.
 - $255*255*255*255 = 4,228,250,625$
- Even with PAT being used within internal networks we have already began to approach the limit requiring the introduction of **IPv6**.
 - **Increases IP Addresses available** by using Hex values instead of decimal values.

Ipconfig / ifconfig

- To Determine the locally assigned IP of a windows computer, we can use the command prompt and type in **ipconfig**.
 - Append **/all** to the end of ipconfig for full details
- On Unix based machine (Linux & Mac) we can open a terminal and type **ifconfig**
- You can find the ip address of a mobile device typically under the network connections “Network Details” section.
- Inside each of these devices it should list the following important pieces of information:
 - MAC Address (physical address)
 - IP Address
 - Gateway
 - Subnet Mask
 - DNS
- You can determine the external ip address of a device connected to the internet by visiting <https://whatismyipaddress.com/>

Ipconfig / ifconfig

- Example of ipconfig /all command information:

 Select Command Prompt

Ethernet adapter Ethernet:

```
Connection-specific DNS Suffix  . : clients.sl.on.ca
Description . . . . . : Realtek PCIe GBE Family Controller
Physical Address. . . . . : 98-29-A6-30-3F-95
DHCP Enabled. . . . . : Yes
Autoconfiguration Enabled . . . . : Yes
Link-local IPv6 Address . . . . . : fe80::556e:9e77:681:c98b%6(Preferred)
IPv4 Address. . . . . : 10.105.156.43(Preferred)
Subnet Mask . . . . . : 255.255.255.0
Lease Obtained. . . . . : Monday, September 9, 2019 8:34:37 AM
Lease Expires . . . . . : Wednesday, September 11, 2019 8:34:36 AM
Default Gateway . . . . . : 10.105.156.2
DHCP Server . . . . . : 142.155.202.1
DHCPv6 IAID . . . . . : 60303782
DHCPv6 Client DUID. . . . . : 00-01-00-01-22-4B-6E-85-98-29-A6-30-3F-95
DNS Servers . . . . . : 142.155.202.1
                        142.155.200.3
                        142.155.216.1
                        142.155.201.1
Primary WINS Server . . . . . : 142.155.202.1
Secondary WINS Server . . . . . : 142.155.216.1
                                142.155.201.1
NetBIOS over Tcpip. . . . . : Enabled
Connection-specific DNS Suffix Search List :
                                clients.sl.on.ca
                                SL.ON.CA
```

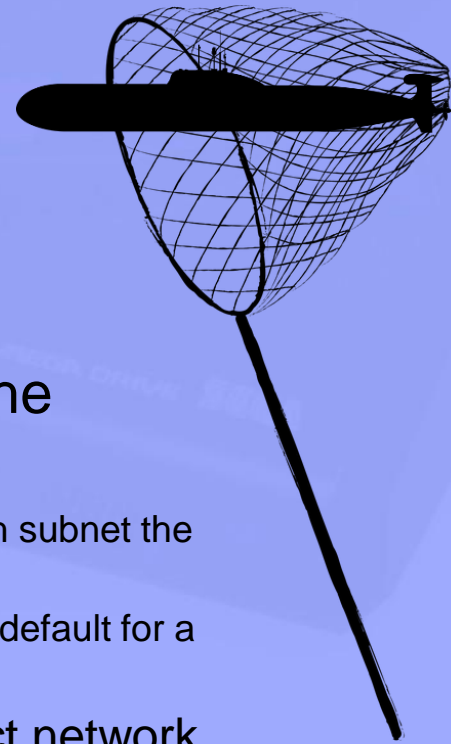
DNS

- DNS = Domain name System
- A domain name is the alphanumeric representation of an IP address.
 - Google.ca is the domain name of an IP address for a google server.
 - We can use the **ping** command from a prompt to send packets to the domain name and determine the IP address of that.

```
Pinging google.ca [172.217.164.195] with 32 bytes of data:  
Reply from 172.217.164.195: bytes=32 time=14ms TTL=53  
Reply from 172.217.164.195: bytes=32 time=12ms TTL=53  
Reply from 172.217.164.195: bytes=32 time=13ms TTL=53  
Reply from 172.217.164.195: bytes=32 time=15ms TTL=53  
  
Ping statistics for 172.217.164.195:  
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),  
    Approximate round trip times in milli-seconds:  
        Minimum = 12ms, Maximum = 15ms, Average = 13ms
```

Subnets

- Subnets help divide networks into subsections.
- Mainly used to allow sectioning of networks to segment clients.
 - An IT admin can easily determine where a Client is connected to a network based on it's IP because of a subnet.
 - Adds additional room for more clients to connect.
- 3 common LAN subnets are:
 - 10.0.0.0, Subnet Mask 255.0.0.0
 - 172.16.0.0, Subnet Mask 255.240.0.0
 - 192.168.0.0, Subnet Mask 255.255.0.0
- Subnet Masks allow an admin to easily parse the subnet out of an IP using AND logic.
 - AND the bit values of the subnet mask with the IP address to get which subnet the IP belongs to.
 - The Default Subnet Masks for a Class A would be 255.0.0.0 and the default for a Class C would be 255.255.255.0.
 - Not Required for IPv6, Mainly used to control and direct network usage rather than add additional IP's.



Default Gateway

- **default gateway** is the IP address of the next routing device the current device is connected to.
 - Meaning it's likely your home **router / modem**.

- When we send out data onto the network, we send it out to the gateway address and it re-routes it to the proper destination.



Ports

- A Port number is a value from 0-65535 typically associated with a specific application running on a device.
 - This allows computers to send out data for multiple applications at the same time.
 - Smaller values of ports are often reserved for specific registered applications.
 - 49152 and above is safe to use privately as they are not registered.
 - Websites using http as an example use a port of 80

DHCP

- Dynamic Host Configuration Protocol (**DHCP**)
- Used to dynamically assign IP's to devices who connect within a local network.
 - Your modem is likely using DHCP to obtain an IP from your ISP.
 - If you disconnect your modem and reconnect it you will likely be assigned a new public IP.
 - By default most home routers are set to be dynamic using DHCP.
- Conversely you can manually set IP addresses known as **static IPs**.
 - These machines maintain this IP even when connections are restarted.
 - Useful for businesses to track network logs to specific devices.

Lecture 2

Summary

- **Basic Networking Concepts and components**
 - Review Hardware
 - Data:
 - Mac Address
 - IP's
 - Subnets (masks)
 - Default Gateways
 - Ports
 - Dynamic vs Static IP's