**Research and Development Document: IP Addressing, Subnetting, MAC Addressing, ARP, and RARP**

**IP Addressing and Subnetting**

**IPv4:**

**IP Addressing Basics:**

* **IPv4 Address**: A 32-bit numerical identifier divided into four octets (e.g., 192.168.1.1).
* **Classes of IPv4 Addresses**:
  + Class A: 0.0.0.0 to 127.255.255.255 (First octet range: 1-126)
  + Class B: 128.0.0.0 to 191.255.255.255 (First octet range: 128-191)
  + Class C: 192.0.0.0 to 223.255.255.255 (First octet range: 192-223)
  + Class D: Reserved for multicast addresses (224.0.0.0 to 239.255.255.255)
  + Class E: Reserved for experimental purposes (240.0.0.0 to 255.255.255.255)

**Subnetting IPv4:**

* **Purpose**: Divide a larger network into smaller sub-networks (subnets) for efficient management of IP addresses.
* **Subnet Mask**: A 32-bit binary mask (e.g., 255.255.255.0) defining network and host portions.
* **CIDR Notation**: Combines IP address and subnet mask bits (e.g., 192.168.1.0/24).
* **Calculations**:
  + **Total Hosts**: 2(32−subnet mask bits)−22^{(32 - \text{subnet mask bits})} - 22(32−subnet mask bits)−2 usable hosts.
  + **Subnet Range**: Identifies IP addresses available for hosts within each subnet.

**IPv6:**

**IPv6 Addressing Basics:**

* **Format**: 128-bit hexadecimal addresses (e.g., 2001:0db8:85a3:0000:0000:8a2e:0370:7334).
* **Subnetting IPv6**:
  + **Prefix Length**: Specified as "/xx".
  + **Advantages**: Large address space, hierarchical addressing.

**Basics of MAC Addressing**

* **MAC Address**: Unique identifier for network interfaces.
* **Format**: Six groups of two hexadecimal digits (e.g., 00:1A:2B:3C:4D:5E).
* **Function**: Enables direct communication within a network segment.

### IP Addressing and Subnetting:

#### IPv4:

**IP Addressing:**

* **IPv4 Address**: A 32-bit numerical identifier divided into four octets, separated by dots (e.g., 192.168.1.1).
* **Classes of IPv4 Addresses**:
  + Class A: 0.0.0.0 to 127.255.255.255 (First octet range: 1-126)
  + Class B: 128.0.0.0 to 191.255.255.255 (First octet range: 128-191)
  + Class C: 192.0.0.0 to 223.255.255.255 (First octet range: 192-223)
  + Class D: Reserved for multicast addresses (224.0.0.0 to 239.255.255.255)
  + Class E: Reserved for experimental purposes (240.0.0.0 to 255.255.255.255)
* **Subnet Mask**: Determines the network and host portions of an IP address. It is a 32-bit binary mask often represented in dotted-decimal format (e.g., 255.255.255.0).
* **CIDR Notation**: Compact representation of subnet masks, combining the network address and the number of significant bits (e.g., 192.168.1.0/24 where "/24" represents the subnet mask).

**Subnetting:**

* **Purpose**: Divide a larger network into smaller sub-networks (subnets) to manage and optimize network resources efficiently.
* **Process**:
  1. Determine subnet requirements (number of subnets, hosts per subnet).
  2. Choose appropriate subnet mask based on requirements.
  3. Allocate subnet ranges accordingly.

**Calculations:**

* **Total Hosts**: Calculate the total number of usable IP addresses in a subnet using 2(32−subnet mask bits)−22^{(32 - \text{subnet mask bits})} - 22(32−subnet mask bits)−2 (subtracting network and broadcast addresses).
* **Subnet Range**: Identify the range of IP addresses available for hosts within each subnet.

#### IPv6:

**IPv6 Addressing:**

* **Format**: 128-bit hexadecimal addresses (e.g., 2001:0db8:85a3:0000:0000:8a2e:0370:7334).
* **Expanded Address**: Written in eight groups of four hexadecimal digits, separated by colons.
* **Shortened Address**: Zeroes can be abbreviated with "::" (once per address).

**Subnetting IPv6:**

* **Prefix Length**: Similar to IPv4 CIDR notation, specified as "/xx".
* **Advantages**: Provides a vastly expanded address space and supports hierarchical and efficient addressing.

**Functionality of ARP & RARP**

**ARP (Address Resolution Protocol):**

* **Purpose**: Maps IP addresses to MAC addresses.
* **Operation**: Resolves IP address to MAC address on local networks.

**RARP (Reverse Address Resolution Protocol):**

* **Purpose**: Maps MAC addresses to IP addresses.
* **Operation**: Retrieves IP address from MAC address, used in diskless systems.