1. Introduction to Link Aggregation (LAG)

Link Aggregation (LAG) is a technique where we combine multiple network connections into a single logical link to increase bandwidth, improve redundancy, and enhance network reliability.

Benefits of LAG

- **Increased Bandwidth**: Aggregates multiple physical links to provide higher data transfer rates.
- **Redundancy and Failover**: If one link fails, traffic is automatically redirected to other links in the group.
- **Improved Reliability**: Reduces the impact of link failures on network performance.

2. Link Aggregation Control Protocol (LACP)

LACP (IEEE 802.3ad) is a protocol that helps network devices automatically combine multiple physical links into a single logical link.

How LACP Works

- LACP ensures that only compatible links are grouped together and actively monitors their status, so if a link fails, traffic is redirected to the remaining links.
- It works by exchanging special messages (LACPDUs) between devices to negotiate and maintain the link aggregation.
- Only links with matching configurations and active negotiation participate in aggregation.

LACP Modes

- **Active Mode**: The active mode actively sends LACP packets to establish and maintain a link aggregation group.
- **Passive Mode**: While the passive mode listens for LACP packets and responds but does not initiate the aggregation.

Device1 Mode	Device2 Mode	Possibility of LAG
Active	Active	✔ Yes
Active	Passive	✔ Yes
Passive	Passive	✖ No

- **Note:** At least one side must be in Active Mode for LACP negotiation to occur.

3. LACP Configuration on Linux

To configure LACP on Linux, we can use the bonding driver.

1. Load bonding module:

   ```
   sudo modprobe bonding
   ```

2. Create bonding interface:

   ```
   sudo ip link add bond0 type bond mode 802.3ad
   ```

3. Add slave interfaces:

   ```
   sudo ip link add eth1 type dummy
   sudo ip link add eth2 type dummy
   ```

4. Set slaves to master:

   ```
   sudo ip link set eth1 master bond0
   sudo ip link set eth2 master bond0
   ```

5. Set bond interface to UP state:

   ```
   sudo ip link set bond0 up
   ```

6. Verify configuration:

   ```
   cat /proc/net/bonding/bond0
   ```

7. To unset slaves to master:

   ```
   sudo ip link set eth1 nomaster
   sudo ip link set eth2 nomaster
   ```

4. cat /proc/net/bonding/bond0

General Bonding Information

- **Ethernet Channel Bonding Driver**: Shows the kernel version of the bonding driver.
- **Bonding Mode: IEEE 802.3ad Dynamic link aggregation**: Indicates that LACP (802.3ad) is being used for link aggregation. If not statically set, the default mode is Round-Robin(rr).

- **Transmit Hash Policy: layer2 (0)**: Specifies the algorithm used to distribute outgoing traffic (layer2 means MAC-based hashing).
- **MII Status: up**: Indicates whether the bonding interface is up or down.
- **MII Polling Interval (ms): 100**: Frequency (in milliseconds) at which the system checks the link status.
- **Up Delay (ms) / Down Delay (ms)**: Time delays before considering a link up or down.
- **Peer Notification Delay (ms)**: Delay before notifying peers about a link state change.

802.3ad (LACP) Specific Info

- **LACP active: on**: Shows whether LACP is enabled on the bonding interface.
- **LACP rate: fast**: Defines the rate at which LACP packets are sent. (`fast` = every 1 second, `slow` = every 30 seconds).
- **Min links: 0**: Minimum number of active links required for the bond to be functional.
- **Aggregator selection policy (ad_select): stable**: Defines how the system selects the active aggregator.

Slave Interface Details

- **Slave Interface: eth1 / eth2**: Shows the individual network interfaces part of the bond.
- **MII Status: up**: Indicates whether the link is operational.
- **Speed / Duplex: Unknown**: Normally shows the speed (e.g., 1Gbps) and duplex mode (Full/Half), but here its "Unknown" because it's a dummy setup.
- **Link Failure Count: 0**: Number of times the link has failed.
- **Permanent HW addr**: MAC address of the network interface.
- **Slave queue ID: 0**: Queue assignment for the bonded interface.
- **Aggregator ID: 3 / 4**: Identifies the LACP aggregator to which the interface belongs.
- **Actor Churn State / Partner Churn State**: Indicates changes in link state (e.g., churned means the link has been lost and recovered).
- **Actor Churned Count / Partner Churned Count**: Number of times the link was detected as churned.

5. Hashing Policies

LACP supports different hashing algorithms for distributing traffic across links.

- **Layer 2 (default)**: Based on MAC addresses.
- **Layer 3+4**: Based on IP and transport layer headers.
- **Layer 2+3**: Based on MAC and IP addresses.

6. LACP Priority and Selection

LACP uses a priority mechanism to determine which links are active in aggregation.

Priority Determination Factors

1. **LAG Type**: Static LAG gets priority over dynamic LAG.
2. **System Priority**: Lower values get higher priority (default: 1-65535, 1 is highest priority).
3. **MAC Address**: If priorities are the same, lower MAC address gets higher priority.

7. Conclusion

LAG with LACP is a powerful feature that enhances network bandwidth and reliability. Understanding LACP modes, priority mechanisms, and configuration methods is crucial for setting up and maintaining high-performance network links.