OSI model layers, their functions, troubleshooting steps, & Linux commands that work universally across distributions:

Layer 1: Physical Layer Function: Ensures hardware connectivity (e.g., cables, NICs).

Commands:-
`ifconfig`: Displays network interfaces and their status. -
`ip addr show`: Lists all network interfaces and their current state. -
`mii-tool`: Checks Ethernet link status and speed. -
`nmcli device status`: Shows the status of all network devices. -
`ethtool ens5`: Displays detailed information about the physical interface (e.g., speed, duplex).

Troubleshooting:
1. Verify cables and hardware connections.
2. Use `ip link show` to check for "NO CARRIER" issues.
3. Check logs with `dmesg | grep -i eth` for hardware errors.

Layer 2: Data Link Layer
Function: Handles MAC addressing and frame transmission.

Commands:
- `netstat --interfaces`: Lists active network interfaces.
- `ip addr show`: Displays MAC addresses and IP configurations.
- `arp -n`: Shows ARP table (MAC-to-IP mappings).
- `ip neigh` or `ip neighbor show`: Displays neighbor cache for MAC-to-IP mappings.

Troubleshooting:
1. Ensure MAC address is correctly assigned using `ip addr show`.
2. Check ARP table with `arp -n` for proper mappings.
3. Use `ethtool eth0 | tail` to verify link connectivity and speed.

Layer 3: Network Layer Function: Manages IP addressing, routing, and packet forwarding.

Commands:
- `route -n`: Displays the routing table without DNS resolution.
- `ip route`: Shows current routes configured on the system.
- `ping <destination>`: Tests IP-level connectivity to a host.
- `traceroute 8.8.8.8` or `tracepath <destination>`: Diagnoses routing paths to a remote host.

Troubleshooting:
1. Verify IP address assignment using `ip addr show`.
2. Test gateway connectivity with `ping -c 5 <gateway>`.
3. Check routes using `ip route show` and add routes if missing (`ip route add <route>`).

Layer 4: Transport Layer
Function: Ensures reliable data transfer (TCP/UDP ports).

Commands:
- `netstat -an | grep 53`: Lists active connections on port 53 (DNS).
- `telnet <host> <port>`: Tests TCP connectivity to a specific port.
- `netstat --listening` or `ss -tln`: Lists listening ports on the system.
- `nc -zv <host> <port>`: Verifies port accessibility using Netcat.

Troubleshooting:
1. Use `ss -tuln` to check open ports by protocol (TCP/UDP).
2. Test remote port availability with Telnet or Netcat (`nc -zv`).
3. Restart services blocking transport-layer communication (`sudo systemctl restart sshd`

Layer 5: Session Layer
Function: Manages sessions between applications (e.g., SSH, HTTPS).

Commands:
- `openssl s_client -connect cloudage.global:443`: Tests SSL/TLS session establishment.

Troubleshooting:
1. Verify session protocols like SSH (`ssh user@host`) or HTTPS (`openssl s_client`).
2. Restart session-related services (`sudo systemctl restart sshd`).

Layer 6: Presentation Layer
Function: Handles encryption, data formatting, and translation.

Commands:
- `cat /etc/resolv.conf`: Displays DNS server configurations.
- `cat /etc/nsswitch.conf`: Shows name resolution order (hosts, DNS, etc.).

Troubleshooting:
1. Verify DNS settings in `/etc/resolv.conf`.
2. Check for misconfigured name resolution in `/etc/nsswitch.conf`.

Layer 7: Application Layer
Function: Interfaces directly with applications (e.g., DNS, HTTP).

Commands:
- `host www.something.com`: Resolves domain names to IP addresses.
- `dig www.something.com`: Performs detailed DNS queries.
- `nslookup www.something.com`: Tests domain name resolution.
- `strace ping www.something.com`: Debugs application-layer processes for network tools like Ping.
- `systemctl restart network`: Restarts networking services to resolve application-level issues.
- `tcpdump -i eth0`: Captures network packets at the application layer for deeper analysis.

Troubleshooting:
1. Test DNS resolution using tools like Dig or Nslookup (`dig`, `nslookup`).
2. Capture traffic with packet analysis tools like Tcpdump (`tcpdump -i eth0`).
3. Restart application-layer services (`sudo systemctl restart apache2`, etc.)