Advanced Linux System Administration

Subject 11. Network administration (Introduction).

Pablo Abad Fidalgo
José Ángel Herrero Velasco

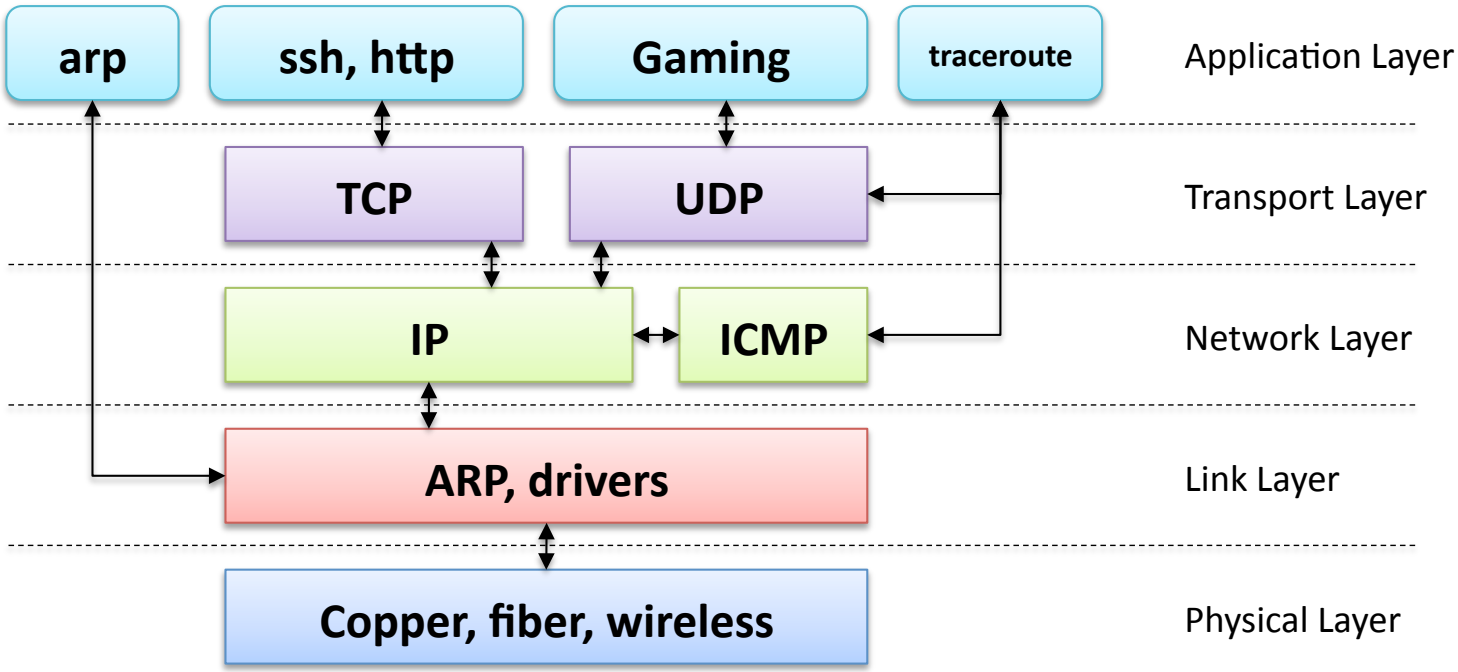
Departamento de Ingeniería Informática y Electrónica

Index

- Introduction (TCP/IP).
- Network Interface.
- Link Layer.
- Network Layer.
- Monitoring/Test.

Introduction (TCP/IP)

- Protocol "Suite", a set of protocols designed to implement interconnection networks:
  - Origin: research project of the USA defense department (ARPANET).
- Multiple components, arranged hierarchically (stack).

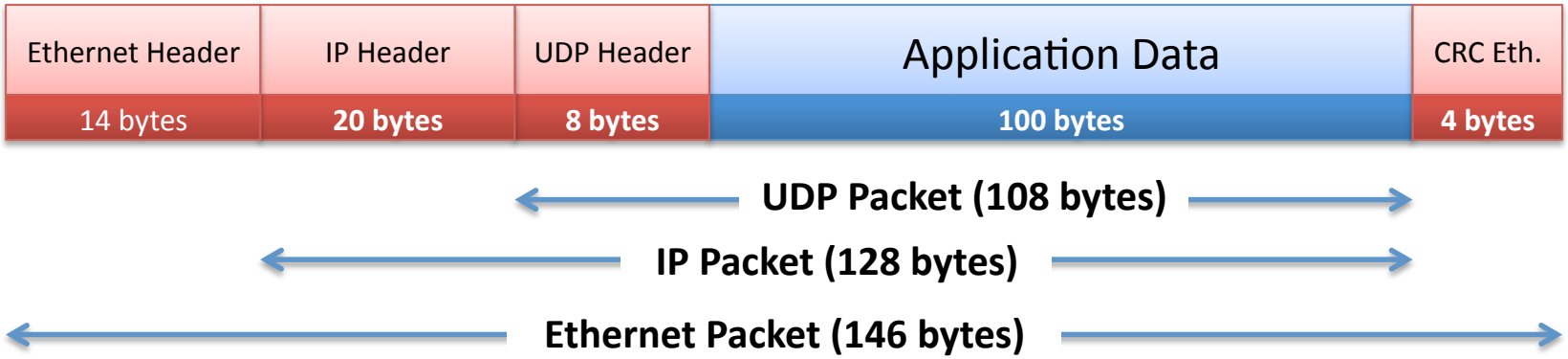


Introduction (TCP/IP)

- Protocol "Suite", a set of protocols designed to implement interconnection networks:
  - Origin: research project of the USA defense department (ARPANET).
- Multiple components, arranged hierarchically (stack):
  - **UDP**, User Datagram Protocol, unverified, one-way data delivery.
  - **TCP**, Transmission Control Protocol, reliable, full duplex, flow controlled, error corrected conversations.
  - **IP**, the Internet Protocol, routes data packets from one machine to another.
  - **ICMP**, the Internet Control Message Protocol, provides low level support for IP: error messages, routing assistance, debugging.
  - **ARP**, Address Resolution Protocol, translates IP addresses into HW address (MAC).

Introduction (TCP/IP)

- **Encapsulation:**
  - Data travels on the network in the form of packets, bursts of data with a maximum length imposed by the link layer.
  - Each packet consists of a header and a payload:
    - Header: includes Source-Destination and protocol information.
    - Payload: the information (Data).
  - As a packet travels down the TCP/IP protocol stack, each protocol adds its own header information.



Introduction (TCP/IP)

- **Packet Addressing:** multiple addressing schemes (at different layers):
  - HW Addressing (link layer):
    - Each net interface has one MAC addr that distinguishes it in the physical network.
    - Ethernet Network: 6 byte direction (2-digit hex bytes: 00:50:8D:9A:3B:DF).
  - IP Addressing (IPv4: 216.58.211.196):
    - Identifies the network interface in Internet. Unique at global level* (NAT & private addr).
    - Physical Address – IP address mapping: ARP protocol.
  - Hostname Addressing:
    - Number-based directions hard to remember (216.58.211.196 ??). Name mapping.
    - File mapping (/etc/hosts) or DNS (world-wide Domain Name Server).
  - Ports:
    - IP identifies the interface, How to identify active services? (multiple connections).
    - Extend IP address with port number: 16 bits identifying a communication channel.
    - Standard services (ssh, ftp, http) are associated to pre-established ports (/etc/services).

Introduction (TCP/IP)

- **IP Addressing:**
  - **IPv4 vs IPv6:** IPv4 limitations (3 february 2011 no more addresses available):
    - https://www.google.com/intl/en/ipv6/statistics.html (may 2017, below 20%).
  - **Types** of IPv4 addresses: (32 bits divided into 4 8-bit fields a.b.c.d):
    - Determines which portion identifies the network and which one the host.
    - Class A: (N.H.H.H) 1.x.x.x – 127.x.x.x (Apple, AT&T, Ford, US DoD…):
      - Network part=a, 126 nets.
      - Host part=b.c.d, +16 millon hosts at each net.
    - Class B: (N.N.H.H) 128.x.x.x – 191.x.x.x:
      - +16K nets, 65K hosts per net.
    - Class C: (N.N.N.H) 192.x.x.x – 233.x.x.x.
    - Classes D and E: 234.0.0.0 – 255.x.x.x:
      - Experimental networks and multicast addressing.

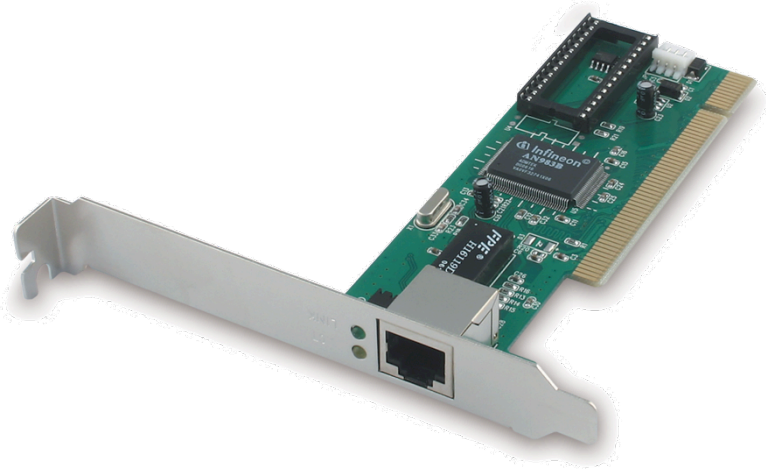
0.0.0.0: My own Host (NO net connection)
0.x.x.x: One machine in our network
127.0.0.1: Loopback. Does not reach the NIC.
255.255.255.255: Bcast in local network.
x.x.x.255: Bcast in specified network.

  - **Subnetting:** A & B oversized, break classes into subclasses:
    - Part of the host identifier is employed to identify the network.
    - Through the network mask (mapping).

Index

- Introduction (TCP/IP).
- **Network Interface.**
- Link Layer.
- Network Layer.
- Monitoring/Test.

Network Interface



- **Host / Interface**:
  - Hosts are computers/individual systems.
  - Each host can have one or more network interfaces (NICs) (Cable + WIFI):
    - Each interface represents a connection to a different network (different IP).
- Basic network equipment:
  - Hubs (level OSI-1): Only interconnects wires.
  - Switches (level OSI-2): Ethernet level management (ARP, MAC, etc.).
  - Routers (level OSI-3): IP packet management, network level.
  - Others: traffic balancing, firewalls…
- Linux **does not** perform net management through *device files:*
  - ethX has no device file associated (/dev/ethX not found).
  - NICs are managed through kernel modules (drivers).

Network Interface

- Configuration (Debian): file **/etc/network/interfaces:**
  - Establishes the configuration of network interfaces.
  - Allows additional functionality: routes*, alias, pre/post operations…
  - Fields:
    - auto <interface>: activates the interface when the system boots up.
    - iface <interface> <ip_addressing> <method>: interface configuration:
      - ip_addressing: inet (IPv4) / inet6 (IPv6).
      - method: dhcp (automatic) / static (manual, requires additional lines for configuration).
  - *Loopback interface:
    - Communication of network apps hosted in the same system.
    - auth lo.

```
auto eth0
iface eth0 inet static
           address 192.168.1.132
           netmask 255.255.255.0
           network 192.168.1.0
           broadcast 192.168.1.255
           gateway 192.168.1.1
```

Network Interface

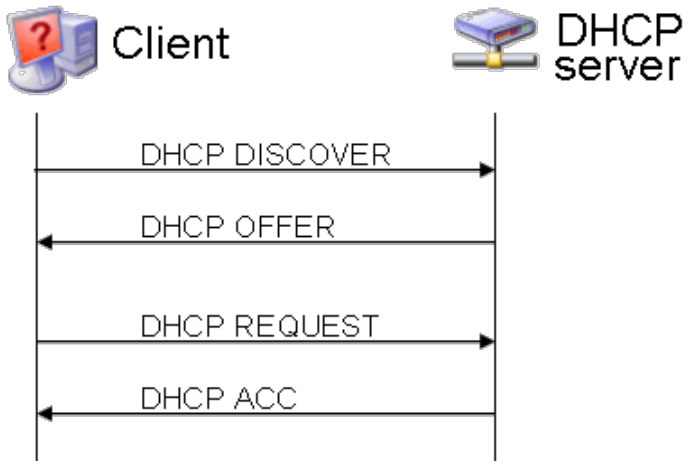
- Configuration (Debian):
  - Interface configuration can be modified in a “running” system:
    - STEP 1. Modification. Edit the file (/etc/network/interfaces or command ifconfig).
    - STEP 2. Re-start. ifdown/ifup or reboot the service (/etc/init.d/networking restart).
  - Commands **ifup/ifdown:** power on/off a network interface:
    - Syntax: ifdown eth0 (power off eth0 card).
  - Command **ifconfig:** net parameter configuration:
    - Syntax: ifconfig <interface> <address> <options>:
      - Example: ifconfig eth0 192.168.1.13 netmask 255.255.255.198 broadcast 192.168.1.191 up.
      - ifconfig –a prints information about available interfaces.
    - Caution!! Changes made with ifconfig are not permanent (do not modify interfaces file).
- Graphic tools: network-admin, webmin…

Network Interface

- **DHCP** (Dynamic Host Configuration Protocol):
  - The DHCP service performs **automatic network configuration** for the system:
    - "Renting" parameters from a server: IP, Gateway, DNS, etc.
    - "Safe": allows forcing network configuration based on MAC address.
    - Easier: centralized management of the whole network.
    - Dynamic: information is only valid temporally.
    - Requires a "client" service at each host.
  - How to specify we want to use DHCP:
    - In /etc/network/interfaces:

```
iface  ethX  inet  dhcp
```

    - man dhclient.
    - ifconfig eth0 up.



Index

- Introduction (TCP/IP).
- Network Interface.
- **Link Layer.**
- Network Layer.
- Monitoring/Test.

Link Layer

- The physical level in TCP/IP, almost always a ethernet network:
  - Each interface (NIC) has a unique MAC address.
  - Layer in charge of IP Frame <–> Ethernet Frame conversion:
    - Need to map IP address and MAC Address: ARP (Address Resolution Protocol).
  - **ARP Protocol:**
    - Search @MAC corresponding to a @IP in the local ARP table (translated address cache).
    - If not in the table, it performs a broadcast and the receiver informs. ARP table is updated for future connections.
    - When destination is not in local network, the IP route tables are employed, sending the message through the gateway MAC.
  - Command **arp**: manipulation/display of ARP table.
  - Configuration/Modification of @MAC:
    - # ifconfig eth0 **hw ether** 00:02:B3:19:C8:21.

Index

- Introduction (TCP/IP).
- Network Interface.
- Link Layer.
- **Network Layer.**
- Monitoring/Test.

Network Layer

- Through ARP only hosts in my net segment can be reached:
  - Cannot reach further than my hub/switch/router.
  - IP routes must be established for external addresses.
- **Route Tables:** information about how to reach IP destinations:
  - **Destination:** identifies destination network.
  - **Gateway:** how to reach to Destination (* means no forwarding is required, the packet is already in that network).
  - **Genmask:** network mask (identifies the subnetwork).
  - **Iface:** network interface to reach destination network.

Destination	Gateway	Genmask	Flags	Metric	Ref	Use	Iface
192.168.10.0	*	255.255.255.0	U	0	0	0	eth1
127.0.0.0	*	255.0.0.0	U	0	0	0	lo
default	192.168.10.1	0.0.0.0	UG	0	0	0	eth1

Network Layer

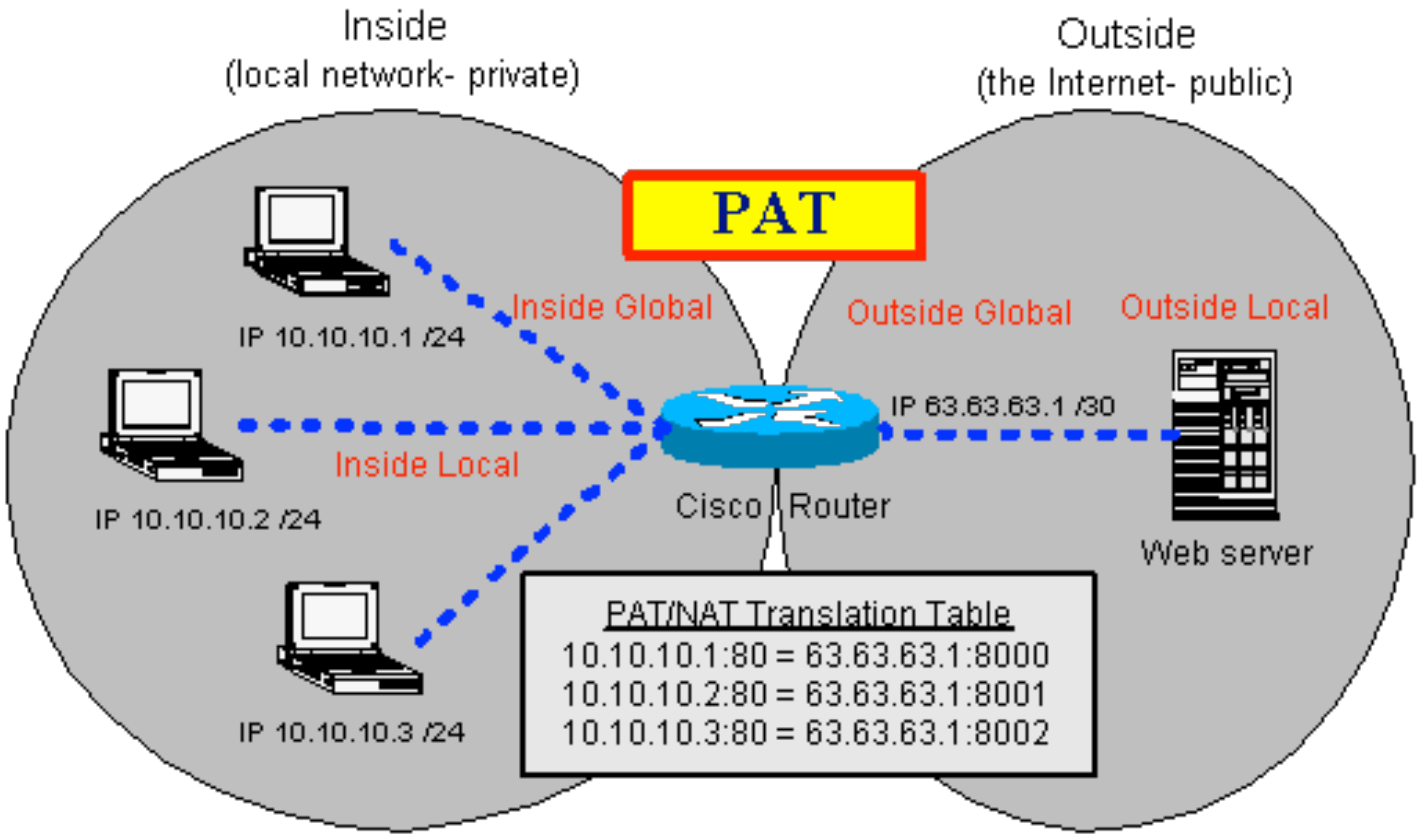
- Manual configuration of route tables:
  - Command **route:** modify/show tables:
    - #route –n: shows route tables.
    - Add a route for a network segment:
      - # route add –net 192.168.1.0 netmask 255.255.255.0 eth0.
    - Add the link element to other subnetworks (default route):
      - # route add default gw 192.168.1.1 eth0.
- Dynamic routes (automatic):
  - Static configuration of tables limits their functionality:
    - Valid for stable networks (not very large…).
    - Requires knowledge about network topology.
  - Complex environments: Dynamic Routes:
    - Daemon “routed” or “gated”. OSFP, RIP, BGP…
    - Maybe one of the most complex aspects concerning network administration.

Network Layer

- **Network Address Translation** (NAT):
  - Routing mechanism for packet exchange between incompatible networks (Public-Private address):
    - Allows a private IP to maintain internet connectivity.
    - For outgoing connections, the router translates the private IP as its own IP.
    - Router keeps information about all outgoing connections, relating them with incoming ones:
      - Outgoing connection: 192.168.1.25(1085) -> 212.106.192.142(1085).
      - Inbound communication: 212.106.192.142(1085) -> 192.168.1.125(1085).
  - NAT Types:
    - **Static NAT:** one-to-one mapping, each private IP is assigned a dedicated public IP.
    - **Dynamic NAT:** the router has a pool of public IPS assigned dynamically to the private IPs making a request.
    - **Port Address Translation (PAT):** single public IP. The port identifies the private IP.

Network Layer

- **Network Address Translation** (NAT):



Network Layer

- **Name Resolution:**
  - Name <-> IP translation, the network phonebook.
  - Option 1. Through the file **/etc/hosts:**
    - Conventional way, editing the file manually or through the command addhost.
    - Reasonable for small and private networks. Not useful for the rest of cases:
      - Adding a new host requires modifying all the /etc/hosts files in the network.
    - Usually employed only for the values required during boot process (localhost, hostname…).
    - Can add the IPs of relevant network servers or those providing essential network services.
  - Option 2. **Domain Name Service** (DNS):
    - Dedicated server in charge of performing the conversion.
    - Each host must be configured to make use of its corresponding name server.
    - The client is configured through the file /etc/resolv.conf.

Network Layer

- **Name Resolution:** the file /etc/resolv.conf:
  - **search:** domain search order:
    - When we try to connect to a host without suffix, it auto-completes.
    - ssh si -> ssh si.localdomain.
    - Priority from left to right (first atc.unican.es, then unican.es).
  - **nameserver:** name server:
    - Try to resolve with the first one.
    - If it fails, keep on descending to lower lines.

```
search localdomain
search atc.unican.es unican.es

nameserver 193.144.193.11
nameserver 193.144.193.22
nameserver 192.168.0.105
```

Index

- Introduction (TCP/IP).
- Network Interface.
- Link Layer.
- Network Layer.
- **Monitoring/Test.**

Monitoring/Test

- Test Command:
  - Command **netstat:** shows network status:
    - Route table (–r), active connections (–a). Also sockets (TCP).
  - Command **ping:** packet ECHO_REQUEST (ICMP) to a host:
    - Check if a destination is reachable (warning, firewall & ICMP).
  - Command **traceroute:** route followed by a packet towards destination:
    - Collects the IP at each gateway traversed.
- Command/Tools for monitoring:
  - Command **iptraf:** traffic statistics at network interfaces.
  - **tcpdump/Wireshark/…:** monitoring sent/received data for each connection.
  - **netperf:** performance measurement for links.
  - More sophisticated ones: MRTG, SAINT, Ganglia-monitor…