Networks

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Lectures

1. System administration introduction
2. Operating System installation
3. User management
4. Application management
5. System monitoring
6. Filesystem Maintenance
7. Local services
8. **Network services**
9. Security and Protection
10. Virtualization

Outline

1. Introduction
   - Goals
   - Previous Considerations
   - Network Address Translation
   - Firewall
2. Servers
3. Services

Goals

Knowledge

- Main services and networking protocols
  - Superserver, portmapper, DNS, FTP, WWW, e-mail
-

Abilities

- Service configurations
  - Superserver
  - DNS
  - FTP
  - WWW
  - E-Mail

Network admin considerations (I)

Security measures

- Never execute services with superuser privileges
- Expose only necessary services – firewalls
- Configure carefully all the offered services
  - Never leave default configurations
  - Disable/Remove unused services
- Monitor the service's logs
- Check for security issues – **be up to date**

Network admin considerations (and II)

Port classification

- Privileged ports: 0 - 1023
  - Controlled and assigned by IANA
  - Only privileged users (`root`) mai install services to those ports
- Registered ports: 1024 - 49151
  - Not controlled but registered by IANA
  - Registry about services using those ports – `/etc/services`
- Dynamic ports: 49152 - 65535
  - Used for temporary connections

/etc/services

- Relates services with corresponding port number
  - various applications use it (netstat,...)

```
servicename    port/protocol    alias list
```

```
echo            7/tcp
echo            7/udp
systat          11/tcp          users
systat          11/udp          users
ftp-data        20/tcp
ftp-data        20/udp
# 21 is registered to ftp, but also used by fsp
ftp             21/tcp
ftp             21/udp          fsp fspd
ssh             22/tcp
ssh             22/udp
telnet          23/tcp
telnet          23/udp
# 24 - private mail system
smtp            25/tcp          mail
smtp            25/udp          mail
domain          53/tcp
domain          53/udp
http            80/tcp          www www-http
http            80/udp          www www-http
```

Network Address Translation – NAT

- Router translates internal addresses by one (or various) of its own
  - Allows using a reserved IP (pool) and keep connectivity to the outside
- The router remembers the output connections to identify its answers
  - Output connection:
    - 192.168.1.25 (port 1085) → 212.106.192.142 (11086)
  - Reply connection:
    - 212.106.192.142 (11086) → 192.168.1.25 (1085)

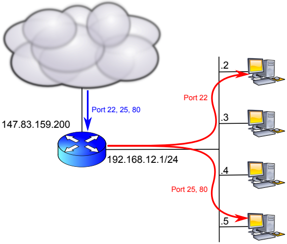
Tools: `iptables` (SNAT), `dnsmasq`

NAT collateral effects

- Private addresses are not visible from the outside
  - Attacks may only fall to the router – except over ongoing connections
- Network security depednds on router security
- Internal machines cannot offer services to the outside
  - Ecxept when using Port Address Translation (PAT)
- Important performance penalty for the network
  - All external connections go through a single router
  - Each packet requires some CPU time for processing
- Some services do not behave properly when using NAT
  - Those establishing connections to the inside
  - FTP, IRC, Netmeeting, . . .

Port Address Translation (PAT)

- Indicate to the NAT router it must forward some input connections to a particular machine
- Map router ports to some internal machine

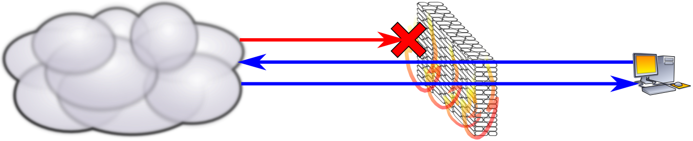


Eines: `iptables` (DNAT)

Firewall

Server that determines which connections may be established between two networks

- It typically works at network and transport layers
  - In general application details are not known
- It can keep connection status (Connection Tracking)
  - It allows related connections: “replies“



Firewall == Security?

- A firewall is another piece of the overall security of a system
- Its use can potentially offer a false security feeling
- Other aspects cannot be neglected
  - Correct application configuration
  - Perform regular security updates on installed software
  - Limit concurrent connections
- Other security tools in the private network and servers are still necessary

Outline

1 Introduction

2 Servers

- Server types

3 Services

Server types

- Connection oriented
  - The server keeps status about the different sessions
  - Better performance
  - Less error resilience
- Connectionless
  - There is no status about the client connections
  - There are no sessions
  - Requests must be self contained
  - Client request must contain all the required information
  - Better failure resilience and recovery

Server types – Depending authority

- Primary
  - They keep a copy of all the information
  - If there is mismatch in the stored information the primary takes precedence
  - There is one per service
- Secondary
  - Keep copies of the information
  - Performing periodic updates with the primary
  - There can be more than one per service
  - Load balancing
  - Are an implicit backup of the primary
- Cache (and/or proxies)
  - Keep –partial– copies of the most used information
  - More than one per service
    - Better performance
  - They can add security checks, filtering, log, . . .

Outline

1 Introduction

2 Servers

3 Services

- Remote Procedure Calls (RPC)
- Domain Name System (DNS)
- Dynamic Host Configuration Protocol (DHCP)
- Hypertext Transfer Protocol (HTTP)
- File Transfer Protocol (FTP)
- Simple Mail Transfer Protocol (SMTP)
- E-mail reception
- Secure Shell
- Network File System (NFS)
- Samba (SMB)

Superserver

- A service even when idle uses resources
  - Many services are requested only from time to time: `telnet`, `ftp`, `ssh`, ...
- Superserver listens to all the ports and activates the service only when needed
  - It detects the request
  - Initiates the service
  - Passes the message
- Limitations
  - Between connections it is not possible to keep information in memory
  - Overhead caused by process creation

Implementations: `inetd`, `xinetd`

/etc/xinetd.conf, /etc/xinetd.d

Indicates the services offered by the superserver

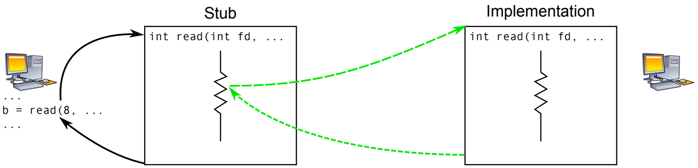
`Service, Protocol, User/group, Server, Parameters`

```
$ cat /etc/xined.conf
includedir /etc/xinetd.d
```

```
$ cat /etc/xined.d/ftp
service ftp
{
        socket_type             = stream
        wait                    = no
        user                    = root
        server                  = /usr/sbin/vsftpd
        log_on_success         += HOST DURATION
        log_on_failure         += HOST
        disable                 = no
}
```

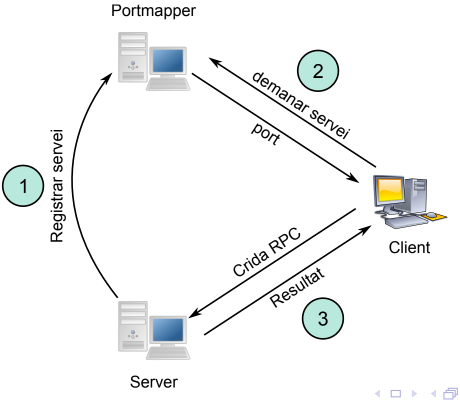
Remote Procedure Calls (RPC)

- Remote subroutine invokation
    - Identified by a service number ID
- RPC Servers
    - They implement a set of remote connections
    - Listen in a dynamic port
- Portmapper
- Registers the RPC servers
    - Maps the port with the subroutines
- Needed by other services
    - NFS, . . .



Portmapper

- All the status is kept on memory
  - If the process fails, is not enough restarting it
  - All RPC servers must be restarted
- All services must be registered upon portmapper start



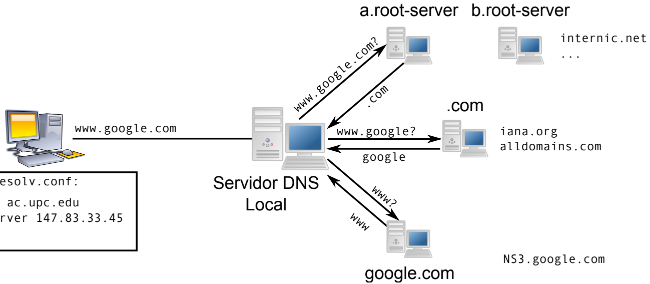
Domain Name System (DNS)

- Name resolution service
  - Hostname → IP address
  - IP Address → hostname
- Issues
  - Large amount of machines
  - Large number of changes
- Solution
  - Hierarchical distribution of the information (domains)
  - Authority delegation

DNS Internals

Authority delegation

- Each domain administers its own server
- Everybody knows the higher servers in the hierarchy (root)
- Everybody knows the server for their domain
- Name resolution is iterative



```
/etc/resolv.conf:
search ac.upc.edu
nameserver 147.83.33.45
```

DNS: RFCs 1034/1035

Service performance

Using ”caches“ is convenient

- High temporal locality
  - Avoids repeating the same query
- High spacial locality
  - Avoids going up to the root servers too often
  - Avoids some steps of the iterative search

DNS can be used for load balancing

- We can have several IPs for the same name
  - Each query returns different values: Round Robin or ”geographical“ criteria

```
$ nslookup www.google.com
Name:    www.google.com
Address: 212.106.221.23
Name:    www.google.com
Address: 212.106.221.27
Name:    www.google.com
Address: 212.106.221.25
...
```

DNS client configuration

- `/etc/host.conf`
  - Where a name is searched and its order
- `/etc/hosts`
  - Locally translated machines
- `/etc/resolv.conf`
  - Automatic domains to be searched
  - IP addresses of the DNS servers

DNS Server configuration

- `/etc/bind/named.conf`
  - What are we administering?
    - DNS Domains
    - IP addresses ranges
  - Indicates primary, secondary, or cache
- Direct translation files
  - Name.domain → IP address
  - 1 file for each administered domain
- Inverse translation file
  - IP Address → name.domain
  - 1 file for each administered IP range

DNS type of registers

- SOA (Start of Authority)
  - Serial number
  - Refresh time and retries
  - Expiration times
  - Minimum TTL
- A - Direct translation
  - Name → IP address

```
romeu IN A 147.83.32.4
```

- CNAME - synonyms
  - Name → name

```
romeu IN CNAME lp_romeu
```

DNS type of registers

- PTR - inverse translation
  - IP Address → DNS name

```
4 IN PTR romeu.ac.upc.edu.
```

- NS - Domain delegation
  - DNS Domain→ server

```
ac IN NS 147.83.32.3
```

- MX - mail exchanger
  - DNS Domain → server

```
ac IN MX 147.83.33.10
```

- I altres. . .
  - HINFO, WKS, . . .

DNS configuration example

Zone ”cluster.craax.upc.edu“, as primary.

```
$ cat /etc/bind/named.conf
options {
        directory "/var/cache/bind";
        forwarders {
                147.83.159.217;
        };
        auth-nxdomain no;    # conform to RFC1035
        listen-on-v6 { any; };
};
zone "cluster.craax.upc.edu"  {
  type master;
  file "/etc/bind/cluster.zone";
};

zone "1.1.10.in-addr.arpa"  {
  type master;
  file "/etc/bind/cluster.rev";
};
```

DNS configuration example

```
$ cat /etc/bind/cluster.zone
$TTL    604800
@       IN      SOA     cluster. cluster.craax.upc.edu. (
                       20101220                ; Serial
                         604800                ; Refresh
                          86400                ; Retry
                        2419200                ; Expire
                         604800 )              ; Negative Cache TTL
;
@       IN      NS      gandalf
$ORIGIN                 cluster.craax.upc.edu.
gandalf         IN      A       10.1.1.1
boromir-1       IN      A       10.1.1.2
```

```
$ cat /etc/bind/cluster.rev
$TTL    604800
@       IN      SOA     cluster. cluster.craax.upc.edu. (
                       20101220                ; Serial
                         604800                ; Refresh
                          86400                ; Retry
                        2419200                ; Expire
                         604800 )              ; Negative Cache TTL
;
@       IN      NS      gandalf
$ORIGIN                 cluster.craax.upc.edu.
1       IN      PTR     gandalf.cluster.craax.upc.edu.
2       IN      PTR     boromir-1.cluster.craax.upc.edu.
```

Exercise

- We have 3 services at (`server1`, `server2` i `server3`) with these registers

```
server1 IN A 123.123.123.1
server2 IN A 123.123.123.2
server3 IN A 123.123.123.3
```

- We want to add the following services
  - `www` at `server1` (`server2` is the backup server)
  - `ftp` at `server1` and `server2`
  - incoming/outgoing mail at `server3`

Which registries would you add?

DNS Related tools

- `whois domain`
  - Provides contact information for a domain
- `dig [@server] query`
  - Performs a DNS query
  - It allows controlling different resources
    - Server, type of register, iterative/recursive resolution, . . .
  - Returns the registers corresponding to the query
    - It supports debugging

Dynamic Host Configuration Protocol (DHCP)

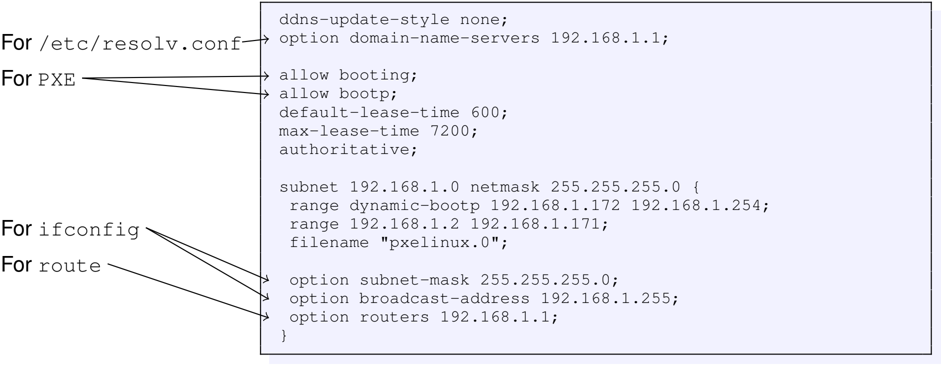
- It delivers automatically the network configuraiton to a host
  - IP assignation, Gateway and DNS
- Machine trustfulness is not verified
  - By default it is assumed that if the host can reach connectivity then it is legitimate
  - It can provide MAC address verification
- IP addresses are assigned from a predefined range

Dynamic Host Configuration Protocol (DHCP)

Remote boot support through BOOTP and PXE

- Preboot Execution Environment (PXE)
- Network card uses BIOS to get network information
- It allows to decide the kernel image to boot
  - Downloaded through TFTP
  - A remote root system can be mounted

Dynamic Host Configuration Protocol (DHCP)



For /etc/resolv.conf

For PXE

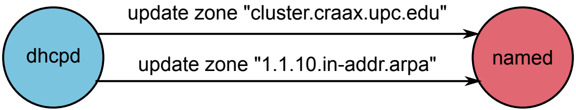
For ifconfig

For route

```
ddns-update-style none;
option domain-name-servers 192.168.1.1;

allow booting;
allow bootp;
default-lease-time 600;
max-lease-time 7200;
authoritative;

subnet 192.168.1.0 netmask 255.255.255.0 {
 range dynamic-bootp 192.168.1.172 192.168.1.254;
 range 192.168.1.2 192.168.1.171;
 filename "pxelinux.0";

 option subnet-mask 255.255.255.0;
 option broadcast-address 192.168.1.255;
 option routers 192.168.1.1;
}
```

Dynamic Host Configuration (DHCP)

DHCP and DNS can work together



dhcpd

update zone "cluster.craax.upc.edu"

update zone "1.1.10.in-addr.arpa"

named

/etc/dhcpd/dhcpd.conf

```
ddns-update-style interim;
key DHCP_UPDATER {
   algorithm HMAC-MD5.SIG-ALG.REG.INT;
   secret pRP5FapFoJ95JEL06sv4PQ==;
};
zone ac.upc.edu. {
   primary 192.168.1.1;
   key DHCP_UPDATER;
}
```

/etc/bind/named.conf

```
key DHCP_UPDATER {
   algorithm HMAC-MD5.SIG-ALG.REG.INT;
   secret pRP5FapFoJ95JEL06sv4PQ==;
};
zone ac.upc.edu. {
   type master;
   file "ac.zone";
   allow-update { key DHCP_UPDATER; };
};
...
```

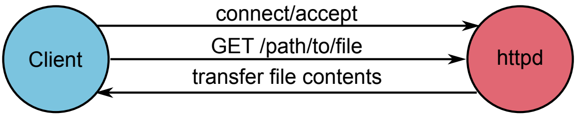
Exercise

In group

- Which potential problem can be caused by a DHCP server crash?
- Propose an implementation to solve it

Hypertext Transfer Protocol (HTTP)

- Data transfer service
- Connectionless
  - There is no state between connections
  - Each petition is self-contained
- Nevertheless it uses TCP



Apache Web Server

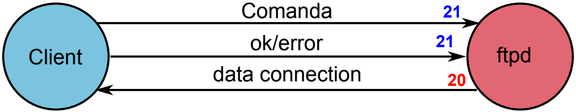
- Implements support for HTTP
- `/etc/apache/httpd.conf`

Main features

- Unprivileged user execution
- Queries are served using memory separated processes/threads
  - Memory sharing configurable by the administrator
  - Maximum concurrent processes limit
- Configuration options in a per directory basis
- Virtual Host configuration
  - By IP address
  - By DNS name

File Transfer Protocol (FTP)

- Data transfer service
- Connection oriented
- Control connection
  - There is state between connections: `cwd`
- Data connection
  - active: does not support NAT
  - passive: NAT is supported
  - There is a new data connection per transfer



FTP Configuration

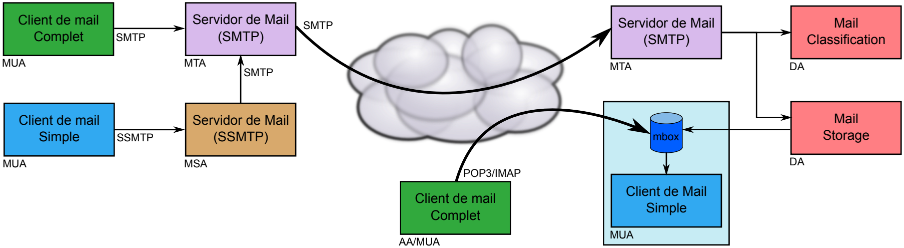
- There are many server implementations
  - `wu-ftpd`, `proftpd`, `vsftpd`, ...
- User level based authorization: `/etc/ftpusers`
  - List of the users that **CAN'T** access FTP
- Use `chroot` for security in Aonymous FTP
  - Changes the root of the process
  - Extra configuration
  - Requires install basic commands and configuration files
    - `/etc/passwd`, `/etc/shadow`
    - `/bin/ls`, `/lib/libc.so`, ...
  - Use it even for regular users

Simple Mail Transfer Protocol (SMTP)

Parts composing the mail system

- MUA - Mail User Agent
  - User application to read/write e-mails
- MSA - Mail Submission Agent
  - Application to transmit the mail from the client to the MTA
  - It make all previous error checking
- MTA - Mail Transport Agent
  - It sends the e-mail between servers
- Delivery Agent
  - Application to store mails into the user's mailbox
  - Sometimes the mails are stored into a database
- Access Agent
  - Application allowing the user to access its e-mail

Mail system components



Internals of an e-mail

- Envelope
  - Message destination
  - Source
  - Not received by the clients – only for servers
- Headers
  - Set of message properties
    - Sending date
    - Source and destination (shown by the e-mail clients)
    - List of servers the message has crossed
- Message body
  - Uses 7 bits ASCII
  - Attachments use Base-64

Mail client configuration

Mail reception

- Access to local mailbox
  - Mailbox/maildir format interpreter
- Remote mailbox access
  - POP3
  - IMAP

Mail sending

- Using an SMTP server

E-Mail server configuration

Mail sending – sendmail/postfix

- Sending direct to the destination
  - Search for MX record in DNS – local destination
- Sending through a Relay
  - No direct access to the destination

Mail reception

- Store the mails locally
  - POP3, DIMAP
- Store the mails in the remote server
  - IMAP

E-Mail server configuration

Mail aliases

- Redirect mail to other users
  - In a remote machine
- Users with multiple names
  - `root`, `postmaster`, `webmaster` → `usuari@host`
- Send a mail to a file instead of a user
  - spam: `/dev/null`
- Send the e-mail to a program
  - autoftp: ”| `/usr/bin/ftpserver`“
- Mailing list definition
  - Is better to use: Majordomo, Mailman, ListProc, SmartList, ...

Aliases defined in `/etc/aliases` or `/etc/mail/aliases`

Security considerations

User authentication

- By default the server does not ask for credentials
  - SASL can be used
- Envelope can be forged — SPAM . . .
- Trust mail relays
  - The server always tries to send the message
  - Even if the headers do not belong to the domain (Open Relays)

Security considerations

Mail privacy

- Mail is sent in plain text
  - Use of TLS (SSL) only between MUA and MTA
- PGP - Pretty Good Privacy
  - Message cyphering and signing
  - Based in public key cryptography
- S/MIME

Filter installation

- Anti-spam
  - `Spamassasin`, gray lists, black lists, . . .
- Anti-virus
  - `Clam AV`, `Amavis`, `f-prot`,. . .

Exercise – In group

We just set up a filter to control spam

- Which action would you take as a server when you detect a spam message?
- And if the filter is an anti-virus?

E-mail reception

Post Office Protocol (POP)

- It allows users to access their mailbox
- It downloads the messages to the local machine
- Authentication without encryption
  - `pop3s` secure alternative using SSL

Internet Message Access (IMAP)

- It allows users to manage their mailbox
- Management is performed remotely
- User authentication
  - Allowing encryption
- `imaps` even more secure alternative using SSL

Secure Shell

- It substitutes rsh/rlogin and telnet
- Adding security
  - It performs authentication based on RSA, DSA, ECDSA
    - Session key is signed by the client's private key
    - The server uses the public key as stored in (`.ssh/authorized_keys`) to check if the signature is correct
    - password based authentication is also supported
  - Connection is fully encrypted
    - Confidentiality: `3DES`, `Blowfish`, `...`
    - Integrity: `hmac-md5`, `...`
- The server runs the specified command or offer a shell
- Transparent session
  - Whenever a pseudo-terminal is not requested
  - It can be used to transfer binary files
- login Session
  - X11 Protocol forwarding can be configured

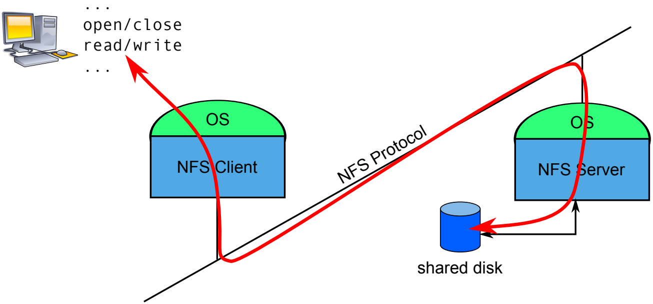
Exercise – In group

Secure Shell actions

- How would you implement secure copy and secure FTP directly with ssh?

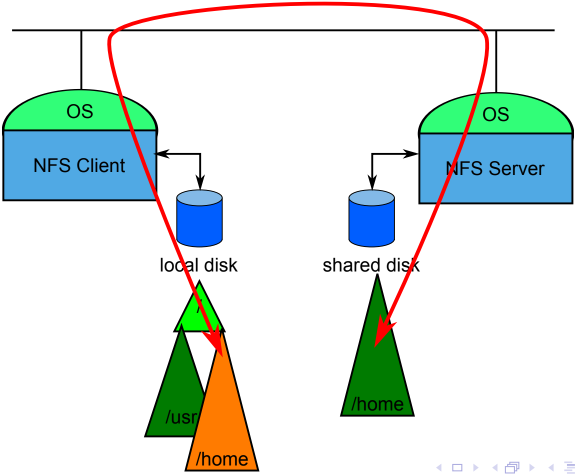
Network File System (NFS)

- File access in a remote server
  - Keeping the semantics (privilege wise) of the local filesystem
- It is transparent to the user
  - Implemented using RPC's



Remote mounting for NFS

The mounted directory is presented as local



Access privileges

- UIDs in the remote machines must be the same as used in local
  - Filesystems store UID rather than usernames
  - This can be adapted by using `idmapd`
- UID automatic translation (`idmapd`)
  - `root`, `nobody`
- Options
  - `no_root_squash`, root can su to any user!
  - `all_squash`, all users become `nobody`
  - We can decide who nobody is

```
anonuid=UID,anongid=GID
```

NFS Configuration

- Determine which resources to export
- Hosts to export to
- Configuration flags

/etc/exports

```
/              master(rw) trusty(rw,no_root_squash)
/projects      proj*.local.domain(rw)
/usr           *.local.domain(ro) @trustedgroup(rw)
/home/joe      pc001(rw,all_squash,anonuid=150,anongid=100)
/pub            (ro,insecure,all_squash)
```

SMB — Samba

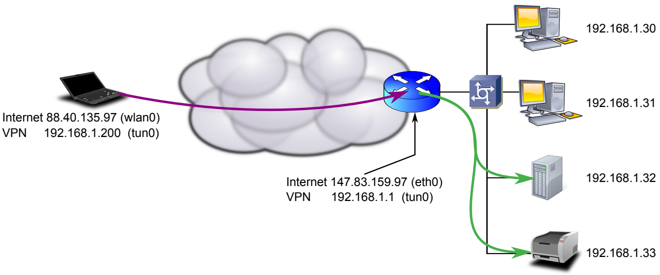
- It allows sharing files and printers
- User level access control
    - Authentication using login and password
        - Based on username not UID
        - Encripted and plaintext password transmission
    - Machine based access restriction
        - It does not allow to change permissions depending on the source
        - One must use different share names

Lightweight Directory Access Protocol (LDAP)

- It provides access to users database
  - Directory format (X.500)
- It offers user authentication methods
  - `/etc/passwd`, `/etc/shadow`, `/etc/group`, . . .
  - . . . they can be dumped to the LDAP database
- Besides regular files, login can also be controlled through the database

Virtual Private Networks (VPN)

- Server and client negotiate a secure connection
- An internal IP is offered through a secure tunnel
  - It grants access to all the internal services


Internet 88.40.135.97 (wlan0)
VPN 192.168.1.200 (tun0)
Internet 147.83.159.97 (eth0)
VPN 192.168.1.1 (tun0)
192.168.1.30
192.168.1.31
192.168.1.32
192.168.1.33