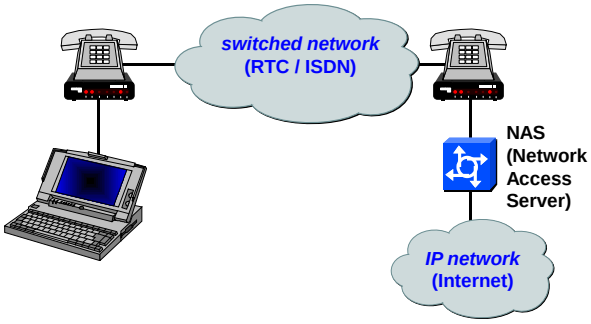
Security of IP networks

Antonio Lioy
< lioy @ polito.it >

Politecnico di Torino
Dip. Automatica e Informatica

Remote access via dial-up lines



Authentication of PPP channels

- **PPP is a protocol ...**
  - ... to encapsulate network packets (L3, e.g. IP) ...
  - ... and carry them over a point-to-point link
    - physical (e.g. RTC, ISDN)
    - virtual L2 (e.g. xDSL with PPPOE)
    - virtual L3 (e.g. L2TP over UDP/IP)
- **activated in three sequential steps:**
  - LCP (Link Control Protocol)
  - authentication (optional; PAP, CHAP or EAP)
  - L3 encapsulation (e.g. IPCP, IP Control Protocol)

Authentication of remote access

- **for dial-up and for wireless and virtual links**
- **PAP**
  - Password Authentication Protocol
  - password sent in clear
- **CHAP**
  - Challenge Handshake Authentication Protocol
  - symmetric challenge
- **EAP**
  - Extensible Authentication Protocol
  - external techniques (challenge, OTP, TLS)

PAP

- **Password Authentication Protocol**
- **RFC-1334**
- **user-id and password sent in clear**
- **authentication only once when the channel is created**
- **very dangerous!**

CHAP

- **RFC-1994 “PPP Challenge Handshake Authentication Protocol (CHAP)”**
- **symmetric challenge (password based)**
  - initial challenge compulsory (at channel creation)
  - authentication request optionally repeated (with a different challenge) during transmission – decision taken by the NAS
- **those that support both CHAP and PAP *must* offer CHAP first**

EAP

- **RFC-2284**
  "PPP Extensible Authentication Protocol (EAP)"
- **a flexible L2 authentication framework**
- **authentication predefined mechanisms:**
  - MD5-challenge (similar to CHAP)
  - OTP
  - generic token card
- **other mechanisms may be added:**
  - RFC-2716 "PPP EAP TLS authentication protocol"
  - RFC-3579 "RADIUS support for EAP"

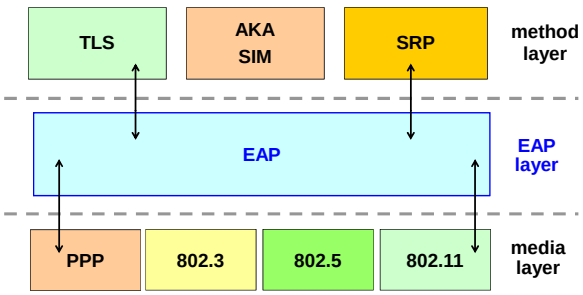
EAP - encapsulation

- **authentication data are transported via its own encapsulation protocol (because L3 packets are not yet available …)**
- **features of EAP encapsulation:**
  - independent of IP
    - supports any link layer (e.g. PPP, 802, …)
  - explicit ACK/NAK (no windowing)
    - assumes no reordering
  - no support for fragmentation

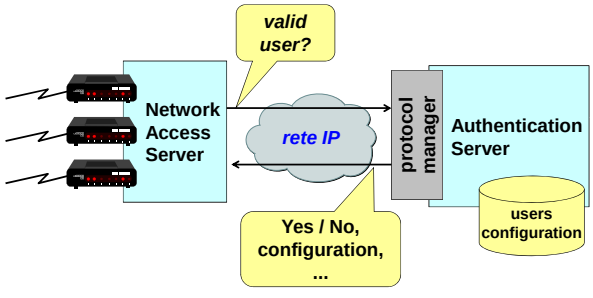
EAP

- **the link is not assumed to be physically secure**
  - EAP methods must provide security on their own
- **methods EAP:**
  - EAP-TLS
  - EAP-MD5
  - tunnelled TLS (to operate any EAP method protected by TLS)
  - EAP-SRP (Secure Remote Password)
  - GSS_API (included Kerberos)
  - AKA-SIM

EAP - architecture



Authentication for dial-up connections



The three A's

- **the NAS manufacturers claim that security needs three functions:**
  - Authentication
  - Authorization
  - Accounting
- **the AS performs exactly these three functions talking with one or more NAS via one or more protocols**

Network authentication protocols

- **RADIUS**
  - the de-facto standard
  - proxy towards other AS
- **DIAMETER**
  - evolution of RADIUS
  - emphasis on roaming among different ISP
  - takes care of security
- **TACACS+ (TACACS, XTACACS)**
  - originally technically better than RADIUS, achieved smaller acceptance because it was a proprietary solution (Cisco)

RADIUS

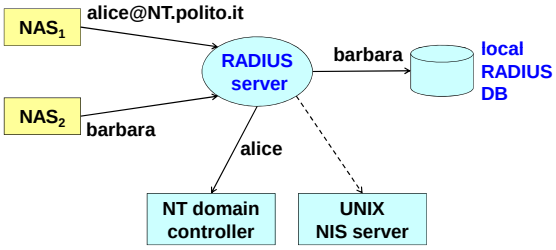
- **Remote Authentication Dial-In User Service**
- **Livingston Technologies**
- **port 1812/UDP (error: 1645/UDP)**
- **supports authentication, authorization and accounting to control network access:**
  - physical ports (analogical, ISDN, IEEE 802)
  - virtual ports (tunnel, wireless access)
- **centralized administration and accounting**
- **client-server schema between NAS and AS**
  - timeout + retransmission
  - secondary server

RADIUS - RFC

- **RFC-2865 (protocol)**
- **RFC-2866 (accounting)**
- **RFC-2867/2868 (tunnel accounting and attributes)**
- **RFC-2869 (extensions)**
- **RFC-3579 (RADIUS support for EAP)**
- **RFC-3580 (guidelines for 802.1X with RADIUS)**

RADIUS proxy

- **the RADIUS server may act as a proxy towards other authentication servers**



RADIUS: data protection

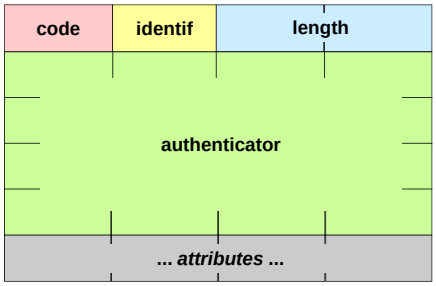
- **packet integrity and authentication via keyed-MD5:**
  - key = shared-secret
  - client without key are ignored
- **password transmitted "encrypted" with MD5 (after padding with NUL bytes to a multiple of 128 bit):**

  password ⊕ md5(key+authenticator)

RADIUS

- **user authentication via PAP, CHAP, token-card and EAP**
  - CISCO provides a free server for CryptoCard
  - others support SecurID
- **attributes in TLV form, easily extensible without modification to installed base:**
  attribute type – length – value

RADIUS - format



RADIUS – packet types

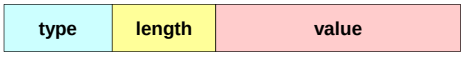
- **ACCESS-REQUEST**
- **ACCESS-REJECT**
- **ACCESS-CHALLENGE**
- **ACCESS-ACCEPT (*parameters*):**
  - SLIP/PPP: IPaddr, netmask, MTU, ...
  - terminal: host, port

RADIUS - authenticator

- **double purpose:**
  - server reply authentication and no replay
  - masking the password
- **in Access-Request:**
  - it is named Request Authenticator
  - 16 byte randomly generated by the NAS
- **in Access-Accept / Reject / Challenge**
  - it is named Response Authenticator
  - it is computed via a keyed-digest:

md5 (code || ID || length || RequestAuth || attributes || secret)

RADIUS - some attributes

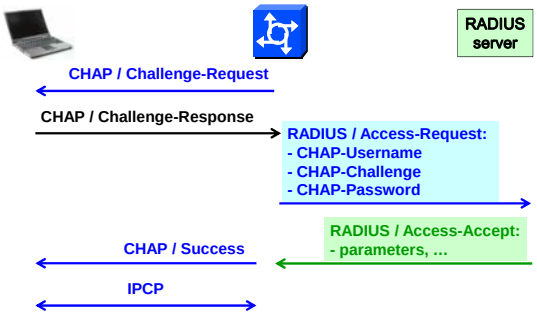


- **type = 1 (User-Name)**
  - value = text, network access identifier (NAI), DN
- **type = 2 (User-Password)**
  - value = password ⊕ md5 (key || RequestAuthent.)
- **type = 3 (Chap-Password)**
  - value = user CHAP response (128 bit)
- **type = 60 (CHAP-Challenge)**
  - value = challenge from the NAS to the user

NAI (Network Access Identifier)

- **RFC-2486**
- **NAI = username [@ realm]**
- **all devices must support NAI up to 72 byte long**
- **the exact syntax for username and realm is in the RFC (note that only ASCII characters < 128 are allowed, but all of them are allowed)**

Example - CHAP + RADIUS



DIAMETER

- **evolution of RADIUS**
- **special emphasis on roaming between ISP**
- **RFC-3588 "Diameter base protocol"**
- **RFC-3589 "Commands for the 3GPP"**
- **RFC-3539 "AAA transport profile"**
- **RFC-4004 "Diameter mobile IPv4 application"**
- **RFC-4005 "Diameter network access server application"**
- **RFC-4006 "Diameter credit-control application"**
- **RFC-4072 "Diameter EAP application"**

Security of DIAMETER

- **compulsory protection via IPsec or TLS:**
  - Diameter client MUST support IPsec and MAY support TLS
  - Diameter server MUST support IPsec and TLS
- **compulsory configurations:**
  - (IPsec) ESP with non null algo for both authentication and privacy
  - (TLS) mutual authentication (client MUST have a public-key certificate)
  - (TLS) MUST support RSA+RC4_128/3DES+ MD5/SHA1 e MAY support RSA+AES_128+SHA1

IEEE 802.1x

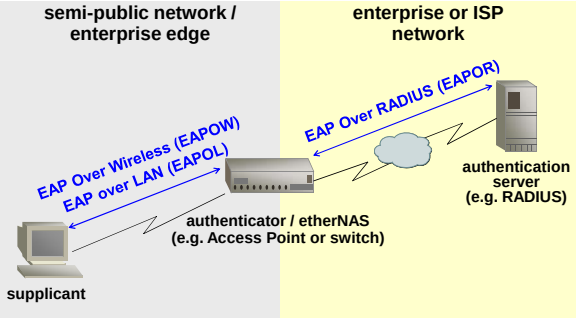
- **Port-Based Network Access Control:**
  - L2 authentication architecture
  - useful in a wired network to block access
  - absolutely needed in wireless networks
- **first implementations:**
  - Windows-XP and Cisco wireless access-points

http://standards.ieee.org/getieee802/download/802.1X-2001.pdf

IEEE 802.1x

- **authentication and key-management framework:**
  - may derive session keys for use in packet authentication, integrity and confidentiality
  - standard algorithms for key derivation (e.g. TLS, SRP, …)
  - optional security services (authentication or authentication+encryption)

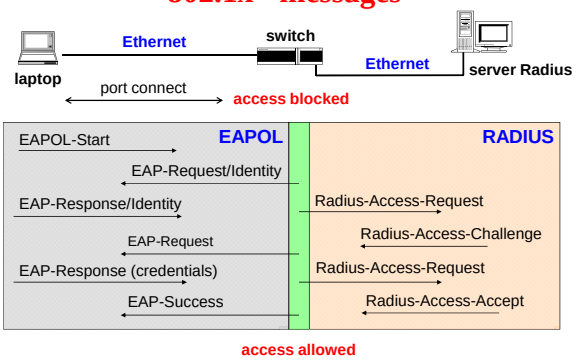
802.1x - architecture



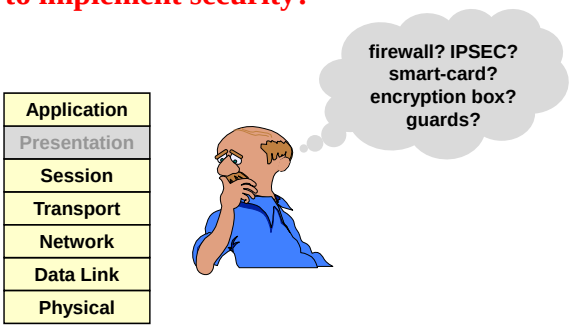
802.1x - advantages

- **exploits the application level for the actual implementation of the security mechanisms**
  - direct dialogue between supplicant and AS
    - NIC and NAS operate as "pass-through device"
  - no change needed on NIC and NAS to implement new mechanisms
  - perfect integration in AAA

802.1x - messages



Which is the best OSI level to implement security?

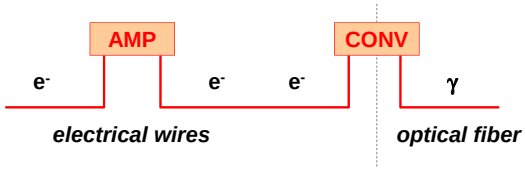


Optimal level?

- **the upper we go in the stack, the more specific are the security functions (e.g. it's possible to identify the user, commands, data) and independent from the underlying network … but we leave more room for DoS attacks**
- **the lower we go in the stack, the more quickly we can "expel" the intruders … but the fewer the data for the decision (e.g. only the MAC or IP addresses, no user identification, no commands)**

Security at physical level (L1)

- **physical protection:**
  - of the transmission media
  - of the amplifiers / repeaters / converters
- **typically only in closed networks (e.g. defence, government, high finance)**

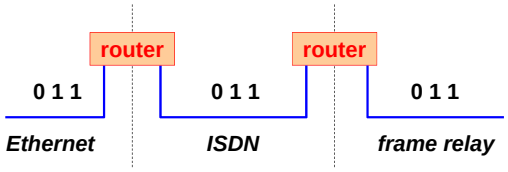


Security measures at physical level

- **use switched networks (i.e. 10baseT o 100baseT) (to try) to get rid of sniffing:**
  - don't use hubs in general
  - don't use hubs attached to a port of a switch
- **physical protection of:**
  - enclosures / rooms where network devices are located
  - cable tunnels (vertical and horizontal)

Security at data-link level (L2)

- **encryption boxes to protect the MAC payload**
- **only for homogeneous segments (i.e. same L2 network technology)**
  - LAN
  - WAN segments



Security measures at data-link level

- **although there exist encrypting NIC for the client, normally L2 is never protected in a LAN but only in point-to-point geographic links**
- **more often the LAN management is associated to the security management:**
  - VLAN
  - switch with protected ports (e.g. 802.1x)
  - alarms when a new MAC is detected
  - static L3 address assignment
  - say no to completely dynamic DHCP

DHCP security

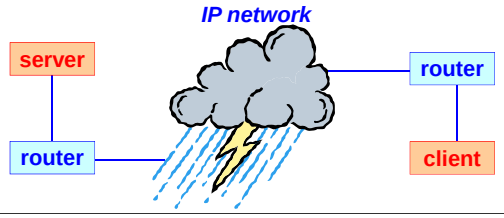
- **non-authenticated protocol**
- **activation of a shadow server is trivial**
- **possible attacks from the fake server:**
  - denial-of-service
    - provides a wrong network configuration
  - MITM
    - provides a configuration with a 2-bit subnet + default gateway equal to an attacker host
    - if we additionally activate NAT we can intercept the replies too

DHCP protection

- **some switch (e.g. Cisco) offers:**
  - DHCPsnooping = only replies from "trusted ports"
  - IP guard = only IP got from a DHCP server (but there is a limit on the number of recognized addresses)
- **RFC-3118 "Authentication for DHCP messages"**
  - use of HMAC-MD5 to authenticate the messages
  - rarely adopted

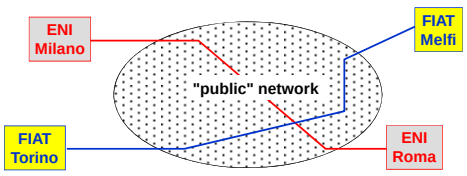
Security at network level (L3)

- **end-to-end protection for L3-homogeneous networks (e.g. IP networks)**
- **creation of VPN (Virtual Private Network)**



What is a VPN?

- **a technique (hardware and/or software) to create a private network ...**
- **... while using shared (or anyway untrusted) channels and transmission devices**



When is a VPN appropriate?

- **when data are transmitted over an untrusted network (e.g. public or shared) ...**
- **... for internal company communications among remote sites (Intranet)**
- **... for closed external communications among companies that previously entered into an agreement (Extranet)**

When is a VPN NOT appropriate?

- **when data are transmitted over an untrusted network ...**
- **... for external communications among companies that have no agreement**
- **... for communications with unknown customers (business-to-consumer e-commerce)**

Techniques to create a VPN

- **via private addressing**
- **via protected routing (IP tunnel)**
- **via cryptographic protection of the network packets (secure IP tunnel)**

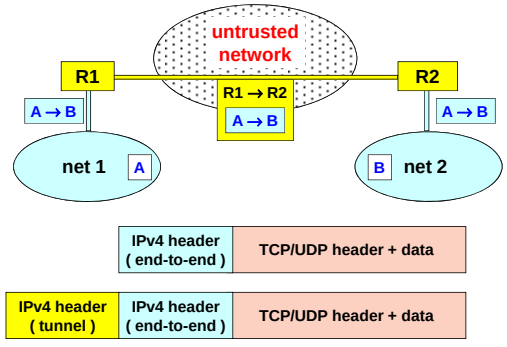
1. VPN via private addresses

- **the networks to be part of the VPN use non-public addresses so that they are unreachable from other networks (e.g. private IANA networks as per RFC-1918)**
- **this protection can be easily defeated if somebody:**
  - guesses or discovers the addresses
  - can sniff the packets during transmission
  - has access to the communication devices

2. VPN via tunnel

- **the routers encapsulate whole L3 packets as a payload inside another packet**
  - IP in IP
  - IP over MPLS
  - other
- **the routers perform access control to the VPN by ACL (Access Control List)**
- **this protection can be defeated by anybody that manages a router or can sniff the packets during transmission**

VPN via IP tunnel



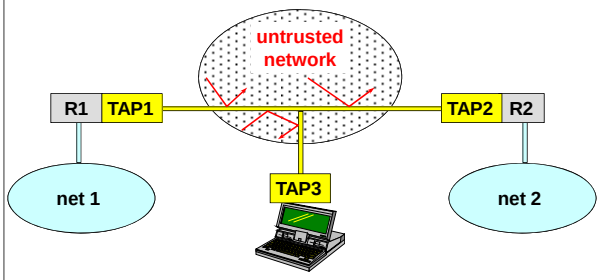
IP tunnel: fragmentation

- **if the packet has size equal to the MTU, then encapsulation will only possible with fragmentation**
- **maximum performance loss = 50%**
- **largest loss for applications with large packets (typically the non-interactive applications, e.g. file transfer)**

3. VPN via secure IP tunnel

- **before encapsulation, the packets are protected with:**
  - digest (integrity + authentication)
  - encryption (confidentiality)
  - numbering (to avoid replay)
- **if the cryptographic algorithms are strong, then the only possible attack is to stop the communications**
- **also known as S-VPN (Secure VPN)**

VPN via secure IP tunnel



IPsec

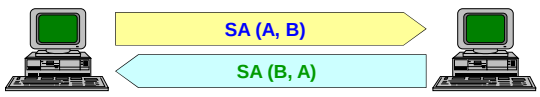
- **IETF architecture for L3 security in IPv4 / IPv6:**
  - to create S-VPN over untrusted networks
  - to create end-to-end secure packet flows
- **definition of two specific packet types:**
  - AH (Authentication Header)
    for integrity, authentication, no replay
  - ESP (Encapsulating Security Payload)
    for confidentiality (+AH)
- **protocol for key exchange:**
  - IKE (Internet Key Exchange)

IPsec security services

- **authentication of IP packets:**
  - data integrity
  - sender authentication
  - (partial) protection against “replay” attacks
- **confidentiality of IP packets:**
  - data encryption

IPsec Security Association (SA)

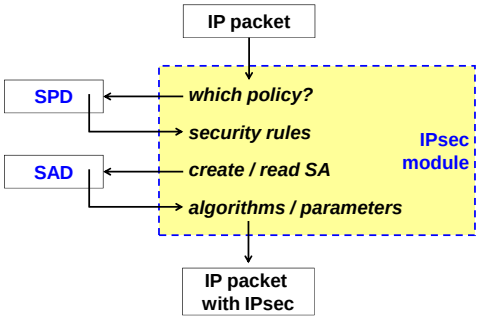
- **unidirectional logic connection between two IPsec systems**
- **each SA has associated different security services**
- **two SA are needed to get complete protection of a bidirectional packet flow**



IPsec local database

- **SAD (SA Database)**
  - list of active SA and their characteristics (algorithms, keys, parameters)
- **SPD (Security Policy Database)**
  - list of security policy to apply to the different packet flows
  - a-priori configured (e.g. manually) or connected to an automatic system (e.g. ISPS, Internet Security Policy System)

How IPsec works (sending)



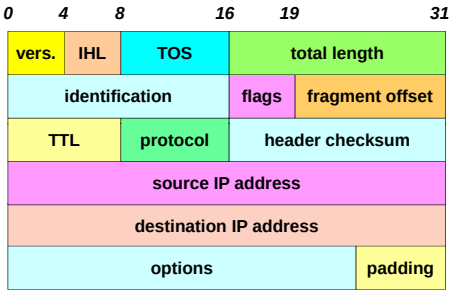
IPsec - second version

- november 1998
- RFC-2411 = IPsec document roadmap
- RFC-2401 = architecture
- RFC-2402 = AH
- RFC-2403 = HMAC-MD5-96 in ESP e AH
- RFC-2404 = HMAC-SHA-1-96 in ESP e AH
- RFC-2405 = ESP DES-CBC with explicit IV
- RFC-2406 = ESP
- RFC-2410 = null encryption in IPsec
- RFC-2451 = algorithms for ESP CBC

IPsec – key exchange

- RFC-2407 = IPsec interpretation of ISAKMP
- RFC-2408 = ISAKMP
- RFC-2409 = IKE
- RFC-2412 = OAKLEY

IPv4 header

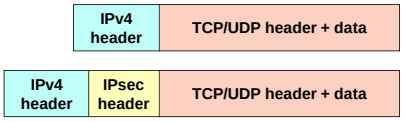


IPv4 header fields

- IP addresses (32 bit) of sender and receiver
- IHL (Internet Header Length) in 32-bit words
- TOS (Type Of Service): nearly ever used (!)
- length: no. of bytes of the IP packet
- identification: ID of the packet (for fragments)
- flags: may/don't fragment, last/more fragments
- TTL (Time To Live): max number of hops
- protocol: protocol of the payload

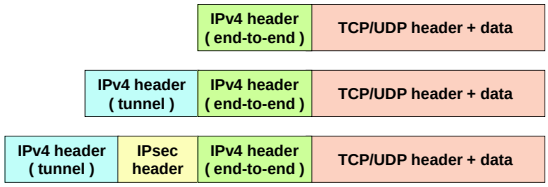
Transport mode IPsec

- used for end-to-end security, that is used by hosts, not gateways (exception: traffic for the gateway itself, e.g. SNMP, ICMP)
- pro: computationally light
- con: no protection of header variable fields



Tunnel mode IPsec

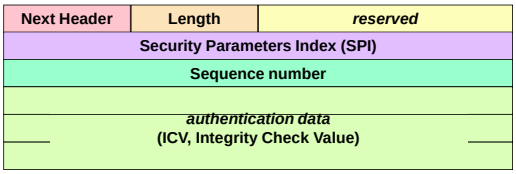
- **used to create a VPN, usually by gateways**
- **pro: protection of header variable fields**
- **con: computationally heavy**

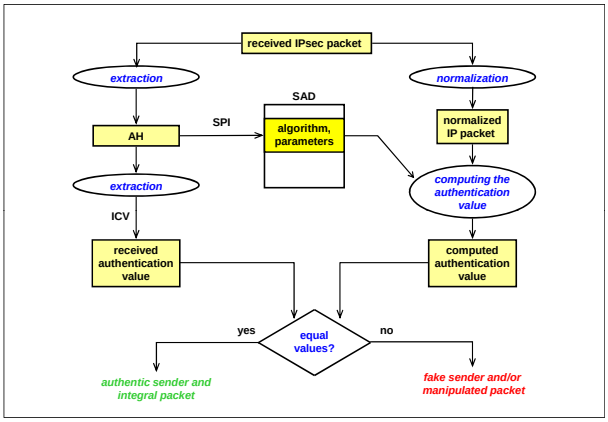


AH

- **Authentication Header**
- **mechanism (first version, RFC-1826):**
  - data integrity and sender authentication
  - compulsory support of keyed-MD5 (RFC-1828)
  - optional support of keyed-SHA-1 (RFC-1852)
- **mechanism (second version, RFC-2402):**
  - data integrity, sender authentication and (partial) protection from replay attack
  - HMAC-MD5-96
  - HMAC-SHA-1-96

AH - format (RFC-2402)





Normalization for AH

- **reset the TTL / Hop Limit field**
- **if the packet contains a Routing Header, then:**
  - set the destination field to the address of the final destination
  - set the content of the routing header to the value that it will have at destination
  - set the Address Index field at the value that it will have at destination
- **reset all options with the C bit (*change en route*) set**

Keyed-MD5 in AH

- **given M normalize it to generate M'**
- **pad M' to a multiple of 128 bit (by adding 0x00 bytes) to generate M'p**
- **pad the key K to a multiple of 128 bit (by adding 0x00 bytes) to generate Kp**
- **compute the authentication value:**

ICV = md5 (Kp || M'p || Kp)

HMAC-MD5-96

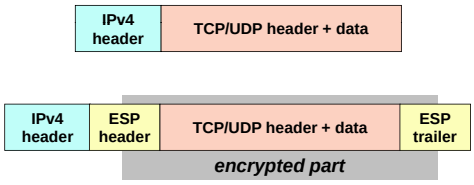
- given M normalize it to generate M'
- pad M' to a multiple of 128 bit (by adding 0x00 bytes) to generate M'p
- pad the key K to a multiple of 128 bit (by adding 0x00 bytes) to generate Kp
- given ip = 00110110 and op = 01011010 (repeated to give 128 bit) compute the authentication base:
  B = md5 ((Kp ⊕ op) || md5 ((Kp ⊕ ip) || M'p))
- ICV = 96 leftmost bits of B

ESP

- Encapsulating Security Payload
- first version (RFC-1827) gave only confidentiality
- base mechanism: DES-CBC (RFC-1829)
- other mechanisms possible
- second version (RFC-2406):
  - provides also authentication (but the IP header, so the coverage is not equivalent to that of AH)
  - the packet dimension is reduced and one SA is saved

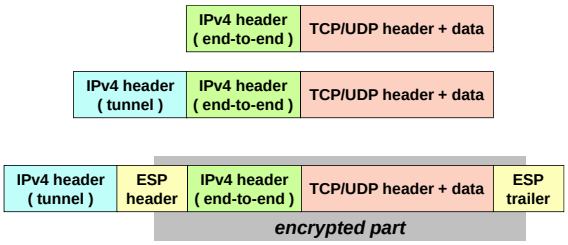
ESP in transport mode

- pro: the payload is hidden (including info needed for QoS, filtering, or intrusion detection!)
- con: the header remains in clear

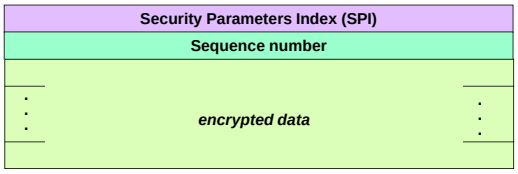


ESP in tunnel mode

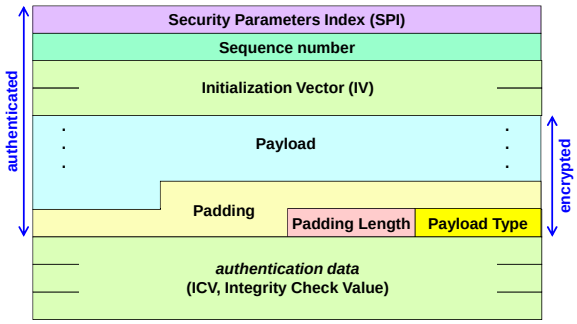
- pro: hides both the payload and (original) header
- con: larger packet size



ESP - format (RFC-2406)



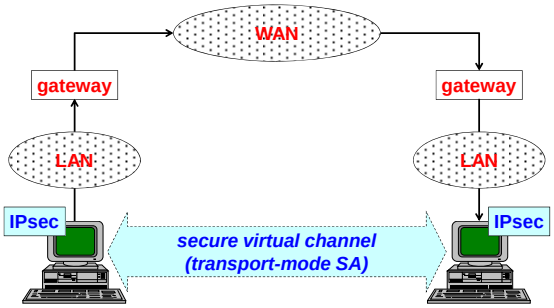
ESP-DES-CBC - format (RFC-2406)



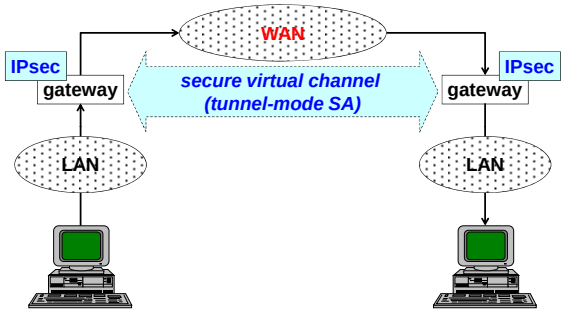
IPsec implementation details

- **sequence number:**
  - not strictly sequential (protection only from replay)
  - minimum window of 32 packets (64 suggested)
- **NULL algorithms :**
  - for authentication
  - for encryption (RFC-2410)
  - to adjust the protection vs. performance trade-off

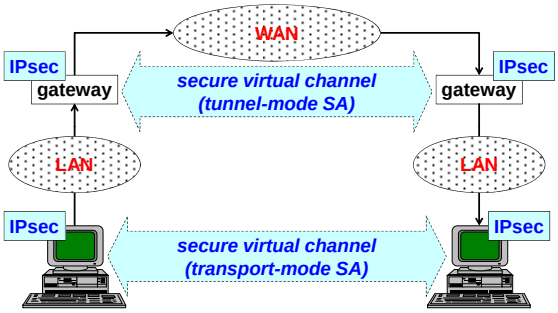
End-to-end security



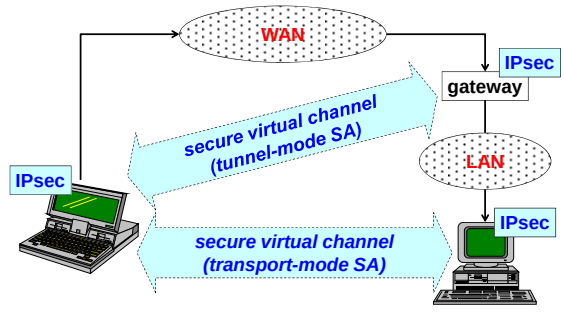
Basic VPN



End-to-end security with basic VPN



Secure remote access



IPsec key management

- **very important component of IPsec**
- **provides to the IPsec parties the symmetric keys used for packet authentication and/or encryption**
- **what about key distribution?**
  - OOB (e.g. manual)
  - automatic in-band (which protocol?)

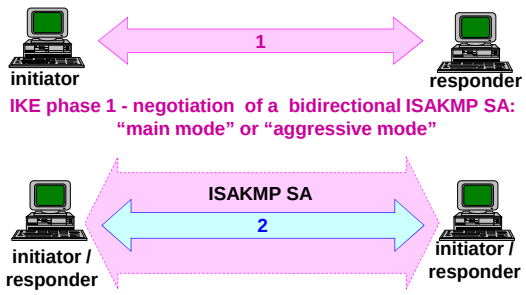
ISAKMP

- **Internet Security Association and Key Management Protocol**
- **RFC-2408**
- **procedures needed to negotiate, set-up, modify and delete a SA**
- **key exchange method not fixed:**
  - OAKLEY (RFC-2412): protocol for authenticated exchange of symmetric keys

IKE

- **Internet Key Exchange (RFC-2409)**
- **= ISAKMP + OAKLEY**
- **creation of a SA to protect the ISAKMP exchange**
- **this SA is used to protect the negotiation of the SA needed by IPsec traffic**
- **the same ISAKMP SA may be reused several times to negotiate other IPsec SA**

IKE: operations



IKE: "modes" of operation

- **Main Mode:**
  - 6 messages
  - protects the parties identities
- **Aggressive Mode:**
  - 3 messages (but doesn't protect the parties identities)
- **Quick Mode:**
  - 3 messages
  - negotiation only of the IPsec SA
- **New Group Mode:**
  - 2 messages

IKE: authentication methods

- **Digital Signature**
  - non-repudiation of the IKE negotiation
- **Public Key Encryption**
  - identity protection in the aggressive mode
- **Revised Public Key Encryption**
  - less expensive, only 2 public-key operations
- **Pre-Shared Key**
  - the party ID may only be its IP address (problem with mobile users)

IPsec in the OS

- **IPsec is available in all recent Unix versions**
  - SUN implemented it with SKIP in Solaris < 8
- **Linux:**
  - native IPsec since kernel 2.6 (derived from Kame)
  - FreeS/WAN (www.freeswan.org) and successors:
    - openswan (www.openswan.org)
    - strongswan (www.strongswan.org)
- **Microsoft has introduced IPsec in its products since Windows-2000**

IPsec in the router

- **all main network equipment manufacturers (Cisco, 3COM, Nortel, ...) have IPsec on the routers**
- **typically used only to create protected channels between the routers but not with the end-nodes**

IPsec in the firewall

- **some firewall manufacturers (e.g. IBM, Checkpoint) offer IPsec as part of their secure tunnel products**
- **typically offer a free Windows client, limited to create IPsec channels only with the firewall itself**

VPN concentrator

- **special-purpose appliance that acts as a terminator of IPsec tunnel:**
  - for remote access of single clients
  - to create site-to-site VPN
- **very high performance with respect to the costs (low)**

System requirements for IPsec

- **on router:**
  - powerful CPU or crypto accelerator
  - not managed in outsource
- **on firewall:**
  - powerful CPU
- **on VPN concentrator:**
  - maximum independence from the other security measures

IPsec influence on performance

- **network throughput is reduced:**
  - larger packet size
    - transport mode AH: +24 bytes
    - transport mode ESP-DES-CBC: >= 32 bytes
  - larger number of packets (for SA activation)
- **usually reduction is not very large**
- **exception: point-to-point link that used L2 compression that now becomes useless or counterproductive when applied to ESP packets**
- **possible compensation via IPComp (RFC-3173) or application-level compression**

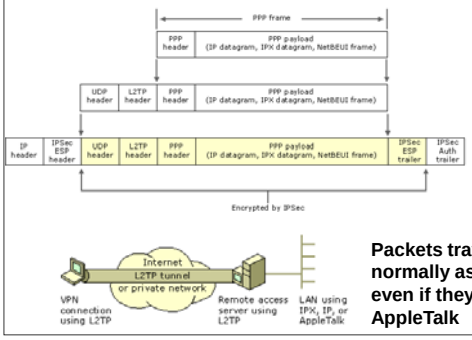
IPsec tunnel mode/L2TP

- **Windows 2000 protects remote access of the client to the gateway by using L2TP with IPsec**
- **MS explains this choice because IPsec tunnel mode:**
  - doesn't permit user authentication
  - doesn't support multiprotocol
  - doesn't support multicast
- **the choice of L2TP generates:**
  - a large performance penalty
  - interoperability problems with various systems

What is L2TP?

- **Layer-2 Tunnel Protocol (RFC-2661)**
- **PPP encapsulation in IP**
- **pro:**
  - can use PPP support for multi-protocol (e.g. for IPX, Netbeui and Appletalk)
  - user authentication (PAP / CHAP)
- **con: overhead**
- **with L2TP each end-point maintains a PPP state machine as if the two parties would be connected via a serial line**

IPsec over L2tp



The PPP packets are encapsulated 2 times and then transmitted as IPsec packets

Packets travel normally as IP packets even if they are IPX or AppleTalk

Applicability of IPsec

- **only unicast packets (no broadcast, no multicast, no anycast)**
- **between parties that activated a SA:**
  - by shared keys
  - by X.509 certificates
- **… therefore in "closed" groups**

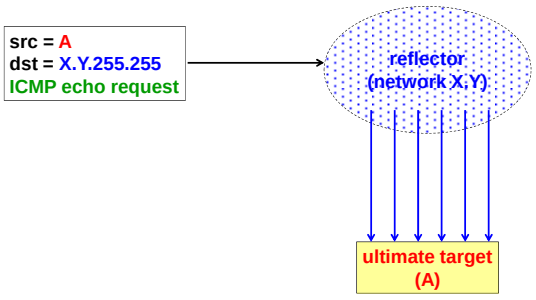
IP (in)security

- **addresses are not authenticated**
- **packets are not protected:**
  - integrity
  - authentication
  - confidentiality
  - replay
- **therefore all protocols using IP as carrier can be attacked, mainly relevant for the "service" protocols (i.e. the non-application ones, such as ICMP, IGMP, DNS, RIP, …)**

ICMP security

- **Internet Control and Management Protocol**
- **vital for network management**
- **many attacks are possible because it has no authentication**
- **ICMP functions:**
  - echo request / reply
  - destination unreachable (network / host / protocol / port unreachable)
  - source quence
  - redirect
  - time exceeded for a datagram

Smurfing attack



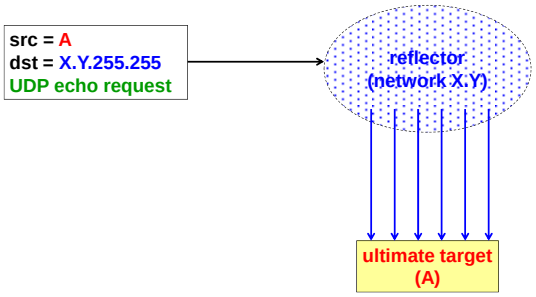
Anti-smurfing countermeasures

- **for external attacks: reject IP broadcast packets at your border**

```
interface serial0
no ip directed-broadcast
```

- **for internal attacks: identify the attacker via network management tools**

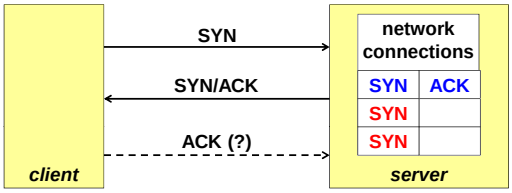
Fraggle attack



ARP poisoning

- **ARP = Address Resolution Protocol (RFC-826)**
  - used to discover the L2 address of a node when knowing its L3 address
  - result stored in the ARP table
- **ARP poisoning:**
  - nodes accept ARP reply without ARP request
  - nodes overwrite static ARP entries with the dynamic ones (obtained from ARP reply)
  - the "ar$sha" ARP field (sender hw address) may differ from the src field in the 802.3 packet
  - used by attack tools (e.g. Ettercap)

TCP SYN flooding



- **multiple requests with IP spoofing**
- **the connection table is saturated until half-open connections timeout (typical value: 75")**

Protection against SYN flooding

- **decrease the timeout**
  - risk to delete requests from valid but slow clients
- **increase the table size**
  - can be circumvented by sending more requests
- **use a router as "SYN interceptor":**
  - substitutes the server in the first phase
  - if the handshake completes successfully, then transfers the channel to the server
  - "aggressive" timeout (risky!)
- **use a router as "SYN monitor":**
  - kills the pending connection requests (RST)

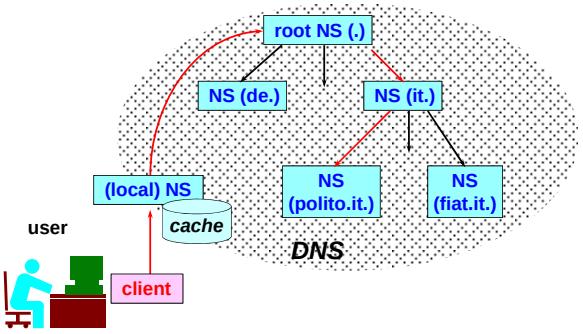
SYN cookie

- **idea of D.J.Bernstein (http://cr.yp.to)**
- **the only approach really effective to completely avoid the SYN flooding attack**
- **uses the TCP sequence number of the SYN-ACK packet to transmit a cookie to the client and later recognize the clients that already sent the SYN without storing any info about them on the server**
- **available on Linux and Solaris**

DNS security

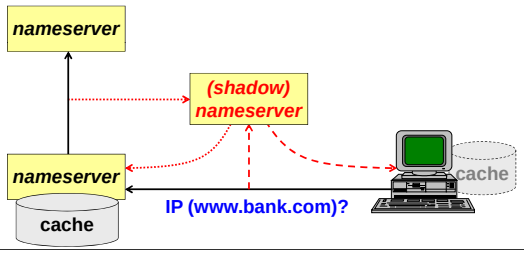
- DNS (Domain Name System)
- translation:
  - from names to IP addresses
  - from IP addresses to names
- vital service
- queries over port 53/UDP
- zone transfers over port 53/TCP
- no security
- DNS-SEC under development

DNS architecture



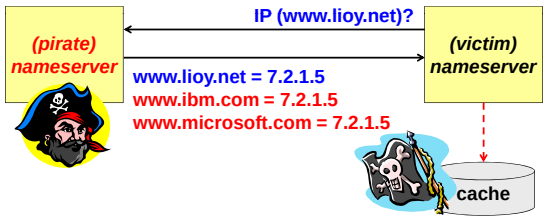
DNS shadow server

- sniffing to intercept the queries
- spoofing to generate fake answers (DoS or traffic redirection to fake sites)



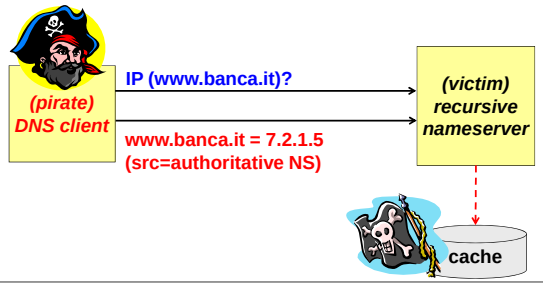
DNS cache poisoning

- attract the victim to make a query on my NS
- provide answers also to queries never done to push / overwrite the victim's cache

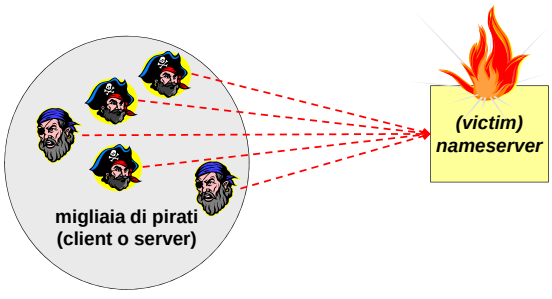


DNS cache poisoning (2nd version)

- make a query and self-provide the (wrong) answer too, to insert it into the victim's cache



(DNS) flash crowd



BIND

- **for DNS security the use (and periodic update!) of BIND is suggested**
- **BIND = Berkeley Internet Name Domain server**
- **free**
- **for Unix and Win-32**
- **http://www.isc.org**
- **subscribe to the BIND mailing list because – since it is a huge piece of software – it has security bugs**

DJBDNS

- **DNS server by D.J.Bernstein, designed for security:**
  - simple and modular
  - developed with secure programming techniques
- **http://cr.yp.to/djbdns.html**
- **three distinct services:**
  - tiny DNS (authoritative nameserver for a domain)
  - dnscache (cache manager)
  - walldns (a reverse DNS wall)

DJBDNS security features

- **unharmful processes:**
  - the UID is not root
  - run chroot'ed
- **dnscache discard:**
  - requests not coming from "trusted" addresses
  - answers from IP addresses different from the one to which the query was submitted
- **dnscache is immune to cache poisoning**
- **tinydns and walldns do not cache any information**

walldns

- **hides the true names of the network nodes**
- **useful when an application server queries the PTR before providing the service**
- **the true names are never disclosed, walldns provides only fictitious names (to satisfy the requestor)**
- **problem with the "paranoid servers", that is those performing a double cross lookup:**
  - N = dns_query (client_IP, PTR_record)
  - A = dns_query (N, A_record)
  - is A equal to the client_IP?

DNSsec

- **digital signature of DNS records**
  - who is "authoritative" for a certain domain?
  - which is the PKI? (certificates, trusted root CA)
- **complex management of the DNS infrastracture**
  - hierachical and delegated signatures
  - distributed signatures
- **handling of non-existent names?**
  - the ABSENCE of a record must be signed too
  - this requires sorting of the records

Some DNSsec issues

- **no signature of the DNS query**
- **no security in the dialogue between the DNS client and DNS (local) server**
  - use IPsec or TSIG
- **encryption to be performed by the DNS server**
  - computational overhead
  - management overhead (on-line secure crypto host)
- **bigger record size**
- **scarce experimental results**
  - configuration? performance?

Routing security

- **low security in the system access to routers for management (telnet, SNMP)**
- **low security in the exchange of routing tables:**
  - authentication based on IP addresses
  - optional protection with a keyed-digest
    - a shared-key is required!
    - key-management is required!
- **dynamical routing variations also on end-nodes possible via ICMP**

Physical router protection

- **limit physical access only to authorized people**
- **serial line console port:**
  - direct connection of a terminal or PC
  - permits direct access with maximum privilege
  - protect it with a password (default: no password!)

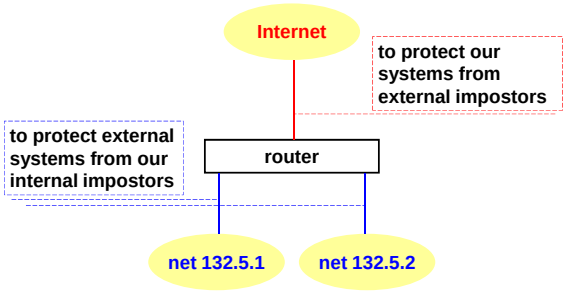
Logical router protection

- **activate the most common ACL**
- **protect the configuration file (wherever it's stored) because it contains:**
  - the passwords (often in cleartext!)
  - the IP-based ACL

Protection from IP spoofing

- **to protect ourselves from external impostors**
- **also to protect the external world from our internal impostors (=net-etiquette)**
- **RFC-2827 "Network ingress filtering: defeating Denial of Service attacks which employ IP source address spoofing"**
- **RFC-3704 "Ingress filtering for multihomed networks"**
- **RFC-3013 "Recommended Internet Service Provider security services and procedures"**

Filters for IP spoofing protection



Example of IP spoofing protection

```
access-list 101 deny ip
  132.5.0.0 0.0.255.255 0.0.0.0 255.255.255.255
interface serial 0
ip access-group 101 in

access-list 102 permit ip
  132.5.1.0 0.0.0.255 0.0.0.0 255.255.255.255
interface ethernet 0
ip access-group 102 in

access-list 103 permit ip
  132.5.2.0 0.0.0.255 0.0.0.0 255.255.255.255
interface ethernet 1
ip access-group 103 in
```

SNMP security

- **packets 161/UDP**
- **SNMP (v1, v2, v3):**
  - default protection via shared secret transmitted in cleartext (the so-called “community” string)
  - no client authentication
  - no message protection
- **SNMPv3 pays more attention to security but it is seldom implemented and often without the security paty**

SNMP access protection examples

```
access-list 10 permit 132.5.1.1
access-list 10 permit 132.5.1.2
snmp-server community public RO 1
snmp-server community private RW 1
```