Virtual Private Networks

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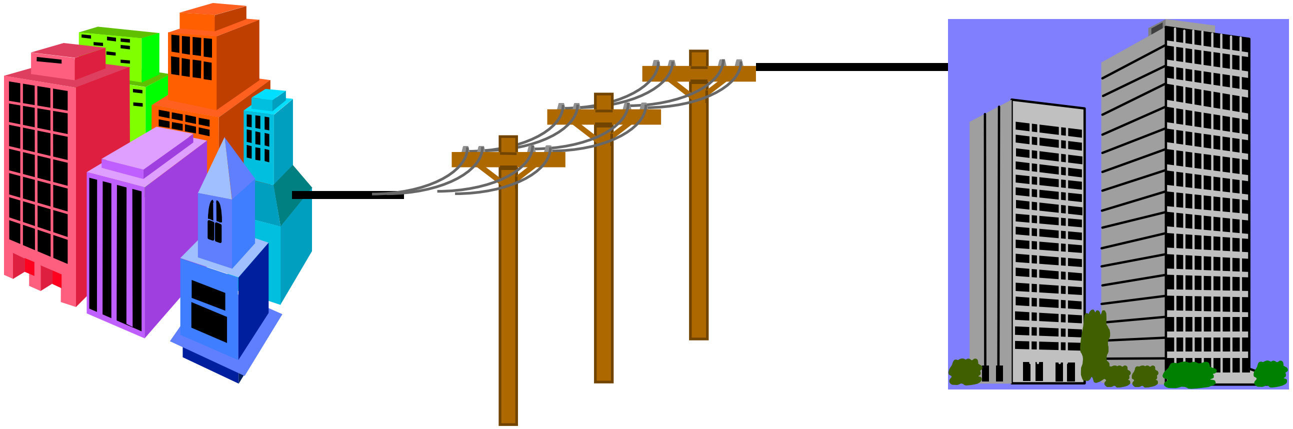
Overview

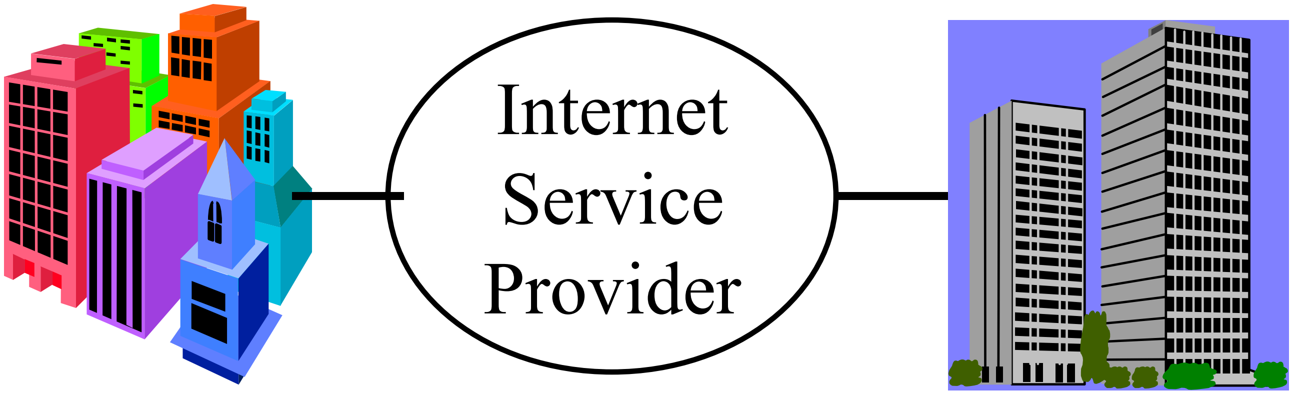
- ❑ Types of VPNs
- ❑ When and why VPN?
- ❑ VPN Design Issues
- ❑ Security Issues
- ❑ VPN Examples: PPTP, L2TP, IPSec

What is a VPN?

- Private Network: Uses leased lines

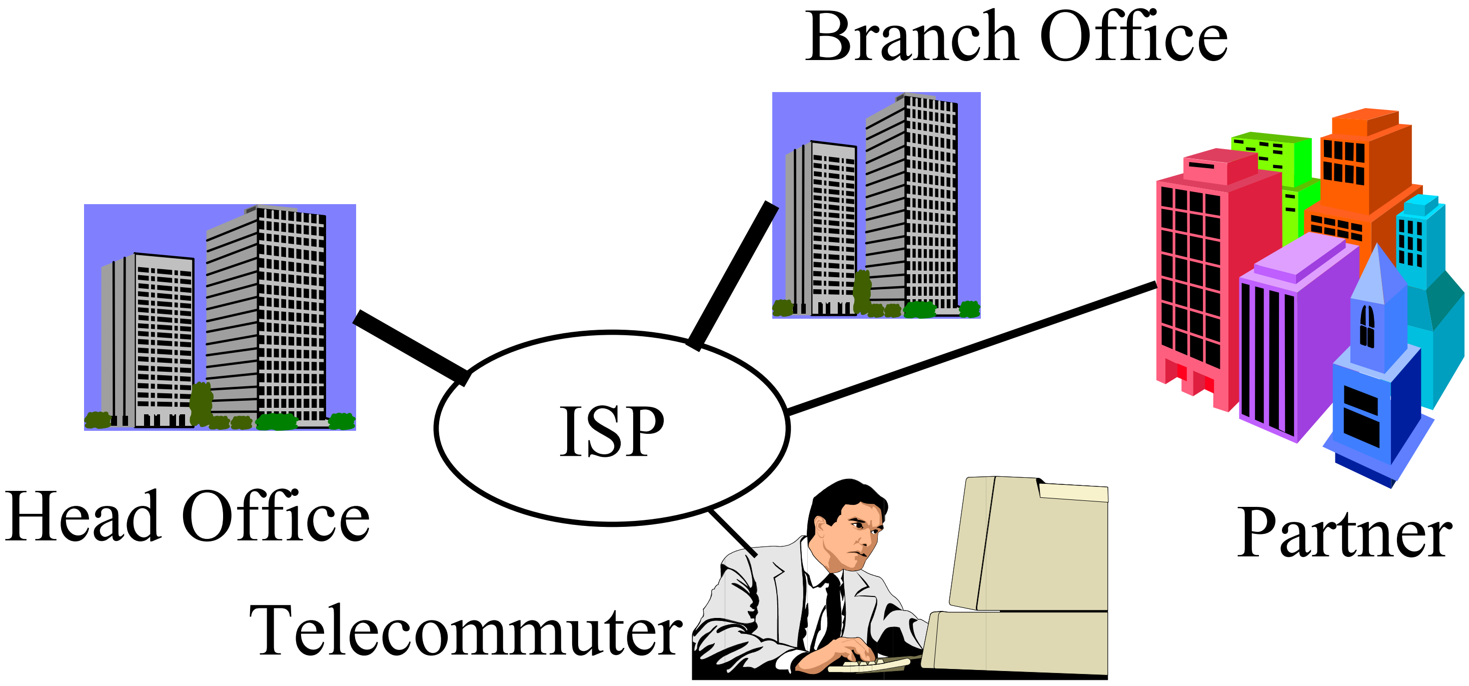


- *Virtual* Private Network: Uses public Internet



Types of VPNs

- WAN VPN: Branch offices
- Access VPN: Roaming Users
- Extranet VPNs: Suppliers and Customers



Branch Office

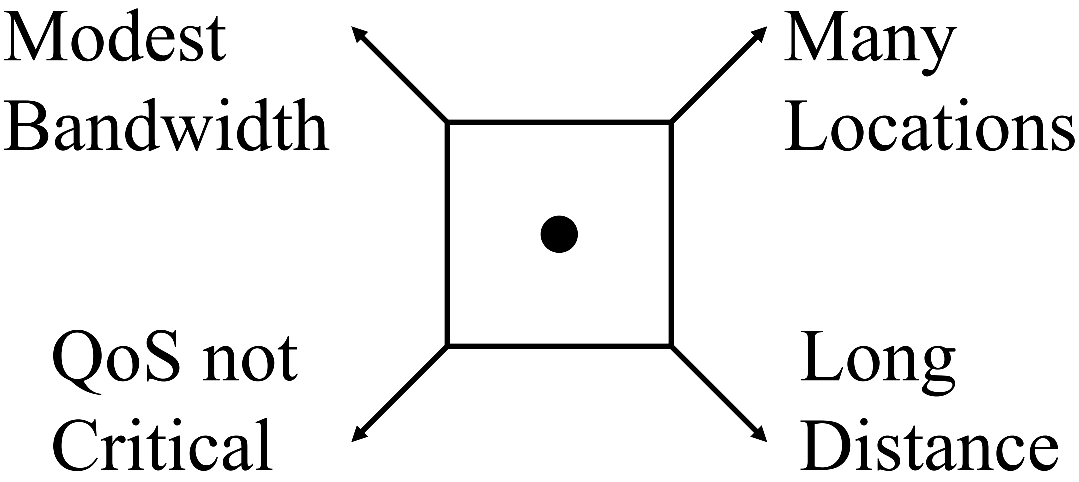
ISP

Head Office

Partner

Telecommuter

When to VPN?



- More Locations, Longer Distances, Less Bandwidth/site, QoS less critical
  ⇒ VPN more justifiable
- Fewer Locations, Shorter Distances, More Bandwidth/site, QoS more critical
  ⇒ VPN less justifiable

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VPN Design Issues

1. Security
2. Address Translation
3. Performance: Throughput, Load balancing (round-robin DNS), fragmentation
4. Bandwidth Management: RSVP
5. Availability: Good performance at all times
6. Scalability: Number of locations/Users
7. Interoperability: Among vendors, ISPs, customers (for extranets) ⇒ Standards Compatibility, With firewall

Design Issues (Cont)

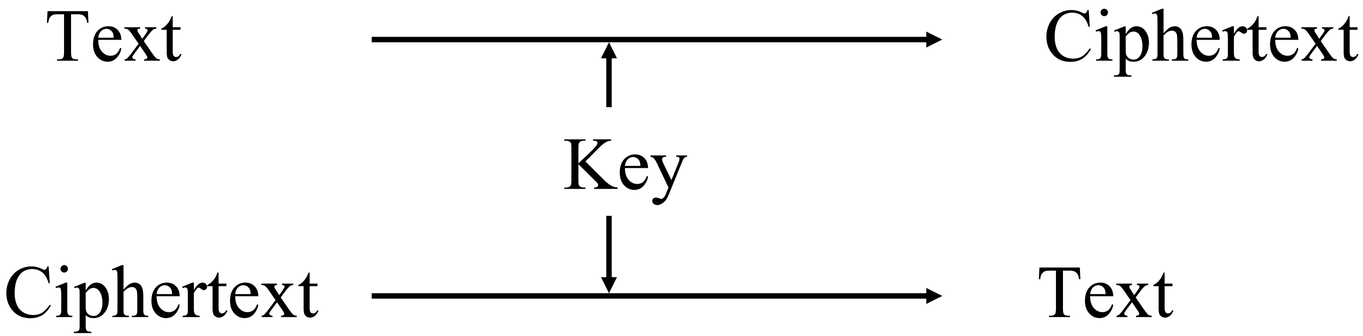
8. Compression: Reduces bandwidth requirements
9. Manageability: SNMP, Browser based, Java based, centralized/distributed
10. Accounting, Auditing, and Alarming
11. Protocol Support: IP, non-IP (IPX)
12. Platform and O/S support: Windows, UNIX, MacOS, HP/Sun/Intel
13. Installation: Changes to desktop or backbone only
14. Legal: Exportability, Foreign Govt Restrictions, Key Management Infrastructure (KMI) initiative
    ⇒ Need key recovery

Security 101

- Integrity: Received = sent?
- Availability: Legal users should be able to use.
  Ping continuously ⇒ No useful work gets done.
- Confidentiality and Privacy:
  No snooping or wiretapping
- Authentication: You are who you say you are.
  A student at Dartmouth posing as a professor canceled the exam.
- Authorization = Access Control
  Only authorized users get to the data

Secret Key Encryption

- Encrypted_Message = Encrypt(Key, Message)
- Message = Decrypt(Key, Encrypted_Message)
- Example: Encrypt = division
- 433 = 48 R 1 (using divisor of 9)



Text

Ciphertext

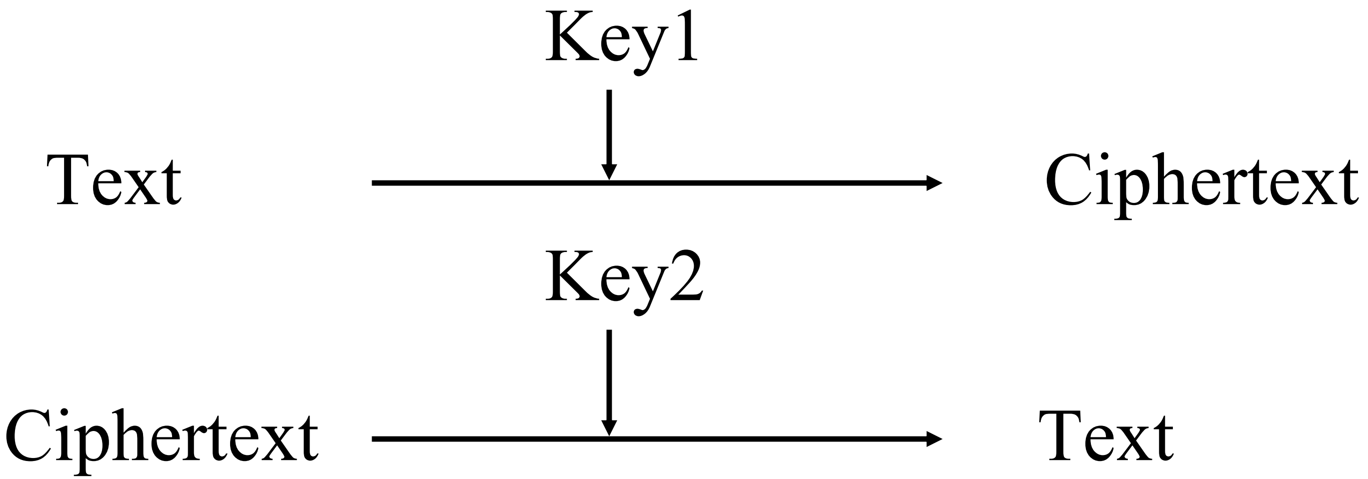
Key

Ciphertext

Text

Public Key Encryption

- Invented in 1975 by Diffie and Hellman
- Encrypted_Message = Encrypt(Key1, Message)
- Message = Decrypt(Key2, Encrypted_Message)



Public Key Encryption

- RSA: Encrypted_Message = m^3 mod 187
- Message = $\text{Encrypted\_Message}^{107}$ mod 187
- Key1 = <3,187>, Key2 = <107,187>
- Message = 5
- Encrypted Message = $5^3 = 125$
- Message = 125^{107} mod 187
  = $125^{(64+32+8+2+1)}$ mod 187
  = {(125^{64} mod 187)(125^{32} mod 187)...
  (125^{2} mod 187)(125)} mod 187 = 5
- 125^4 mod 187 = (125^2 mod 187)^2 mod 187

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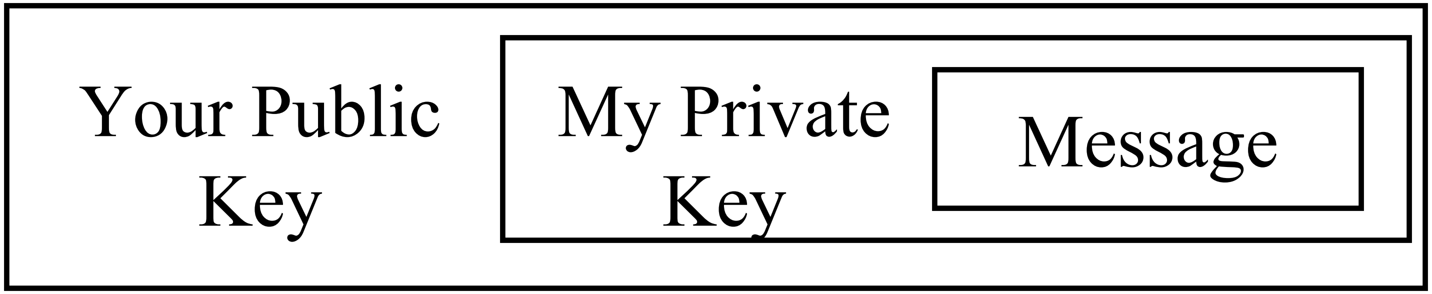
Public Key (Cont)

- One key is private and the other is public
- Message = Decrypt(Public_Key,
  Encrypt(Private_Key, Message))
- Message = Decrypt(Private_Key,
  Encrypt(Public_Key, Message))

Confidentiality

- User 1 to User 2:
- Encrypted_Message = Encrypt(Public_Key2, Encrypt(Private_Key1, Message))
- Message = Decrypt(Public_Key1, Decrypt(Private_Key2, Encrypted_Message) ⇒ Authentic and Private

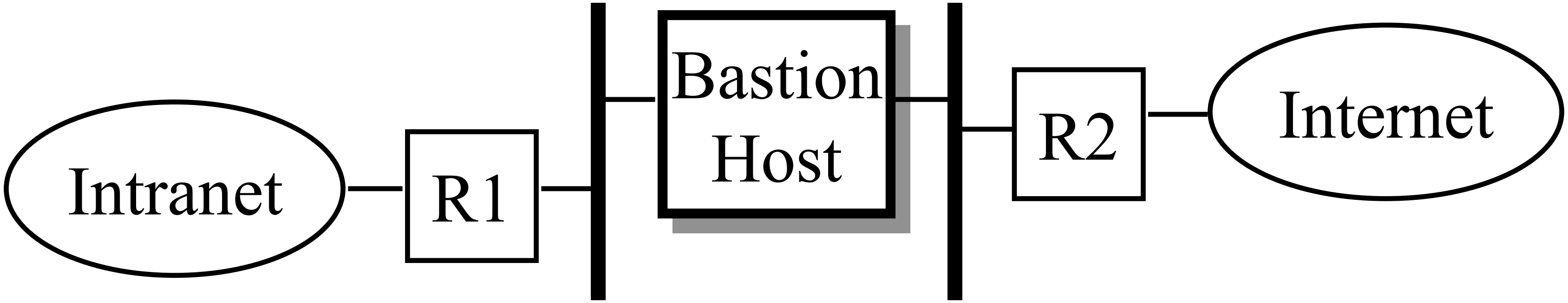


Your Public Key

My Private Key

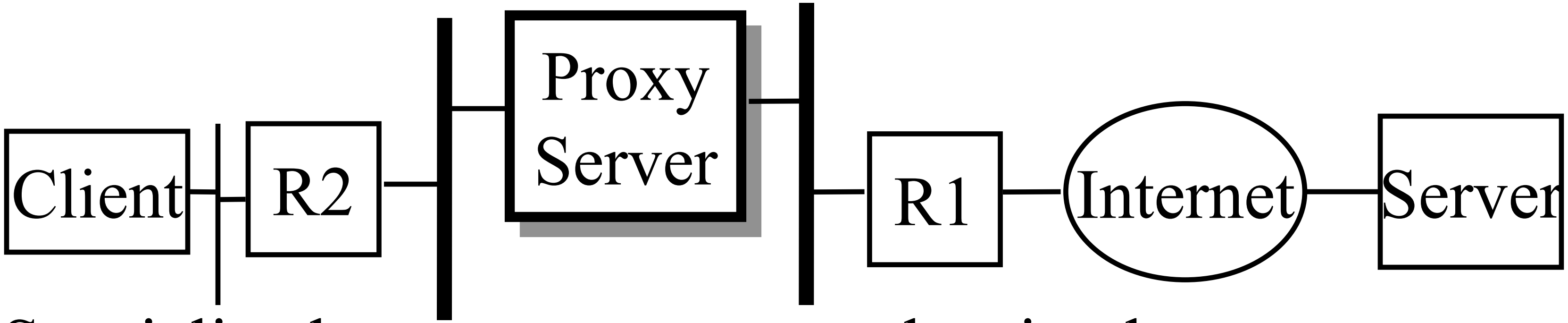
Message

Firewall: Bastion Host



- Bastions overlook critical areas of defense, usually having stronger walls
- Inside users log on the Bastion Host and use outside services.
- Later they pull the results inside.
- One point of entry. Easier to manage security.

Proxy Servers



- Specialized server programs on bastion host
- Take user's request and forward them to real servers
- Take server's responses and forward them to users
- Enforce site security policy
  ⇒ May refuse certain requests.
- Also known as application-level gateways
- With special "Proxy client" programs, proxy servers are almost transparent

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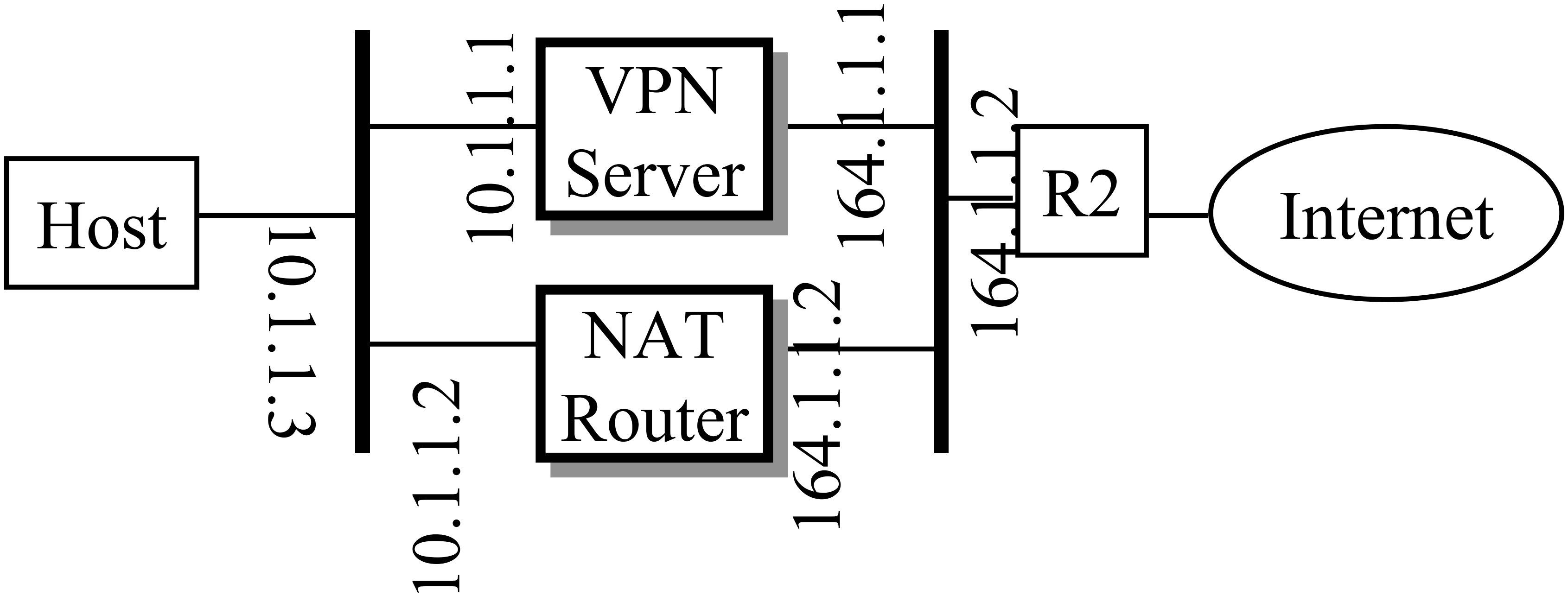
VPN Security Issues

- Authentication methods supported
- Encryption methods supported
- Key Management
- Data stream filtering for viruses, JAVA, active X
- Supported certificate authorities (X.509, Entrust, VeriSign)
- Encryption Layer: Datalink, network, session, application. Higher Layer ⇒ More granular
- Granularity of Security: Departmental level, Application level, Role-based

Private Addresses

- 32-bit Address ⇒ 4 Billion addresses max
- Subnetting ⇒ Limit is much lower
- Shortage of IP address ⇒ Private addresses
- Frequent ISP changes ⇒ Private address
- Private ⇒ Not usable on public Internet
- RFC 1918 lists such addresses for private use
- Prefix = 10/8, 172.16/12, 192.168/16
- Example: 10.207.37.234

Address Translation



- NAT = Network Address Translation
  Like Dynamic Host Configuration Protocol (DHCP)
- IP Gateway: Like Firewall
- Tunneling: Encaptulation

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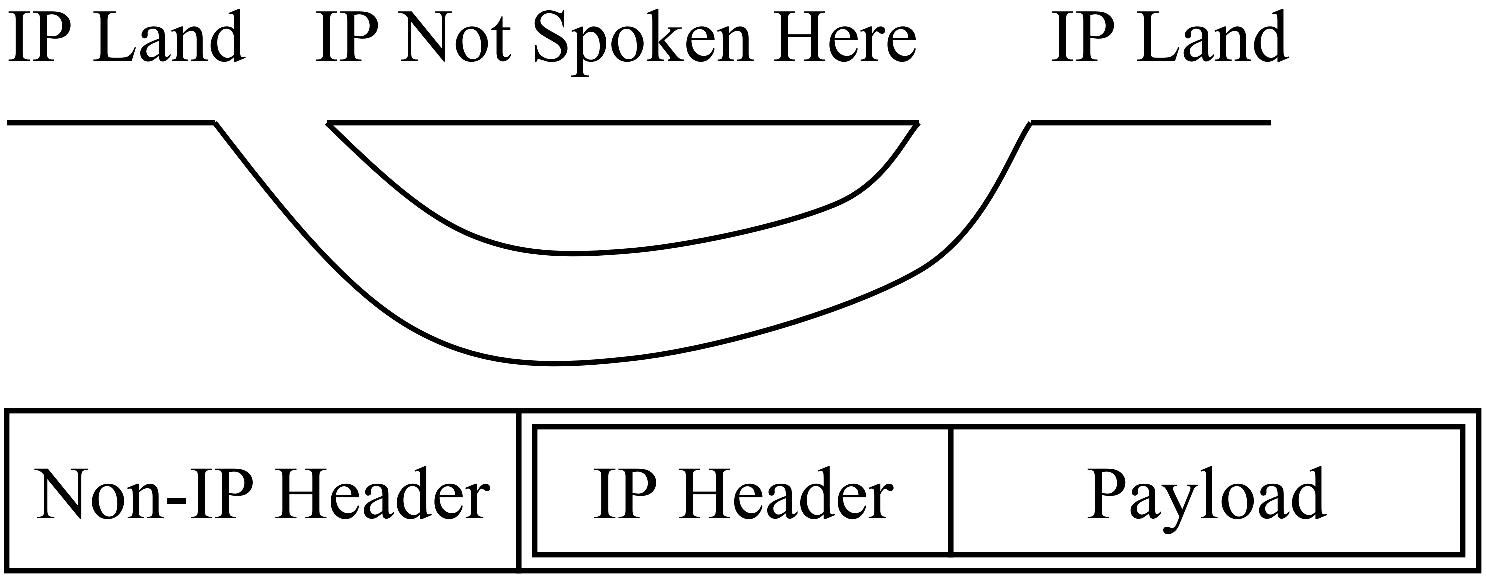
Tunnel



IP Land

IP Not Spoken Here

IP Land

Non-IP Header

IP Header

Payload

- Tunnel = Encaptulation
- Used whenever some feature is not supported in some part of the network, e.g., multicasting, mobile IP

VPN Tunneling Protocols

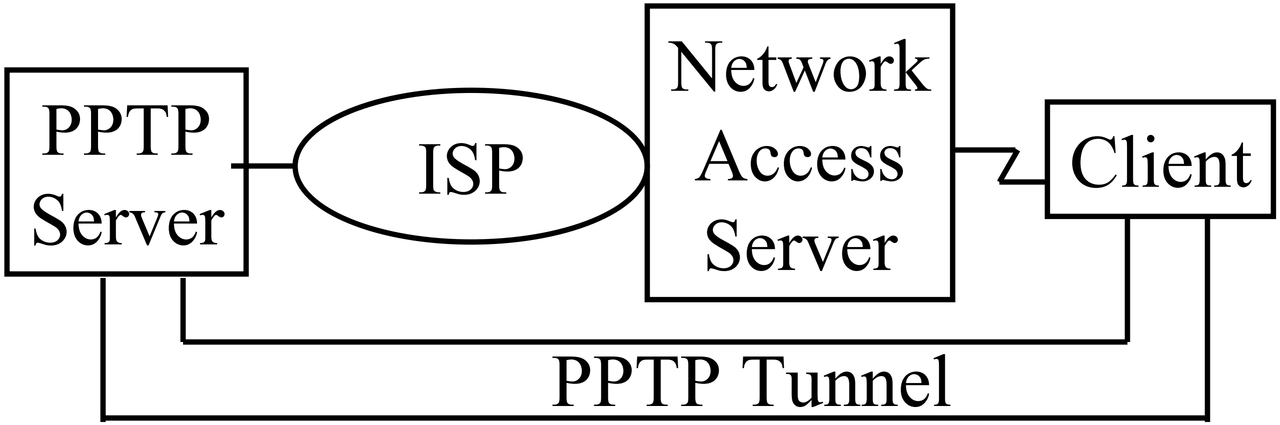
- GRE: Generic Routing Encaptulation (RFC 1701/2)
- PPTP: Point-to-point Tunneling Protocol
- L2F: Layer 2 forwarding
- L2TP: Layer 2 Tunneling protocol
- ATMP: Ascend Tunnel Management Protocol
- DLSW: Data Link Switching (SNA over IP)
- IPSec: Secure IP
- Mobile IP: For Mobile users

GRE

Delivery Header	GRE Header	Payload

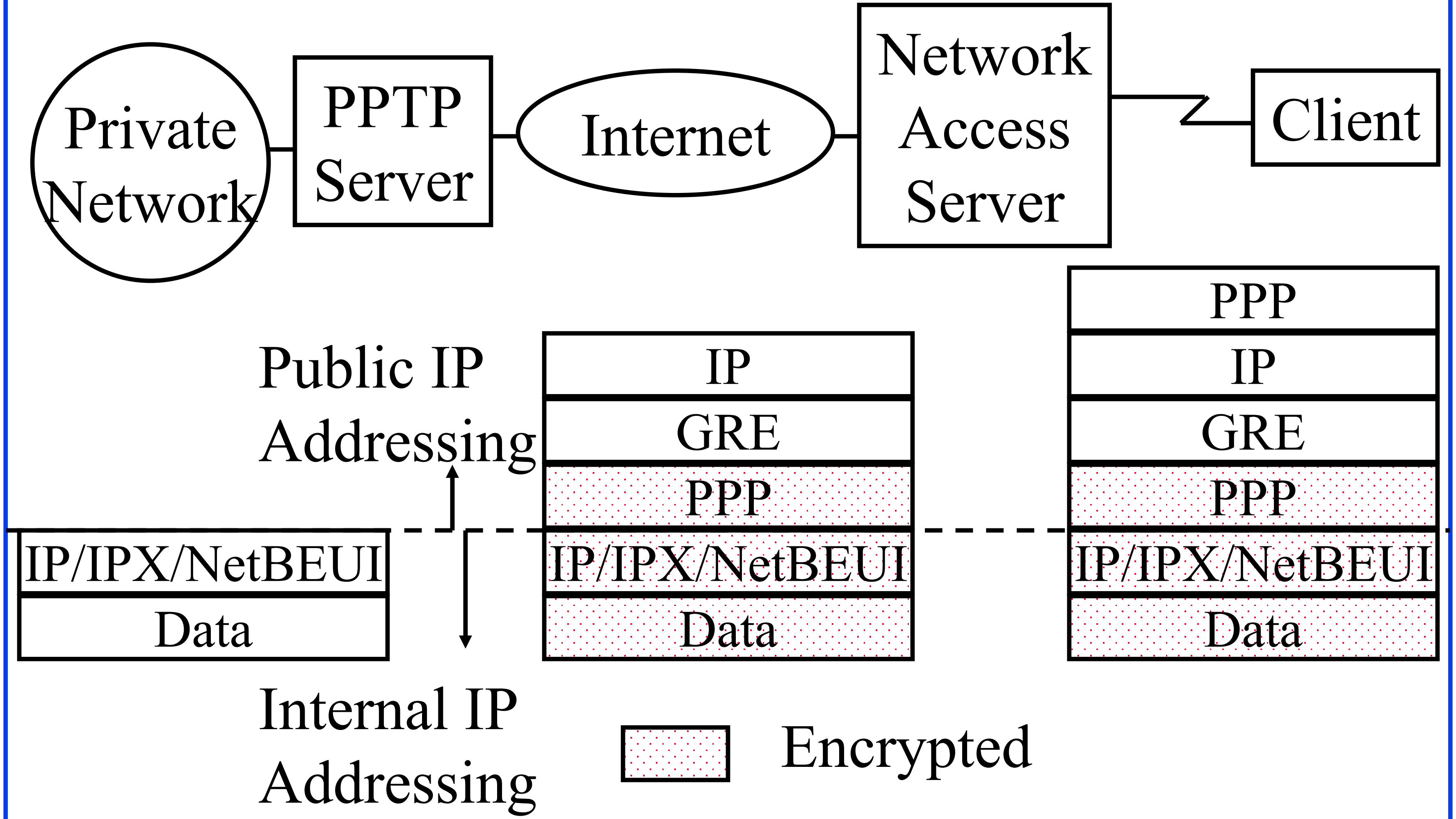
- Generic Routing Encaptulation (RFC 1701/1702)
- Generic ⇒ X over Y for any X or Y
- Optional Checksum, Loose/strict Source Routing, Key
- Key is used to authenticate the source
- Over IPv4, GRE packets use a protocol type of 47
- Allows router visibility into application-level header
- Restricted to a single provider network ⇒ end-to-end

PPTP



- PPTP = Point-to-point Tunneling Protocol
- Developed jointly by Microsoft, Ascend, USR, 3Com and ECI Telematics
- PPTP server for NT4 and clients for NT/95/98
- MAC, WFW, Win 3.1 clients from Network Telesystems (nts.com)

PPTP Packets



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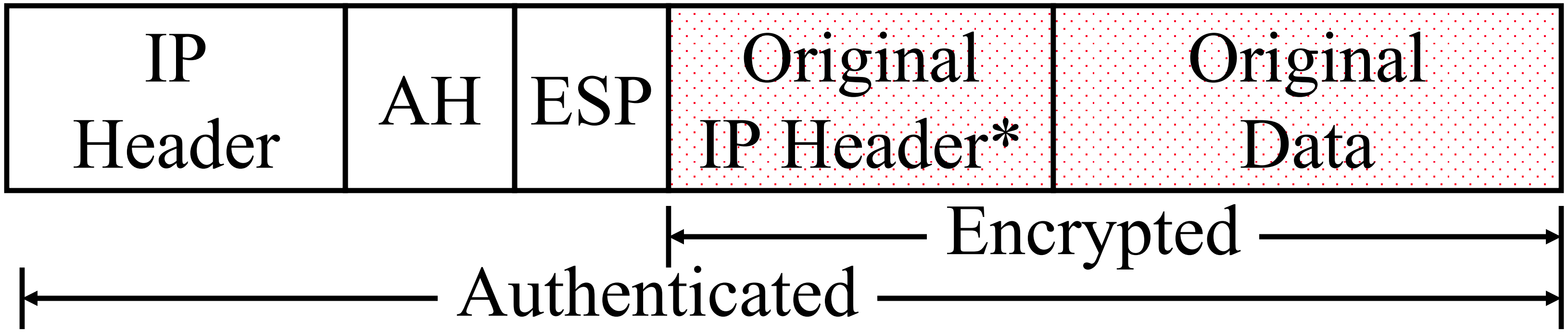
L2TP

- Layer 2 Tunneling Protocol
- L2F = Layer 2 Forwarding (From CISCO)
- L2TP = L2F + PPTP
  Combines the best features of L2F and PPTP
- Will be implemented in NT5
- Easy upgrade from L2F or PPTP
- Allows PPP frames to be sent over non-IP (Frame relay, ATM) networks also (PPTP works on IP only)
- Allows multiple (different QoS) tunnels between the same end-points. Better header compression. Supports flow control

IPSec

- Secure IP: A series of proposals from IETF
- Separate Authentication and privacy
- Authentication Header (AH) ensures data integrity and authenticity
- Encapsulating Security Protocol (ESP) ensures privacy and integrity



* Optional

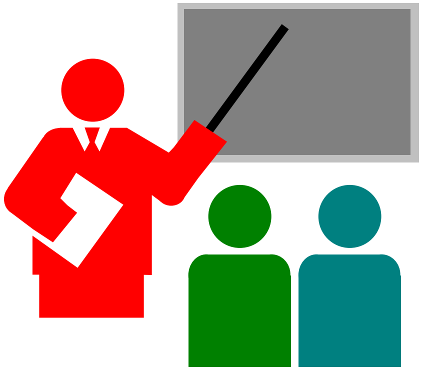
IPSec (Cont)

- Two Modes: Tunnel mode, Transport mode
- Tunnel Mode ⇒ Original IP header encrypted
- Transport mode ⇒ Original IP header removed. Only transport data encrypted.
- Supports a variety of encryption algorithms
- Better suited for WAN VPNs (vs Access VPNs)
- Little interest from Microsoft (vs L2TP)
- Most IPSec implementations support machine (vs user) certificates ⇒ Any user can use the tunnel
- Needs more time for standardization than L2TP

Application Level Security

- Secure HTTP
- Secure MIME
- Secure Electronic Transaction (SET)
- Private Communications Technology (PCT)

Summary



- VPN allows secure communication on the Internet
- Three types: WAN, Access, Extranet
- Key issues: address translation, security, performance
- Layer 2 (PPTP, L2TP), Layer 3 (IPSec), Layer 5 (SOCKS), Layer 7 (Application level) VPNs
- QoS is still an issue ⇒ MPLS

References

- For a detailed list of references, see http://www.cse.ohio-state.edu/~jain/refs/refs_vpn.htm