PART XIX

PRIVATE NETWORK INTERCONNECTION (NAT AND VPN)

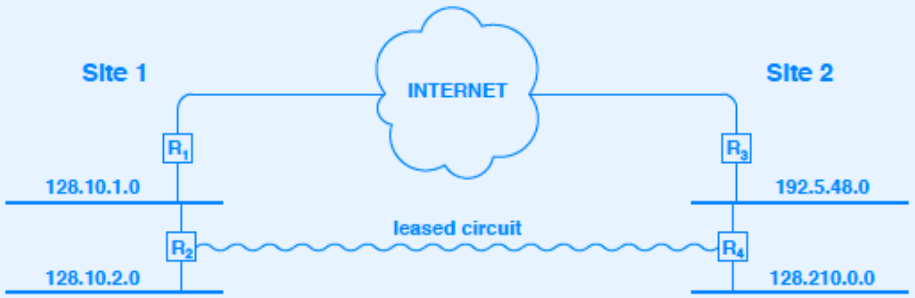
Definitions

- An internet is *private* to one group (sometimes called *isolated*) if none of the facilities or traffic is accessible to other groups
  - Typical implementation involves using leased lines to interconnect routers at various sites of the group
- The global Internet is *public* because facilities are shared among all subscribers

Hybrid Architecture

- Permits some traffic to go over private connections
- Allows contact with global Internet

Example Of Hybrid Architecture



The Cost Of Private And Public Networks

- Private network extremely expensive
- Public Internet access inexpensive
- Goal: combine safety of private network with low cost of global Internet

Question

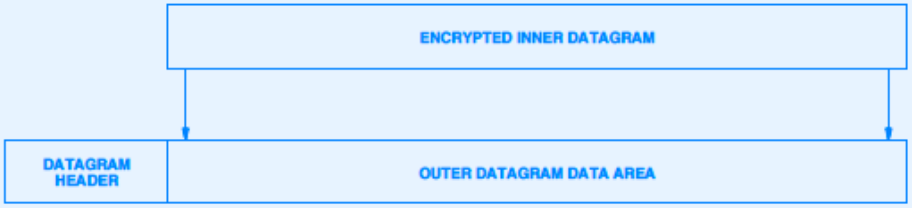
How can an organization that uses the global Internet to connect its sites keep its data private?

- Answer: *Virtual Private Network* (*VPN*)

Virtual Private Network

- Connect all sites to global Internet
- Protect data as it passes from one site to another
  - Encryption
  - IP-in-IP tunneling

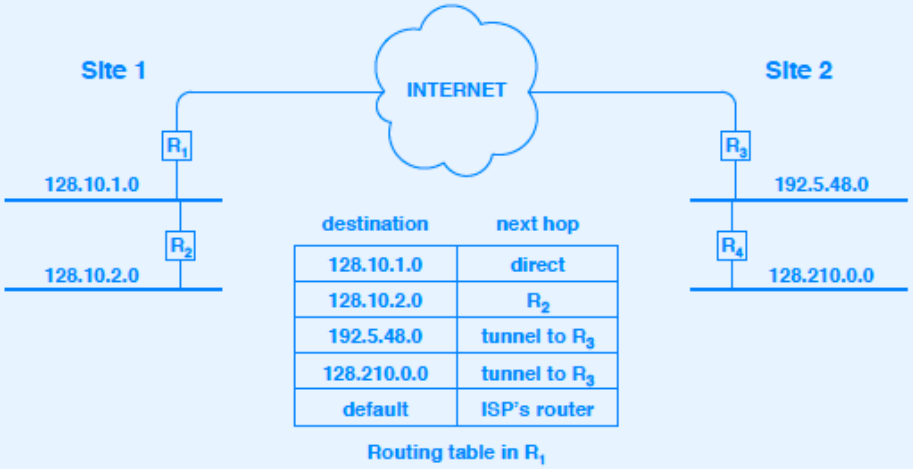
Illustration Of Encapsulation Used With VPN



The Point

A Virtual Private Network sends data across the Internet, but encrypts intersite transmissions to guarantee privacy.

Example Of VPN Addressing And Routing

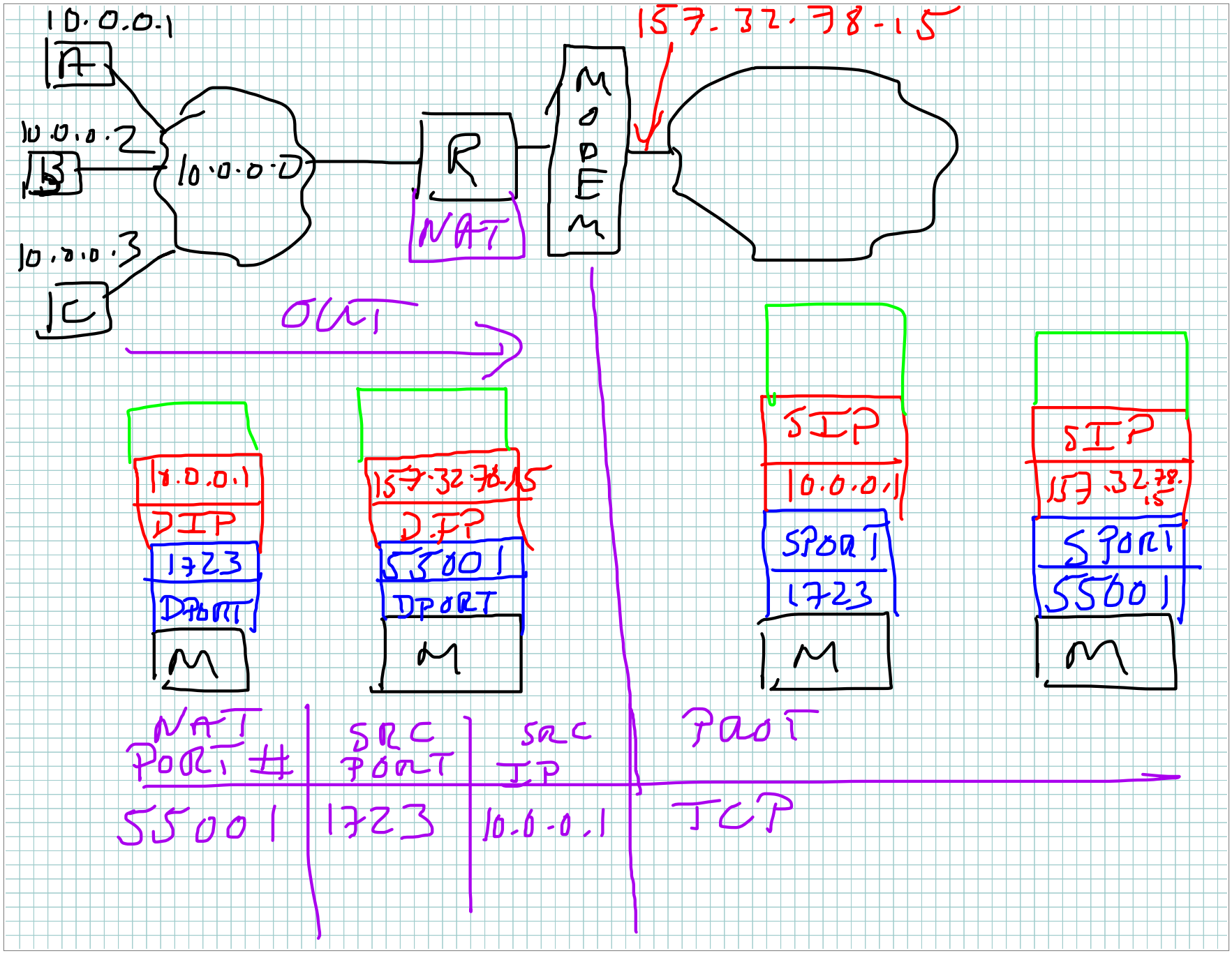


destination	next hop
128.10.1.0	direct
128.10.2.0	R_2
192.5.48.0	tunnel to R_3
128.210.0.0	tunnel to R_3
default	ISP's router

Routing table in R_1

Example VPN With Private Addresses

- Advantage: only one globally valid IP address needed per site


10.0.0.1
A
10.0.0.2
B
10.0.0.3
C
10.0.0.0
R
NAT
MODEM
157.32.78.15
OUT
10.0.0.1
DIP
1723
DPORT
M
157.32.78.15
DIP
55001
DPORT
M
SIP
10.0.0.1
SPORT
1723
M
SIP
157.32.78.15
SPORT
55001
M
NAT PORT #
SRC PORT
SRC IP
PROT
55001
1723
10.0.0.1
TCP

General Access With Private Addresses

- Question: how can a site provide multiple computers at the site access to Internet services without assigning each computer a globally-valid IP address?
- Two answers
  - Application gateway (one needed for each service)
  - *Network Address Translation* (*NAT*)

Network Address Translation (NAT)

- Extension to IP addressing
- IP-level access to the Internet through a single IP address
- Transparent to both ends
- Implementation
  - Typically software
  - Usually installed in IP router
  - Special-purpose hardware for highest speed

Network Address Translation (NAT) (continued)

- Pioneered in Unix program *slirp*
- Also known as
  - *Masquerade* (Linux)
  - *Internet Connection Sharing* (Microsoft)
- Inexpensive implementations available for home use

NAT Details

- Organization
  - Obtains one globally valid address per Internet connection
  - Assigns nonroutable addresses internally (net 10)
  - Runs NAT software in router connecting to Internet
- NAT
  - Replaces source address in outgoing datagram
  - Replaces destination address in incoming datagram
  - Also handles higher layer protocols (e.g., pseudo header for TCP or UDP)

NAT Translation Table

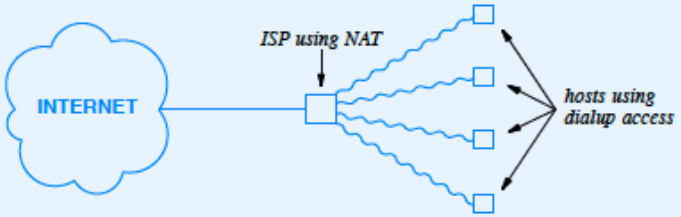
- NAT uses translation table
- Entry in table specifies local (private) endpoint and global destination.
- Typical paradigm
  - Entry in table created as side-effect of datagram leaving site
  - Entry in table used to reverse address mapping for incoming datagram

Example NAT Translation Table

Private Address	Private Port	External Address	External Port	NAT Port	Protocol Used
10.0.0.5	21023	128.10.19.20	80	14003	tcp
10.0.0.1	386	128.10.19.20	80	14010	tcp
10.0.2.6	26600	207.200.75.200	21	14012	tcp
10.0.0.3	1274	128.210.1.5	80	14007	tcp

- Variant of NAT that uses protocol port numbers is known as *Network Address and Port Translation* (*NAPT*)

Use Of NAT By An ISP



Higher Layer Protocols And NAT

- NAT must
  - Change IP headers
  - Possibly change TCP or UDP source ports
  - Recompute TCP or UDP checksums
  - Translate ICMP messages
  - Translate port numbers in an FTP session

Applications And NAT

NAT affects ICMP, TCP, UDP, and other higher-layer protocols; except for a few standard applications like FTP, an application protocol that passes IP addresses or protocol port numbers as data will not operate correctly across NAT.

Summary

- Virtual Private Networks (VPNs) combine the advantages of low cost Internet connections with the safety of private networks
- VPNs use encryption and tunneling
- Network Address Translation allows a site to multiplex communication with multiple computers through a single, globally valid IP address.
- NAT uses a table to translate addresses in outgoing and incoming datagrams