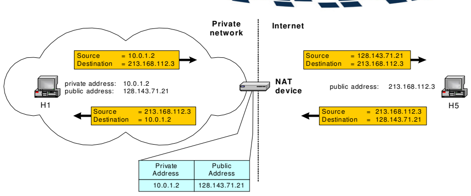
Advanced Networking: Network Address Translation (NAT)

Renato Lo Cigno
Renato.LoCigno@disi.unitn.it

Network Address Translation

- Originally (RFC 1631 - obsolete) a “simple” method for connecting a private network to the public Internet
  - Also called *network or IP masquerading*
- Now (Traditional NAT, RFC 3022) includes also port translation and is more correctly called NAPT: Network Address and Port Translation
  - Payload (application) independent and almost transparent
- NAT evolved and evolves highly intertwined with Firewalls, Routing (a NAT is always also a Router), Traffic Monitoring, and Proxy
  - Often NAT techniques and implementations go beyond RFCs … which follow up
- NAT and NAT traversal evolves in parallel and are intertwined

Basic operation of NAT



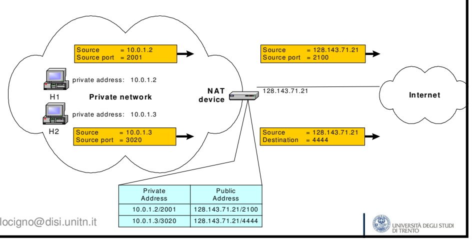
- NAT device must map addresses
- A one-to-one translation brings little advantages
  - Not many public IP “spared” specially if computers are always on

One use of Basic NAT

- **Supporting migration between network service providers**
- **Scenario:** IP addresses are obtained from the service provider. Changing the service provider requires changing all IP addresses in the network.
- **NAT solution:**
  - Assign private addresses to the hosts of the corporate network
  - NAT device has static address translation entries which bind the private address of a host to the public address
  - Migration to a new network service provider merely requires an update of the NAT device. The migration is not noticeable to the hosts on the network
- The same can be done with properly configured DHCP: obsolete use!!

IP masquerading or NAPT

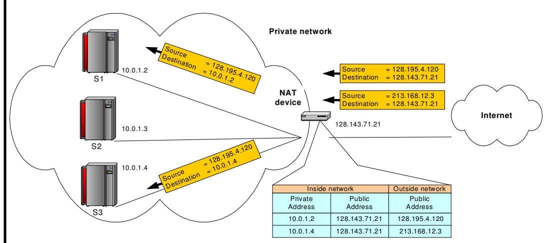
- A single (or few) public IP address is mapped to multiple hosts in a private network
  - Assign private addresses to the hosts of the corporate network
  - NAT device modifies the port numbers for outgoing traffic
  - Ports should be translated as well



Load balancing of servers

- Balance the load on a set of identical servers, which are accessible from a single IP address
  - servers are assigned private addresses
  - NAT device is a front-end for requests to the server from the public network
  - The NAT device changes the destination IP address of arriving packets to one of the private addresses for a server
- Many strategies for assignment
  - Simple round-robin
  - Weighted round robin
  - With feedback from servers on the actual load

Load balancing of servers



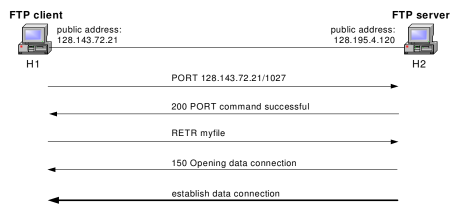
Concerns about NAT

- Changing the IP address requires that NAT boxes recalculate the IP header checksum
- Modifying port number requires that NAT boxes recalculate TCP checksum
- Additional care is needed if a fragmented datagram reaches a NAT device to avoid inconsistent assignments to pieces of the same packet
- End-to-end connectivity:
  - NAT destroys universal end-to-end reachability of hosts on the Internet
  - A host in the public Internet often cannot initiate communication to a host in a private network
  - The problem is worse, when two hosts that are in a private network need to communicate with each other

Further concerns about NAT

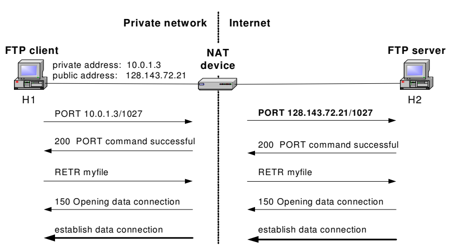
- Applications that carry IP addresses in the payload generally do not work across a NAT
- Some NAT boxes inspect the payload of widely used application layer protocols and, if an IP address is detected in the payload, translate these addresses too
- Typical example is ftp
- Further problems with sftp because the payload is encripted

NAT and FTP



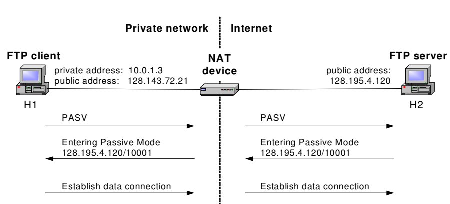
- Normal FTP operation

NAT and FTP



- NAT device with FTP support

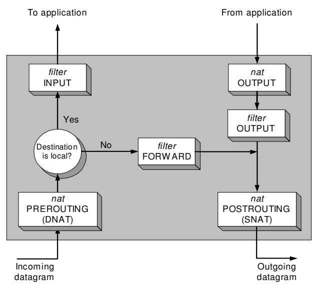
NAT and FTP



- FTP in passive mode and NAT

Configuring NAT in Linux

- Linux uses the Netfilter/iptable package to add filtering rules to the IP module



Iptable based NAT: examples

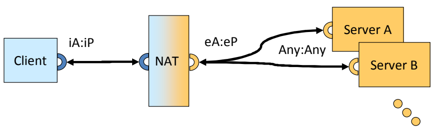
- **First example:**
```
iptables –t nat –A POSTROUTING –s 10.0.1.2
         –j SNAT --to-source 128.143.71.21
```
- **Pooling of IP addresses:**
```
iptables –t nat –A POSTROUTING –s 10.0.1.0/24
         –j SNAT --to-source 128.128.71.0–128.143.71.30
```
- **ISP migration:**
```
iptables –t nat –R POSTROUTING –s 10.0.1.0/24
         –j SNAT --to-source 128.195.4.0–128.195.4.254
```
- **IP masquerading:**
```
iptables –t nat –A POSTROUTING –s 10.0.1.0/24
         –o eth1 –j MASQUERADE
```
- **Load balancing:**
```
iptables -t nat -A PREROUTING -i eth1 -j DNAT --to-
destination 10.0.1.2-10.0.1.4
```


NAT traversal and classification

- Classification of NAT techniques come with methods to traverse NAT boxes
- STUN (Simple Traversal Utility for NAT – RFC3489)
- Same acronym modified to Session Traversal Utilities for NAT in RFC5389
- Universally supports traversal for UDP only
  - RFC5389 supports (with some limits) also TCP and TLC
- STUN is a client-server protocol, with the server on the public side
- STUN servers are identifies via srv records of DNS
  - **`stun`** for UDP
  - **`stuns`** for TCP/TLC

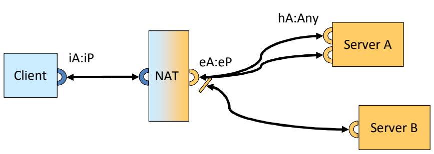
Full-cone NAT

- Known as one-to-one NAT
- Does a semi-static mapping (iAddr:iPort) ↔ (eAddr:ePort)
  - any packets from iAddr:iPort is sent through eAddr:ePort
- External hosts can send packets to iAddr:iPort by sending packets to eAddr:ePort



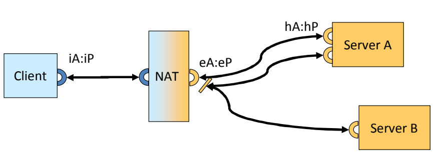
Address-restricted-cone NAT

- Does a semi-static mapping (iAddr:iPort) ↔ (eAddr:ePort)
  - any packets from iAddr:iPort is sent through eAddr:ePort
- An external host (hAddr:any) can send packets to iAddr:iPort by sending packets to eAddr:ePort only if iAddr:iPort has previously sent a packet to hAddr:any
  - The sending (server) port number doesn't matter



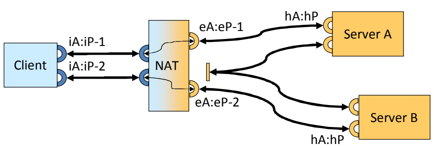
Port-restricted-cone NAT

- Like an address restricted cone NAT, but the restriction includes port numbers
- Does a semi-static mapping (iAddr:iPort) ↔ (eAddr:ePort)
  - any packets from iAddr:iPort is sent through eAddr:ePort
- An external host (hAddr:hPort) can send packets to iAddr:iPort by sending packets to eAddr:ePort only if iAddr:iPort has previously sent a packet to hAddr:hPort



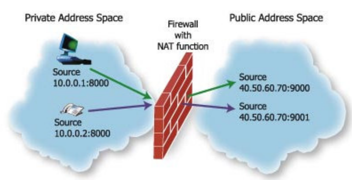
Symmetric NAT

- Packets from (iAddr:iPort) to different (hAddr:hPort) are mapped to different (eAddr:ePort)
  - A host apperas with different (eAddr:ePort) to different hosts!!
- Only an external host that receives a packet from an internal host can send a packet back
  - Strong firewalling, very difficult to traverse



NAT Problems (reprise

- NAT means a 'table' binding private and public addresses and ports
- ‘Bindings' can only be initiated by outgoing traffic
- NAT breaks end-to-end semantics



Source: http://www.newport-networks.com/whitepapers/nat-traversal.html

Methods of solving the ‘NAT Problem’

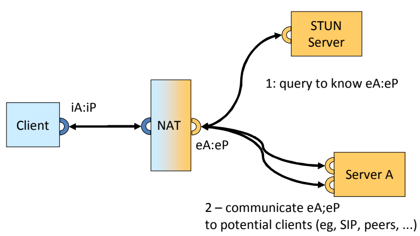
Some proposals for solving NAT traversal are:

- Simple Traversal of UDP Through Network Address Translation devices (STUN)
- Traversal Using Relay NAT (TURN)
- Universal Plug and Play (UPnP)
- Tunnel Techniques

STUN

- Lightweight protocol that allows applications to discover the presence and types of NATs and firewalls between them and the public Internet
- Provides the ability for applications to determine the public Internet Protocol (IP) addresses allocated to them by the NAT
- STUN works with many existing NATs, and does not require any special behavior from them
- A STUN server in the public address space informs STUN-enabled clients of the Public NAT IP address and port being used for that particular session

STUN



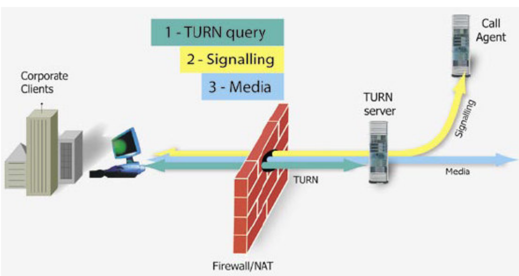
Operation of STUN

- STUN identifies eA;eP by inspecting STUN messages that arrive at the STUN server
- STUN-enabled hosts send an exploratory message to the external STUN server to determine the transmit and receive ports to use
- The STUN server examines the incoming message and informs the client which public IP address and ports were used by the NAT
- These are communicated to e.g.
  - SIP proxies/buddies in the call establishment messages

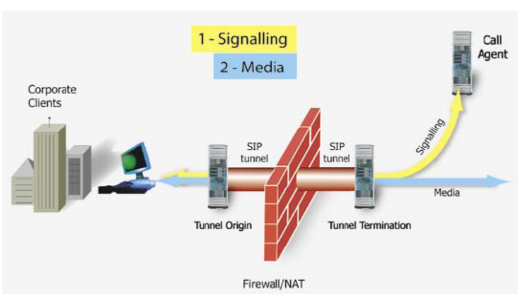
TURN - Traversal Using Relay NAT

- TURN relies on a “counter” middlebox that is inserted in the communication path
- A TURN server is located
  - in the campus DMZ
  - in the Service Provider network
- A TURN-enabled client sends initial messages to the TURN server
- The TURN server will forward the traffic reverting the NAT operation
- This information is used e.g.
  - in the SIP call establishment messages and for subsequent media streams
  - in P2P gossipping messages
- Works with symmetric NAT
  - No change in the destination address seen by the NAT
  - Heavy protocol!!
  - Can be used as a second resort
  - See also ICE (Interactive Connectivity Establishment)

TURN setup



Tunnel Techniques



Tunnel Techniques

- A tunnel can be used to cross any Firewall/NAT
- The tunnel termination can be anywhere
- The Tunnel can be also secure (see IPSec)
- Can even be used to anonymize communications (see Onion Routing and Tor)
- Blocking tunnels is diffcult
  - impossible if they are TLS