Network Address Translation

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CS 3103: Compute Networks and Protocols
NAT: Network Address Translation

All datagrams leaving local network have same single source NAT IP address: 138.76.29.7, different source port numbers.

Datagrams with source or destination in this network have 10.0.0/24 address for source, destination (as usual).
**Motivation:** Distribution of addresses through ISPs has created a problem:

- If the business grows or the household needs a larger range, the ISP may not be able to grant the demand because the addresses before and after the range may have already been allocated to other networks.

- In most situations, however, only a portion of computers in a small network need access to the Internet simultaneously.
NAT: Network Address Translation

- **Motivation:** local network uses just one IP address as far as outside world is concerned:
  - range of addresses not needed from ISP: just one IP address for all devices
  - can change addresses of devices in local network without notifying outside world
  - can change ISP without changing addresses of devices in local network
  - devices inside local net not explicitly addressable, visible by outside world (a security plus).
NAT: Network Address Translation

Implementation: NAT router must:

- **outgoing datagrams: replace** (source IP address, port #) of every outgoing datagram to (NAT IP address, new port #)
  
  ...remote clients/servers will respond using (NAT IP address, new port #) as destination addr.

- **remember (in NAT translation table)** every (source IP address, port #) to (NAT IP address, new port #) translation pair

- **incoming datagrams: replace** (NAT IP address, new port #) in dest fields of every incoming datagram with corresponding (source IP address, port #) stored in NAT table
NAT: Network Address Translation

1: Host 10.0.0.1 sends datagram to 128.119.40.186, 80

2: NAT router changes datagram source addr from 10.0.0.1, 3345 to 138.76.29.7, 5001, updates table

3: Reply arrives dest. address: 138.76.29.7, 5001

4: NAT router changes datagram dest addr from 138.76.29.7, 5001 to 10.0.0.1, 3345

NAT translation table

<table>
<thead>
<tr>
<th>WAN side addr</th>
<th>LAN side addr</th>
</tr>
</thead>
<tbody>
<tr>
<td>138.76.29.7, 5001</td>
<td>10.0.0.1, 3345</td>
</tr>
<tr>
<td>……</td>
<td>……</td>
</tr>
</tbody>
</table>

S: 10.0.0.1, 3345
D: 128.119.40.186, 80

S: 138.76.29.7, 5001
D: 128.119.40.186, 80

S: 10.0.0.1, 3345
D: 128.119.40.186, 80
NAT: Network Address Translation

- RFC 2663, 3022

- 16-bit port-number field:
  - 60,000 simultaneous connections with a single LAN-side address!

- What are the limitations of NAT?
NAT: Limitations

- NAT is controversial:
  - routers should only process up to layer 3
  - violates end-to-end argument
    - A service should be carried out in a layer if 1) needed by all clients of that layer and 2) can be completely implemented in that layer
    - Should keep network core as simple as possible
  - address shortage should be solved by IPv6
  - NAT traversal problem
    - NAT possibility must be taken into account by app designers, e.g., P2P applications
NAT traversal problem

- client wants to connect to server with address 10.0.0.1
  - server address 10.0.0.1 local to LAN (client can't use it as destination addr)
  - only one externally visible NATed address: 138.76.29.7

- solution 1: statically configure NAT to forward incoming connection requests at given port to server
  - e.g., (123.76.29.7, port 2500) always forwarded to 10.0.0.1 port 25000
NAT traversal problem

- solution 2: Universal Plug and Play (UPnP) Internet Gateway Device (IGD) Protocol. Allows NATed host to:
  - learn public IP address (138.76.29.7)
  - add/remove port mappings (with lease times)

i.e., automate static NAT port map configuration
NAT traversal problem

- solution 3: relaying (used in Skype)
  - NATed client establishes connection to relay
  - External client connects to relay
  - relay bridges packets between to connections