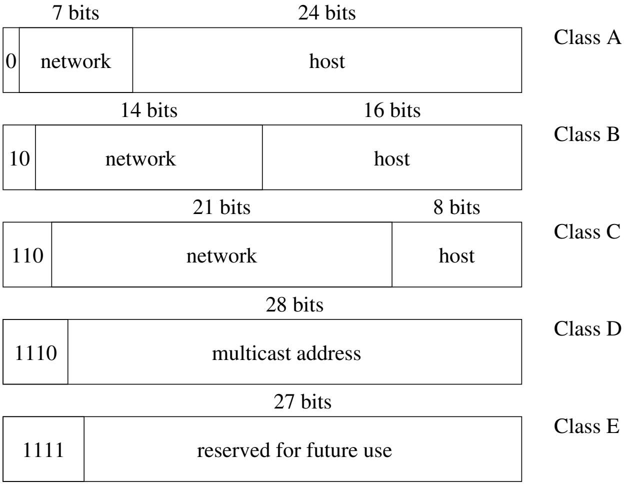
IP Addresses



IP address ranges

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Network 17.0.0.0, a class A address, is allocated to Apple

Network 193.0.0.0, a class C address, is allocated to *Réseaux IP Européens* (RIPE), the Internet Registry responsible for the allocation of IP addresses within Europe

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Thus the number of usable host addresses in a network is 2 fewer than you might think

IP Addresses

- Host part all 0s: “this host”. Originally specified to refer back to the originating host. But some implementations mistakenly used this as a broadcast address, so for safety it is not commonly supported as a valid host address. For, say, a class B network `17.16`, a packet sent to `172.16.0.0` *should* boomerang right back to the sender. But rarely does

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- (Network part all 0s: “this network”. E.g., `0.0.12.34` would send to a host on the current B network. Again, not often implemented)

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- . . . 255 is a broadcast address
- . . . 0 may or may not be supported, so best to avoid it

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- Notice this is different from the same host sending to itself via an external network (e.g., using the interface's own address) as the former packet possibly won't go through the normal Ethernet/whatever software and hardware.
- The loopback network is there even if there is no real network hardware attached

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To understand classless allocation, we first need to look at *subnetting*

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A single big network is not a very good idea

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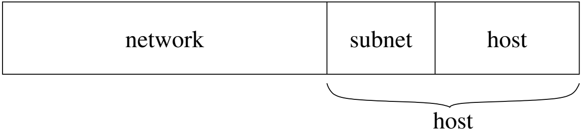
And to do this, also just like the Internet, we further split the host part into some bits for the subnetwork and the rest for the actual hosts



Subnet addressing

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For example, the University of Bath has a class B, address `138.38`. The top 16 bits are the network address

The netmask 111111111111000000000000 indicates which bits are in the network part

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This corresponds to the netmask
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network address	138.38.96.0	10001010 00100110 01100000 00000000
broadcast address	138.38.103.255	10001010 00100110 01100111 11111111
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This is not on a nice byte boundary, so visually is harder for humans to work with using decimal `x.y.z.w` style notations

IP Address Subnetting

So `138.38.100.20` *is* on the subnet

host address	138.38.100.20	10001010 00100110 01100100 00010100
netmask	255.255.248.0	11111111 11111111 11111000 00000000
AND	138.38.96.0	10001010 00100110 01100000 00000000
network address	138.38.96.0	10001010 00100110 01100000 00000000

IP Address Subnetting

But `138.38.104.20` is *not* on the subnet

host address	138.38.104.20	10001010 00100110 01101000 00010100
netmask	255.255.248.0	11111111 11111111 11111000 00000000
AND	138.38.104.0	10001010 00100110 01101000 00000000
network address	138.38.96.0	10001010 00100110 01100000 00000000

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Subnets can be further subnetted for exactly the same reason

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The "all 0s" and "all 1s" addresses now apply within the *subnet*: all 1's broadcasts to the subnet; and don't use all 0s

IP Address Exhaustion

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But, as the Internet grows, people want more addresses

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Most class A's have now been split and the subnets allocated to various institutions

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And internally to the institution there are eight separate networks, too

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(A recurrent problem with improving Internet protocols: a lot of software out there assumes the old way of doing things is the only way, and rejects any patterns or protocols it doesn't recognise)

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We shall be looking at each of these

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Blocks of C addresses are allocated to regions, e.g.,

194.0.0.0-195.255.255.255	Europe
198.0.0.0-199.255.255.255	North America
200.0.0.0-201.255.255.255	Central and S America
202.0.0.0-203.255.255.255	Asia and the Pacific

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Note that the software within routers does need to be updated to support this: but this has now been done everywhere

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A network of $2^{32-21} = 2^{11} = 2048$ addresses, i.e., 2046 hosts

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And we have repurposed class A and B networks similarly

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Thus we have:

- Classful: implicit, fixed split of network/host
- Classless: explicit (netmask), variable split of network/host

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Not enough...

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How is this possible?

NAT

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Some IP addresses are reserved for *private networks*, originally reserved to allow local experimentation:

- 10.0.0.0-10.255.255.255 (Class A)
- 172.16.0.0-172.31.255.255 (Class B)
- 192.168.0.0-192.168.255.255 (Class C)

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One class A-size network, 16 class B and 256 class C-size networks are guaranteed never to be allocated for public use in the Internet

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They are called *unroutable* addresses

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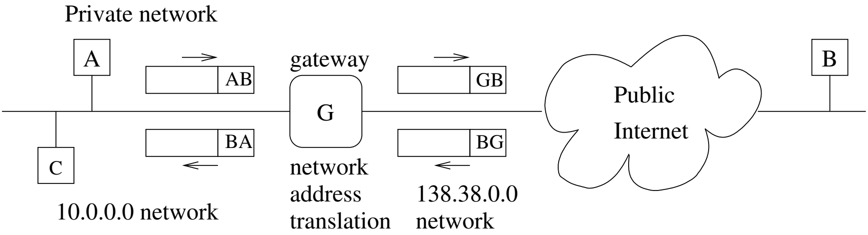
A gateway host joins the private network to the public Internet, rewriting the addresses on packets as they go past

NAT



Network Address Translation

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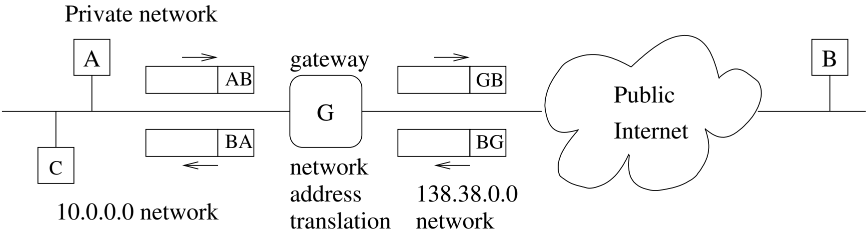
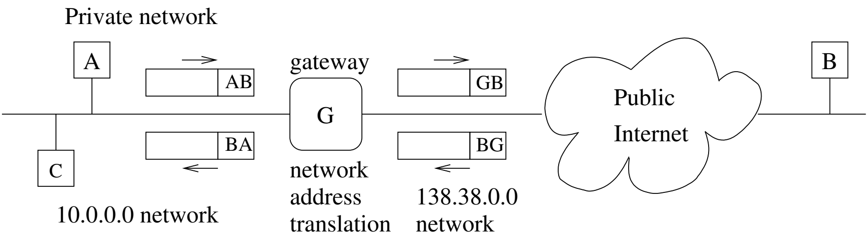


Network Address Translation

A packet from `10.0.1.1` (A) is sent to `212.58.226.33` (B); B is not on the local network so the packet is sent to the gateway;

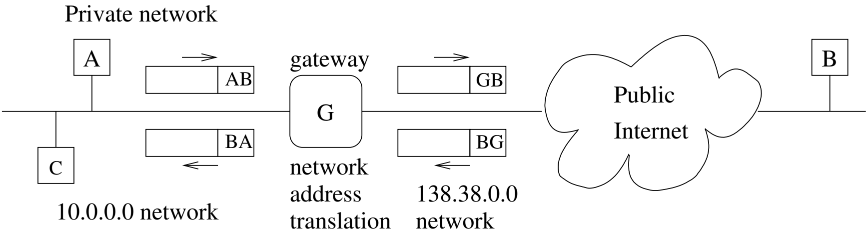
NAT



Network Address Translation

The gateway overwrites the source address with its own public address (G) and forwards the packet;

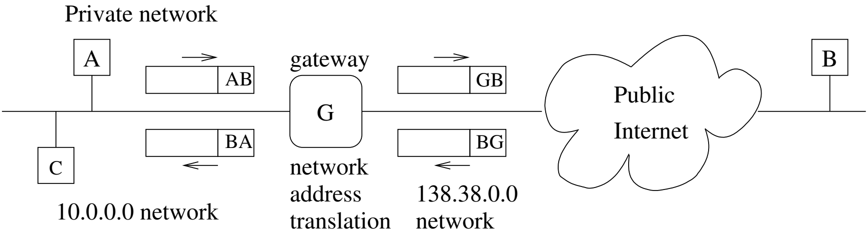
NAT



Network Address Translation

The packet reaches B in the normal way;

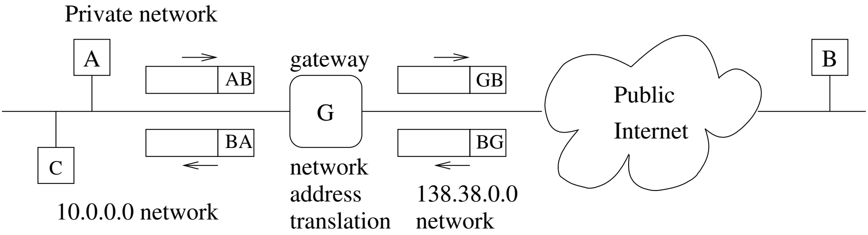
NAT



Network Address Translation

B replies with a packet with destination address G;

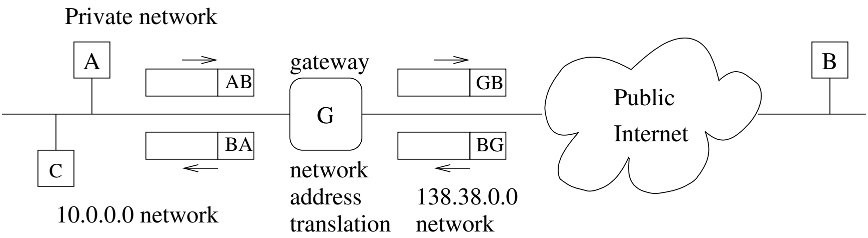
NAT



Network Address Translation

The gateway recognises this packet as a reply to A and rewrites the destination address to A before passing it on to the private network;

NAT



Network Address Translation

A thinks it is connected to the public Internet, and B thinks data is coming from G

NAT

G needs to keep a record of connections from A to the world and recognise replies to outward travelling packets

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Explanation later, in the next layer

NAT

Exercise If both A and C are communicating with B, what are the addresses on their packets as they reach B? And on the replies as they reach G?

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Exercise Compare with *bridging*, a similar idea but for very different reasons

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Even if a packet somehow gets to the gateway, the gateway will not know how to rewrite its address as this was not a reply to an outgoing packet; so it get dropped here, too