Networking  
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### 1. Addresses

We now take another look at IP addresses

In particular there are several types of address that can refer to more than one host at a time

### 2. Addresses

IPv4 has three types of address

* Unicast: an address refers to a single destination (ignoring NAT!). A “normal” address
* Broadcast: as in the link layer, a single packet goes to every host in the local network. But, now, the “network” is at the IP layer, so may comprise more than one link layer network
* Multicast: in between uni- and broadcast. A single packet goes to one or more hosts

### 3. Addresses

IPv6 adds

* Anycast: a packet goes to any **one** of a selection of servers, usually the “closest” in some sense

In fact, IPv6 also removes broadcast as its job can be done by multicast

So we need to look at four types of address

### 4. Unicast Addresses: v4 & v6

**Unicast**

* 1-to-1 data flow; one source, one destination
* Most current IP traffic is unicast

### 5. Broadcast Addresses: v4

**Broadcast**

* 1-to-many data flow; one source, “all” destinations
* Broadcast is simple: a single packet read by all hosts on the local network
* Reduces traffic on the local network as (for most link layers) we don’t have copies of mostly-identical packets, one for each destination, but just one packet that is read by every host
* Scales well (locally): it is independent of the number of destination hosts
* Don’t have to know how many destination hosts there are

### 6. Broadcast Addresses

Broadcasts are generally limited to the local network: otherwise the entire Internet would be permanently flooded

We have seen IPv4 broadcast addresses before: when the host part of the IP address is all 1s

E.g., 172.16.1.255 on the subnet 172.16.1/24

We can also use 255.255.255.255 as a broadcast to the local network for when we don’t yet know our network address

### 7. Broadcast Addresses

As mentioned, IPv6 does not support broadcast separately, so there are no IPv6 broadcast addresses per se

IPv6 uses multicast to achieve the same effect

### 8. Multicast Addresses: v4 & v6

**Multicast**

For sending a single packet to multiple hosts, not necessarily all hosts

E.g., for streaming radio we could send individual unicast packets to all listening hosts, but it would be much more efficient to send a single packet that the listening hosts receive and the non-listening hosts don’t

Also, we can’t use broadcast as broadcast is network-limited: listeners can be spread far and wide over multiple networks

### 9. Multicast Addresses: v4

One class of IPv4 addresses is reserved for multicast

Multicast addresses

Multicast addresses

In IPv4, class D (224.0.0.0 to 239.255.255.255) addresses are used for multicast

### 10. Multicast Addresses: v4

*Multicast groups* are formed from those hosts that wish to receive packets from a given source. e.g., a group to listen to BBC Radio 4

A multicast group id is a 28 bit number with no further structure: about 270 million possible groups

The set of hosts listening to a particular multicast address is also known as a *host group*

Host groups can cross multiple networks and there is no limit on the size of a group; and generally you can’t know how big the group is

### 11. Multicast Addresses: v4

Some group addresses are preallocated by IANA: the *permanent host groups*

* 224.0.0.1: all multicast aware hosts on this subnet (not all IPv4 hosts support multicast)
* 224.0.0.2: all multicast routers on this subnet

### 12. Multicast Addresses: v4

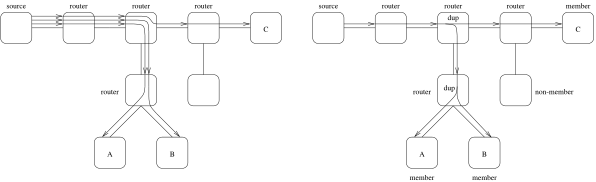
The process of joining and leaving groups is governed by the Internet Group Management Protocol (IGMP)

A host that wishes to join a multicast group provided by a server sends an IGMP message towards the server

The routers on the path to the server take note and so know to route multicast packets for this group towards the joining host

The server itself is not interested or involved in the IGMP message

### 13. Multicast



Unicast vs. Multicast

### 14. Multicast Addresses: v4

Similarly for a host leaving a group: a host is supposed to send an IGMP message towards the server that the routers can read and act upon

Extra complication arises as hosts may not (or can’t if they crash) always send “group leave” messages

So there is more protocol to monitor and maintain groups using timeouts and maintenance messages

**Exercise** Read about this

### 15. Multicast Addresses: v6

<+(0)->While multicast was optional in IPv4, it is required in IPv6 (otherwise it would not have broadcast!)

IPv6 multicast is much as v4, but simplified

IPv6 multicast addresses

IPv6 multicast addresses

* Addresses start with hex FF
* Four bits of flags, including the T bit which means transient group (as opposed to a permanent IANA allocated group)
* Four bits of scope. Limit the range of this multicast to, e.g., the local network; the organisation; the country; worldwide

### 16. Addresses

#### Multicast

**Exercise** Read about how IPv4 uses the TTL to limit scope

**Exercise** Find out what IPv6 needs to do to broadcast to the local network

### 17. Addresses

#### Multicast

Multicast is not used as much as it should be

It is used in routing protocols (i.e., those protocols that help routers create their routing tables), but relatively little elsewhere in IPv4

**Exercise** Read about the *Simple Service Discovery Protocol* (SSDP)

**Exercise** And the *Multicast Domain Name System* (mDNS)

### 18. Addresses

#### Multicast

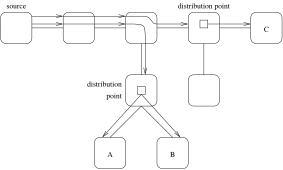
Multicast is hard to use for an on-demand system (e.g., BBC iPlayer, Netflix) as it requires everyone in the group to be receiving the same thing at the same time

While ideal for a live transmission, multicast does not work when everyone wants to watch things at different times

Most big streaming providers rely on having many local distribution points containing identical data, even for live streams

### 19. Addresses

#### Not Multicast



Content distribution points

The source supplies (relatively few) distribution points using unicast, which serve content directly using unicast

**Exercise** Read about *content delivery networks*

### 20. Addresses

#### Multicast

Furthermore, most providers use have to use unicast as multicast is not well supported in home systems

And routing companies want to avoid supporting multicast, claiming undue complexity to support it: each group needs extra state in every router the multicast traffic passes through, making scaling to the full Internet a problem

A router must keep a record of all multicast paths passing through it, so routers on popular paths (e.g., in internet exchanges) might need to keep a large amount of data

### 21. Addresses

#### Multicast

Multicast is used by some pay-tv services, but usually in the context of a closed and controllable system, e.g., a institutional intranet multicasting a seminar, or holding a multi-way video conference

Generally in the case where the same institution owns all the infrastructure from source to destinations

**Exercise** Read about BT TV

### 22. Addresses

#### Anycast: v6

**Anycast**

Anycast in IPv6 sends a single packet to a single destination chosen out of several possible destinations

For example, replicated Web servers: have many servers around the world with identical content and the same anycast address. A browser would get pages from the closest server, thus sharing load

The reply would be unicast

### 23. Addresses: v6

#### Anycast

Only works well with connectionless transport protocols (see later) as multiple requests might go to different servers: this doesn’t fit well with connection-oriented protocols

Address format?

Any unicast address that happens to be assigned to more than one server. It is up to the routers to figure this out

### 24. Addresses: v6

There are anycast groups, much as multicast groups and a join/leave protocol

Notice the symmetry: muticast is groups of clients, while anycast is groups of servers

Anycast has plenty of potential, but we need to be using IPv6 to get it properly, though some people do support it in IPv4

**Exercise** <1.1.1.1> is an anycast address. Investigate

### 25. Addresses

How does a host get an IP address?

An Ethernet address is burned into the hardware, so there’s no problem there

IP addresses are software addresses, so they must be set up somehow

The simplest way is for the host simply to be configured to have that address, stored in a configuration file on the host somewhere

An administrator takes into account certain criteria, e.g., network or subnetwork addresses, and gives the machine a currently unused address

But it is not always feasible to do this

### 26. DHCP

* Not all machines have administrators, e.g., home PCs
* Some administrators are not sufficiently competent to allocate addresses correctly, e.g., home PCs
* Some installations have too many machines to get around and configure them all, e.g., in the library
* Some installations have machines that come and go all the time, e.g., laptops in the library