La durée d'écoute est désormais limitée : sans action de votre part (un simple clic), la diffusion s'arrête au bout d'un temps déterminé selon les stations. En effet, pour nous, diffuseurs, les technologies actuelles imposent un coût dépendant de la durée et du nombre d'auditeurs. Plusieurs éléments nous indiquent que les internautes ayant accès à l'internet illimité ne coupent pas l'écoute, lorsqu'ils quittent leur ordinateur allumé. Radio France ne peut continuer à financer pour celui qui n'écoute pas. C'est pourquoi nous avons mis en place ce système de confirmation, un peu contraignant, mais qui nous permet de mieux contrôler les coûts de diffusion.

http://viphttp.yacast.net/V4/radiofrance/jip_bd.m3u
IP Multicast

Unicast = send to one destination
Multicast = send to a group of destinations

IP has multicast addresses:
IPv4: 224.0.0.0 to 239.255.255.255;
IPv6: ff00::/8

A multicast address is the logical identifier of a group

- No topological information, does not give any information about where the destinations (listeners) are
- Routers keep have to keep state information for each multicast address

Member of a group = listener
Operation of IP Multicast: destinations need to explicitly join multicast group

Source simply sends one single packet for *n* destination

Destinations subscribe via IGMP (Internet Group Management Protocol, IPv4) or MLD (Multicast Listener Discovery --IPv6); join messages sent to router

Routers build distribution tree via a multicast routing protocol or by other method

Packet multiplication is done by routers

1. S sends packets to multicast address *m*; there is no member, the data is simply lost at router R5.
2. A joins the multicast address *m*.
3. R1 informs the rest of the network that *m* has a member at R1; the multicast routing protocol builds a tree. Data sent by S now reach A.
4. B joins the multicast address *m*.
5. R4 informs the rest of the network that *m* has a member at R4; the multicast routing protocol adds branches to the tree. Data sent by S now reach both A and B.
Is there Multicast ARP?

Recall ARP = find MAC address that corresponds to an IP address; here the target MAC address is a multicast MAC address. There is no ARP for multicast. IP multicast address is algorithmically mapped to a multicast MAC address.

- Last 23 bits of IPv4 multicast address are used in MAC address.
- Last 32 bits of IPv6 multicast address are used in MAC address.

Several multicast address may correspond to same MAC address.

- if needed, operating system removes packets received unnecessarily.
- it is hoped that this rarely happens.

<table>
<thead>
<tr>
<th>MAC multicast addr.</th>
<th>Used for</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-00-5e-XX-XX-XX</td>
<td>IPv4 multicast</td>
</tr>
<tr>
<td>33-33-XX-XX-XX-XX</td>
<td>IPv6 multicast</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IP dest address</th>
<th>229.130.54.07</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP dest address (hexa)</td>
<td>e5-82-36-cf</td>
</tr>
<tr>
<td>IP dest address (bin)</td>
<td>...-10000010-...</td>
</tr>
<tr>
<td>Keep last 23 bits (bin)</td>
<td>...-00000010-...</td>
</tr>
<tr>
<td>Keep last 23 bits (hexa)</td>
<td>02-36-cf</td>
</tr>
<tr>
<td>MAC address</td>
<td>01-00-5e-03-36-cf</td>
</tr>
</tbody>
</table>
Some (non smart) switches simply treat multicast frames as broadcast.

Some other (smart) switches simply listen to IGMP /MLP and overhear who listens – deliver only to intended recipients.
IP Principle #3

Exact Match for Multicast Addresses

Router has one forwarding table for unicast + one forwarding table for multicast

When multicast enabled router has one IP packet to forward it

- Tests whether destination address is multicast
- If so, look whether this address exists in the multicast forwarding table
Unicast: R1 has one single entry for all addresses starting with B

Multicast: R1 needs the explicit list of all ports on which there is a listener, for every multicast address – since the location of listeners depends on applications and users, not on the network topology
Multicast in Practice

Multicast is good for sources
- One packet sent for $n$ destinations
- Multiplication is done repeatedly, $O(\log(n))$ times

Multicast suffers from per-flow state in routers
- Scalability problems (non aggregation)
- Possible denial of service attacks

Multicast is not supported everywhere, but is:
- At EPFL and other academic networks
- Internet TV distribution
- In some corporate / smart grid networks for news, sensor streaming, time synchronization etc...

Works only with UDP, TCP does not work with multicast IP
A. In order to send to a multicast group a system must first join the group with IGMP or MLD

B. In order to receive from a multicast group a system must first join the group with IGMP or MLD

C. A system can know whether a packet is multicast by analyzing the IP destination address.
The destination MAC address is...

A. A group address derived from the last 23 bits of the IPv6 destination address
B. A group address derived from the last 24 bits of the IPv6 destination address
C. A group address derived from the last 32 bits of the IPv6 destination address
D. A broadcast address
E. The MAC address of an ARP server
F. I don’t know
Conclusion

IP multicast came as an after-thought and uses a different principle than IP unicast (exact match versus longest prefix match) – is not widely deployed

- IP multicast addresses cannot be aggregated

IP multicast require the deployment of a solution to compute the multicast trees between routers (with a multicast routing protocol or with a network management application, SDN)