Scalable Internet broadcasting using multicast QUIC

Presentation to YANA0318

16th March 2018

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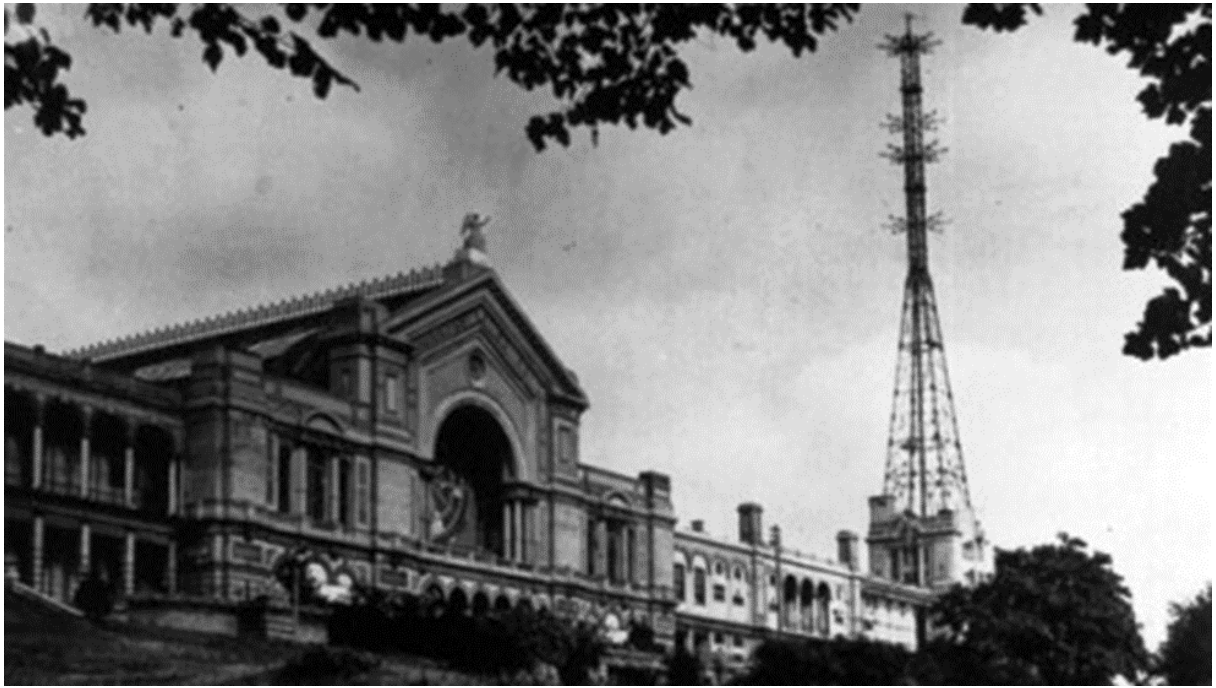
BBC | Research & Development

Motivation

Life for broadcasters used to be simple…

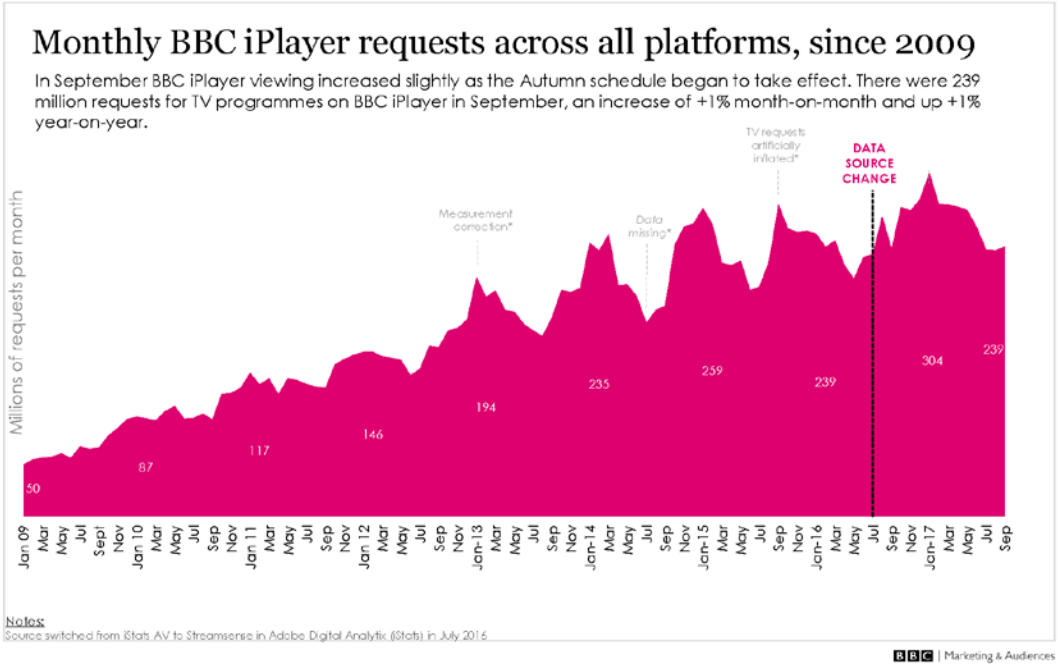


Source: BBC

- Broadcasting from a terrestrial transmitter has a fixed cost.
- The cost doesn't depend on how many people tune in.

The Internet doesn't work like this!

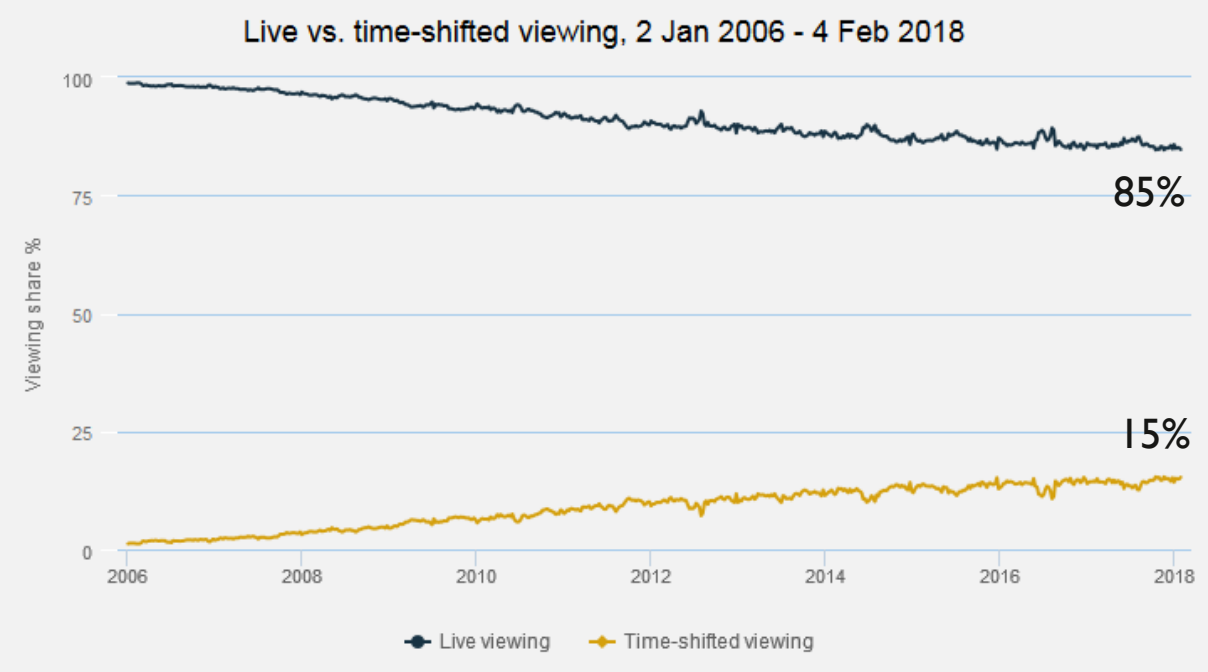
The iPlayer service keeps getting more popular



- Usage of the BBC iPlayer service is climbing steadily.
  - **272M** on-demand programmes requested per month in 2017.
  - First episode of Blue Planet II was requested **4.8M** times.
- CDNs charge per byte delivered by the edge cache.

The cost of providing the service rises in proportion to its popularity.

On-demand viewing is gaining ground…
…but linear viewing still dominates

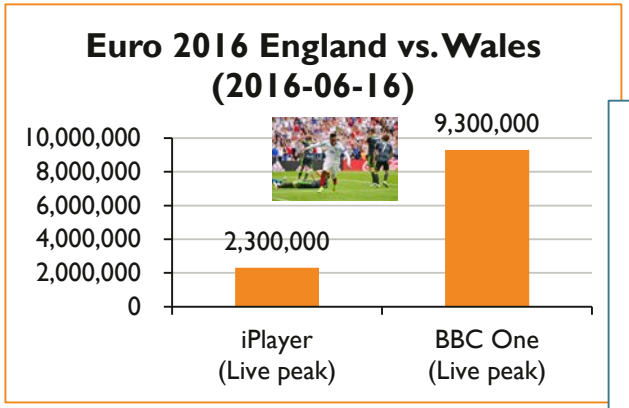


Source: BARB

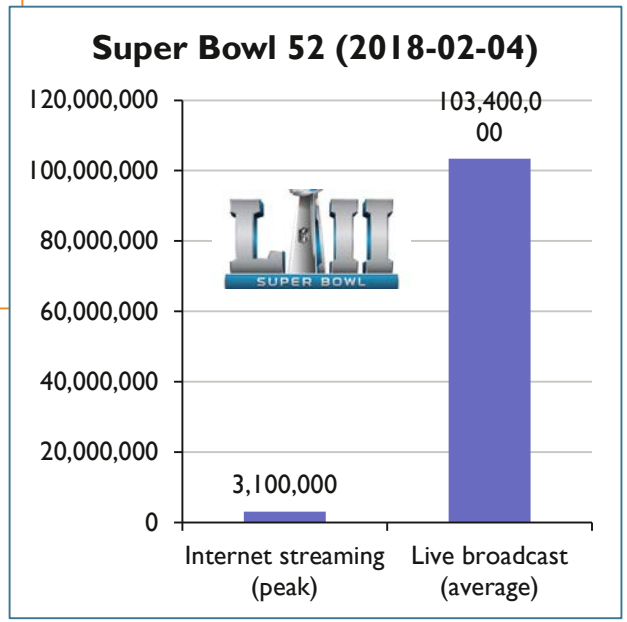
- For the main TV channels in the UK, on-demand viewing represents only **85%** of consumption.
- The remaining **15%** is **DVR time-shifting**, **downloading** and **on-demand streaming**.
  - Time-shifting works best for genres like drama, comedy, entertainment and documentary.

But linear viewing still plays a major role for news, sport and big events.

Linear television is still popular for big events



Source: Radio Times



Source: AdWeek; USA Today

- The BBC's biggest streaming event to date was England vs. Wales in the Euro 2016 competition.
  - **2.3M** simultaneous users.
  - About **20%** of total peak.
- Super Bowl 52 was watched by nearly fifty times as many viewers.
  - Streaming represented only **3%** of total audience.

The potential audience for linear streaming is huge and scary.

There are more and more bits to shift!

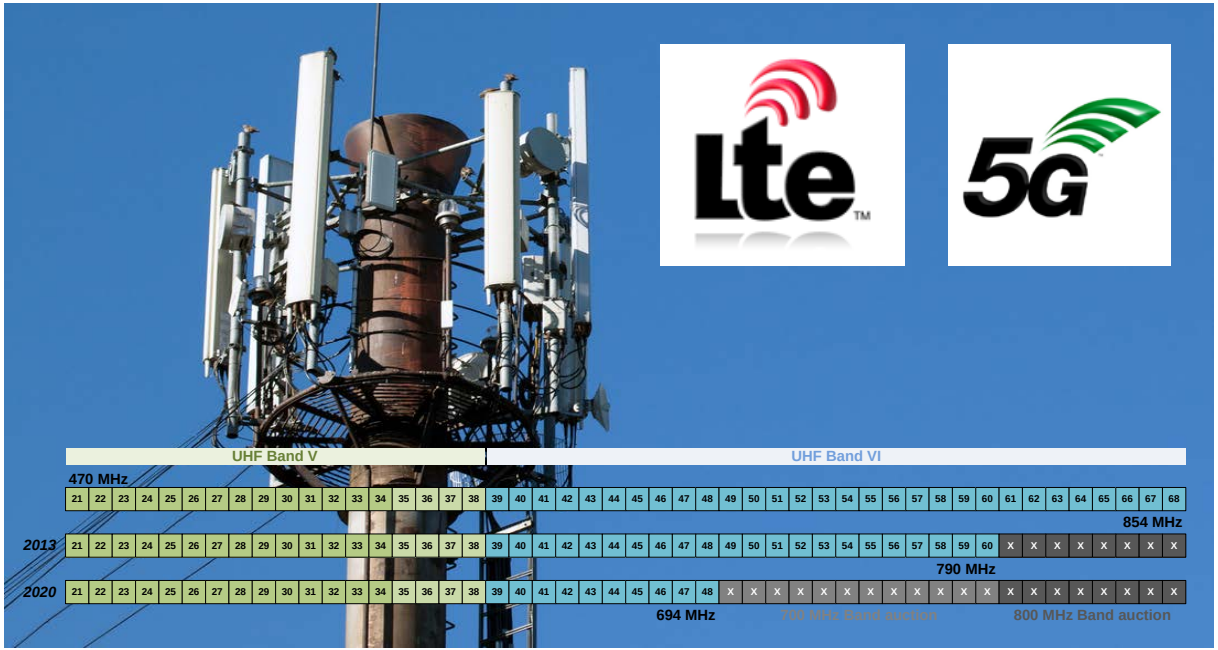
- Higher spatial resolution (SD, HD, UHD).
- Improved colour fidelity (High Dynamic Range).
- Better motion depiction (Higher Frame Rate).

Not to mention:

- New content experiences (3D, 360° Video, AR, VR).
- Next Generation Audio.

All this keeps driving up our CDN distribution costs.

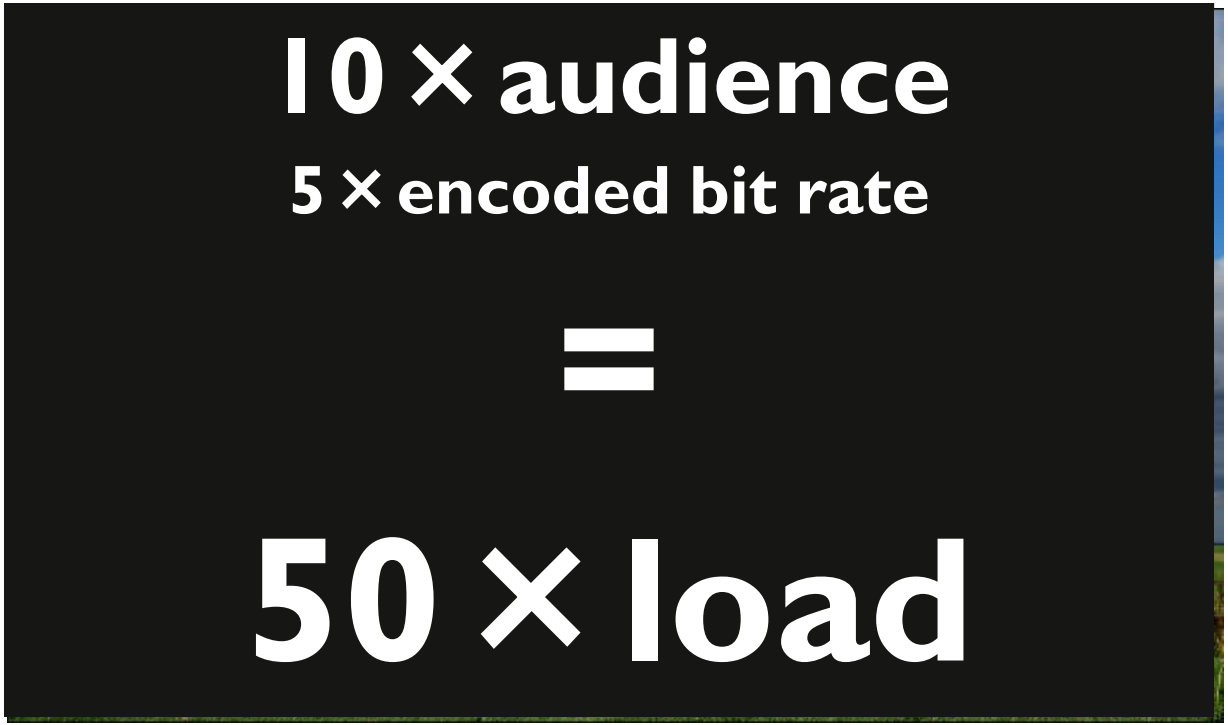
Cellular is biting at our heels



- MNOs are hungry and have deep pockets.
  - 800 MHz band auctioned in 2013 for 4G.
  - 700 MHz band due to be auctioned soon for 5G.
- 3GPP has developed a technology stack called MBMS for media streaming over cellular radio networks.

Our ability to innovate in the broadcast space is now hampered by lack of available spectrum.

The challenge



- How to reach 98% of the UK population without any terrestrial spectrum.

To put that into perspective:

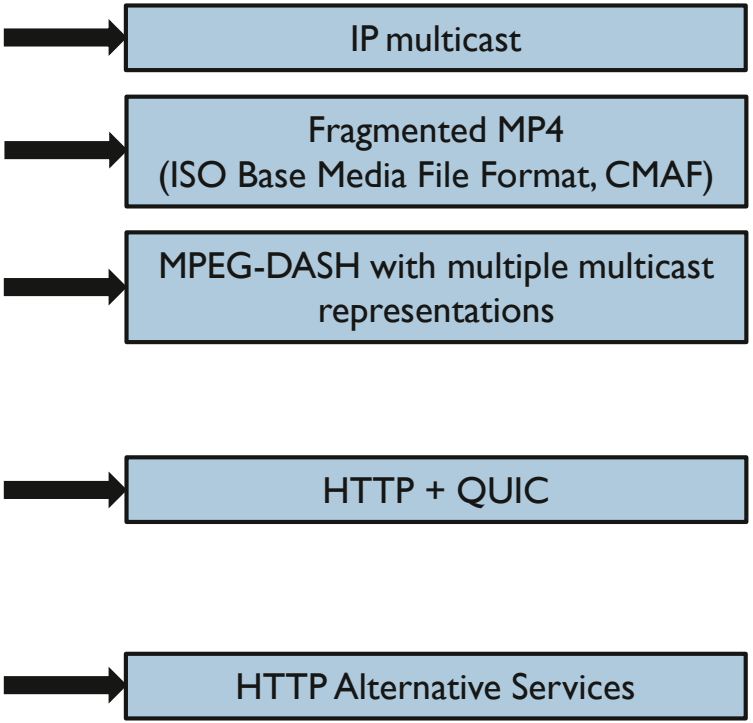
- The last Royal Wedding (April 2011) attracted a total UK live audience of more than 25M across all distribution modes.

Even if CDNs could deliver to that size of audience, we probably couldn't afford to pay for it.

What about IP multicast?

Objectives for a scalable IP-based TV distribution system

1. Address **mass audience reliably** via **managed** and **unmanaged** networks.
2. Reduce operational costs by using **common media packaging** across unicast and multicast delivery modes.
3. React to variable network conditions using **dynamic adaptation** techniques.
4. Reduce client complexity by adopting **common network protocols** across unicast and multicast delivery modes.
   - **HTTP** offers a common Layer 7 semantic for multicast delivery and unicast repair.
   - **QUIC** offers the possibility of a common Layer 4 across both modes (once some specification gaps are filled).
5. Web-oriented mechanism for **discovering** the availability of multicast services



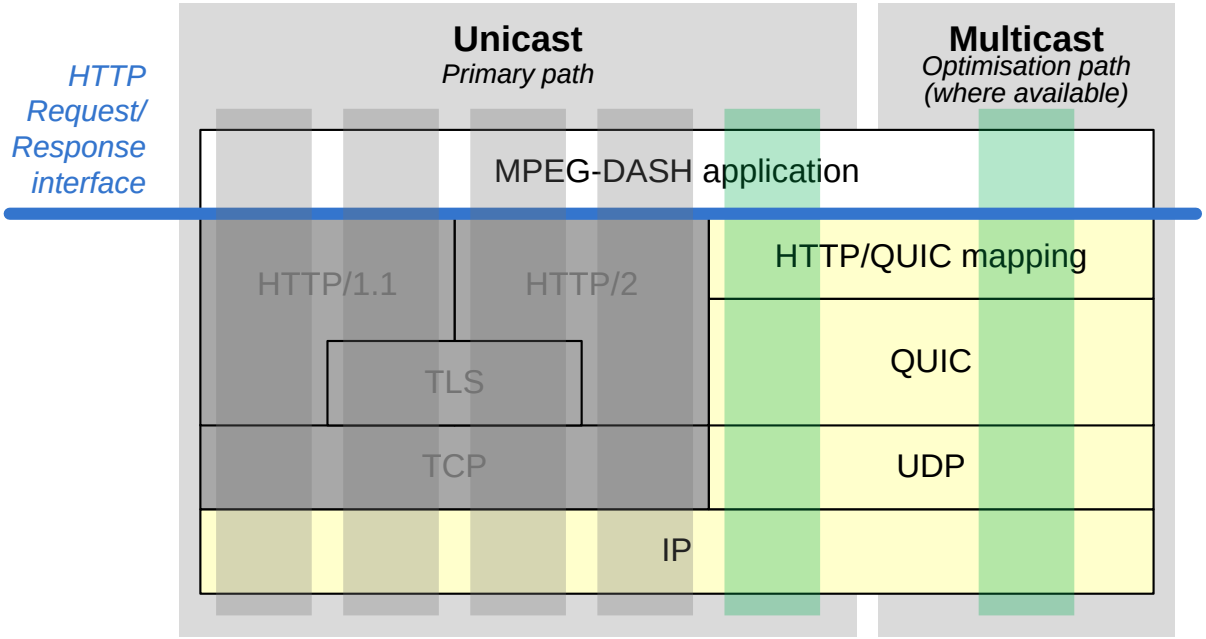
IP multicast

- Layer 3 packet replication is efficient.
- We are looking at **source-specific multicast**.
  - Avoid putting to much additional load on network routers.
- Our solution works with **IPv6** as well as IPv4.
  - Easier deployment with IPv6.
  - Fewer address space constraints.
- We will put a reasonable bound on the total number of multicast groups.
  - Keep the state held in routers down to a minimum.

What is QUIC?

- New transport protocol that addresses some long-standing shortcomings of TCP.
  - Originally developed by Google, but currently being standardised through IETF QUIC Working Group, targeting publication as a set of RFCs late 2018.
- Like TCP, it is **connection-oriented** and **reliable**. Unlike TCP, it is **secure** by design.
- But these features are layered on top of unreliable, insecure and connectionless **UDP datagrams**
  - Can be implemented easily on existing operating systems, outside the kernel in user space libraries.
  - Promotes **rapid prototyping** of new features and **early adoption**.
- **Fast connection establishment** (0-RTT, 1-RTT) achieved by caching and subsequently reusing security context from previous connections between the same client and server pair.
- **Multiplexing** of logical application-level data flows ("**streams**") over a single transport connection in such a way that data loss on one stream does not block progress on others.
  - **Independent flow control window** for each multiplexed stream, plus a separate window for the overall connection.
  - Reduces the impacts of congestion and data loss on unreliable networks.

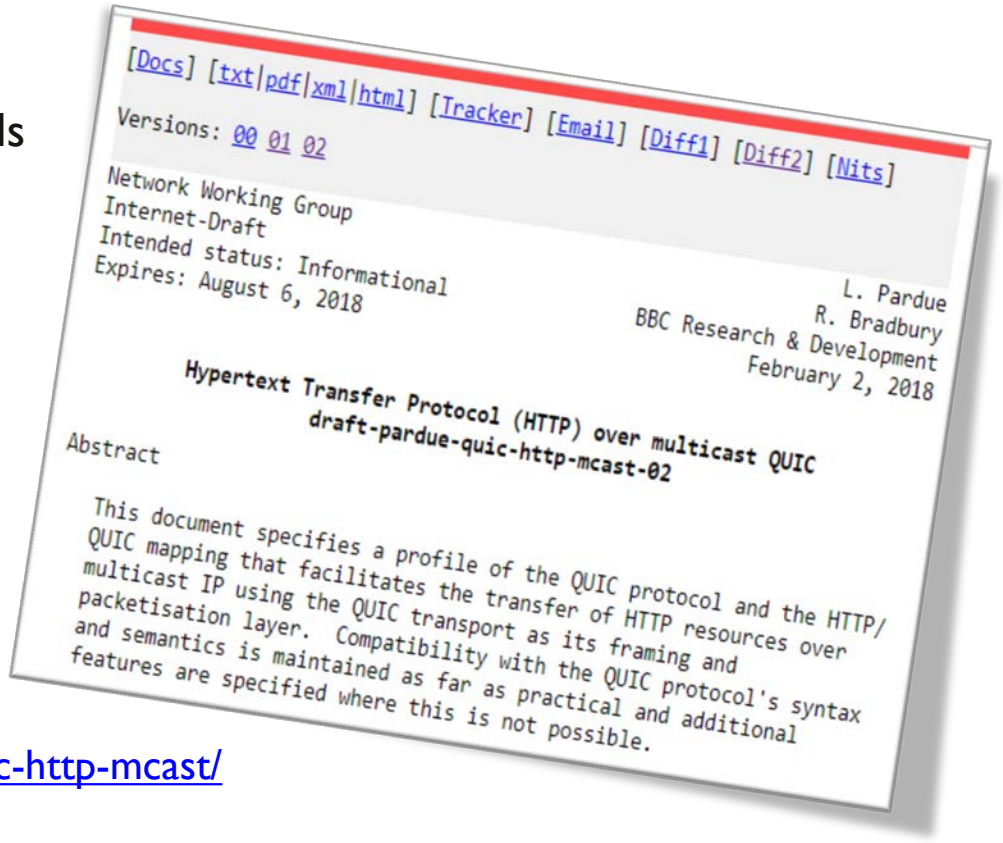
Protocol stack: Common layer 7 and layer 4



- HTTP provides a well-understood request/ response abstraction.
- Conventional (unicast) QUIC supports this abstraction by means of an HTTP/QUIC mapping layer.
- We have adapted this to multicast usage, so we end up with a common Layer 7 semantic and the same URL.
- At Layer 4, the QUIC datagrams also share a common packet format.

HTTP over multicast QUIC

- An independent **Internet Draft** that fills some gaps between IP unicast and multicast.
- Describes a means of service discovery using **HTTP Alternative Services** [RFC 7838].
- Bulk file delivery that intentionally supports a broad range of Use Cases.



[Docs] [txt|pdf|xml|html] [Tracker] [Email] [Diff1] [Diff2] [Nits]

Versions: 00 01 02

Network Working Group
Internet-Draft
Intended status: Informational
Expires: August 6, 2018

L. Pardue
R. Bradbury
BBC Research & Development
February 2, 2018

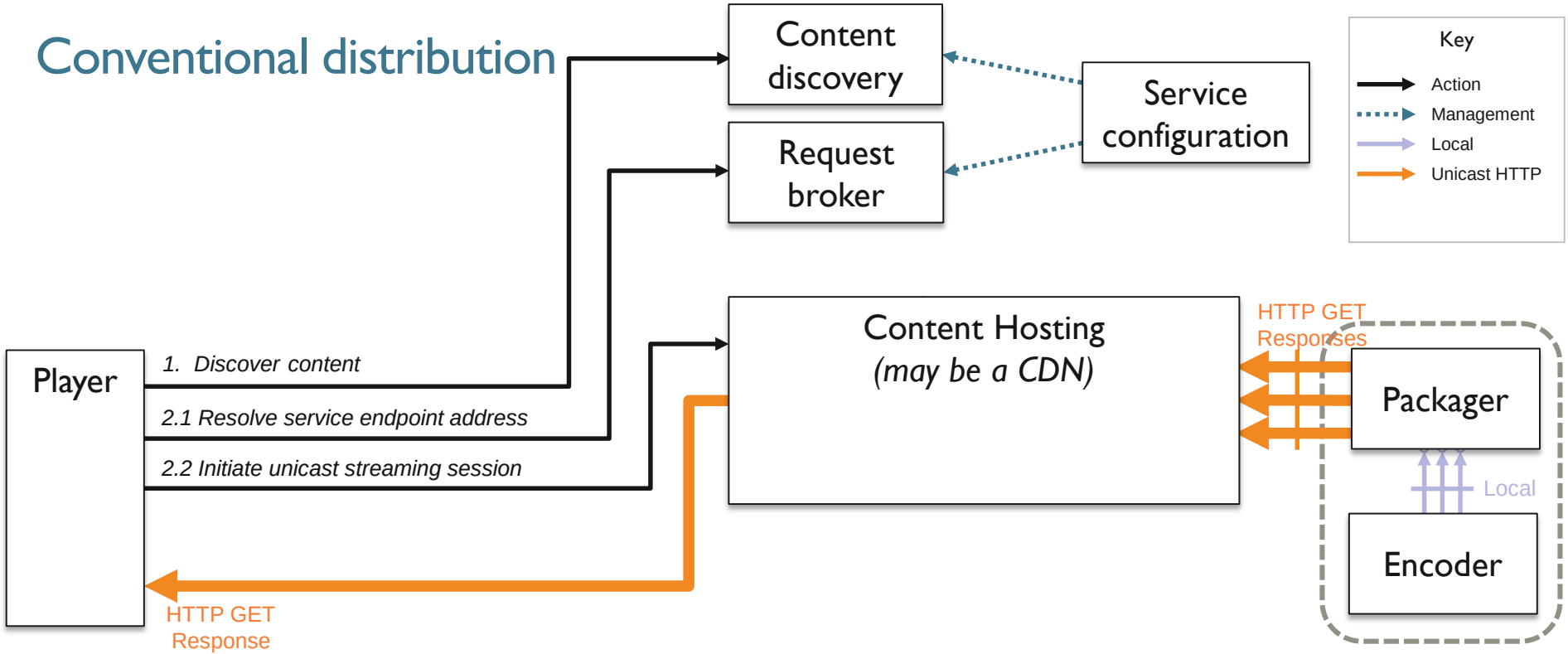
Hypertext Transfer Protocol (HTTP) over multicast QUIC
draft-pardue-quic-http-mcast-02

Abstract

This document specifies a profile of the QUIC protocol and the HTTP/QUIC mapping that facilitates the transfer of HTTP resources over multicast IP using the QUIC transport as its framing and packetisation layer. Compatibility with the QUIC protocol's syntax and semantics is maintained as far as practical and additional features are specified where this is not possible.

https://datatracker.ietf.org/doc/draft-pardue-quic-http-mcast/

Conventional distribution



HTTP Alternative Services (Alt-Svc): Advertising HTTP over multicast QUIC

- Alt-Svc provides a means to advertise alternative protocols or endpoints that a client may wish to switch to.
- We use it to decorate unicast HTTP responses with the details of our multicast QUIC streams.
- As part of this advertisement we need to be able to signal QUIC session parameters that would normally be negotiated between a QUIC client and a QUIC server at connection establishment.

Unicast request:

```
GET /representation1/segment.m4s HTTP/1.1
Host: media.example.org
```

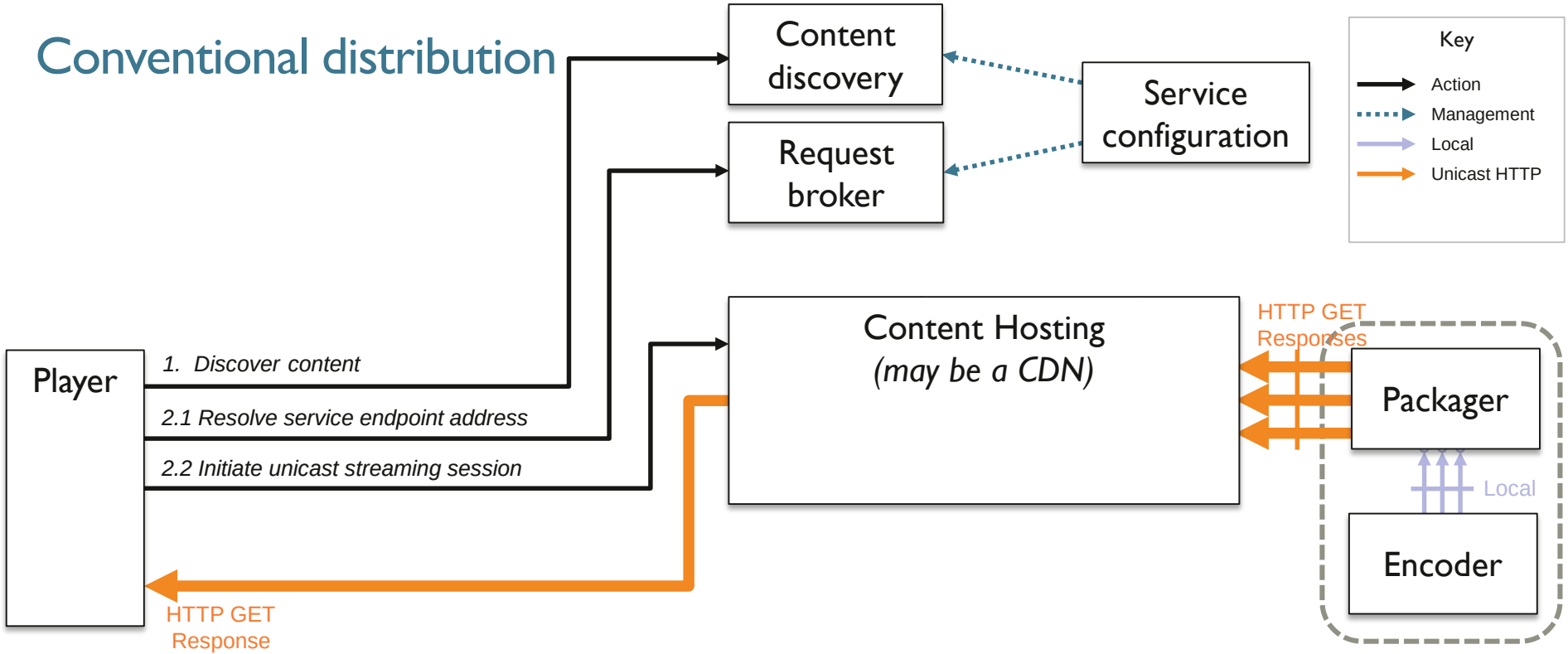
Unicast response:

```
HTTP/1.1 200 OK
Content-Type: text/html
Alt-Svc: hqm="[ff3e::1234]:2000"; ma=7200;
source-address="2001:db8::1"; quic=1; session-id=10;
session-idle-timeout=60; max-concurrent-resources=10; peak-
flow-rate=10000; cipher-suite=1301; key=4adf1eab9c2a37fd
```

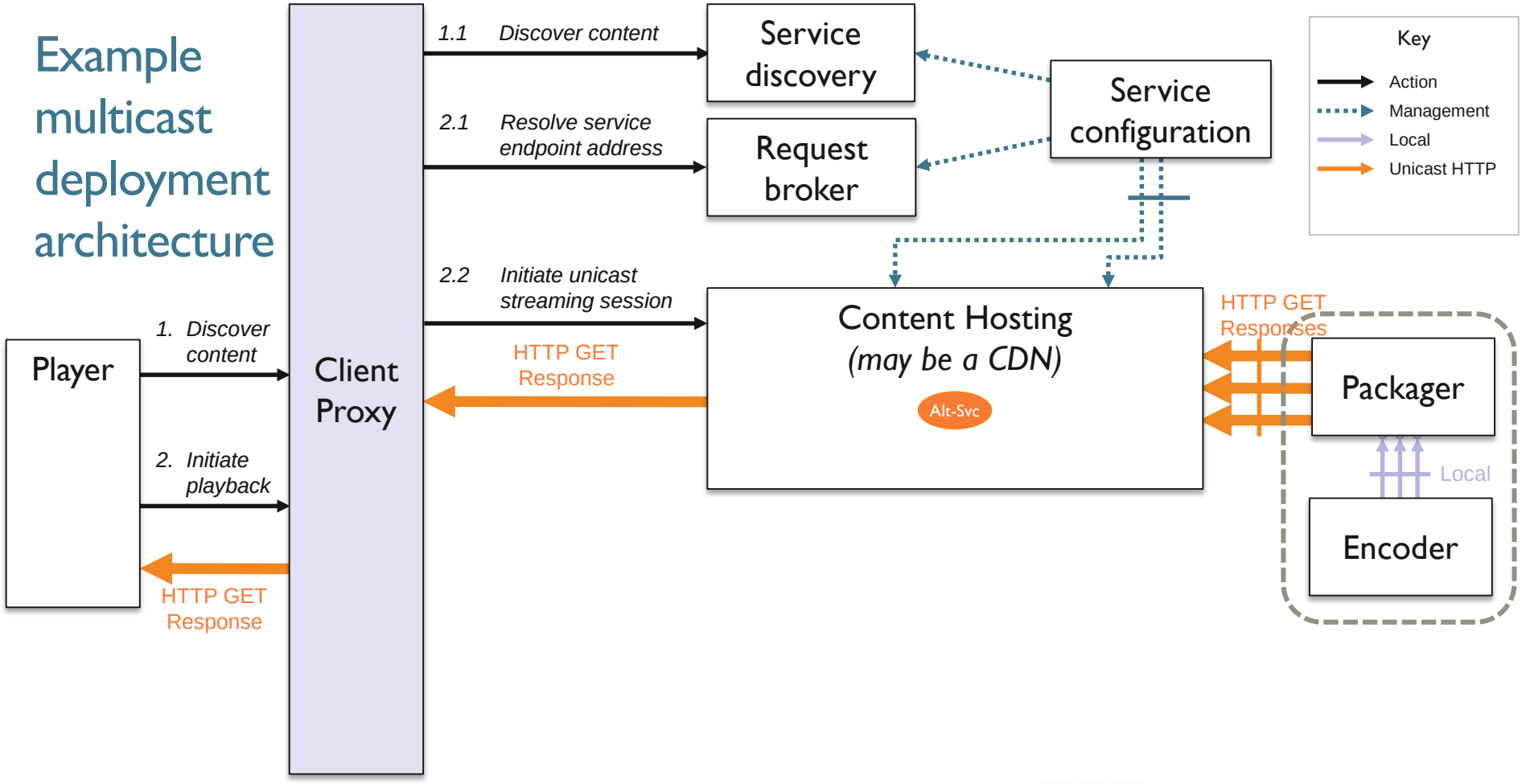
RFC 7838 key fields

- ALPN protocol ID
- Alternative host
- Port number
- Maximum age parameter

Conventional distribution



Example multicast deployment architecture



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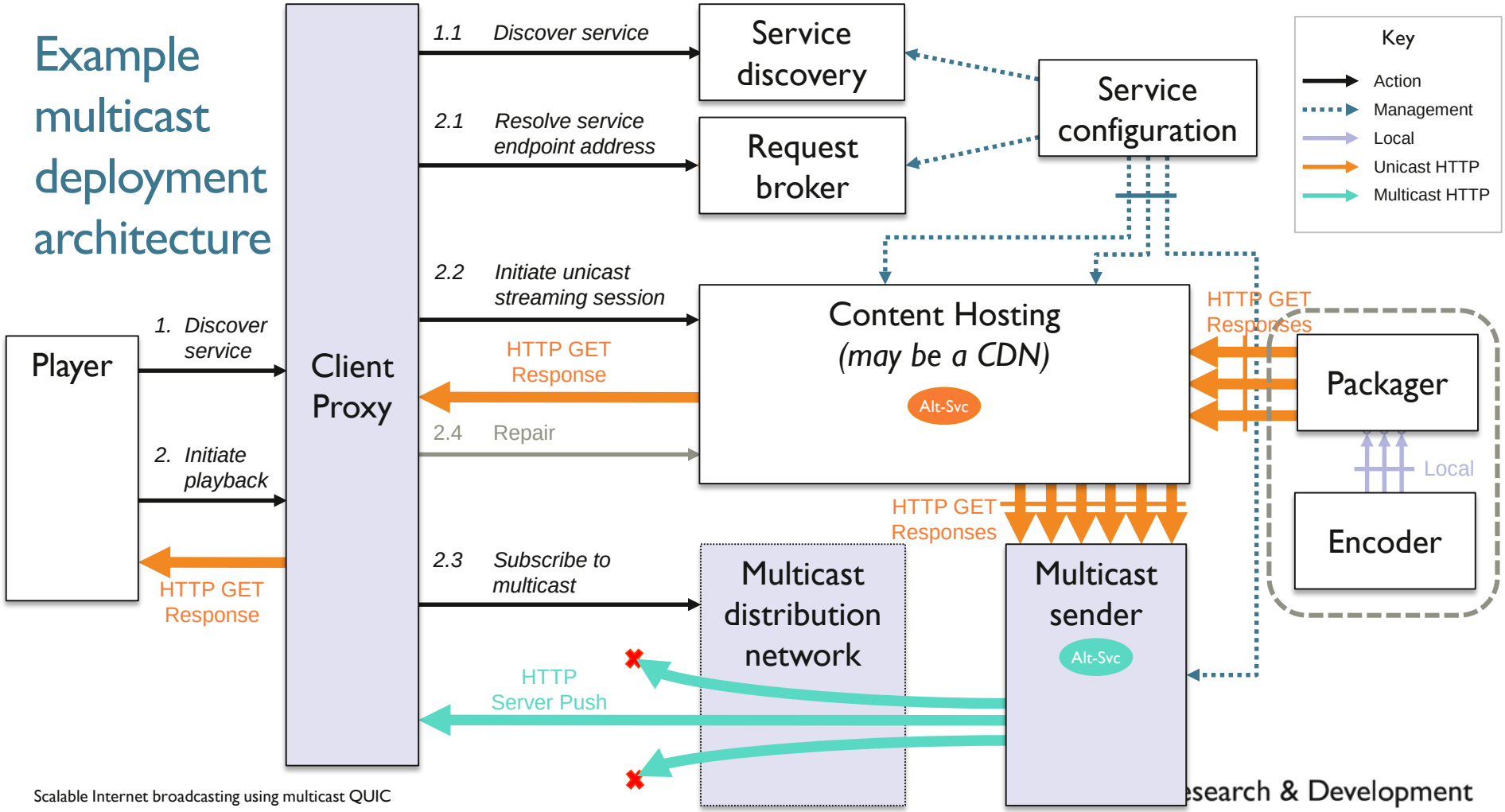
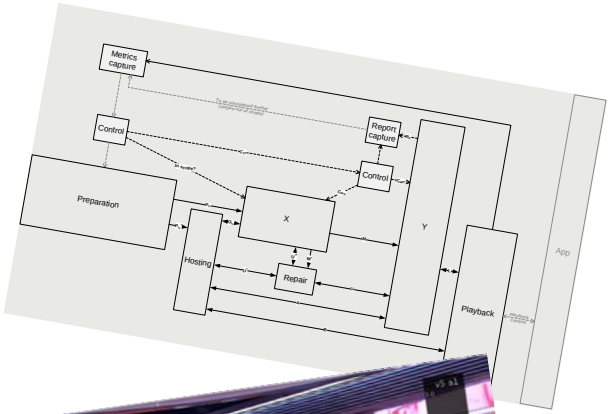


Prototype progress

- We have taken our Internet Draft and specialised it for the **linear media streaming** Use Case.
  - We envisage that this particular profile of HTTP over multicast QUIC could be standardised.
- We have an **end-to-end working prototype** of a multicast sender and a Client Proxy receiver.
  - Based on an earlier Google specification of the QUIC protocol syntax while we wait for the IETF to publish its variant as RFCs.
  - The Client Proxy runs on embedded devices such as the Raspberry Pi 2 and OpenWRT/LEDE routers.
- We are currently trying to demonstrate how the Client Proxy functionality can work in a web browser.
  - Plugging IP multicast into a browser environment is challenging!
  - Ultimately, we want to encourage native browser support for HTTP over multicast QUIC.



Conclusion

- We think that the future of linear television distribution over IP networks will be a mixture of unicast CDNs and IP multicast.
  - The two modes need to work hand-in-hand with each other to give a seamless user experience.
  - HTTP provides a common Layer 7 to achieve this seamlessness.
  - QUIC provides a common Layer 4 packet syntax.
  - Alt-Svc supports discovery of multicast from unicast.
- We have prototyped a system to demonstrate these principles.
  - It works well in our (relatively benign) lab' environment.
- We'd like to try it out on some real networks to see how these ideas work in practice.

Thank you

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