Streaming & Connected TV

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What is connected TV?

- Connected TV is a term used to describe equipment and services where TV receivers have an Internet connection
  - Related terms are IPTV (TV services provided over the Internet)
  - OTT (Over the Top content) is on-line delivery of video and audio without the Internet service provider being involved in the control or distribution of the content itself
- Connected TVs normally include applications to access services such as YouTube (Youku) and other user-generated content video services, Internet radio, catch-up TV services, subscription film libraries and often a web browser – sometimes video conferencing

Connected TV and 2nd screen

- Connected TV may not be the main TV set
- It may be
  - PC
  - Tablet
  - Smart phone
  - Games console
- Content may not be the same as broadcast TV
  - Movies from a server
  - Previously broadcast programmes
  - Programmes specially made to be streamed

Streaming video

- Live TV cannot be distributed as files, but must be streamed and a special protocol
  - RTSP (real-time streaming protocol) has been developed to support this.
- Streaming is also used to access previously broadcast TV programmes or movies stored on servers.
- Because the file sizes are large, it would take a long time to download a programme and need large quantities of storage at the client
  - 6GB per movie, 50 minutes to download at 2Mbs

IP video streaming

- Some internet video services (e.g. Youku) download a video to play it (but may start playing before it is all downloaded)
- Live IPTV services rely on streaming
  - Streaming sends individual transport stream packets as IP packets as soon as they are available
- Streaming video over the Internet gives several problems:
  - Available bandwidth
  - Packet loss
  - Jitter
  - Latency

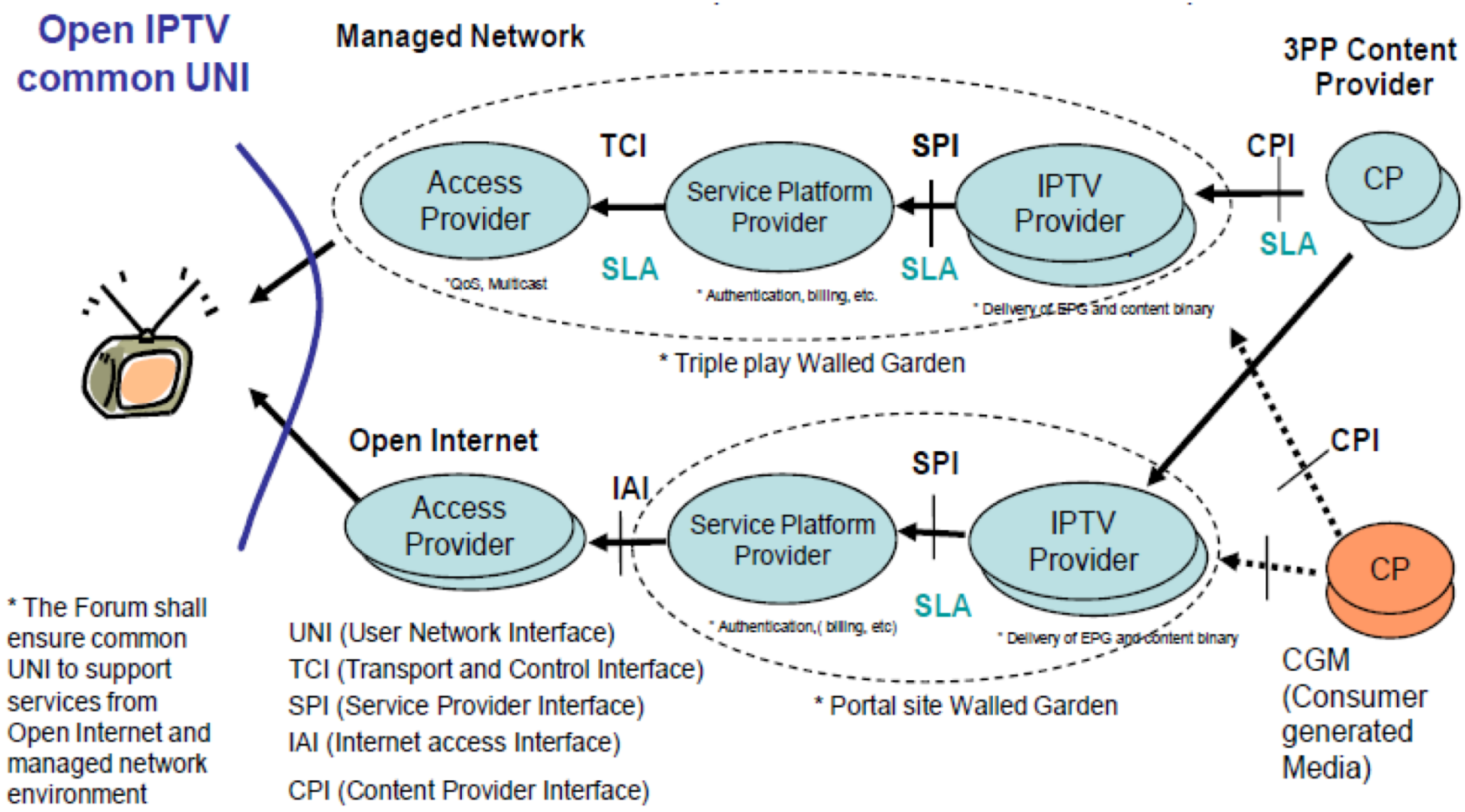
HLS streaming solution

- **HTTP Live Streaming** (**HLS**) is an HTTP-based streaming communications protocol.
- Implemented by Apple in QuickTime and iOS .
- Breaks the overall stream into a small HTTP-based file downloads, each download loading one short chunk of the transport stream.
- The client selects from alternate streams containing the same material encoded at a variety of data rates, so the streaming session can adapt to the network.
- As it only uses standard HTTP, it can traverse any firewall or proxy server (unlike RTP).

DASH streaming solution

- Dynamic Adaptive Streaming over HTTP (DASH or MPEG-DASH)
- Similar to Apple's HLS solution, MPEG-DASH breaks the content into a sequence of small HTTP-based file segments made available at different bit rates.
- The client automatically selects from the alternatives the next segment to download and play back based on current network conditions.
- The client selects the segment with the highest bit rate possible that can be downloaded in time for play back without causing stalls or rebuffering events in the playback and seamlessly adapts to changing network conditions, providing high quality play back.
- MPEG-DASH is the first adaptive bit-rate HTTP-based streaming solution that is an international standard. MPEG-DASH is not a protocol — the protocol is HTTP, hence the "H" in the name.
- The solution can be used universally, unlike more proprietary solutions such as HLS by Apple, Smooth Streaming by Microsoft, or HDS by Adobe.

A system overview



System Overview

- Two possible delivery routes are shown from managed network (IPTV) and open Internet (OTT – over the top)
  - An ISP who offers live TV services as part of an integrated group of telephone, Internet and TV services to the home
  - TV services delivered by an ISP who does not include TV services as part of a package
  - Some of the interfaces between parts of the system are shown
  - SLA = Service Level Agreement – a definition of the quality of the service guaranteed
- Diagram is from Open IPTV forum

Economics

- The cost of chips capable of sophisticated video processing continues to fall
- The bandwidth of broadband internet to domestic subscribers increases
- Storage costs for the large files that video produces have fallen fast (a medium length SD movie takes 2GB – a large HD one around 6GB)
- The cost per GB of transmitting data falls
- It will soon be cheaper to deliver TV via the internet than via satellite

Bandwidth issues

- HD TV is likely to require at least 2 Mbs.
  - A household will expect to be able to receive two streams at once so that one can be recorded while the other is viewed.
  - Around 8 Mbs is the real average broadband connection, which can support this and some other internet activities (provided they do not include networked action gaming) but many people receive lower bandwidth connections
- Broadband is implemented using concentrators that have to simultaneously handle the connections from a group of households, so concentrators will have a much higher bandwidth requirement.

Some bandwidth calculations

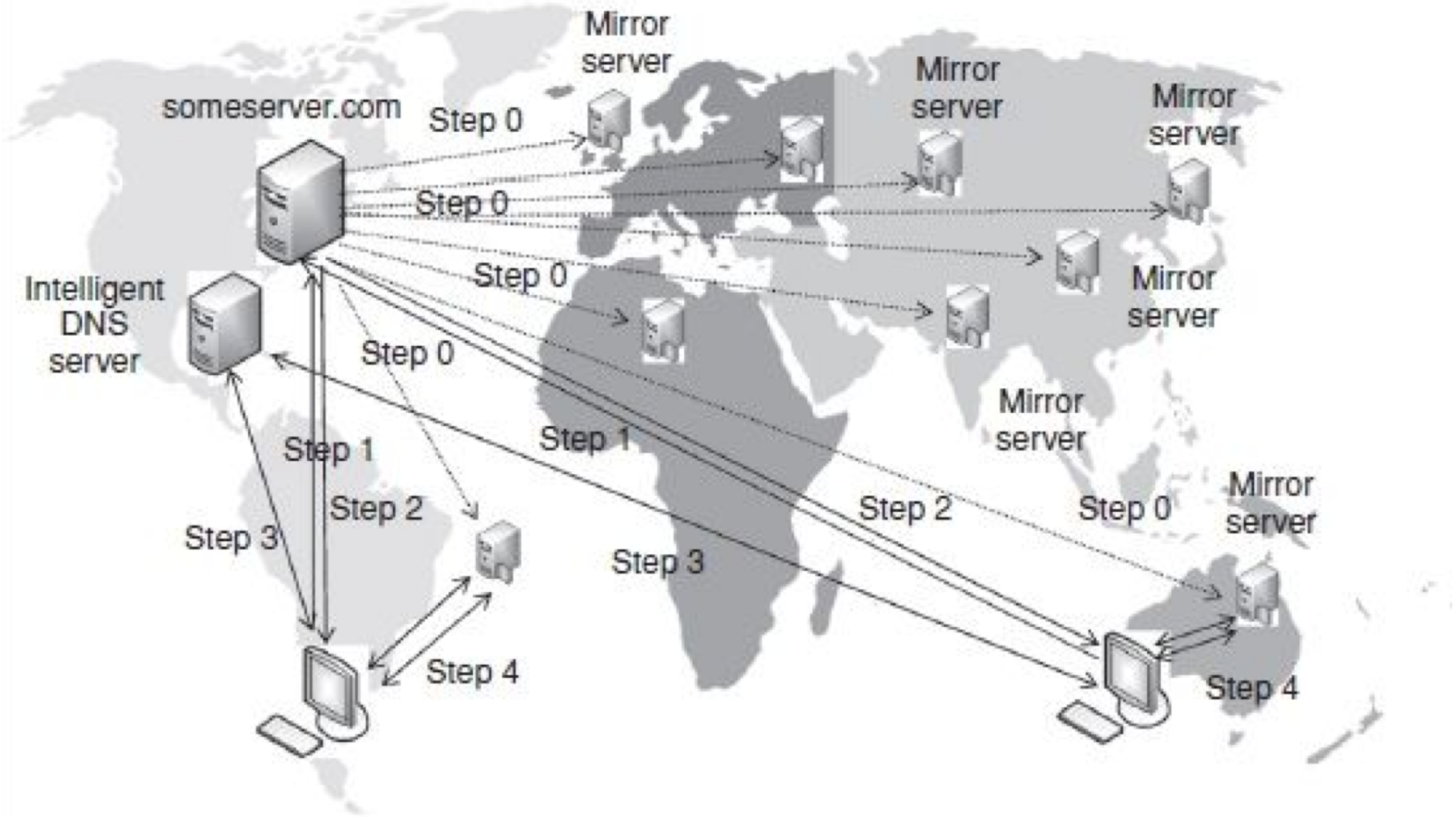
- Movies use 24 frames per second; however, the rate of the frames can change according to standards being used so that there are different kinds of frame rates, for instance, North America is using approximately 30 frames per second where the Europe television frame rate is 25 frames per second. Each digital video has dimensions width and height; e.g. SDTV is 720×480 pixels, on the other hand, numerous HDTV requires 1920×1080 pixels. Moreover, whilst for SDTV, two bytes (16 bits) is enough to create the colour depth, HDTV requires three bytes (24 bits) to create the colour depth.

- Thereby, with a rate of 30 frames/second, the uncompressed data rate for SDTV becomes 30×720×480×16, in other words, 147,456,000 bits per second. Moreover, for HDTV, at the same frame rate, uncompressed date rate becomes 30×1920×1080×24 or 1,492,992,000 bits per second. With that simple calculation, it is obvious that without using a lossy compression method a service provider's service delivery to the subscribers is limited.

- In addition, Audio adds additional bandwidth on the order of 128-256kbps (assuming that you're encoding as MP3 or AAC.)

- There is no absolute answer for the bandwidth requirement for the IPTV service because the bandwidth requirement is increasing due to the devices inside the household. Thus, currently compressed HDTV content can be delivered at a data rate between 8 and 10 Mbit/s, but if the home of the consumer equipped with several HDTV outputs, this rate will be multiplied respectively.

Content Distribution Networks (CDN)

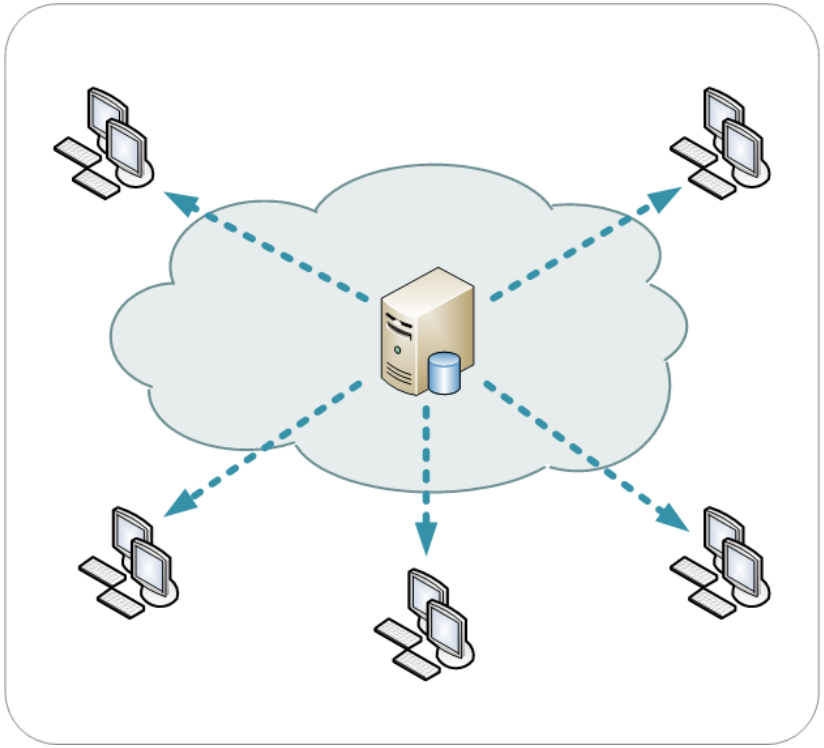


The content is copied to a number of mirror servers that are geographically distributed

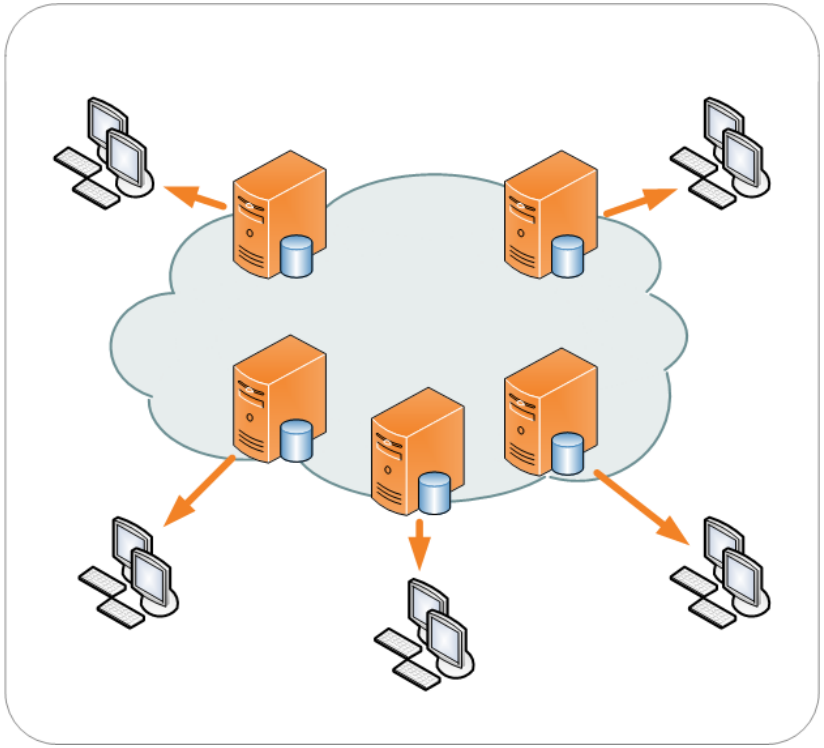
CDN

- The intelligent DNS server will direct an initial DNS request to the server nearest the client
  - If that server is overloaded the direction will be to an alternative nearby server
- This limits the demand on an individual server and reduces the bandwidth demand on any particular link in the network
- The DNS management is *multicasting* as supported in IPv6
- Well known CDNs are *Microsoft Azure* and *Amazon Cloudfront*. Netflix is building a CDN.

CDN cont.



Single Server

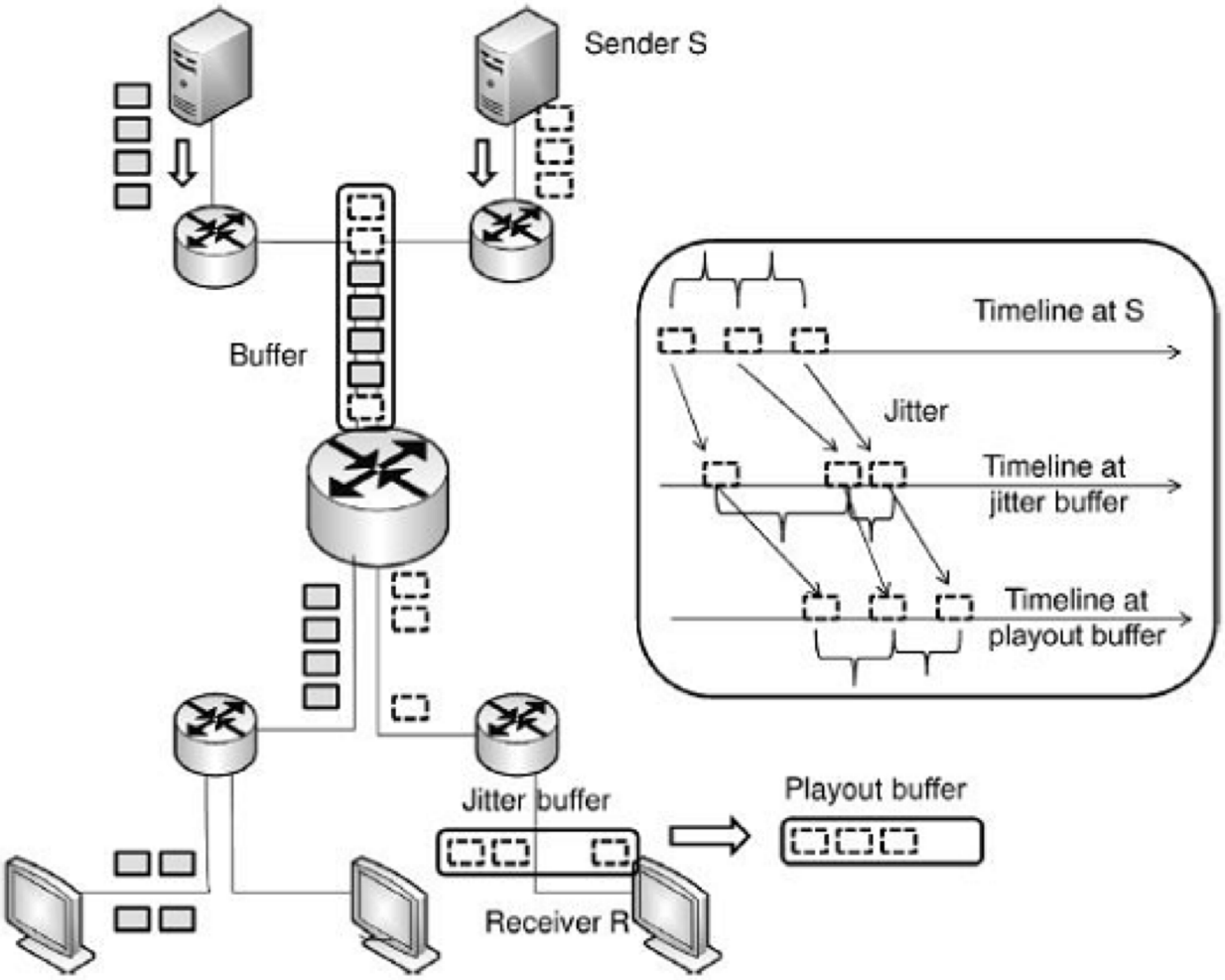


Content Delivery Network

Causes of Network problems for streaming

- The basic problem is network congestion
  - If a buffer at a router is overloaded packets will be lost
  - Variable numbers of packets from other services inserted between the video packets will cause jitter
  - There may be problems with the number of simultaneous requests made to the content server
- These issues mean that live TV has to be treated specially in the Internet to give high quality at the customer

Client buffering for Jitter



A buffer of about 5 seconds at the client can even out packet spacing

Packet Loss

- Packet loss is probable in the Internet because packets will pass through a series of routers, each of which has a buffer.
  - If the buffer becomes full new arrival packets are discarded
  - In TCP/IP a request is made to re-send the lost packet, but this is not a solution for streaming video as packets are then massively out of order
  - A protocol is required that gives priority to the multimedia packets
  - This can be achieved relatively easily in a closed network where the ISP offers TV as a service, but is more difficult in the open Internet

Solving the network problem

- Quality of Service (QoS) management and a broadcast-quality IP video gateway are needed
- QoS is typically handled by routers and switches in the network. Important components are
  - multi-protocol label switching (MPLS)
  - traffic classification, metering, shaping, and admission control policies.

IP and Multimedia

- When telecom companies decided to convert their networks from circuit switching to packet switching (IP protocol) they developed a structure to handle multimedia – IP Multimedia Subsystem (IMS)

IPTV architecture

- Media and service discovery is the IPTV application server that is queried to find the services that are available
  - Discovery and selection phase. User status is checked and a list of the allowed services is sent to the user
- Media and control delivery is the server that streams the multimedia content
  - The terminal capabilities are queried to determine the correct stream to use

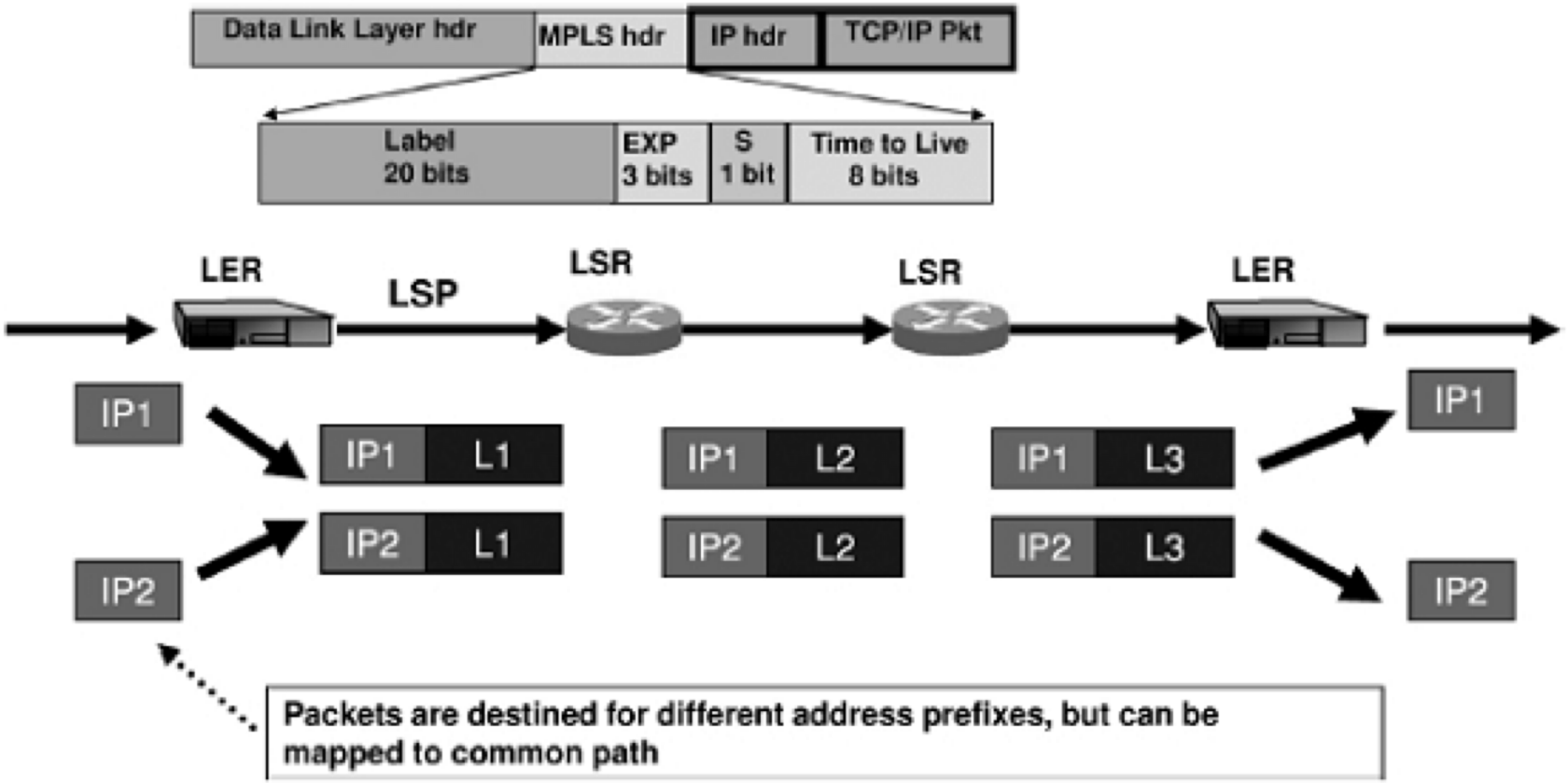
Multi-protocol Label Switching

- Multi-protocol Label Switching (MPLS) enables the creation of virtual connection-oriented paths within a network.
  - Bandwidth can be reserved for each virtual path.
  - Network performance parameters, such as loss and jitter, can be guaranteed throughout the traffic flow.
  - MPLS can provide bandwidth guarantees for video traffic by separating these flows from other best-effort paths assigned to Web or e-mail traffic.

MPLS

- IP packets are encapsulated in a larger structure starting with a label. This is done at label edge routers (LERs)
- Other label switching routers (LSRs) then treat these packets preferentially and the packets take a label switched path (LSP)
- In the LSP the packet is routed by the label, which is fast and efficient
- MPLS allows the service provider to control the route for the IPTV packets
- It also allows them to decide how much traffic is allowed to flow through a path and to divert to another path if there is an overload

MPLS system



More network techniques

- Traffic metering, shaping and admission control policies are other forms of Quality of Service (QoS) work.
  - By controlling the entry traffic, network congestion can be avoided and packet loss and jitter become minimized.
- Other QoS techniques, such as differentiated services, traffic classifications and priority queuing mechanisms, also allow video traffic to be treated with higher priority than standard voice or data traffic.
- **Jitter** due to queuing in the routers, occasional packet loss or out-of-sequence delivery caused by network outages can still occur.

IP video gateways

- Functions of the gateway are
  - Conversion from bit-serial interfaces to packet-based IP interfaces.
  - Clock recovery and synchronization.
  - Recovery from packet loss and out-of-order packets.
  - Network monitoring and reporting
- Forward Error Correction (FEC) techniques can be used sending repair packets together with the original stream of packets containing the video data.
  - When packets are lost and never make it to the receiver, the repair packets, combined with the non-missing packets, are used to reconstruct the lost packets

IP Video gateways cont.

- Gateways need to implement a smart buffer scheme, combining the synchronization, jitter, reorder and FEC buffers so latency at the receiver is minimized.
  - Minimizing latency is particularly critical in an environment where large delays can be problematic, such as interactive TV applications
- Real-time network statistics such as packet loss ratio, maximum burst loss and network jitter are needed.
- These statistics are used to optimize the operations of the IP network, video codec and video gateways.
  - If such operations are tuned correctly, IP networks should be capable of carrying perfect, broadcast-quality video

Standardising connected TV

- Standards allow all broadcasters to use the same software to deliver connected TV services on different hardware
- Standards help economies of scale
- Two standards that have been developed are **YouView (UK)** and **Hybrid broadcast broadband TV (HbbTV)** – a European standard
- HbbTV is being adopted in several countries and uses the MPEG-DASH adaptive streaming over HTTP standard
- The Hollywood studios have developed an Ultraviolet (UV) standard to protect content for use in connected TV systems
- There are attempts to align these standards as much as possible.

China Connected TV Standard

- China Video Industry Association (CVIA) released China's first set of online TV multimedia communications standards in April 2011
- The standards are the first to be drafted that address internet-connected TV sets and TV peripherals
- 40% of the TV sets sold in China in 2012 were connected TVs