The Future of Television

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Who still watches TV?

• Who subscribes to traditional linear broadcast TV from an operator (e.g., Comcast Cable, Verizon FiOS, DISH/DirectTV, etc.)?
  • How many do so just for live sports?
  • How many do so just because they like flipping channels?
  • How many do so because it has better quality/reliability?

• Who gets their video primarily from an Internet streaming service (e.g., Netflix, Hulu, Amazon, YouTube, Roku/AppleTV/SmartTV, etc.)?
  • How many do so because it’s cheaper a la carte (or pirated)?
  • How many do so because there’s no fixed schedule (binge watching)?
  • How many do so because it’s easier to find content you want/like?
The Challenge of On-Demand Cloud Delivery

• Bandwidth is cheap and plentiful, so what’s the problem?
  • Problem: Bandwidth is neither cheap nor plentiful.

• Multicast: to the Home/Node
  • Super Bowl Problem: Why unicast when everyone is watching the same show?
  • \( \text{num\_channels} \ll \text{num\_users} \times \text{num\_devices} \)
  • Super Bowl Timeshift Problem: What if everyone presses pause/rewind?

• Application Multicast: CDN Caching
  • Urban Node/Rural Node Problem: How close can you position a cache?
  • \( \text{num\_channels} \times \text{num\_caches} \ll \text{num\_users} \times \text{num\_devices} \)
  • Nomadic Footprint Problem: How do you support mobile clients?
Multicast HLS

• Framing: Segment-based vs. Packet-based Delivery
• Repair: FEC vs. NACK vs. On-Demand Unicast Repair
• Manifest: In-band vs. Generated
• Adaptive Bitrate: SVC vs. Multiple Streams
• Fast Channel Change/Startup: Segment vs. GOP boundary
• In-home device: Multicast Clients vs. Unicast Gateway
• Cellular Multicast: LTE eMBMS
• Wifi/Cellular handoff
CDN Federation

- Global Footprint: Build vs. Buy vs. Partner
- Delivery Redundancy: Overflow Protection vs. Physical Backup
- Content Synchronization: Single Origin vs. Time Sunk Packaging
- Request Routing: Internal Surrogate Selection vs. URI Consistency
- Delivery Cost: Peering Charges vs. Subscriber Affinity
- Delivery Analytics: Billing vs. Troubleshooting
- Client Identification: Billing vs. Authorization
- What about content that cannot be cached?
Private Copy Network DVR

• Sony Corp. of America v. Universal City Studios, 464 U.S. 417 (1984)
  • The BetaMax VTR has some legal uses

  • Playing the same physical VHS for multiple customers is a public performance

• Cartoon Network v. CSC Holdings, 536 F.3d 121 (2008)
  • Remote DVR is ok because there are unique copies for each viewer
  • Recording is a volitional act by the user creating a unique copy
  • It “may limit the potential audience of a transmission”; it’s not to the public
  • The only shared buffers contain .1 and 1.2 seconds of broadcast data

• Ericsson Video Storage and Processing Platform
Private Copy On-Demand Cloud Delivery

  • Buying DVDs and streaming from individual DVD players violates copyright
  • They had physical copies, but did not respect release windows
• Fox Television Stations v. FilmOn X, 966 F.Supp.2d 30 (2013)
• American Broadcasting Companies v. Aereo, 134 S.Ct. 2498 (2014)
  • Individual antennas to capture over the air TV broadcast
  • Retransmission over the Internet, with remote DVR capabilities
  • Aereo is like a cable company and cable companies broadcast to the public
  • Intervening hardware that creates an individualized retransmission irrelevant
• What does that mean for Cloud-based Delivery
The Challenge of Monetizing On-Demand Cloud Delivery

• How do we make money? Subscription Fees vs. Ad Revenue
• Who makes the money? Content Providers vs. Network Operators
• Subscriptions: Direct to Consumer vs. Aggregated through Operator
  • Per platform/device restrictions
  • In-home/Cellular/OTT restrictions
  • Per program/network restrictions
• Ad Selection/Insertion/Tracking: Regional vs Targeted
  • Can/should we enforce advertisements in network DVR?
  • Client-side ad selection/insertion always generates a flash crowd
• How do we make sure people pay subscriptions or watch the ads?
The Challenge of Protecting and Enforcing Rules for On-Demand Cloud Delivery

• Encryption: Transport vs. Content
• Key Generation: Per-Content vs. Per-User vs. Per-Session
• Authentication: Device vs. User
• Key Delivery: In-band vs. Out-of-band
• Entitlement Delivery: In-band vs. Out-of-band
• Revocation: Device vs. User
• Root of Trust: Hardware/Software Verification and Secure Boot
• Obfuscation: What happens when everything is just javascript?
Problems for the Networking Community

• Manifest Standardization: Ad Insertions, Rights Enforcement
• Bandwidth Efficiency: Can caching ever replace multicast?
• Startup Latency: Can segment-based delivery ever be real-time?
• CDN Federation: Internal vs. External
• Key Delivery: Content/Signing Key vs. Key of Keys
• Key Revocation/Rotation: Reactive vs. Proactive
• Where does CCN come into play?
• Where does HTTP2 come into play?
Questions?