Management of time-shifted IPTV services through transparent proxy deployment

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Introduction
- IPTV
- access network architecture

Time-shifted television
- concept
- caching algorithms
- deployment options

Proxy implementation
- RTSP proxy
- streaming session setup
- performance measurements

Conclusions
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Conclusions
High priority: IPTV services

- requirements: high bandwidth, low delay and jitter
- today: broadcast TV (live) or VoD (older content)
  - highly loaded VoD servers at the network edge
  - complete files are stored
- solution: time-shifted TV for (very) recent content
  - distributed servers in the access network
  - fragments are stored
Introduction

Current ATM-based broadband aggregation

ATM DSLAMs
- Unintelligent Layer 1 aggregation
- Low-speed ATM uplinks
- Mostly Central Office - based

Complex, fixed connections
- PPP-based
- Bound to DSL CPE in the home
- Provisioning cost high

Centralized B-RAS
- Optimized for best-effort internet
- Lack of scalable routing and QoS
- Typical OC-12 handoff to IP core

Lack of network resiliency
- Outages tolerated
- Minimal financial repercussions

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PPP obstructs
- scalability
- multicast support
- auto-configuration

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Introduction

Next-generation Ethernet/IP-based broadband aggregation

IP DSLAMs
- Intelligent aggregation with multicast support
- Gigabit Ethernet Uplinks
- Increasingly RT-based

Simple, flexible connections
- DHCP-based
- Independent of device
- User-based
- Provisioning cost low

Distributed routers
- Optimized for QoS-sensitive services
- Highly scalable
- 10 GbE handoff to IP/MPLS core

Highly available network
- Little to no tolerance of service interruptions
- Risk of churn if reliability metrics aren’t met

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Network view
- caching of fragments
- p2p caches

CS: central server
ER: edge router
AR: access router
AM: access multiplexer

User 1: real-time
User 2: delayed $t_1$
User 3: delayed $t_2$
Streaming diagram

- supports user interactivity
Time-shifted TV

- **Caching algorithm**
  - **storage space**
    - small part $S$ for learning (< 1 GB)
    - large part $L$ for storage of popular/distant fragments, determined by the parameters $A_{n,p}$
  - **time intervals $\Delta$**
    - during $\Delta$: as requests arrive, all parameters $A_{n,p}$ are updated
  - after $\Delta$: store “occupied” fragments and fragments with highest value for $A_{n,p}$

request for program $p$

<table>
<thead>
<tr>
<th>program stored locally?</th>
<th>window appropriate?</th>
<th>is it new?</th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
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</table>

- stream locally - set to “occupied” - adapt $A_{n,p}$
- stream from other cache
- stream from server - cache in $S$
- stream from other cache - adapt $A_{n,p}$
Time-shifted TV

- **Input parameters**
  - 5 tsTV channels
  - 6 programs per channel
  - 45 minutes per program
  - exponentially decreasing popularity
  - $\Delta = 5$ minutes

- **Deployment options**
  - hierarchical caching
    - caches at AR and AM level
  - co-operative caching
    - co-operating caches at AM level

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Hierarchical caching

Server load reduced by 50% to 70% with 0.5GB caches

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Co-operative caching

Server load reduced by 95% with 6 co-operating 0.5GB caches

![Graph showing cache size vs. % requests]
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RTSP proxy

- implementation using RTP / RTCP / RTSP
Time-shifted TV

Detailed scenario

- **C:** Cacher
- **CVM:** CacheVerdictManager
- **RP:** RTSPProxy
- **PH:** PacketHandler

### Time Points
- **0:**
  - **server**
  - **cache:**
    - RTSPMessage: `describe <program url>`
    - ok + SDP data
    - RTSPMessage: `setup <stream> to clientIP:port x`
    - ok
    - RTSPMessage: `play <program url> at <time>`
    - ok
  - **proxy:**
    - RTP stream to clientIP:port x
  - **client:**
    - update cache state

- **1a:**
  - **server**
  - **cache:**
    - RTP stream to proxyIP:port y
    - ok
  - **proxy:**
    - RTP stream to proxyIP:port y
  - **client:**
    - update cache state

- **2a:**
  - **server**
  - **cache:**
    - cache from server!
  - **proxy:**
    - RTP stream to clientIP:port x
  - **client:**
    - update cache state

### Additional Notes
- CSE: Common Service Environment
- RTC: Real-Time Communication
Detailed scenario

Time-shifted TV

server

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cache

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proxy

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client

- RTSP
- RTP
- CSE
- internal

RTSPMessage

verdict?

RTSPSession

setup <stream> to clientIP:port x

play <program url> at <time>

RTP stream to clientIP:port x

update cache state

RTP stream to cacheIP:port y

update cache state

C: Cacher

CVM: CacheVerdictManager

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RTSP proxy

- measurements
  - AMD Athlon™ 64 (512MB RAM), 1GB links
  - handling of simultaneous client RTSP requests (low priority), while serving RTP streams (high priority)
RTSP proxy

- measurements
  - AMD Athlon™ 64 (512MB RAM)
  - delay between PLAY request and first RTP packet in a server-proxy-client configuration
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Access network transformation

- from ATM based broadband aggregation to multi-service IP-aware access networks
- increased flexibility, scalability and availability

IPTV

- identified as highest-priority, bandwidth intensive residential telecom service
- server load and access network load reduced effectively through time-shifted TV using distributed and transparent proxy streamers, especially for co-operative caching
- proxy implementation using RTP / RTCP / RTSP protocol suite