Co-operative proxy caching algorithms for time-shifted IPTV services

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Outline

• Introduction
  - advanced access network services
  - IPTV
  - access network transformation

• Time-shifted television
  - concept
  - caching algorithms
  - simulation results

• Proxy implementation
  - RTP / RTCP / RTSP

• Conclusions
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Network requirements for next-generation services

- content delivery (IPTV, VoD)
  - high bandwidth, low jitter
- multiplayer games (server based, P2P)
  - low delay
- distributed storage
  - low delay, high availability
- conferencing (IP telephony, video conferencing)
  - low delay and jitter
- home management (automation, security)
  - high availability

=> increasing bandwidth and QoS
• High priority: IPTV services
  - 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, storing fragments
• Current architecture
  - access network per service
  - broadband Internet (DSL / ATM based)
    • PPP terminated in single device (BAS)
    • Single device per subscriber
      - NAT breaks E2E connectivity
    • PPP setup hampers autoconfiguration
    • PPP conflicts with application-based QoS and multicast support
Access network

- **Next-generation architecture**
  - Converged access
  - IP awareness
    - Multicast support
    - Local P2P traffic
  - Multi-edge
    - Scalability
    - High availability
  - New services (triple play)
  - Application based QoS

The diagram illustrates the components of an access network, including DSLAM, ATM switch, aggregation network, ISP1, ISP2, NAP, edge router, CPN, ADSL modem, IP telephone, gateway, and service enablers (e.g., firewall, caches).
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• Network view
  - caching of fragments
  - p2p techniques at cache level

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

User 1: real-time
User 2: delayed t₁
User 3: delayed t₂
• Streaming diagram

Time-shifted TV

- User 1: real-time
- User 2: delayed $t_1$
- User 3: delayed $t_2$
Caching algorithm

- **storage**
  - small part $S$ (< 1 GB) for learning
  - large part $L$ for storage of popular / distant segments

- **during each interval $\Delta$ (e.g. 5 minutes)**
  - parameter $A_{n,p}$ is increased every time a request for program $p$ passes by cache $n$
  - increase $A_{n,p}$ by 1 (pure popularity) or by the hopcount between cache $n$ and the serving node (popularity & distance)

- **after each interval $\Delta$**
  - store all “occupied” segments
  - store segments with highest $A_{n,p}$

![Diagram]

- request for program $p$
  - program stored locally?
    - yes: store locally
    - no: continue
  - is it new?
    - no: stream from other cache or set to “occupied”
    - yes:
      - window appropriate?
        - no: stream from other cache
        - yes: stream from server or adapt $A_{n,p}$

- stream from other cache
- adapt $A_{n,p}$
- cache in $S$
• Input parameters
  - 5 tsTV channels
  - 6 programs per channel
  - 45 minutes per program
  - 2.5 Mbps streams
    ($\approx 1$ GB per hour)
  - popularity halved after each
    interval $\Delta$ (= 5 minutes)

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

Server load reduced by 50% to 70% with 0.5GB caches
Time-shifted TV

- Co-operative caching

Server load reduced by 95% with 6 co-operating 0.5GB caches
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• RTSP proxy
  - implementation using RTP / RTCP / RTSP
• 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
  - necessary to meet QoS requirements

• IPTV
  - identified as highest-priority, bandwidth-intensive residential telecom service
  - server load and access network load reduced effectively through time-shifted TV using distributed proxy streamers
  - implementation using RTSP proxy streamers