Peer-to-Peer IPTV Services

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Summary

1. Introduction
2. Review of Existing Architectures
3. Challenges of P2PTV Systems
4. Proposal of a Novel Architecture
5. Problems to Investigate
6. Conclusion
IPTV: alternative delivering system to cable and broadcast. Service promises to be in the future Internet. **Problems**: ↓ visual quality, regulatory issues. **Types**:  
- **Commercial IPTV**  
  - Private architectures ⇒ limited population served  
  - Guarantee of quality of service  
  - Normally provided in triple play services  
- **Cooperative IPTV**  
  - Public architectures ⇒ global population served  
  - Quality of service sought through best effort networks  
  - Cooperative environment, clients’ resources, P2PTV
Contribution and Objectives

- Proposal of a novel P2P architecture for cooperative IPTV
- Evolution of this type of system, which is still in infancy
- Identification of common challenges
- Incorporation of solutions in the architecture
- Search for competitiveness with traditional television
- Offer of an efficient alternative to commercial IPTV
Overlay Structure Approaches

- **Tree** (End System Multicast – ESM)
  - Explicit delivery structures ⇒ data-push approach
  - +: ↓ delay
  - -: No fault-tolerance, do not employ leaf nodes’ bandwidths

- **Mesh** (CoolStreaming, PPLive, PPStream)
  - On demand delivery structures ⇒ data-pull approach
  - +: Fault-tolerance, employ leaf nodes’ bandwidths
  - -: Data-driven scheduling cost, ↑ delay

- **Multiple Trees** (CoopNet, SplitStream, Chunkyspread)
  - Redundancy of data and network paths
  - +: ↓ delay, fault-tolerance, employ leaf nodes’ bandwidths
  - -: Tree management overhead, implementation complexity

- **Tree Mesh Hybrid** (mTreebone)
The CoopNet System

- P2P media streaming **live** (synchronized distribution)
- Supports peer heterogeneity and network congestion (bandwidth adaptation protocol);
- Employs LMDC and multiple distribution trees
- Peer: **interior** node in just one tree and **leaf** node in the remaining trees
Challenges of P2PTV Systems (1)

- **Short Start-up Delay**
  - Buffers $\Rightarrow$ delays
  - Worse with $\neq$ s channels

- **Need for Incentive Mechanisms**
  - Autonomy of peers, $\downarrow$ altruism
  - Worse with $\uparrow$ quality and $\neq$ s channels

- **Need for Some Dedicated Infrastructure**
  - Outgoing BW $<$ incoming BW $<$ streams
  - Worse with $\uparrow$ quality and $\neq$ s channels

- **Support for Flash Crowds and High Churns**
  - $\uparrow$ arrival rates (FC), $\uparrow$ departure rates (HC)
  - Worse with $\neq$ s channels
Challenges of P2PTV Systems (2)

- **Support for Client Heterogeneity**
  - ≠ capacities: adaptation
  - Single rate: ↑ − prov. peers and ↓ + prov. peers

- **Synchronization of Client Playback**
  - ≠ delays for peers
  - Problems with live and interactive broadcast

- **Better NAT and Firewall Traversal**
  - ↑ peers behind NATs/firewalls: unreachable
Architecture
Improvements and Contribution (1)

- **Challenge:** Short Start-up Delay
  ⇒ *Employment of multiple trees rather than mesh, distribution of the tree management overhead by multiple servers, distinct scheme for channel switching*

- **Challenge:** Need for Incentive Mechanisms
  ⇒ *Distinct incentive scheme for cooperation, integrated to the architecture*

- **Challenge:** Need for Some Dedicated Infrastructure
  ⇒ *Introduction of the 2nd layer of the architecture, with dedicated infrastructure (DSNs)*
Challenge: Support for Flash Crowds and High Churns
⇒ Employment of redundancy of data (MDC) and network path (multiple trees)

Challenge: Support for Client Heterogeneity
⇒ Employment of LMDC for bandwidth adaptation and incentive scheme with deferred remuneration

Challenge: Synchronization of Client Playback
⇒ Possible optimization of overlay structures

Challenge: Better NAT and Firewall Traversal
⇒ Possible employment of the STUN protocol
Channel Switching Scheme
Basic Working

1. RN requests an operation of channel browsing to TSN
2. RN leaves the 1st set of trees and is admitted into the 2nd set of trees, changing its state to “browsing mode”
3. After channel selection, RN requests an operation of admission with pre-selection of channel to the upper DSN
4. DSN redirects RN to the least loaded TSN of that channel
5. RN is admitted by the new TSN into the 1st set of trees, changing its state back to “watching mode”
Channel Switching Scheme

Characteristics

- Playback engine with **multiple buffers FIFO**
- Channel Switching in **RNs**:
  - **Start-up delay** for browsing: admission into the 2\textsuperscript{nd} set of trees + filling up playback engine’s buffers
  - After start-up delay ⇒ channel switching is **immediate**, except when **swapping** scheme is necessary
  - Problem: synchronization of the streams from the old TSN and from the new TSN
- Channel Switching in **TSNs**:
  - Separation of the channels served and watched ⇒ free browsing without affecting descendant RNs
  - Descriptions received from DSN through the **same connection** ⇒ no trees, no swapping, no delay, just switch of playback buffers
Admission Control

Basic Working

- Peer consults DNS, which returns a DSN in a circular way
- Contacted DSN checks if the peer will become TSN
  - If affirmative:
    - DSN redirects the peer to the least loaded DSN
    - Chosen DSN admits the peer as TSN for a ch. with < TSNs
  - If negative:
    - DSN checks if there is a pre-selection of channel
    - If affirmative:
      - DSN redir. the peer to the least loaded TSN of that channel
      - Chosen TSN admits the peer as RN into the 1st set of trees
        (“watching mode”)
    - If negative:
      - DSN redirects the peer to the least loaded TSN
      - Chosen TSN admits the peer as RN into the 2nd set of trees
        (“browsing mode”)


Benefits of temporal de-linkage between cooperation and remuneration:

- Employment of cooperation from offline users (↑ credits)
- Exemption of cooperation for a period of time (↓ credits)
- Reception of higher stream quality (↓ credits)
- Handling of asymmetric links
- Emergence of TSNs (affiliate servers)

Model of affiliate servers:

- Comparable to the Internet advertisement business model
- Qualified TV content ⇒ periodic earning (+$)
- TSNs enlarge system capacity on demand (−$)
- Dynamic resource allocation vs. static provision of infrastructure
Incentive Scheme

Incentive Patterns Employed

Banking ⇒ for TSNs ($) and RNs
- **Storage** of credits from cooperation in banking accounts
- Asynchronous rem. ⇒ **temporal de-linkage** coop./rem.

Barter Trade ⇒ for TSNs and RNs
- Balancing between **cooperated** and **consumed** bandwidths
- **Credit** or **debit** in accounts per unit of time

Community (Reputation) ⇒ for TSNs only
- Classification of TSNs ⇒ **fairness** and **selection**
- **Capability-related** metrics: delay and throughput
- **Behavioral** metrics: session mean time and abrupt disc.
Problems to Investigate (1)

Bandwidth optimization for DSNs
- **Complete graph** ⇒ dep. # channels, SPs and DSNs
- Employment of multicast (network or application), multiple trees, mesh ⇒ \( \uparrow \) hops ⇒ \( \uparrow \) delay

Different overlay structures for RNs
- Multiple trees ⇒ \( \downarrow \) start-up delay
- Employment of different distribution approaches and overlays, mesh as an auxiliary structure (mTreebone)
Problems to Investigate (2)

**Stream synchronization at channel switching**
- Synchronization of *ni* (new TSN) with *mi* (old TSN)
- Employment of Piggybacking, larger buffers, abrupt switching (simplistic approach)

**Dynamic variation of network resources**
- Deferred remuneration, client heterogeneity, FCs/HCs ⇒ rapid oscillation between resource scarcity/excess
- Employment of dynamic adaptation by the incentive mechanism ⇒ var. of reputations, thresholds, taxes
In this work:
- Common challenges of P2PTV were identified
- Some solutions for them were studied
- An architecture for cooperative IPTV was proposed

Aims:
- Evolution of cooperative IPTV
- Competitiveness with traditional TV and commercial IPTV

Current status:
- The architecture is currently under development
- We hope to have the evaluation of its efficacy soon.
Architecture Overview

Temporary Super Node (TSN)

TSN (Ch 1)

TSN (Ch 4)

TSN (Ch 6)

TSN (Ch 2)

TSN (Ch 1)

Layer 3

(Watching Mode)

n' c n4

n4

(Surfing Mode)

M

m' c M

Layer 4

Regular Node (RN)

RN (Ch 4)

RN (Ch 4)

RN (Ch 4)

RN

RN

RN

RN