Peer-to-Peer IPTV Services

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Summary

Introduction

- IPTV: alternative delivering system to cable and broadcast
- Service promises to be in the future Internet
- **Problems**: $\Downarrow$ visual quality, regulatory issues
- **Types**:
  - **Commercial IPTV**
    - Private architectures $\Rightarrow$ limited population served
    - Guarantee of quality of service
    - Normally provided in triple play services
  - **Cooperative IPTV**
    - Public architectures $\Rightarrow$ 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 $\Rightarrow$ data-push approach
  - $+$: $\Downarrow$ delay
  - $-$: No fault-tolerance, do not employ leaf nodes' bandwidths
- **Mesh** (CoolStreaming, PPLive, PPStream)
  - On demand delivery structures $\Rightarrow$ data-pull approach
  - $+$: Fault-tolerance, employ leaf nodes' bandwidths
  - $-$: Data-driven scheduling cost, $\Uparrow$ delay
- **Multiple Trees** (CoopNet, SplitStream, Chunkyspread)
  - Redundancy of data and network paths
  - $+$: $\Downarrow$ 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

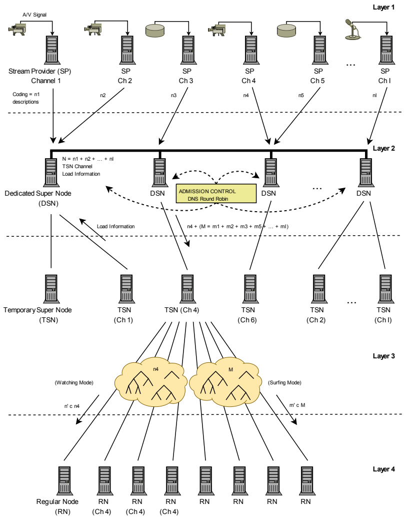
Challenges of P2PTV Systems (1)

- **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**
  - $\neq$s capacities: adaptation
  - Single rate: $\Uparrow -$ prov. peers and $\Downarrow +$ prov. peers
- **Synchronization of Client Playback**
  - $\neq$s delays for peers
  - Problems with live and interactive broadcast
- **Better NAT and Firewall Traversal**
  - $\Uparrow$ peers behind NATs/firewalls: unreachable

Architecture
Overview



Architecture

Improvements and Contribution (1)

- **Challenge:** Short Start-up Delay
  $\Rightarrow$ *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
  $\Rightarrow$ *Distinct incentive scheme for cooperation, integrated to the architecture*
- **Challenge:** Need for Some Dedicated Infrastructure
  $\Rightarrow$ *Introduction of the 2^{nd} layer of the architecture, with dedicated infrastructure (DSNs)*

Architecture

Improvements and Contribution (2)

- **Challenge:** Support for Flash Crowds and High Churns
  $\Rightarrow$ *Employment of redundancy of data (MDC) and network path (multiple trees)*
- **Challenge:** Support for Client Heterogeneity
  $\Rightarrow$ *Employment of LMDC for bandwidth adaptation and incentive scheme with deferred remuneration*
- **Challenge:** Synchronization of Client Playback
  $\Rightarrow$ *Possible optimization of overlay structures*
- **Challenge:** Better NAT and Firewall Traversal
  $\Rightarrow$ *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 1^{st} set of trees and is admitted into the 2^{nd} 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 1^{st} 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^{nd} set of trees $+$ filling up playback engine's buffers
  - After start-up delay $\Rightarrow$ 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 $\Rightarrow$ free browsing without affecting descendant RNs
  - Descriptions received from DSN through the same connection $\Rightarrow$ 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 1^{st} 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 2^{nd} set of trees ("browsing mode")

Incentive Scheme

Characteristics

- Benefits of temporal de-linkage between cooperation and remuneration:
  - Employment of cooperation from offline users ($\Uparrow$ credits)
  - Exemption of cooperation for a period of time ($\Downarrow$ credits)
  - Reception of higher stream quality ($\Downarrow$ credits)
  - Handling of asymmetric links
  - Emergence of TSNs (affiliate servers)
- Model of affiliate servers:
  - Comparable to the Internet advertisement business model
  - Qualified TV content $\Rightarrow$ 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 ⇒ ⇑ hops ⇒ ⇑ delay

Different overlay structures for RNs

- Multiple trees ⇒ ⇓ 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

Conclusion

- 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

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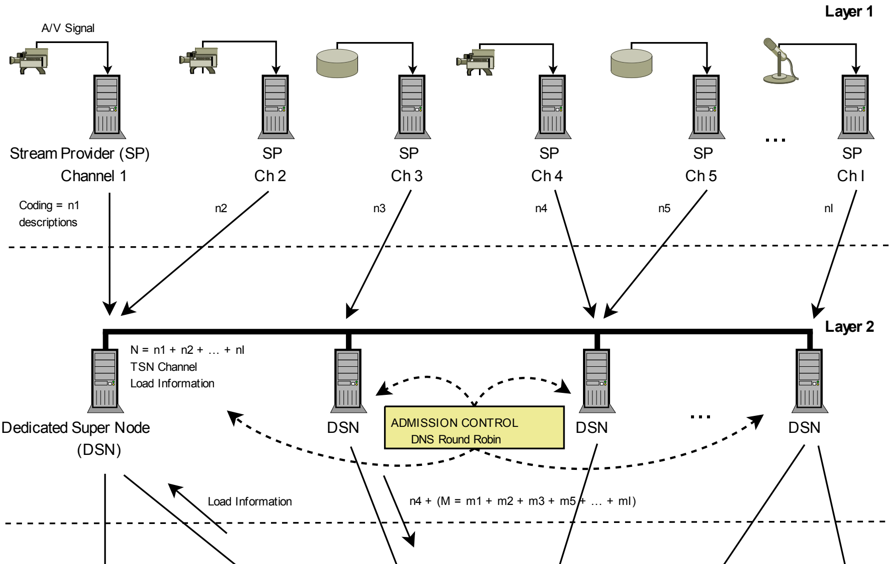

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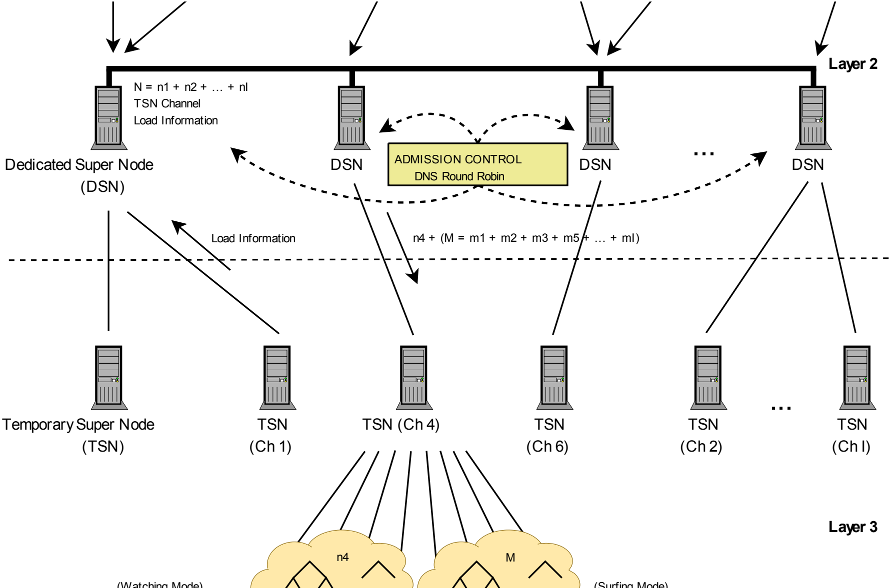

Architecture
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