Maximizing Revenue through Resource Provisioning and Scheduling in Delay-Tolerant Multimedia Applications

Saraswathi Krithivasan
Sridhar Iyer
IIT Bombay
Existing work treats multimedia dissemination as a soft real-time application that can tolerate some loss but requires \textit{minimal} startup delay.

Our work focuses on Multimedia applications that can tolerate startup delays......
Delay-Tolerant Applications

- Clients put in a request for multimedia content, specifying
  - Minimum rate $\text{Min}_{\alpha_i}$
  - Delay tolerance $d_i$

- Content Service Provider (CSP)
  - Performs admission control of client requests
  - Provides required QoS to admitted clients
  - Uses resources (streaming channels, buffers, and transcoders) judiciously to maximize revenues.
• **Given**
  - Heterogeneous network with different link capacities
  - Buffers at network nodes
  - Transcoding ability at intermediate nodes

• **Objective**
  - Use a single stream to service clients
    • With optimal quality that maximizes revenue
    • Exploiting their delay tolerance
Motivating Example

S: Source
R1,..R4: Relay nodes
C1,…C4: Clients
T: Play out duration: 1 hour
Base Encoding rate: 512 kbps
Maximizing revenue

Objective
• Using a single stream, exploit delay tolerance requirement of clients to provide best quality that maximizes revenue
  - Admit clients so that their requirements can be satisfied
  - Provision resources such as buffers, transcoders appropriately
  - Adjust streaming schedule such that all admitted clients are served and revenue is maximized
Problem formulation

• Phase 1: Finding optimal rate at clients and placement of transcoders to achieve these rates
  - TOPRATES: Tool to find Optimal RATES

• Phase 2: Schedule the stream based on price points and arrival patterns
  - TOPREVENUE: Tool to find Option for maximum REVENUE
Solution Approaches - Phase 1

• Optimization approach
  - Designing problem as non-linear multi-variable optimization
  - Solved using fmincon function in optimization toolbox of MATLAB

• Heuristic approach
  - Recursive greedy algorithm that assigns maximum of best possible rates for clients in sub trees starting at the top level

![Rates Delivered to Clients]

- Rates at clients (in kbps)
- Rates Delivered to Clients
- Clients
- Optimization results
- Heuristic results
TOPRATES: Tool to find OPtimal RATES

Input:
Network characteristics
Client requirements
Multimedia characteristics

Given:
Resources: buffers, transcoders
Assumptions:
Closed User Group, Static network

Output:
Rates at clients
Transcoder placement and rates
TOPRATES: Architecture

Input:
- Topology spec (T)
- Client requirement spec (C)

Validator

Pre-processor:
Set up data structures

Feasibility Checker

Local optimization module
Find optimal rate at each client considering its path in isolation

Global optimization module
Find optimal rates for all clients in the network

Post Processor
Solution Approach - Phase 2

• Scheduling and admission control
  - Exploiting “residual delay tolerance” to maximize revenues

  *Residual delay tolerance* results when a client receives the stream at the best possible rate at a time earlier than its requested time

  • reschedule streaming for a later time \( t_{1+\Gamma} \), where \( \Gamma \) is the time until when all admitted clients requirements can be met
  • Admit new clients in the interval \( \Gamma \)
On-going work: Scheduling and admission control

- Exploiting residual delay tolerance
  - Run a predictive tool to assess number of arrivals in $\Gamma$
  - Define price points for enhanced quality and new admissions
  - Compare revenue from starting stream at $T$ to revenue if stream were rescheduled to $t+ \Gamma$ and recommend appropriate option
TOPREVENUE: Tool to find Option for maximum REVENUE

Input 1: (from TOPRATES)
Rates at clients
Remaining delay tolerance

Input 2:
Price points
• For enhanced quality
• For admission

Output:
Option that maximizes revenue
Conclusions

• Delay tolerant applications cater to clients’ convenience while enhancing QoS
• CSP’s can exploit delay tolerance to enhance revenue through optimal utilization of resources and appropriate scheduling
• TOPRATES and TOPREVENUE are tools being developed to aid CSPs to decide on the correct options