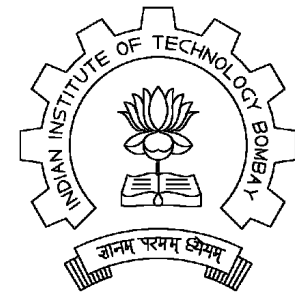


Maximizing Revenue through
Resource Provisioning and Scheduling
in
Delay-Tolerant Multimedia Applications

Saraswathi Krithivasan
Sridhar Iyer
IIT Bombay



Existing work

treats multimedia dissemination
as a soft real-time application
that can tolerate some loss
but requires *minimal* startup delay

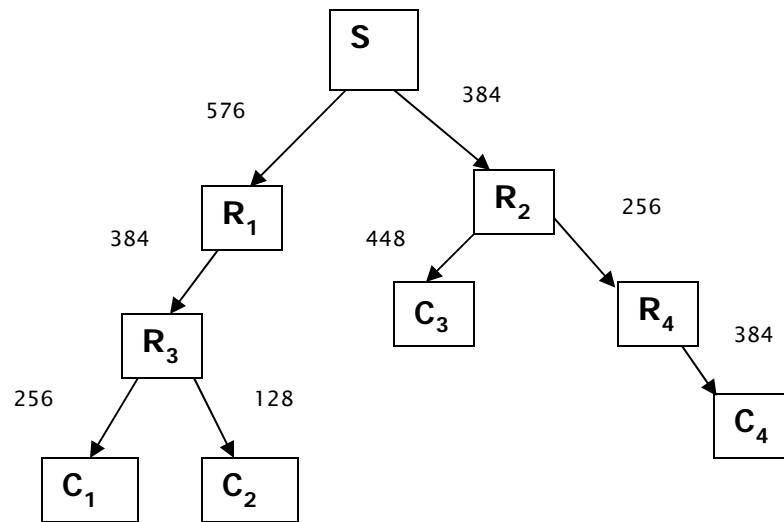
Our work focuses on Multimedia
applications that can tolerate
startup delays.....

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



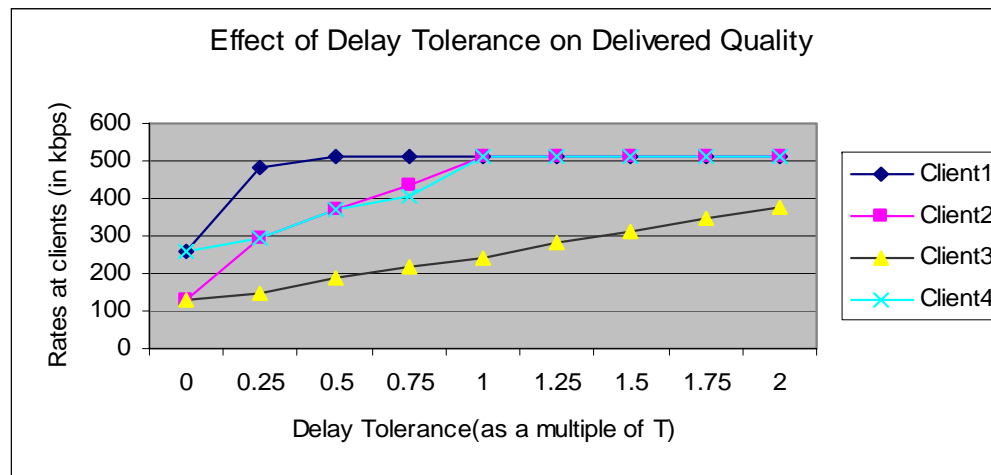
S: Source

R_1, \dots, R_4 : Relay nodes

C_1, \dots, C_4 : Clients

T: Play out duration: 1 hour

Base Encoding rate: 512 kbps



Maximizing revenue

Objective

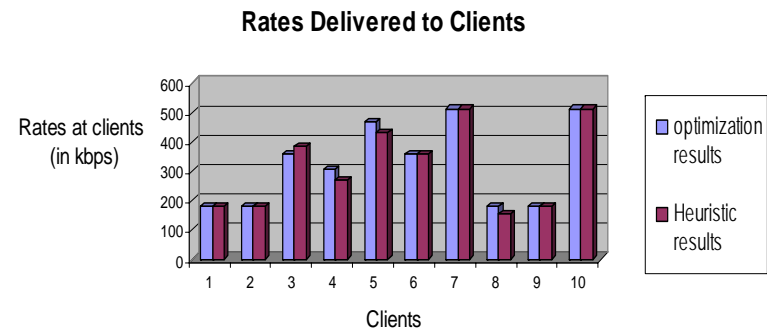
- Using a single stream, exploit delay tolerance requirement of clients to provide best quality that maximizes revenue
 - Admit clients so that their requirements can be satisfied
 - Provision resources such as buffers, transcoders appropriately
 - Adjust streaming schedule such that all admitted clients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

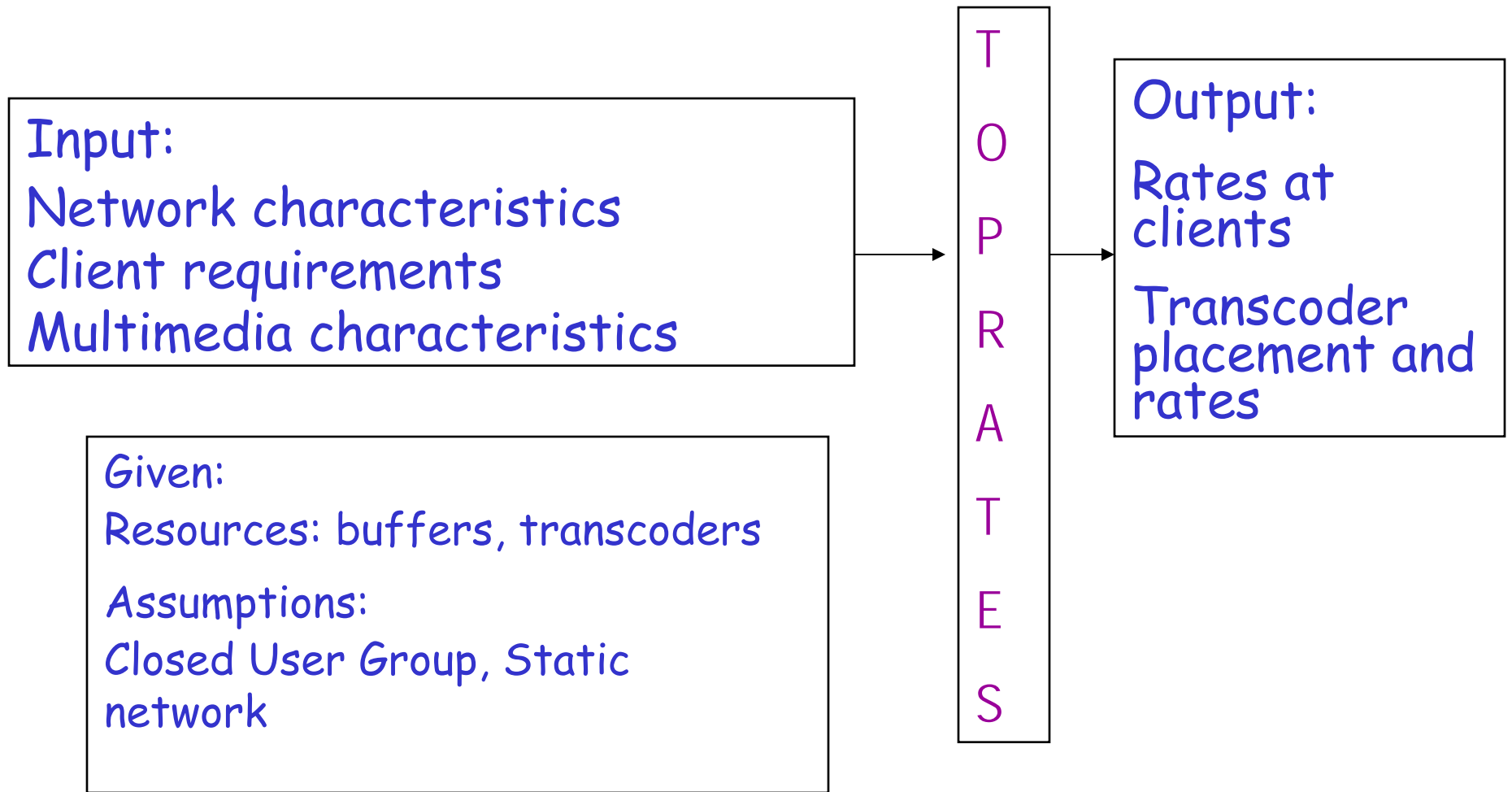
Solution Approaches - Phase 1

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

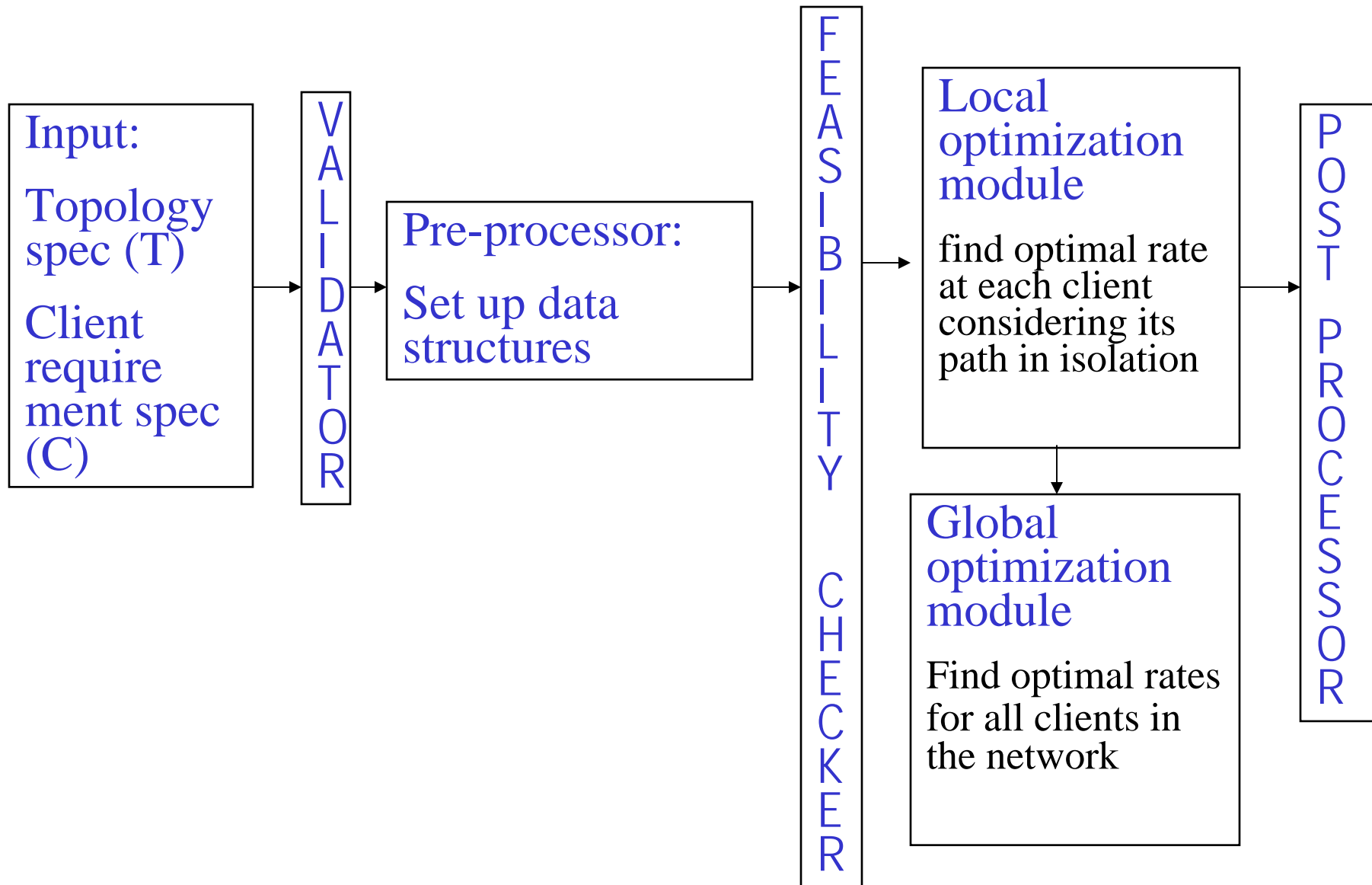


- Heuristic approach
 - Recursive greedy algorithm that assigns maximum of best possible rates for clients in sub trees starting at the top level

TOPRATES: Tool to find OPTimal RATES



TOPRATES: Architecture



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

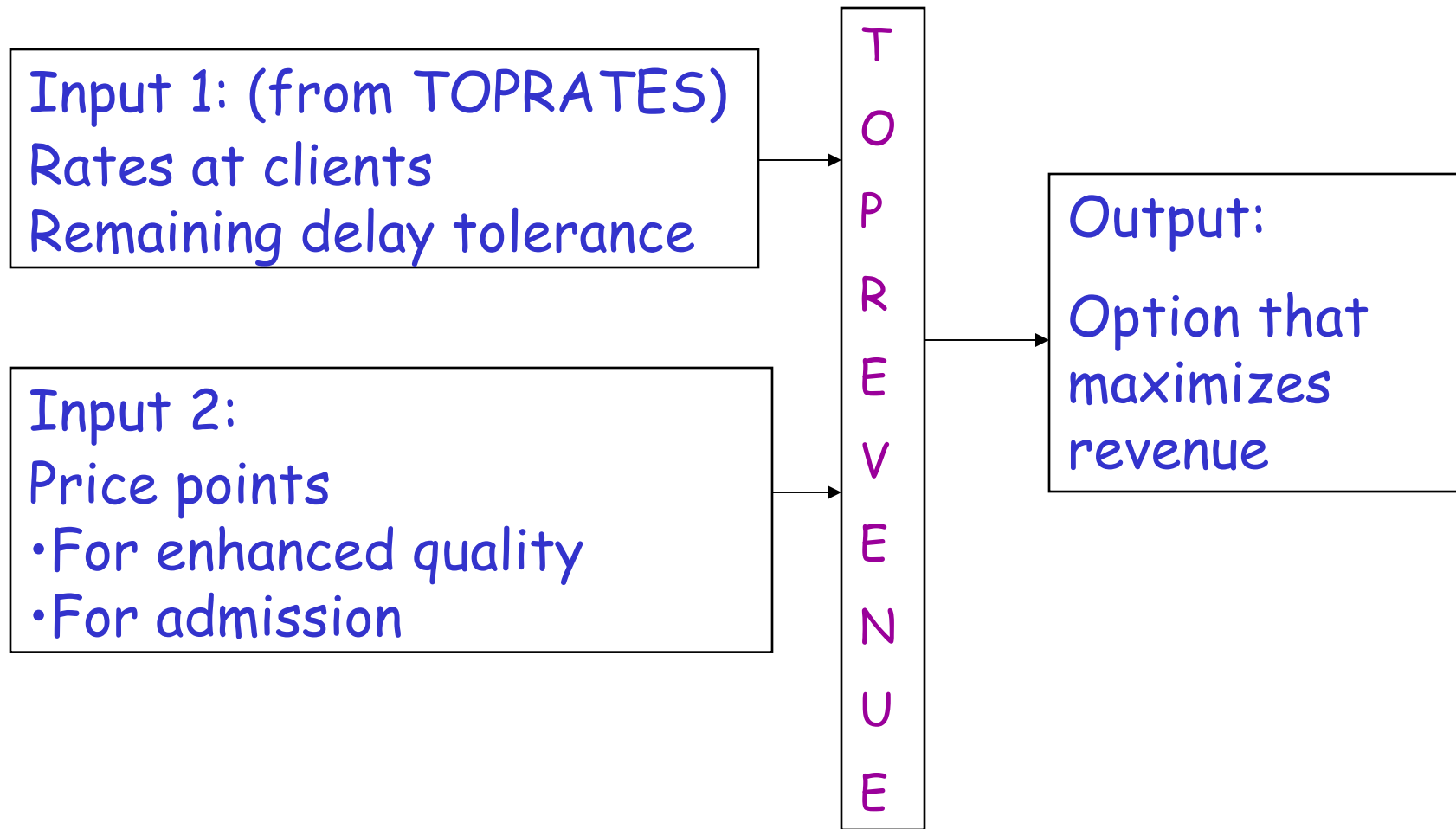
- reschedule streaming for a later time $t_1 + \Gamma$, where Γ is the time until when all admitted clients requirements can be met
- Admit new clients in the interval Γ

On-going work: Scheduling and admission control

- Exploiting residual delay tolerance
 - Run a predictive tool to assess number of arrivals in Γ
 - 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



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