Simple Economic Management Approaches of Overlay Traffic in Heterogeneous Internet Topologies

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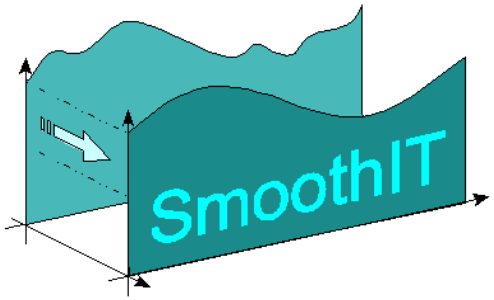

A Framework of Economic Traffic Management Employing Self-organization Overlay Mechanisms

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Outline

- Introduction
- Analysis of key concepts
- Interworking of SOMs and ETM
  - Application in BitTorrent
- Concluding remarks

Introduction

Motivation

- P2P applications have become very popular, but lead to:
  - Significant and increasing amount of P2P traffic
  - Suboptimal selection of peers due to information asymmetry
    - Underlay *topology* unknown to overlay
    - Overlay *requirements* unknown to underlay
- Consequence: Non-optimized overlay traffic in the underlay:
  - Higher costs in the underlay for the ISP
  - Lower QoS in overlay for the application provider and his users
- Conventional traffic management techniques not suitable

The FP7-ICT Project *SmoothIT*

***S**imple Economic **M**anagement Approaches **o**f **O**verlay **T**raffic in **H**eterogeneous **I**nternet **T**opologies*

- Main objectives:
  - Bridge information gap between overlay and underlay
  - Optimize overlay traffic (file-sharing and Video-on-Demand), in mutually beneficial way for all ISP, user, application provider
    → win-win-win situation
- Approach: Economic Traffic Management (ETM)
  - Main tool: incentives of stakeholders
- Duration: January 2008 – December 2010
- Consortium: 4 industrial and 4 academic partners

Analysis of Key Concepts

Incentives' Mechanisms

- Incentives' mechanism: Offers selections to participating agent
  - Each agent responds selfishly
    → Performs selections so as to improve own benefit
  - Individual benefit may also depend on other agents' decisions

- Examples of user incentives offered by mechanisms:
  To attain improvement of :
  - the tradeoff between QoS and charge levels
  - the "long-term" value received, e.g. by means of a reputation-based mechanism encouraging contribution

Stakeholders and their Incentives (I)

- Stakeholders: ISP, overlay provider, user

- Economic incentives classification:

1. Monetary
   - Reduction of providers' costs, increase of their income
   - Value-for-money for users
2. Performance-related
   - Applies to both overlay and underlay
   - Of particular interest to users
3. Reputation
   - Applies to providers → leads to increased user-base

Stakeholders and their Incentives (II)

- Users and the application provider have compatible incentives

- Overlay and ISP may have conflicting incentives; e.g.:
  - improvement of overlay performance may lead to higher inter-domain traffic and costs

Win-win-win (TripleWin) Situations

- The incentives of all stakeholders promoted simultaneously
  - possibly heterogeneous incentives

- Example: “Locality aware” file-sharing:
  Promoting downloading from local peers may:
  - improve overlay performance

    and
  - reduce ISP inter-domain traffic and its charge

- Increase of providers’ monetary income can be attained with performance differentiation

A First Example

Economic Traffic Management (ETM)

- Employs economic incentives' mechanisms for overlay traffic control and management

- Desired effect:
  1. User selects the individually optimal choice
  2. This affects the traffic patterns beneficially for the ISP

- ISP, through ETM, shapes users' behavior and drives system to a desired state by means of:
  - providing underlay information; e.g. RTTs
  - employing underlay policies; e.g. QoS differentiation

Self-organization Mechanisms (SOMs)

- SOMs run in the overlay and aim at improving some application-level characteristic(s):
  - response times
  - degree of availability

- The SOM's algorithm ran by each peer
  - employs information provided by other peers or the underlay
  - evaluates alternative selections by means of a metric:
    - Reputation, content similarity, RTT, …
  - makes local decisions that achieve self-optimization
    - in interplay with the decisions made by other peers

Interworking of Self-Organization Mechanisms and Economic Traffic Management

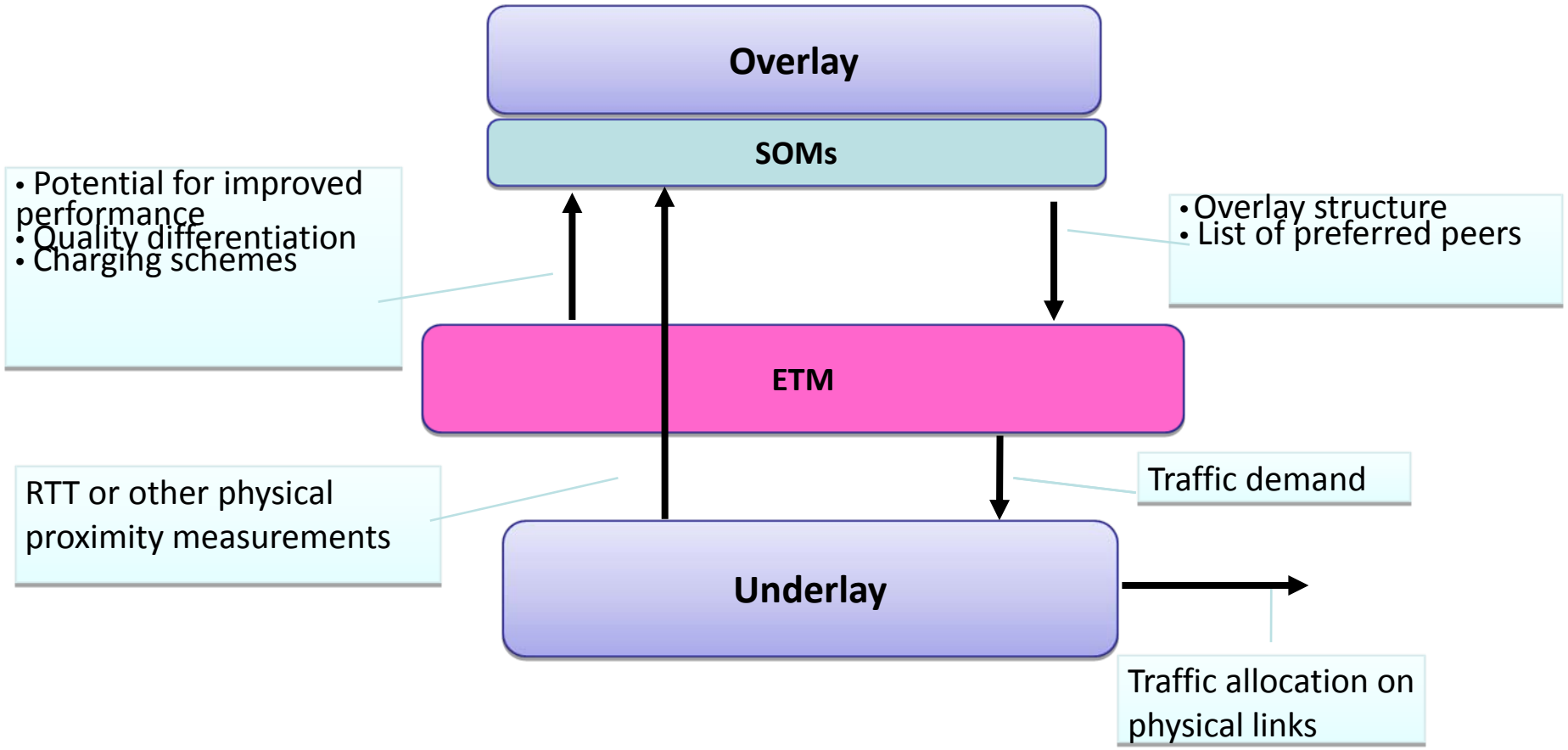
ETM and SOMs

- SOMs can serve as the economic incentives' mechanisms employed in ETM
  - Advantage: the distributed nature of overlays is exploited

- The ISP should influence the evolution of the SOM and ultimately the overlay traffic patterns
  - Mainly by providing information to the SOMs

- Not all SOMs can enable ETM → appropriate SOMs:
  - Provide selections to peers that offer immediate incentives related to the underlay:
    e.g. bandwidth-based selection of the peer to download from:
    " tit-for-tat"

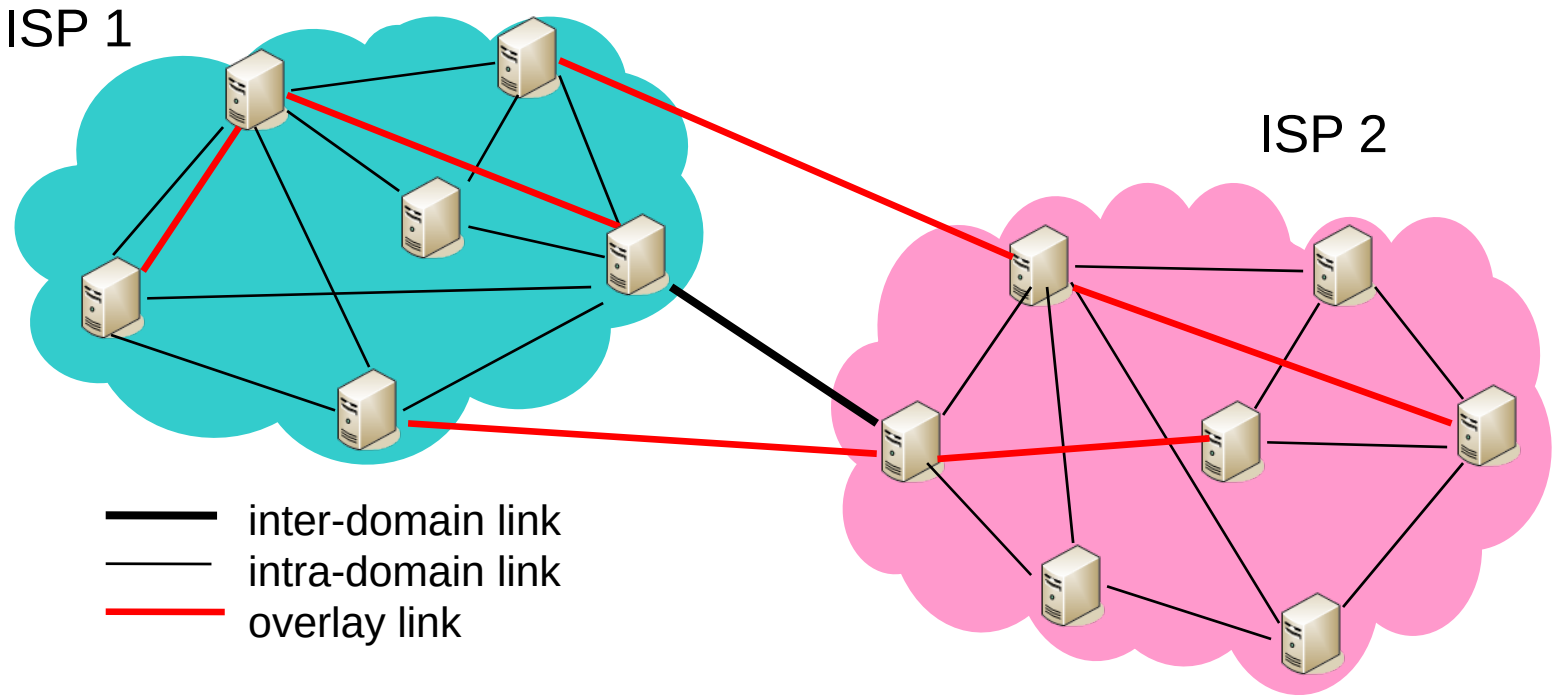
Interworking of SOMs and ETM



Example: ISP-aided BitTorrent

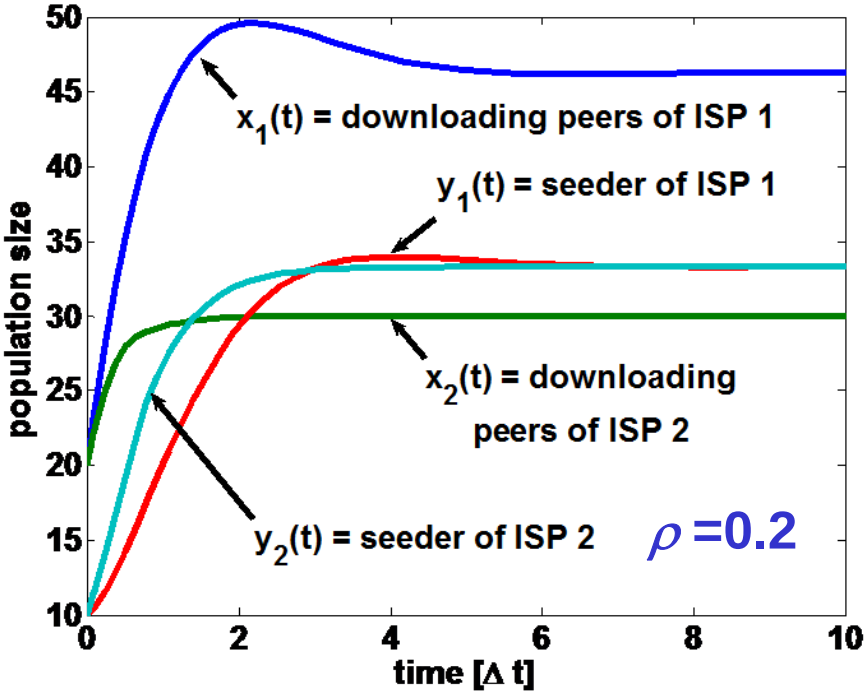
- ISP aids BitTorrent peers select “close by” peers, by:
  - Providing proximity information (AS, RTT etc.) to trackers
- Trackers suggest to peers those that lead to the highest downloading throughput
  - plus some randomly selected peers
    - to avoid network separation
- The approach can lead to a win-win-win situation

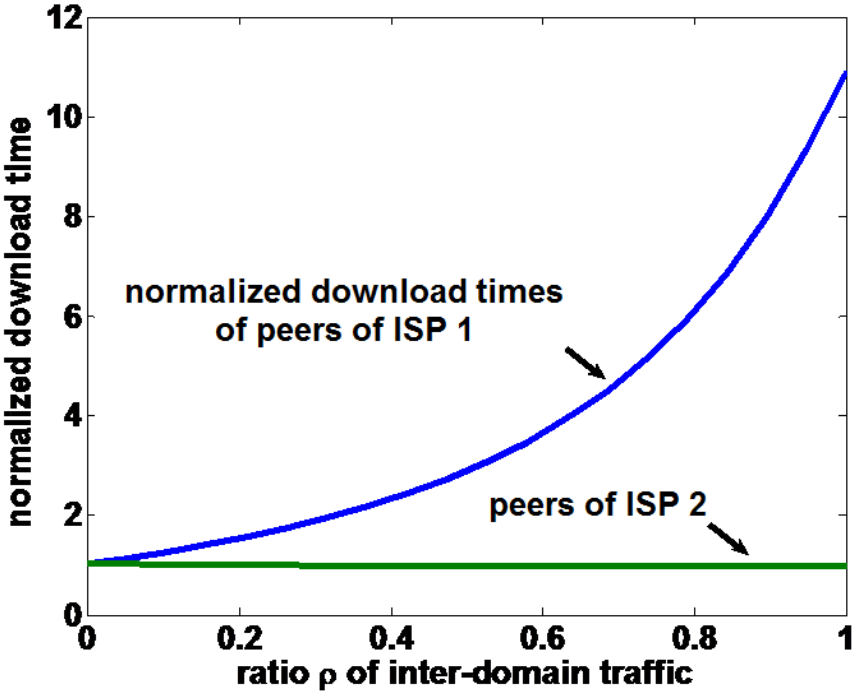
Evaluation Setting



- ISP1 blocks incoming interdomain traffic
- ISP2 employs ETM approach
  - A portion ρ of uploads at ISP1 peers are destined to ISP2
- Analysis by means of Fluid model by Qiu & Srikant

Evaluation Results





- ISP2 outperforms ISP1in terms of:
  - Effectiveness in completion of downloads
  - Downloading times per chunk

Implementations of ETM

1. With active overlay provider, who is offered incentives to modify protocol, e.g. Tracker

2. Transparently for overlay provider, but still leading to improved overlay performance
   - User is offered incentives by ISP
     - Proximity information for other peers, by ISP‘s information service
     - Option for enhanced QoS: *HighThroughputData & MMStreaming*
   - Alternative: active participation of ISP to overlay
     - ISP-owned peers, caching

Concluding Remarks

Contribution

- Presented a new framework:

  Economic Traffic Management that employs Self-Organization Mechanisms

- Analyzed:
  - the incentives of stakeholders and their relations
  - the interworking of SOMs and ETM: conditions and possible implementations
  - a first application of ETM in BitTorrent

- SOMs can successfully serve as enablers for ETM

Further Work

- SmoothIT has already specified a variety of ETM approaches:
  - ISP-managed information service, for Locality promotion and QoS/QoE differentiation
  - ISP-owned peer, that can perform active caching
  - Distributed ETM, performed autonomously by peers, routers etc.

  and defined the architecture

- Future work:
  - Evaluation of ETM approaches
  - Validation by means of laboratory and external trials

Trends in Overlay Traffic Management

- Management of overlay traffic is a hot topic

- Several approaches take collaboration between ISP and overlay provider (or user) for granted
  - SmoothIT does not necessarily rely on such a collaboration;
    it may only apply in conjunction with incentive compatibility

- Most approaches apply to file-sharing:
  - SmoothIT ETM approaches and/or their intelligence are innovative and
    address both file-sharing and peer-to-peer streaming

Thank you for your attention!

More information in: *www.smoothit.org*

Thanks to all SmoothIT's project partners:

UZH, DOCOMO, TUD, AUEB, PrimeTel, AGH, ICOM, UniWue, TID

Supporting Material

SOMs and Incentives

Possibilities w.r.t. the selections provided by a SOM

1. No selections: e.g. DHT-based content location in Chord

2. Selections not offering immediate incentives:
   e.g. list of Kademlia-based neighboring peers

3. Selections offering immediate application-layer incentives:
   e.g. which chunk to download first in BitTorrent:“rarest first”

4. Selections offering immediate incentives related to the underlay: e.g. bandwidth-based selection of the peer to download from: “ tit-for-tat”
   Mainly these SOMs can enable ETM