

*Simple Economic Management Approaches of
Overlay Traffic in Heterogeneous Internet Topologies*

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Improvement of BitTorrent Performance and Inter-Domain Traffic by Inserting ISP-owned Peers

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Outline

- BitTorrent & Locality
- Insertion of ISP-owned Peer
- Simulations
- Results
- Conclusions
- Future work

BitTorrent & Locality

BitTorrent

- ❑ P2P file-sharing overlay application
- ❑ Efficient dissemination of large files to large number of peers
- ❑ Important terms:
 - Torrent file
 - Chunks
 - Tracker
 - Seeds / leechers
 - Swarm = one overlay per file

Unchoking algorithm

- The famous ‘tit-for-tat’ principle
 - Applies only for leechers
 - Based on the highest *upload* bandwidth criterion

- Seeds do not follow tit-for-tat!
 - Unchoking based on the highest *download* bandwidth criterion

Inefficiency

- ❑ BitTorrent generates a great amount of the overall Internet traffic
- ❑ Selection of neighboring peers is performed **randomly!**
- ❑ Information asymmetry
 - AS provides necessary information to the overlay
- ❑ Result: Inter-domain traffic increase
 - ... which implies charge for interdomain traffic increase!
 - Monetary penalties may even arise due to traffic pattern changes

Approaches

- Alternative peer selection algorithms
- *Locality awareness*: employ some **proximity** criterion, e.g.
 - AS
 - RTT
 - Number of hops

Possible effects

- ❑ Reduction of interdomain traffic and possibly of associated charge
 - Not necessarily for certain prominent charging schemes based on the difference of inbound – outbound traffic 😊

- ❑ Possible deterioration of end-users completion times! 😞

- ❑ Need for mutually beneficial approach
 - Incentive compatibility between underlay and overlay

Insertion of ISP-owned Peer

Objective(s)

- ❑ Achieve interconnection cost reduction by means of inter-domain traffic reduction
- ❑ Maintain or improve end-users completion times

SmoothIT project

- Employ **Economic Traffic Management**

- Goals:
 - Achieve better traffic management both in underlay (physical network) and overlay
 - Reduce traffic on interdomain links
 - Improve or retain end-users's completion times
 - Lead *all* players (ISP, Overlay, End-users) to a winning situation (or at least non-lose)
 - Achieve **incentive compatibility!**

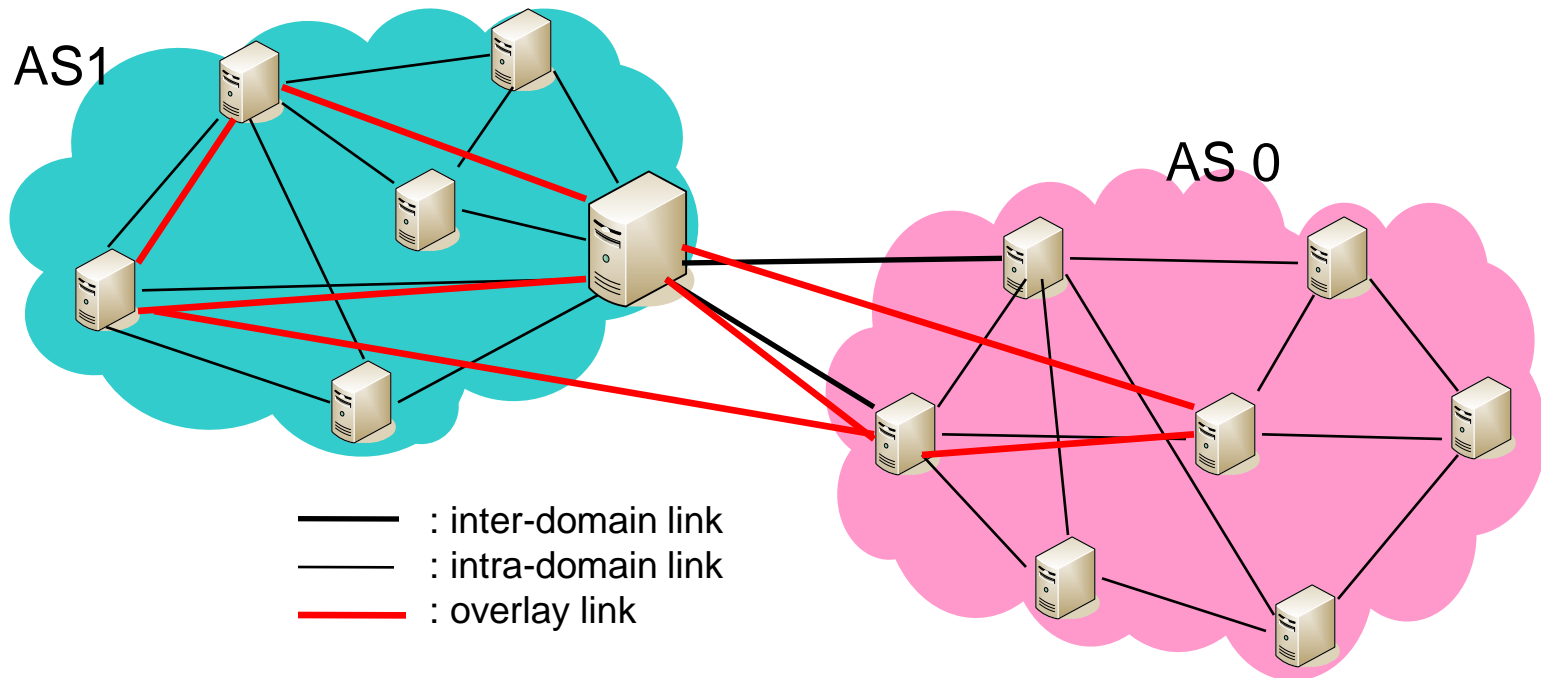
Our approach

- Insertion of **ISP-owned Peers** in the overlay
 - Entities *controlled* by the ISP
 - Equipped with *high* resources (bandwidth, storage)
 - *Run* the overlay protocol, e.g. BitTorrent
 - *Exception*: larger number of unchokes available
 - *Issue*: only legal content
 - No traffic interception!

- Legal issues?
 - Possible interconnection agreement with Content Provider

Insertion of ISP-owned Peer

- ❑ Not an intervening cache
- ❑ Not a gateway peer



Variations

- Just IoP insertion
 - Exploitation of the tit-for-tat principle
- Combination with some ‘proximity’ criterion
 - E.g. locality awareness* (or AS awareness)
- Worst case: IoP has initially no content stored
 - Initially ‘leeching’, then seeding
- Best case: IoP has already the content
 - Acts as an extra ‘powerful’ seed

* R. Bindal, P. Cao, W. Chan, J. Medval, G. Suwala, T. Bates, A. Zhang, “**Improving Traffic Locality in BitTorrent via Biased Neighbor Selection**”, 26th IEEE International Conference on Distributed Computing Systems, p. 66, 2006

Incentives for all players

- ISP
 - Reduction of interconnection traffic
 - Improvement of customers QoS
 - What about intra-domain traffic?
- Content / Overlay Provider
 - Improvement of customers QoS
 - Possible interconnection agreement with ISP?
- End-user
 - *Transparent* to the end-users!!
 - Though experience of higher QoS

Simulations

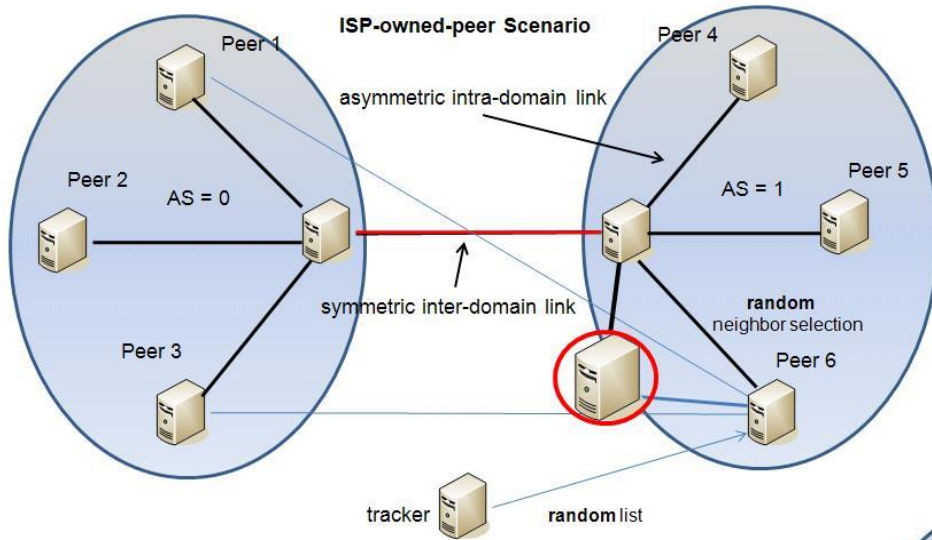
Simulator

□ bittorrent.patch** for *ns-2*

- BitTorrent-like protocol
- Functions simplified
 - Unchoking algorithm and Chunk selection algorithm implemented
- *Modular* implementation
- Uplink is the *bottleneck*
- Downlink neglected

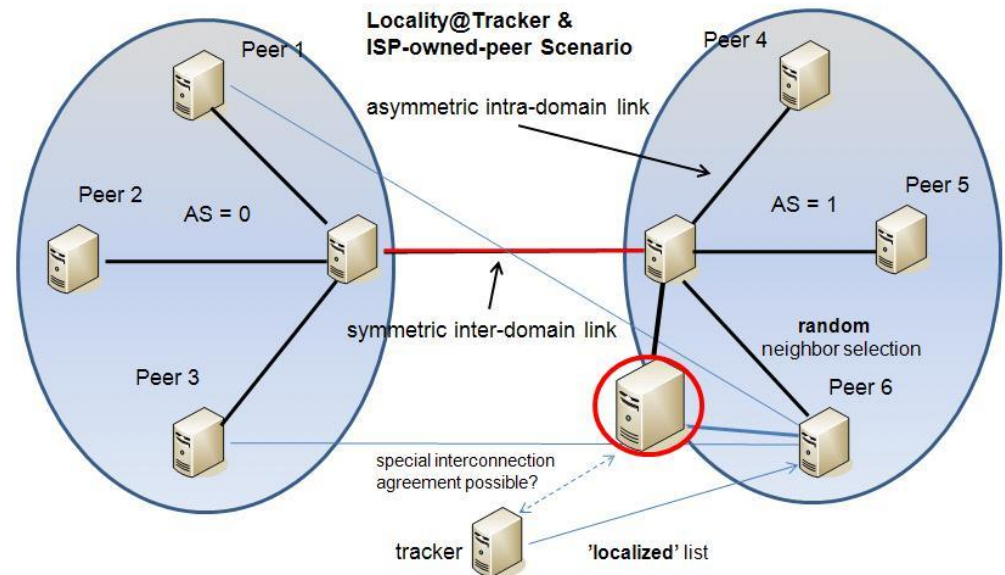
** K. Eger, T. Hoßfeld, A. Binzenhöfer, G. Kunzmann, "**Efficient Simulation of Large-Scale P2P Networks: Packet-level vs. Flow-level Simulations**", 2nd Workshop on the Use of P2P, GRID and Agents for the Development of Content Networks (UPGRADE-CN'07) in conjunction with IEEE HPDC, Monterey Bay, USA, June 2007

Dumbbell Topology



Insertion of IoP in BitTorrent
without locality awareness

Insertion of IoP in BitTorrent
combined with locality awareness



Simulation scenarios

1. Original BitTorrent
 2. BitTorrent and locality awareness
 3. Insertion of IoP in original BitTorrent
 4. Insertion of IoP in BitTorrent with locality awareness
- Symmetric or Asymmetric
 - Symmetric: 25 peers per AS, e.g. 2 Tier-3 ISPs
 - Asymmetric: 35 and 15 peer respectively in each AS, e.g. Tier-2 and Tier-3 ISPs
 - All-together or Split
 - All-together: Joining time of all peers $\sim U(0,10)$
 - Split: Joining time of 5 peers in each AS $\sim U(150,300)$, joining time of the rest of the peers and the ISP-owned peer $\sim U(0,10)$

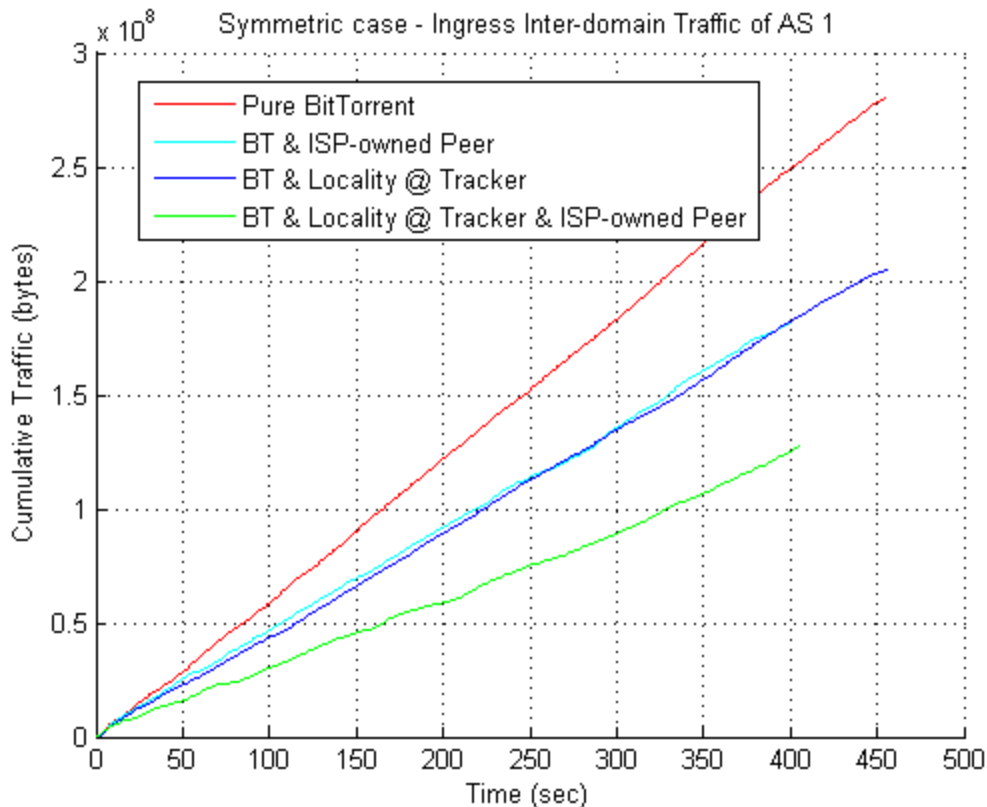
Simulation parameters

Description	Value
Number of peers	50
Number of seeds	1
Number of ASes	2
Number of peers per AS	(25,25), (35,15)
Upload capacity of regular peers	512K
Download capacity of regular peers	4096K
File size	20M
Number of peers requested from tracker (Size of tracker's list)	25
Number of local peers replied by tracker	20
Number of connections	20
Choking interval	10
Number of unchoked connections permitted per peer	4, 10 (in case of IoP)
Number of ISP-owned peers	1
Upload/download capacity of ISP-owned peers	40960K

Results

Insertion of IoP in original BitTorrent

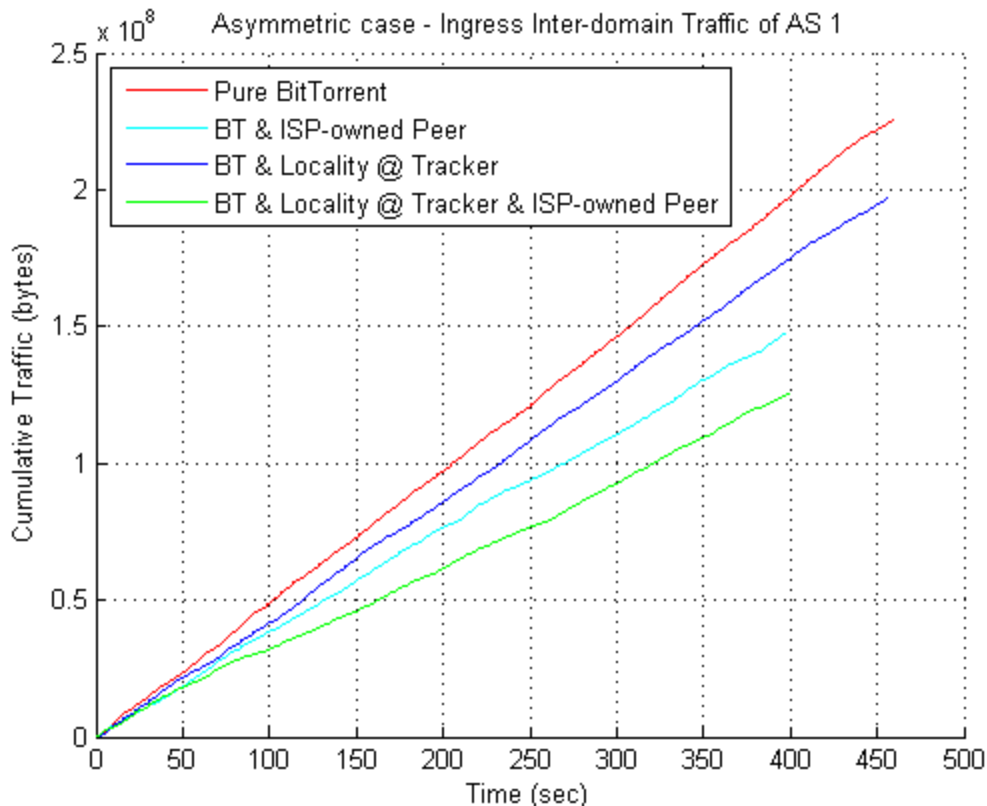
- Symmetric, All-together
- Inbound inter-domain traffic for AS 1



- Up to 35% traffic reduction when IoP is inserted (either in BT or in BT&LA)
- Up to 50% traffic reduction when IoP insertion is combined with LA vs. original BT

Insertion of loP in original BitTorrent

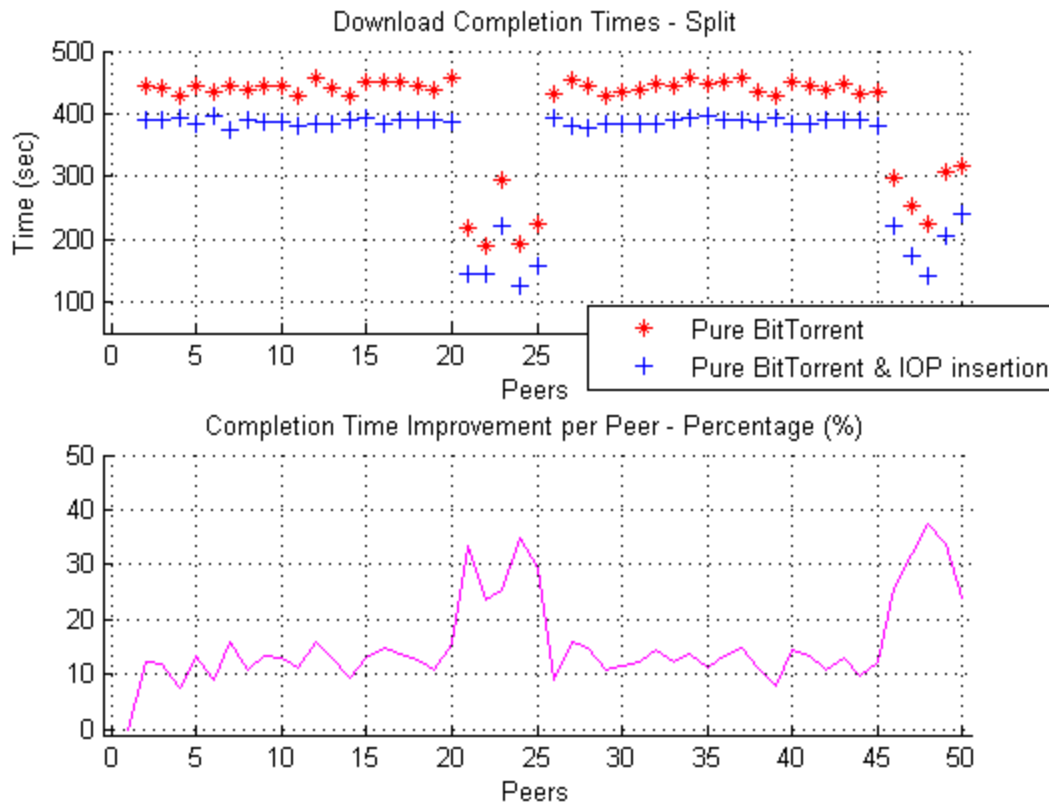
- Asymmetric, All-together
- Inbound inter-domain traffic for AS 1



- Up to 31% and 37% traffic reduction when loP is inserted (in BT and in BT&LA resp.)
- Up to 44% traffic reduction when loP insertion is combined with LA vs. original BT
- Sole loP insertion is better than sole LA!

Insertion of IoP in original BitTorrent

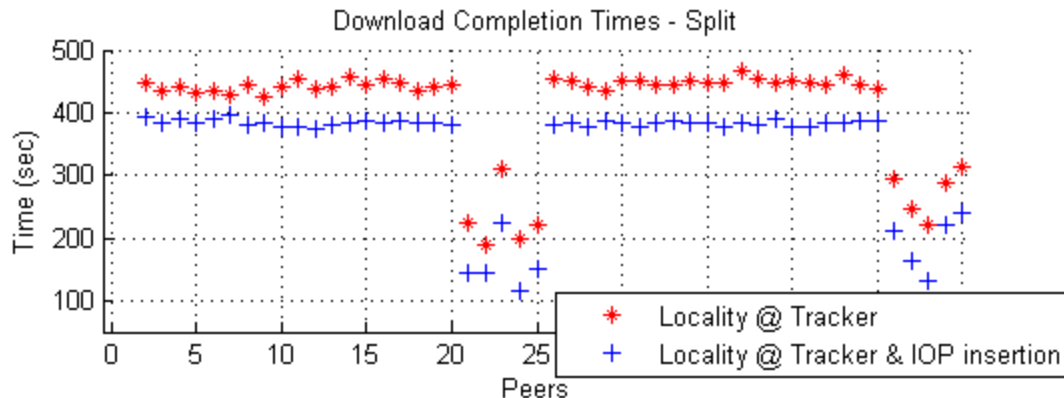
- Symmetric, Split
- End-users' completion times



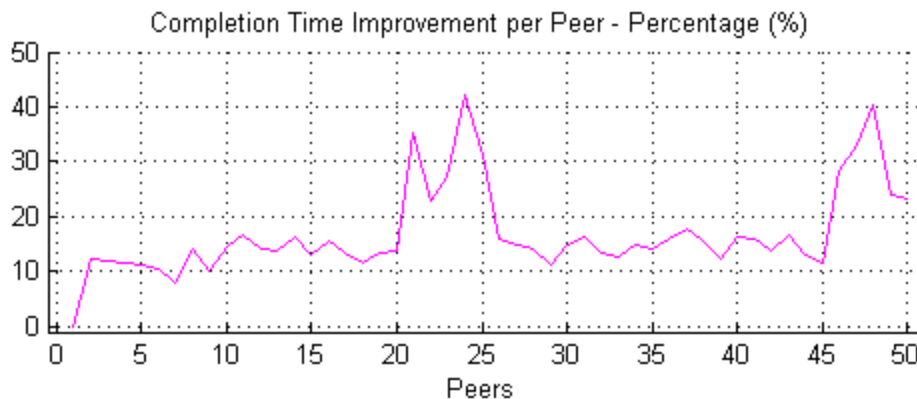
- Significant improvement especially for peers that enter the swarm later, when IoP has already turned into a seed

Insertion of IoP in BitTorrent with locality awareness

- Symmetric, Split
- End-users' completion times

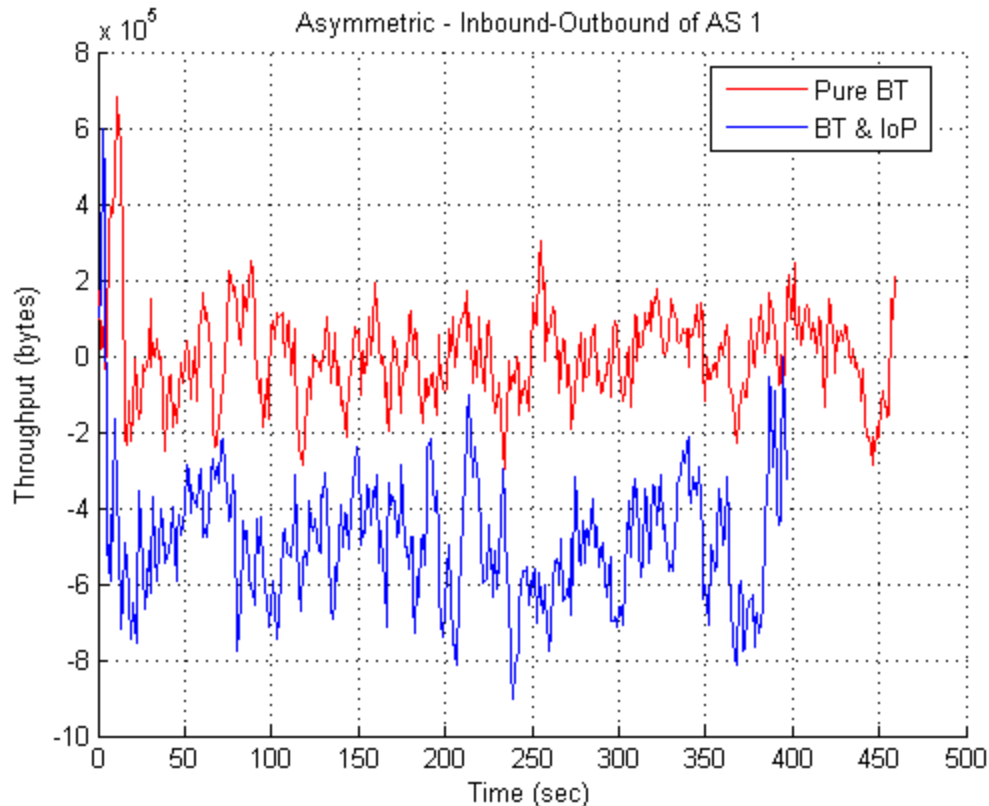


- IoP seems to reverse the bad effect of LA on end-users' completion times



Insertion of IoP in original BitTorrent

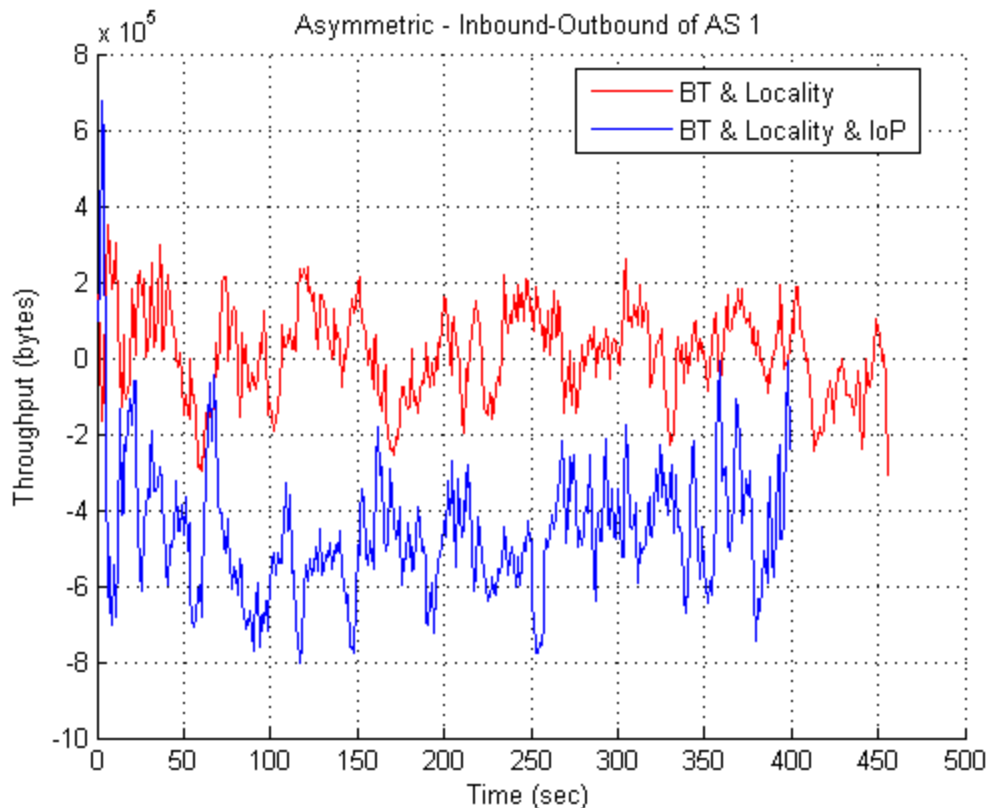
- Asymmetric, All-together
- Instantaneous difference between inbound-outbound traffic of AS 1



- Consider an interconnection charging scheme that takes into account the ***difference*** of inbound-outbound

Insertion of IoP in BitTorrent with locality awareness

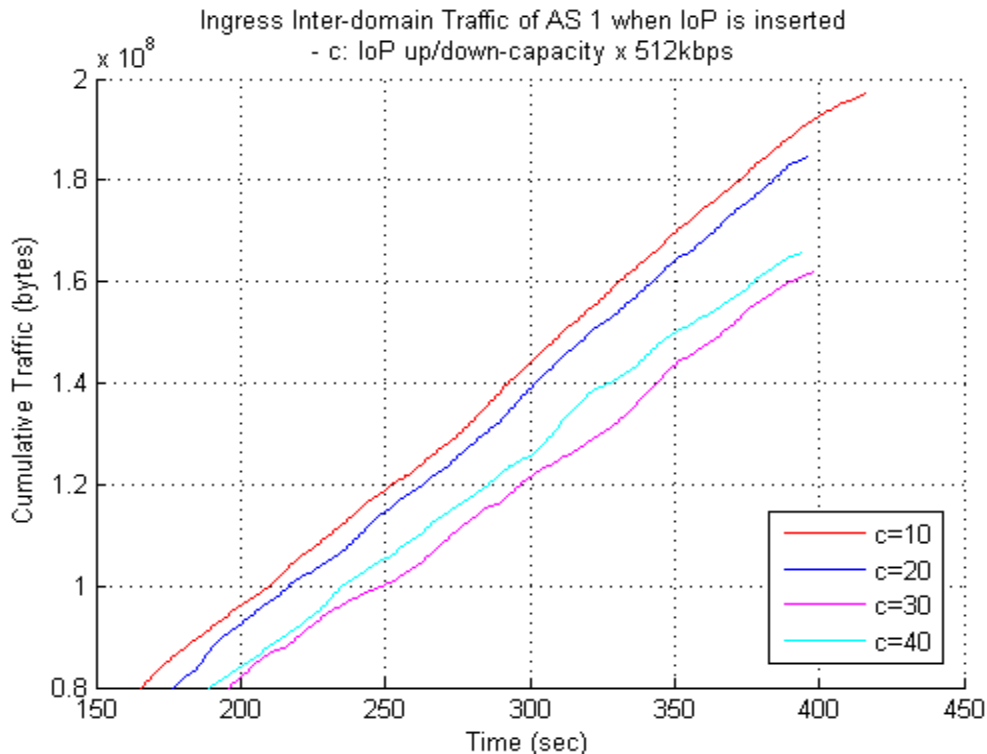
- Asymmetric, All-together
- Instantaneous difference between inbound-outbound traffic of AS 1



- LA achieves only symmetric traffic reduction!
- Under *difference-based charging schemes*, e.g. (95th percentile) that would imply no reduction for interconnection charges

Insertion of loP in original BitTorrent

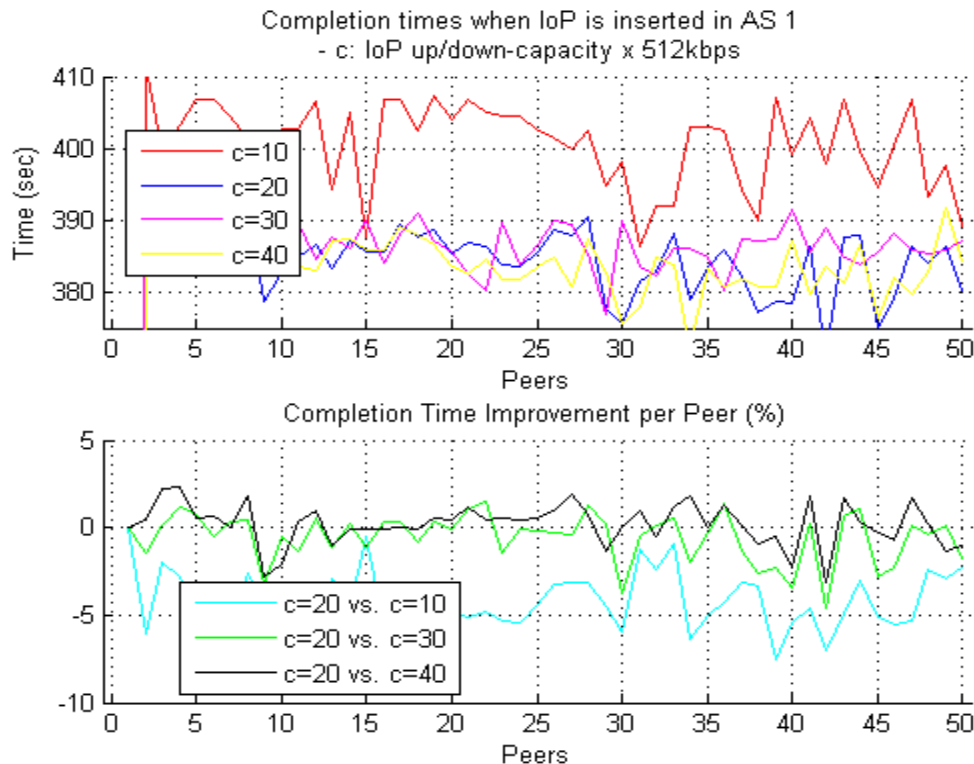
- Symmetric, All-together
- Inbound inter-domain traffic for AS 1
- c : loP's down/up bandwidth



- Increase of loP's capacity achieves further reduction of inbound inter-domain traffic only until a threshold

Insertion of loP in original BitTorrent

- Symmetric, All-together
- End-users' completion times
- c : loP's down/up bandwidth



- Over-dimensioning of loP is beneficial only up to a certain point
- Afterwards, either no performance improvement, or even performance degradation is observed

Conclusions

Incentive Compatibility

- Locality awareness does not necessarily lead to incentive compatibility
 - Risk for the ISP to lose customers due to deteriorated performance

- IoP achieves simultaneously:
 - Significant inbound inter-domain traffic reduction of the AS that deploys the IoP
 - Improvement of end-users' completion times
 - Reduction of charges for interdomain traffic under a charging schemes based on:
 - Inbound traffic
 - Difference between inbound-outbound

Work in progress

- Investigation of the insertion of ISP-owned Peer acting as a seed from the moment it enters a swarm
 - Unchoking policies
 - Simulations in *ns-2*

- Markovian model for the evaluation of ISP-owned peer insertion and its variations
 - Transient analysis
 - Discrete time

Thank you for your attention!