Ideas on traffic management in CCN

Orange Labs

Sara Oueslati

Joint work with J. Roberts, N. Sbihi (INRIA)

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Motivations

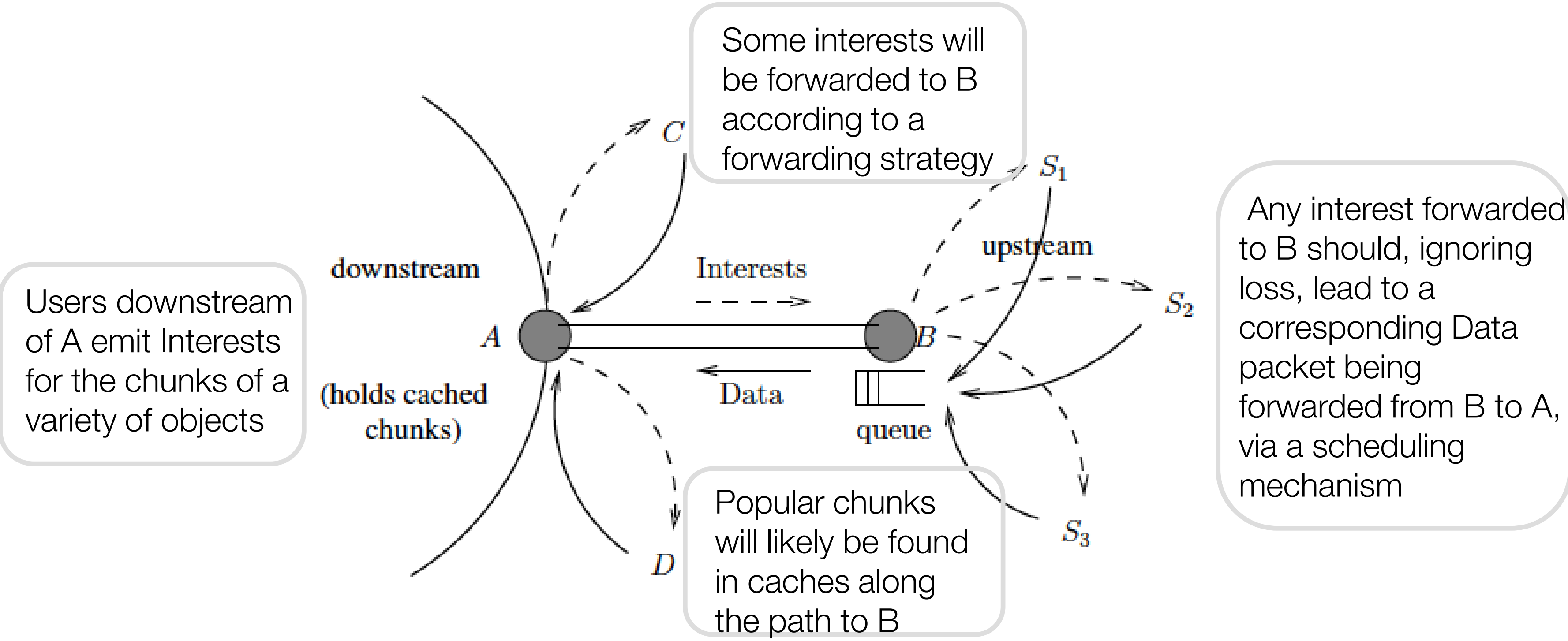
- Internet needs to be redesigned to match current usage
- CCN from PARC is a compelling proposal (security, mobility, efficiency) but does not precisely answer the question of:

  How should bandwidth sharing be controlled in CCN to ensure applications experience acceptable quality?

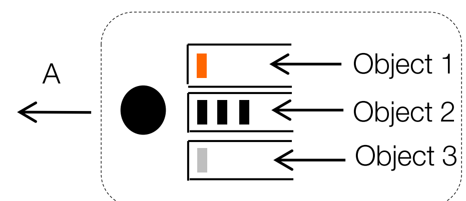
- We raise open issues, we hint to solutions that build on 3 interesting features of CCN for traffic control:
  - in-network caching
  - path symmetry
  - receiver-oriented nature

Overview

Caching & bandwidth sharing



- Systematic caching use => localization of most exchanges, transit traffic reduction
- Traffic received at Node B is composed of a process of independent flows, where a flow relates to a named object



Bandwidth sharing between concurrent flows at face B ->A

Forwarding & bandwdith sharing

- Forwarding in a CCN router is based on: the FIB, the PIT and the CS
- Imposes route symmetry !
- Mullticast comes for free!
- Not clear how to ensure: 1) chunks of real time objects experience low latency; 2) to prevent “aggressive” flows disrupting performance

When an interest is received on a face f:

1. checks the CS and if the chunk is present returns a copy via f
2. if not, checks if the PIT has an entry for this chunk and, if so, adds f to the entry
3. if not, creates a new PIT entry containing f and forwards the Interest on the face(s) indicated by the FIB for that chunk name

When a data packet is received:

1. returns the chunk over all faces indicated by the corresponding PIT entry and deletes that entry,
2. stores a copy of the chunk (if appropriate) in the CS

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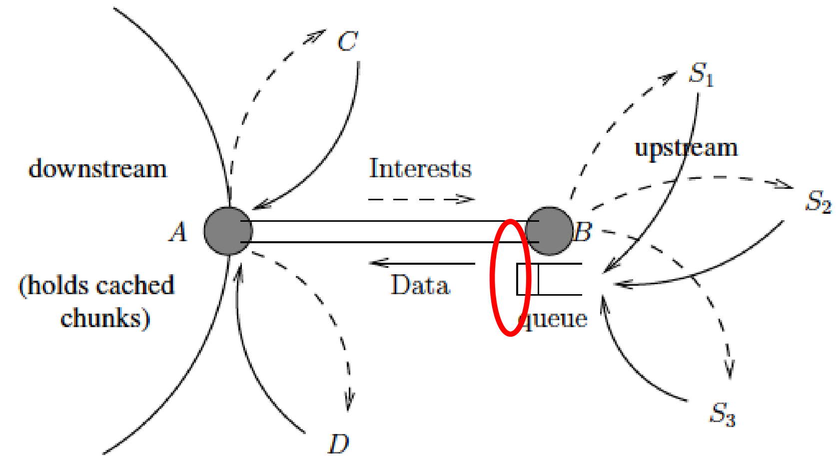
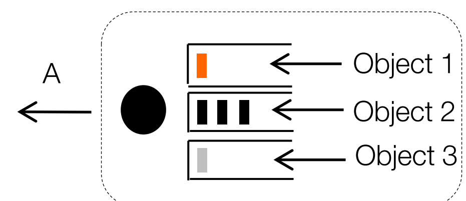
⇒ the notion of a buffer distinct from the CS, implementing some form of buffer management is necessary

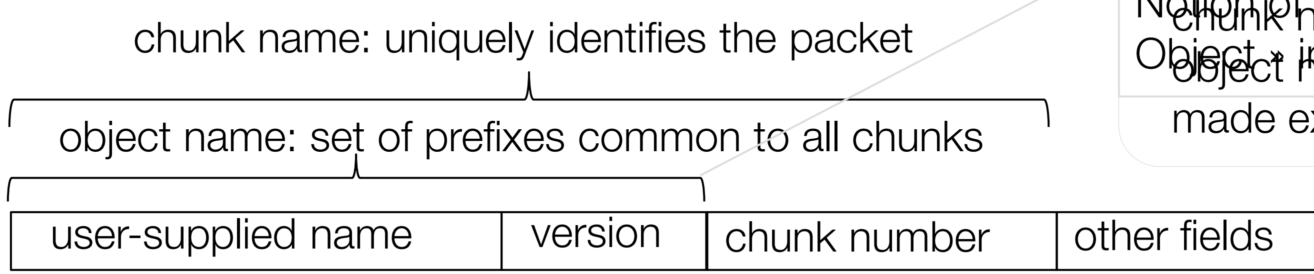




Bandwidth sharing between concurrent flows at face B ->A

Naming & flows

- CCN Data packets (or chunks) are returned in response to an interest packet with the same name (chunk name)



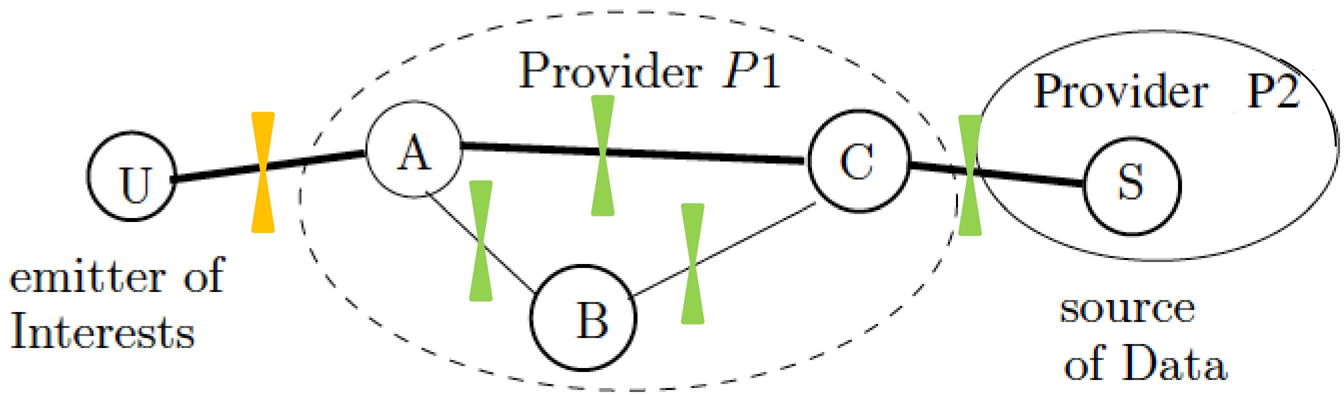
!! Distinction between chunk number and object name is not made explicit

Notion of « Data Object » in NetInf

- for purpose of traffic management, flows could be identified by parsing the chunk name to determine the object names they relate to
  - e.g., a video stream, a voice call, a stored document
  - may aggregate the traffic of several users (multicast, popular downloads)

Network and user faces

- In CCN, only access nodes are aware of end-users addresses
- We may therefore distinguish
  - "*network faces*" situated between CCN nodes
  - "*user faces*" through which packets are exchanged between users and their access node



Overview

Possible solutions for bw sharing on network faces

Adapt IP QoS management

- Reservation of pre-allocated resources: doubtful efficacy, major revision in CCN
- Diffserv: pb of trust in marking and imprecise business models

Flow-aware networking

- Advocated in IP, well adapted to CCN

Economic incentives

- Congestion pricing [Gibbens Kelly]
- In CCN, congestion marks might be piggybacked on Data packets
- Charging end-users is generally considered unworkable (slight charge for each mark)
- [Jacquet et al] police the rate at which any end-user may receive congestion marks using a token bucket, efficacy?
- Alternative to avoid charging, enforce conformance to some approved response across a wide range of applications, feasibility?

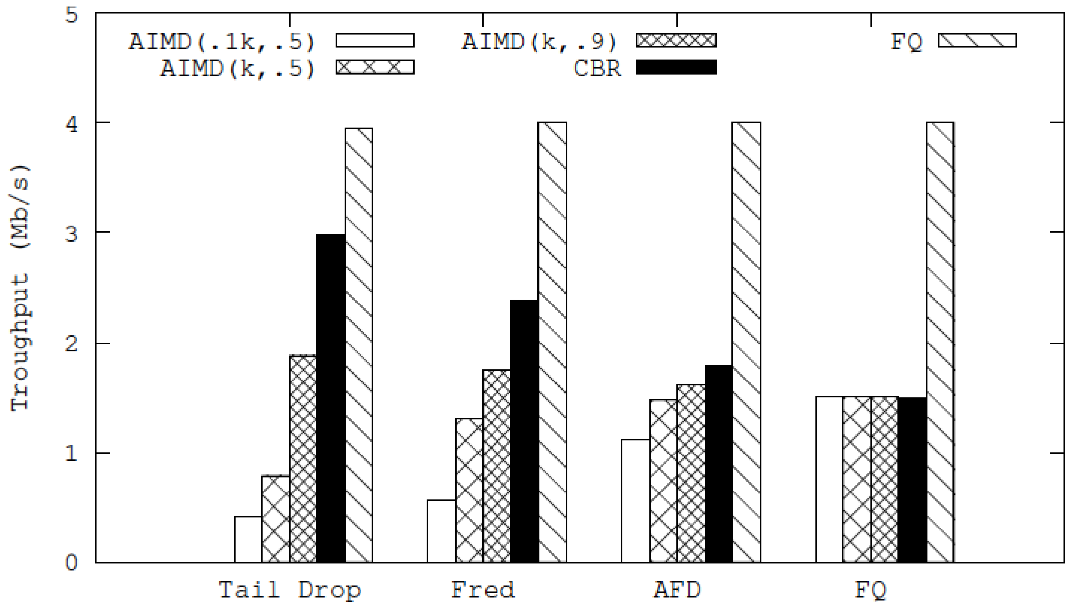
Flow-aware networking

- Consists in ensuring flows locally realize max-min fair bandwidth sharing
- 2 main advantages
  - Dispense with “TCP friendly” congestion control
  - Implicit QoS differentiation
    - Only flows whose rate exceeds the fair rate experience significant packet latency)
    - On normally loaded link (e.g. C=10 Gb/s, rho=90%), the fair rate C(1-rho) >> peak rate of conversational and streaming flows
    - Condition that needs to be secured by some form of overload control

Achieving fairness: traffic considerations

- Link of capacity C equipped with a dedicated buffer
- The number of flows that need scheduling (*active flows*) is relatively small for any mix of flows
  - Active flow: a flow that have (or very recently had) packets in the buffer
  - ~ O(100), broadly independent of C [Kor2005], *flows in progress* ~ (100 of thousands)
- Most likely mix of flows
  - a large number of low rate flows => Poisson packet process
  - handful of high rate flows, sharing the residual bandwidth => expected faire rate ~C(1-rho)
- Fair dropping or fair queuing?

Fairness comparison



C=10 Mb/s, a 4 Mb/s Poisson background traffic shares the link with 3 responsive flows (AIMD) and 1 unresponsive flow (CBR).

AIMD to control the number of pending interests (.1k,.5), AIMD(k,.5), AIMD(k,.9)

- FQ is efficient and scalable under nominal load conditions (< 90%, say), no parameters to configure compared to AFD
- Fair sharing, by whatever mechanism, requires a form of overlaod control to ensure scalability and QoS

Potentialities of Interest pacing

- Interest and Data packets visit exactly the same network nodes
- A router can limit the rate at which it receives Data packets to be forwarded downstream by pacing the emission of Interests on the corresponding upstream flow
- Use cases
  - A network provider would have an economic incentive to implement such a control, if it had to pay for delivered data
  - Interest pacing, an alternative for enforcing fair sharing ? (requires further investigation)
- It remains to define effective algorithms & evaluate their impact in a realistic e2e CCN context

Overview

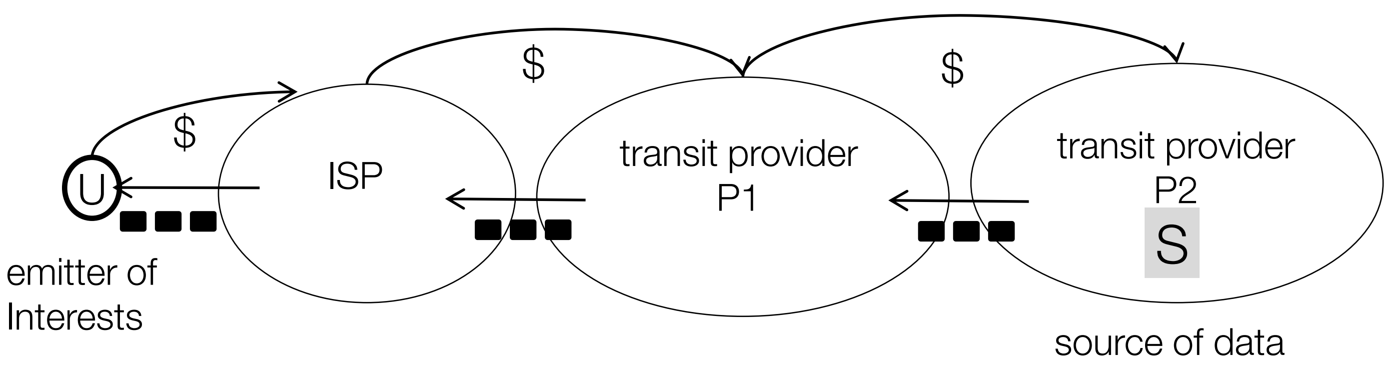
Bandwidth sharing on user faces

- Control bandwidth sharing between users
  - Often a shared interface (e.g., wireless networks, PONs)
  - Each user can obtain a fair bandwidth share
  - Notion of fairness may be tariff biased (weights depending on purchased access rates)
- Sharing between the user's own flows
  - Priority queueing at the access node on the basis of priorities supplied by the user in each Interest packet.
- Open question: user proxies necessary at access nodes?
  - To limit overhead induced by interests on upstream links (e.g. wireless networks)

Overview

A simple business model for transport: Charge for delivering data

- Idea: Network providers recover the cost of infrastructure from revenue gained for delivering packets
- Builds on receiver oriented nature of ICN + path symmetry
- Provides clear incentive to ISPs for in-network caching
- Avoiding packet loss downstream is desirable
  - e.g., through Interest pacing?



Overview

Conclusion

- Ideas to supplement the CCN proposal from PARC to enable controlled bandwidth sharing by concurrent flows
- Flows in CCN can be defined as packets relating to a given named object (voice, stream, file download)
- Per-flow fair sharing should be imposed on network faces
  - via scheduling (e.g. FQ), AQM (e.g. AFD) or interest pacing?
- For last mile, implement priority scheduling at access node, with priorities of downstream data packets defined by users in interests
- CCN offers an opportunity for new business models for transport: Pay for delivered data!

Ongoing work

- Evaluate algorithms for interest pacing
- Further explore charging models
- Further explore controlled sharing in the last mile
- Design and evaluate adaptive forwarding strategies (e.g. path selection, multipath)
- Develop analytical models for throughput prediction in CCN
- Design and evaluate cache partitioning strategies

Work on CCN will be carried out in CONNECT (French national project on CCN)

Joint work with ALU-Bell Labs (G Carofiglio, D. Perino)

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