Beyond TCP-friendliness: A New Paradigm for End to End Congestion Control

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Overview

- Introduction.
- Definition of Congestion.
- Properties of an Ideal Congestion Control Protocol.
- The FS Paradigm.
- Practical Aspects.
- FS paradigm vs. TCP-friendly paradigm.
- Conclusion.

Introduction

- One standard for Congestion Control: TCP.
  - Collaborative protocol (linear increase, multiplicative decrease)
- The TCP-Friendly paradigm for applications that can not use TCP:
  - Rely on an analytical evaluation of the behavior of TCP.
  - Compatible with TCP.
  - End-to-End, no modification of the network.
  - Appealing, can be applied immediately in the Internet.

Introduction

- Collaborative assumption for CC:
  - Strength:
    - Does not require any network support to achieve fairness and efficiency.
  - Weakness:
    - Requires collaboration of all end users, can not be longer assumed.
    - New applications perform better with nonTCP-friendly protocol.
    - Very constraining when devising new CC protocols.
- TCP-friendly well suited for short term, NOT for long term.

Introduction

- The network support can help CC:
  - Wide range of network support: from buffer management to active networking.
  - We have to respect the End-to-End argument.
- Network support can simply be a Fair Scheduler (FS), Two main contributions:
  - Keshav: Fair Queuing (FQ) + Packet Pair.
  - Shenker: Game theoretic study of CC.
- Two very promising results but still no proposition for the Internet.
- There is no study that tackles the practical problem of CC as a whole.

Definition of Congestion

- Congestion related to:
  - User satisfaction.
  - Network performance.
  - Such a definition introduced by Keshav.
- Definition of congestion:
  - Congestion: decrease of satisfaction due to a modification of the characteristics of the connection.
- A CC protocol must avoid congestion.

Properties of an Ideal CC Protocol

- We assume selfish users.
- Abstract formulation: the properties remain very general.
- Nash equilibrium, Pareto optimality.
- Properties of an ideal CC protocol:
  - Stability: Existence and uniqueness of Nash equilibrium.
  - Efficiency: Nash equilibrium is Pareto optimal.
  - Fairness: Max-min fairness.
  - Robustness: Against malicious, misbehaving, and greedy users.
  - Scalability: With heterogeneous latencies or bandwidths.
  - Feasibility: Technical requirements (Hardware, Software, Easy to evaluate,…).
- How can we devise such a CC protocol?

The FS Paradigm

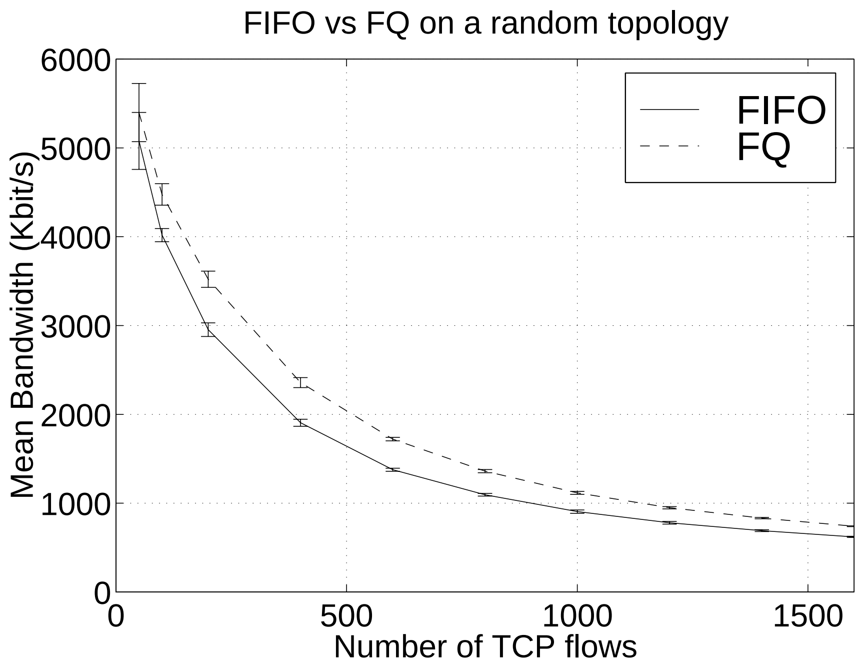
- Paradigm for Congestion Control:
  - Set of assumptions.
  - To devise CC protocols.
  - Allows to devise compatible CC protocols (same set of properties).
- The Fair Scheduler (FS) paradigm (set of assumptions):
  - Network Part (NP): We assume a Fair Scheduler network.
  - End System Part (ESP): We assume selfish and non-collaborative end users.
- Weak assumptions about the end user, great flexibility to devise End-to-End CC protocols (THE fundamental property).
- Which properties does the FS paradigm enforce?

The FS Paradigm

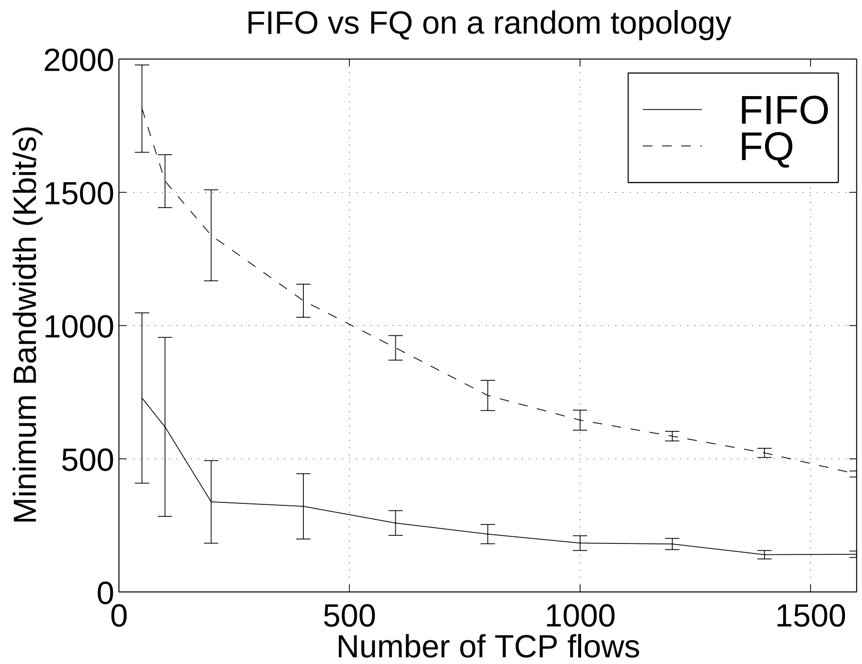
- This paradigm allows to devise End-to-End CC protocols that meet almost all the properties of an ideal CC protocol:
  - Stable, Fair, Robust, Scalable, Feasible.
  - Not ideally efficient: tradeoff among the performance parameters bandwidth, delay, and loss.
- Practical issues:
  - Is the FS-paradigm compatible with the TCP.
  - How to deploy the FS paradigm (mainly the NP assumption).

Practical Aspects

- Mean bandwidth



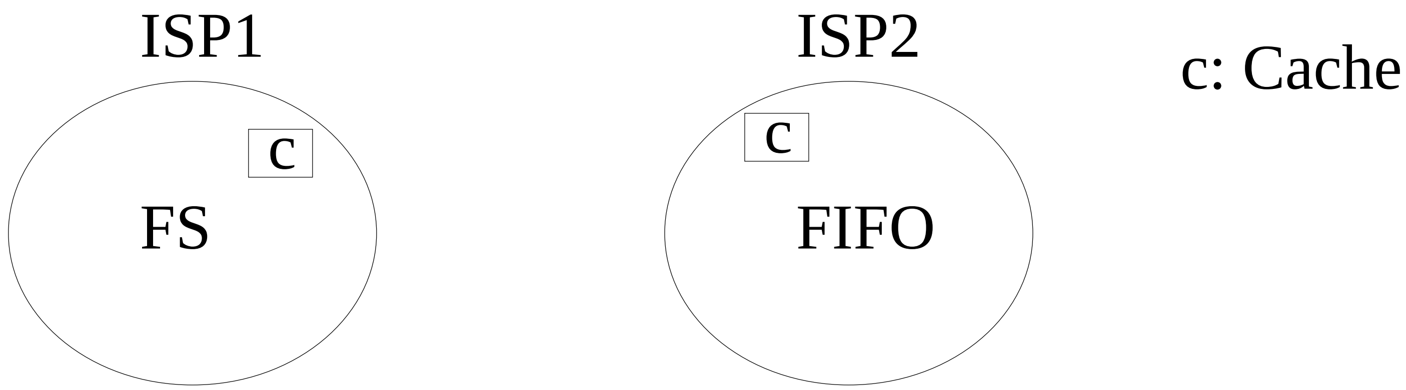
- Minimum bandwidth



- Mean bandwidth 25% higher with FQ than with FIFO.
- Minimum bandwidth 250% higher with FQ than with FIFO.

Practical Aspects

- Issues due to the deployment of the FS paradigm only related to the deployment of the NP assumption.



- Financial interest in the deployment of the FS paradigm:
  - Immediate benefits.
  - Improvement of performance with new CC protocols.

FS Paradigm vs. TCP-friendly Paradigm

Properties	FS paradigm	TCP-friendly paradigm
Stability	+	-
Efficiency	+	-
Fairness	+	-
Robustness	+	-
Scalability	+	+
Feasibility	-	+

Conclusions

- We formally study congestion control as a whole:
  - We give a definition of congestion slightly different from the Keshav's definition.
  - We formally define the properties of an ideal congestion control protocol.
  - We define the FS paradigm that allows to devise nearly ideal CC protocols.
- The deployment of the FS paradigm is feasible and leads to immediate benefits.

The Hierarchical Topology