Economic perspectives on congestion

Frank Kelly
University of Cambridge

easyJet.com

Choose your flight

Click on a fare from the timetable below to add it to your basket or search again using the search options below.

Flying from
London (All Airports)

Going to
Geneva GVA

Outbound
2 | September 2010

☐ Return

2 | September 2010

[Search again]

Your Basket

Show in currency | Pounds Sterling

✈ **London (All Airports) to Geneva**
Please select a flight on the left

[+ Add more flights]   [Continue »]

Lowest outbound fares

July	£67.99
August	£27.99
September	£21.99
October	£26.99
November	£27.99
December	£27.99
January	£27.99

[3 day view]   [3 week view]   [Year view]

✈ **Outbound** journey

Your journey is **one way only**.

London Gatwick to Geneva

Wed 01 Sep	Thu 02 Sep	Fri 03 Sep
£30.99 Dep 08:15 Arr 10:50	£30.99 Dep 08:15 Arr 10:50	£32.99 Dep 08:15 Arr 10:50
£37.99 Dep 12:20 Arr 14:55	£38.99 Dep 12:20 Arr 14:55	£50.99 Dep 12:25 Arr 14:55
£30.99 Dep 17:05 Arr 19:40	£30.99 Dep 17:05 Arr 19:40	£32.99 Dep 17:05 Arr 19:40
£30.99 Dep 20:10 Arr 22:45	**LOWEST FARE** £29.99 Dep 20:10 Arr 22:45	£42.99 Dep 20:10 Arr 22:45

London Luton to Geneva

Wed 01 Sep	Thu 02 Sep	Fri 03 Sep
£27.99 Dep 07:35 Arr 10:20	£27.99 Dep 07:35 Arr 10:20	£36.99 Dep 07:35 Arr 10:20
£28.99 Dep 18:25 Arr 21:10	**SAVE** £21.99 Dep 18:25 Arr 21:10	£34.99 Dep 18:25 Arr 21:10

Transport for London

Search: [ ] [Search]

| Home | Live travel news | Getting around | Tickets | Road users | Corporate | Business & partners |

⬈ Getting around
⬈ Taxis and minicabs
⬈ Taxis
⬇ **Taxi fares**
   Extra charges
▸ **Tariffs**

Tariffs

The meter automatically adds a charge based on time for any part of the journey when the speed drops below 10.4mph. Other extras may be included in the final fare.

Tariff 1

For any hiring during Monday to Friday other than on a public holiday between 06:00 and 20:00

- For the first 279.6 metres or 60.0 seconds (whichever is reached first) there is a minimum charge of £2.20
- For each additional 139.8 metres or 30.0 seconds (whichever is reached first), or part thereof, if the fare is less than £15.80 then there is a charge of 20p
- Once the fare is £15.80 or greater then there is a charge of 20p for each additional 98.0 metres or 21.1 seconds (whichever is reached first), or part thereof

Tariff 2

For any hiring either during Monday to Friday between 20:00 and 22:00 or during Saturday or Sunday between 06:00 and 22:00, other than on a public holiday:

- For the first 227.0 metres or 48.8 seconds (whichever is reached first) there is a minimum charge of £2.20
- For each additional 113.5 metres or 24.4 seconds (whichever is reached first), or part thereof, if the fare is less than £19.00 there is a charge of 20p
- Once the fare is £19.00 or greater then there is a charge of 20p for each additional 98.0 metres or 21.1 seconds (whichever is reached first), or part thereof

Tariff 3

For any hiring between 22:00 on any day and 06:00 the following day or at any time on a public holiday

- For the first 183.4 metres or 39.4 seconds (whichever is reached first) there is a minimum charge of £2.20
- For each additional 91.7 metres or 19.7 seconds (whichever is reached first), or part thereof, if the fare is less than £23.00 there is a charge of 20p
- Once the fare is £23.00 or greater then there is a charge of 20p for each additional 98.0 metres or 21.1 seconds (whichever is reached first)

Sample path shadow prices

arriving
load

capacity

time

sample path shadow price: 1

0

Shadow prices for queue

buffer load

buffer capacity

time

arrivals:

sample path shadow price: 1

0
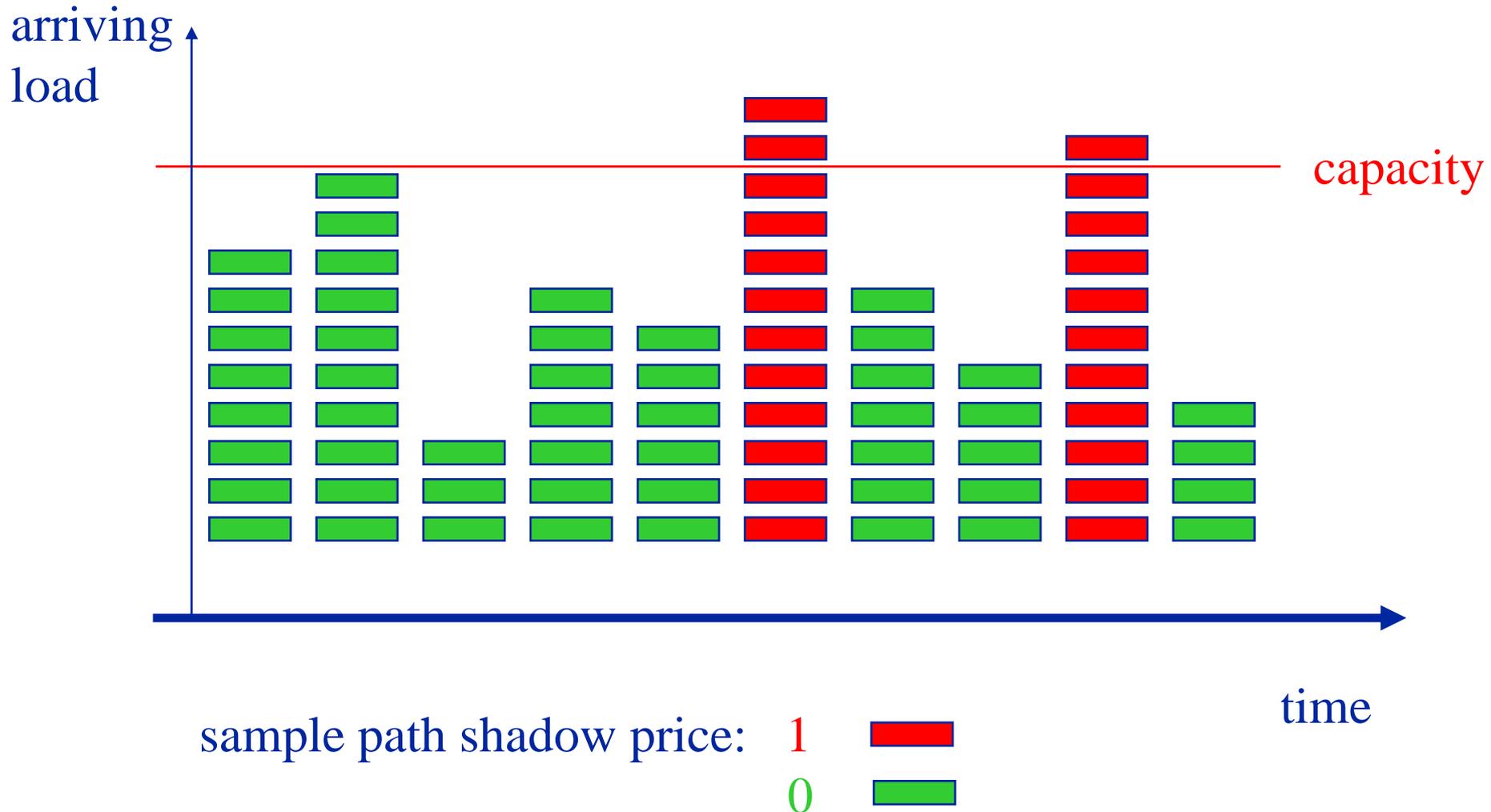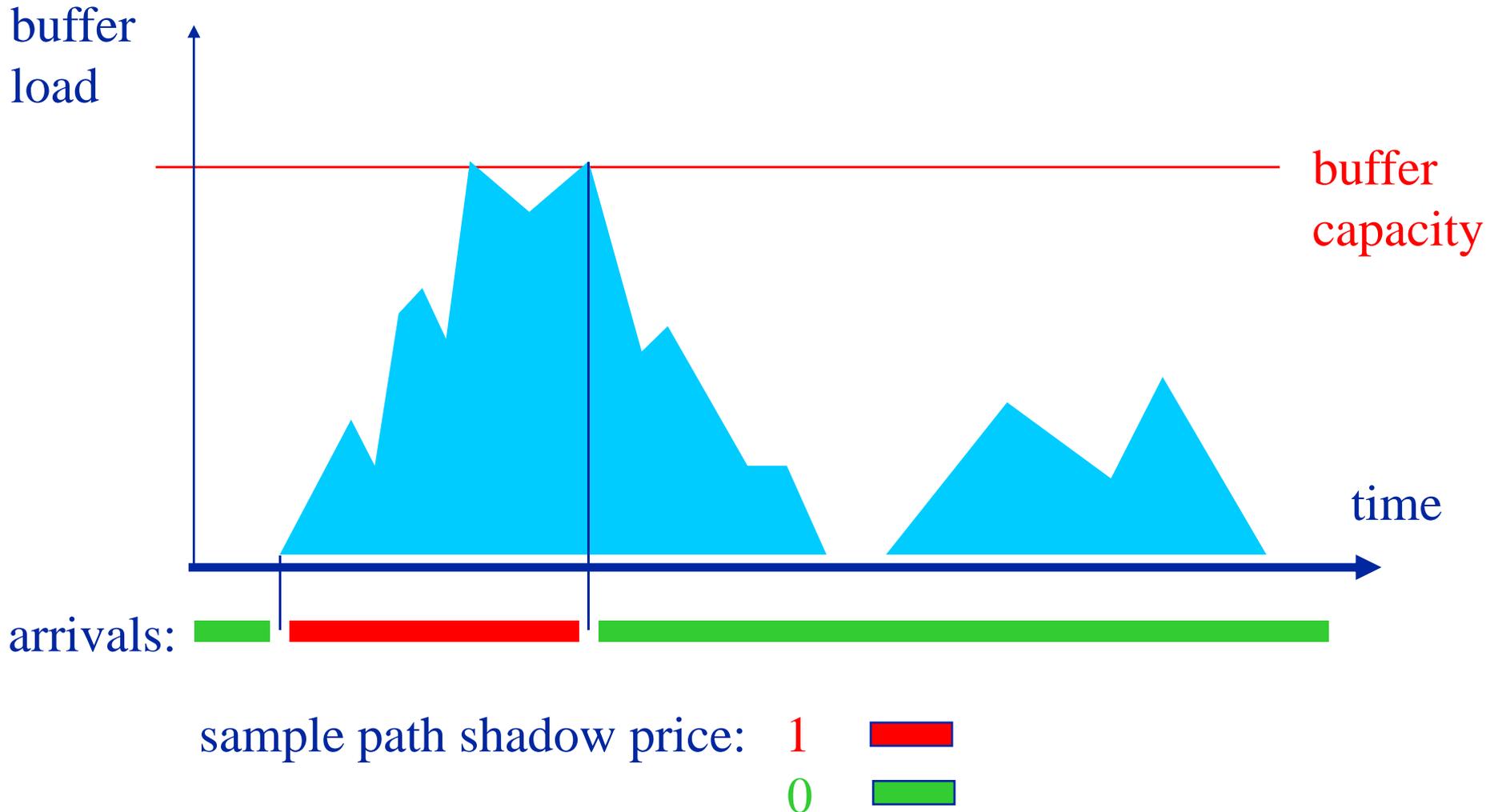
End-to-end congestion control
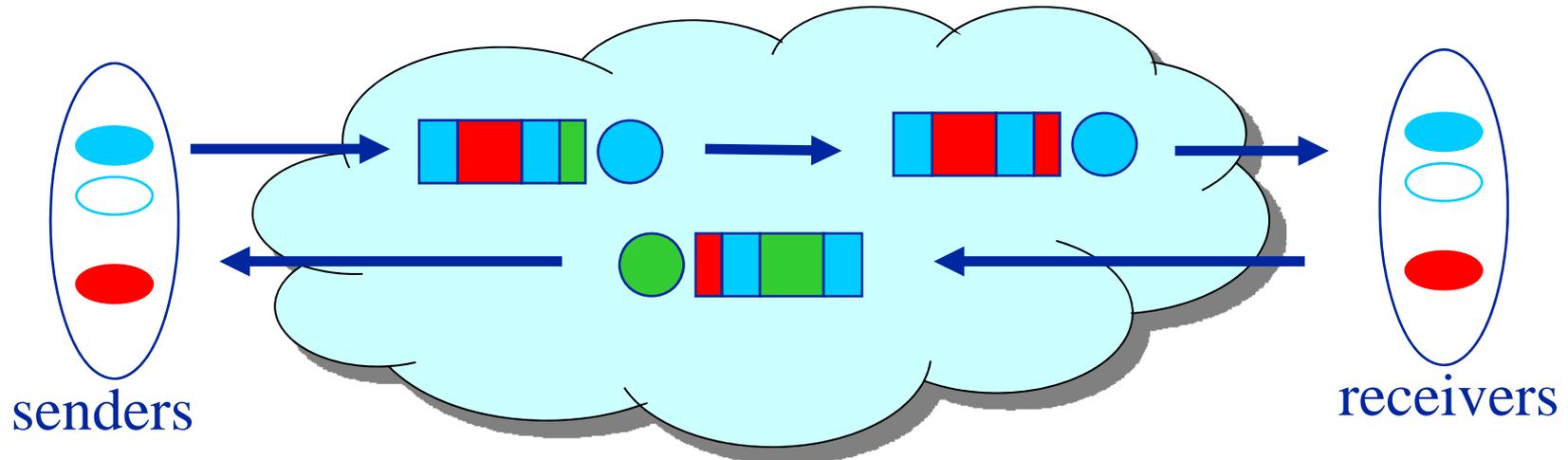
senders

receivers

Senders learn (through feedback from receivers) of congestion at queue, and slow down or speed up accordingly. With current TCP, throughput of a flow is proportional to

$$1/(T\sqrt{p})$$

T = round-trip time, p = packet drop probability. (Jacobson 1988, Mathis, Semke, Mahdavi, Ott 1997, Padhye, Firoiu, Towsley, Kurose 1998, Floyd and Fall 1999, …)

Conclusion

- Infrastructure networks with hard capacity constraints require demand to adapt to these constraints, either by time-shifting, route-shifting, or moderating the volume of demand.

- In the Internet the signal to adapt is generally given by damage of some form to a packet, such as delay or loss.

- It is possible to expose congestion without damage.

- Then many different forms of adaptation become possible, provided incentives are aligned with congestion signals.