Economic perspectives on congestion

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Tariffs

The meter automatically adds a charge based on time for any part of the journey when the speed drops below 10.4 mph. 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 199.8 metres or 30.0 seconds (whichever is reached first), or part thereof, if the fare is less than £15.00 then there is a charge of 20p
- Once the fare is £15.00 or greater then there is a charge of 20p for each additional 93.0 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 48.0 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 £15.00 then there is a charge of 20p
- Once the fare is £15.00 or greater then there is a charge of 20p for each additional 95.0 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 35.4 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 then there is a charge of 20p
- Once the fare is £23.00 or greater then there is a charge of 20p for each additional 95.0 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

Arrivals:

Sample path shadow price: 1 0
End-to-end congestion control

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

$$\frac{1}{T\sqrt{p}}$$

$T =$ round-trip time, $p =$ packet drop probability.

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.