Internet Service Differentiation using Transport Options:
the case for policy-aware congestion control

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RIPQoS Workshop, Karlsruhe, Germany
27 August 2003

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Hypothesis

- many networks are well provisioned and therefore lightly utilised (high capacity links, delays <= 10ths ms, loss rates rarely exceeding 0%)
- Observation : the stability of the network (and the service quality) depends more on long-term provisioning decisions and the interconnection practices of the service providers than on the micro-management of transmission rates at short time-scales
- Hypothesis : if the network is *not* congested, users can easily transmit more aggressively (than the current standards prescribe) without posing any threat the network or disrupting others
- in many cases more optimistic (or informed) adaptive strategy can lead to considerable performance improvements (make better use of the available capacity)
- Open issues :
    - how do we know in which networks and when this should be used
    - how do we know that users are more aggressive *only* when they should be and *not* always (regardless of remote endpoint location, or network load) …

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Transport Options (1) – the idea

- Think of the part of a transport protocol used for the adaptive control of the transmission rate (window) (‘ congestion control ’) as a service provided by the host OS.
- in practice, it turns out that this part of the OS has economic significance (influences bandwidth sharing at bottlenecks at arbitrary places inside the network)
- ..as such it could be a service offered by the ISP.

Example: the ‘ownership’ of the IP address (static or dynamic)

Transport Options (1) – the idea

- more than one, adaptive transmission control behaviours are available by the OS (called Transport Options)
- each behaviour creates a (notional) service class (1-to-1 relationship)
- different behaviours (classes) have different performance *expectations*
- there are no quantitative specifications in the service description, so differentiation between classes is relative
- provider offers service contracts (SLAs) which give the right to use a particular class
- provider should be able to monitor or enforce terms specified in the contract
- the actual payoff to the user (in performance terms) from using a particular Transport Option at a certain point in time is uncertain (although relative differentiation in the payoffs from different classes should be consistent).

Transport Options (2) - purpose

performance enhancement (in networks where more aggressive transmission behaviour most likely will not cause congestion problems)

Example 1: “relax” congestion control rules for all TCP connections within a corporate intranet.

Example 2: In FreeBSD TCP used a very large initial cwnd for all connections with destinations on the same LAN

```
if ( in_localaddr(inp->inp_faddr) )
        tp->snd_cwnd = mss*ss_fltsz_local ;
else
        tp->snd_cwnd = mss*ss_fltsz ;
```

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Transport Options (2) - purpose

commercial exploitation : introduces a new type of service in the contracts (SLAs) offered by ISPs to their customers

Example: lease IP addresses to customers (DHCP), have different tariffs for *static* and *dynamic* allocations.

Analogy :

create a menu of available transport protocols or transmission control behaviours (which apply to a transport protocol e.g. TCP)

lease Transmission Control Behaviours which apply to all communications to/from certain network addresses as specified in a contract.

easy to offer SLAs which combine Transport Options usage based charging (volume)

Transport Options (3) - implementation

- each Transport Option is assigned a unique identifier (TOid)
- TOid semantics are well-defined and compatible across hosts (e.g. TOid =0 corresponds to the default or reference transport)
- TOids are ordered :

    minimum TOid corresponds to the default behaviour (e.g. 0 to standard TCP)

    maximum corresponding to the most “rewarding” (in performance expectation terms)

    the convention is : greater TOids are preferred

- use of appropriate TOid negotiated at connection setup phase (with TCP 3-way handshake, similar to MSS negotiation)
- preconfigured **policy rules** at the connection end-points determine which TOid will be used, settle for the minimum of the two

Transport Options (3) - implementation

- preconfigured **policy rules** at the connection end-points determine which TOid will be used, settle for the minimum of the two
- Policy rules :: table entries in a configuration file, with two parts

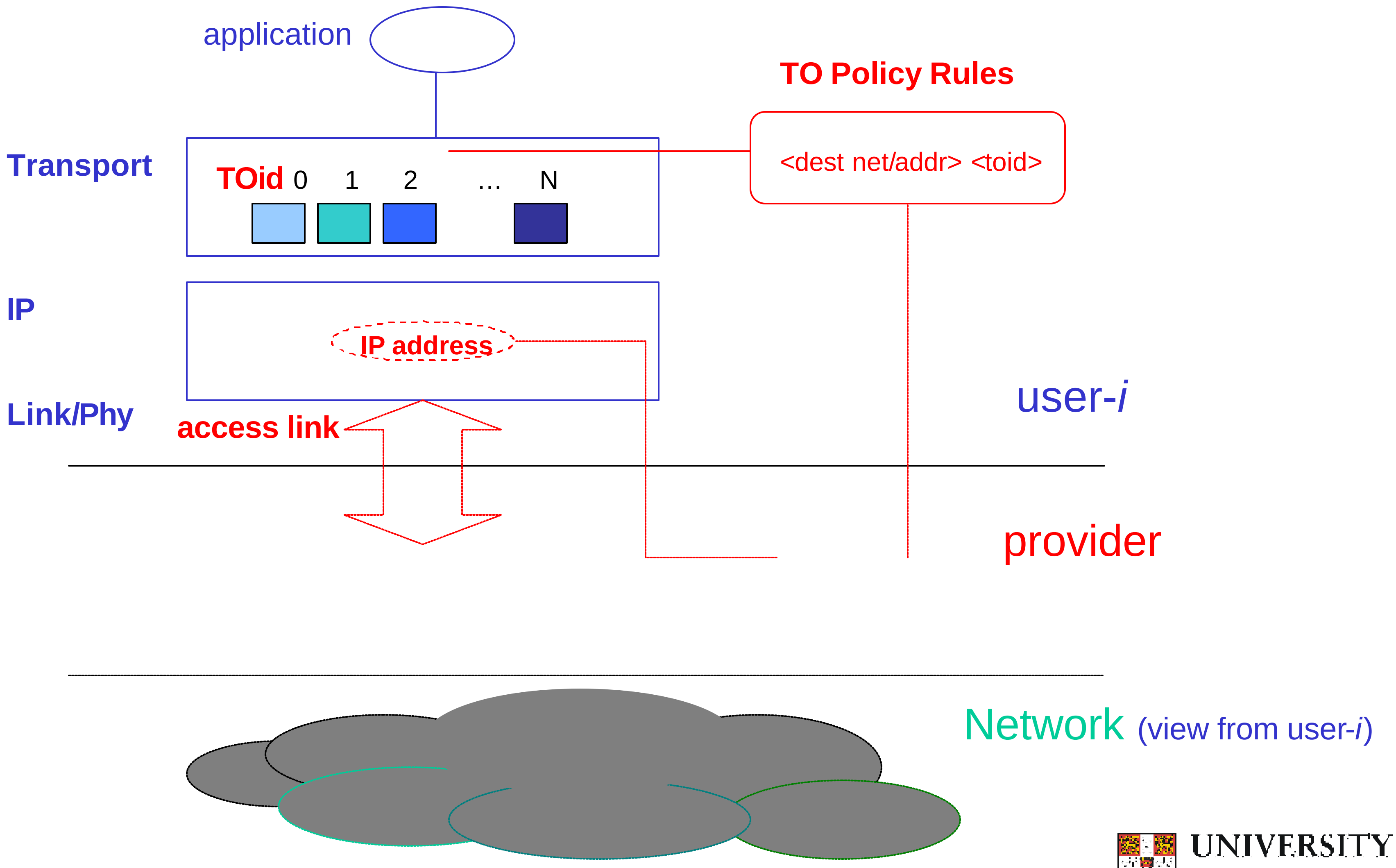
  <condition> <action>

  <*condition*> : location attribute e.g. Autonomous System number, network number, or IP address of the remote endpoint.

  <*action*> : maximum allowed TOid (range [0.. max])

- Use maximum TOid permitted for the initialisation of the connection’s TCP control block structure (cwnd initialisation and update functions).
- Policy rules will be explicitly stated in the SLA and will normally be static i.e. will not change during the lifetime of the contract (short-term or long-term SLAs).

Transport Options (3) - implementation



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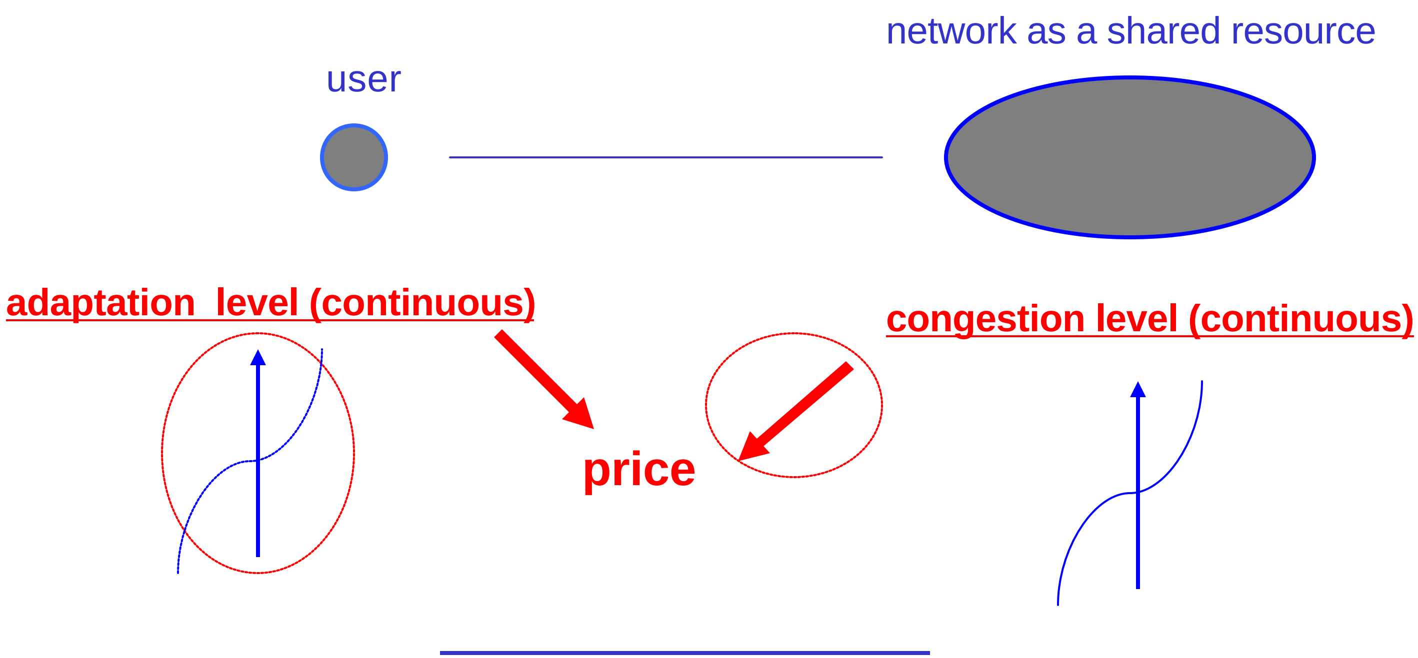
Congestion Pricing vs.Transport Options



special feedback required for conveying the congestion level (I.e congestion marks -- packet loss is **not** sufficient indication)

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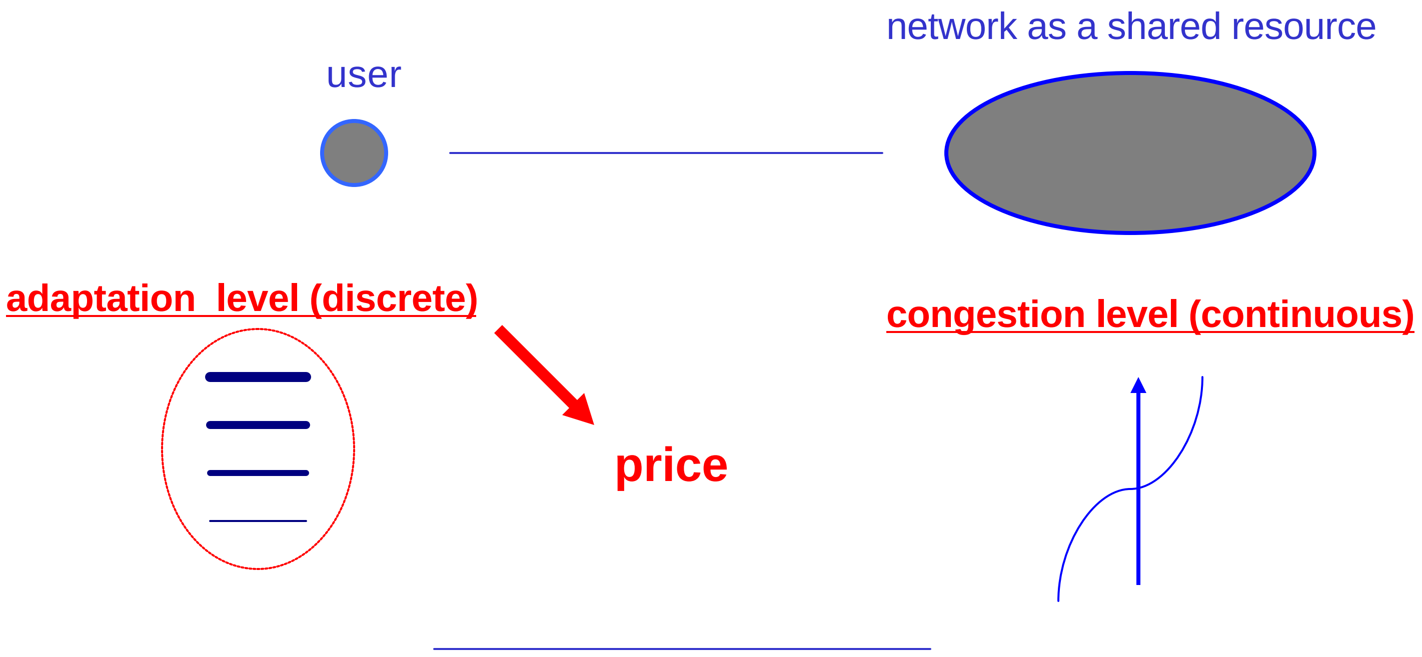

no special feedback required for conveying information about the congestion level (packet loss is sufficient indication)

Transport Options (4) – evaluation

- benefits to providers
  - (claim to be) 'deployable'
  - built in long-term SLAs -> so easy to manage,
  - 'packaged' in a form in which users can buy
  - allow flexibility in pricing schemes (e.g. offer subsets of rules or TOid ranges)
  - approach is more general (I.e not confined to data transport)
- benefits to the user
  - user is not involved (TOs take effect automatically as soon as the appropriate configuration file is installed)
  - user can verify the difference
  - low level details are hidden

Transport Options (4) – evaluation

- downside

  technically difficult to write contracts on adaptive behaviour compared to contracts on traffic characteristics (rate, packet size, burst size etc.)

  easy to monitor traffic, but adaptive behaviour has to be inferred (by monitoring and traffic or analysis) by other means

  extends provider control to user's 'private space' : Big Brother concerns

  Implications for provider interconnection : not yet been explored …

  no quantitative guarantees (is this a problem?)

Summary (…)

- powerful abstraction: pushes the policy enforcement boundary higher ..uses the endpoints but delegates *responsibility* from the endpoint to the provider (ISP: globally recognizable/accountable entity),
- provider becomes reference point for trust – price paid: the provider should now police *not* the traffic but the behaviour of the endpoints (customers)
- new issues in traffic exchange between ISPs : open …
- scalable way to differentiate at random bottlenecks far beyond the provider's domain (more important with broadband access which eliminates first/last hop bottleneck).