

# Solving the Congestion Problem using ICN Principles

*Ioannis Psaras*

EPSRC Fellow

University College London

[i.psaras@ucl.ac.uk](mailto:i.psaras@ucl.ac.uk)

<http://www.ee.ucl.ac.uk/~uceeips/>

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# In-Network Resource Pooling

## In-net caching from a different angle

**ACM HotNets 2014**

I. Psaras, L. Saino, G. Pavlou

*"Revisiting Resource Pooling:  
The case for In-Network Resource Sharing"*

# The Resource Pooling Principle

*“Pooling of customer demands, along with pooling of the resources used to fill those demands”*

*“networked resources behave as a pooled resource”*

- Internet (among others): a network of resources
  - From bandwidth, computation and storage resources, to information/content and service resources
  - *Packet switching* enables pooling of link capacities and routers processing power
  - *Buffers* enable pooling of link capacity at adjacent time periods
  - *MPLS TE* and *ECMP* enable pooling of multiple paths

## Pooled resources

Links

Switching devices

Buffers

Packet switching

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Paths

ECMP, MPLS TE,  
MPTCP

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Sub-paths

Packet caches

Our proposal

# The Resource Pooling Principle

We claim that:

Pooling can be thought of as **a tool to manage uncertainty**.

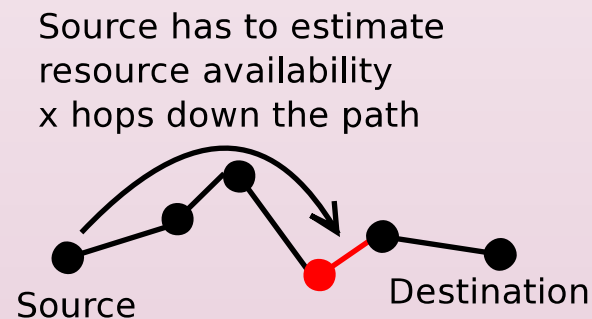
- Uncertainty in the Internet (among others):
  1. Senders overloading the network with traffic
  2. Excessive demand for bandwidth over some particular link/area

**Target:** Maintain **stability** and guarantee **fairness**

# Current State of Affairs

## The Long Long Discussion on TCP

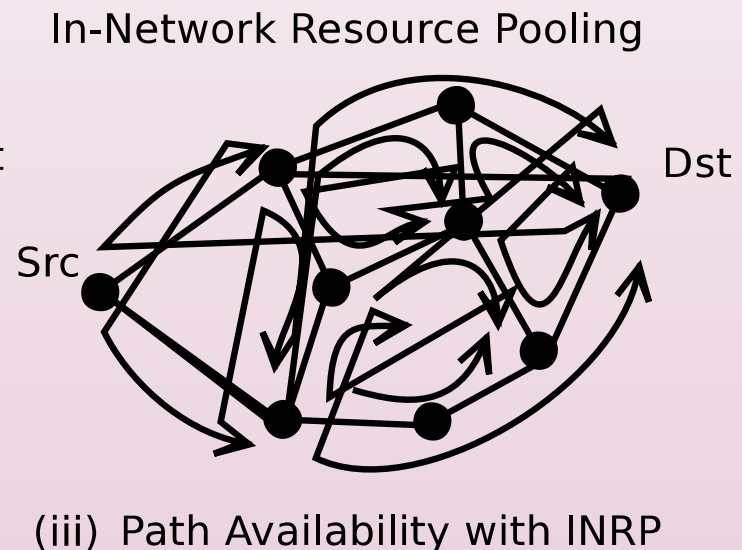
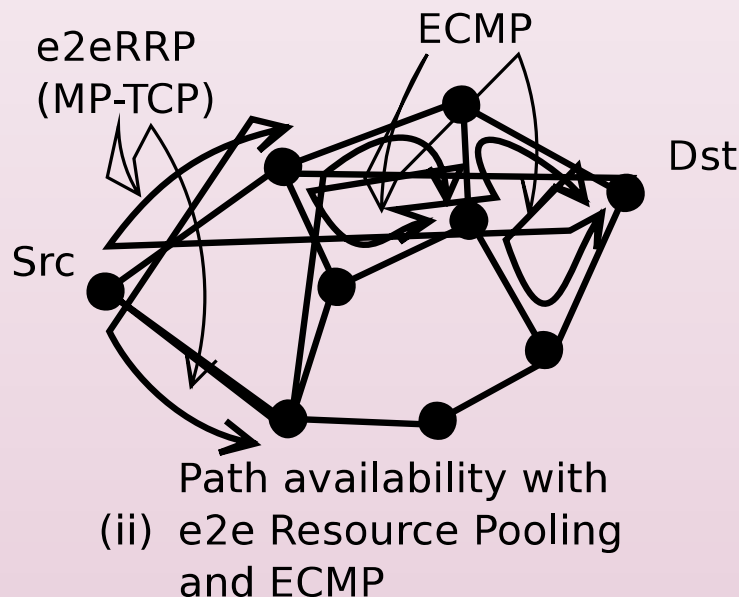
- TCP deals with uncertainty using the “*one-out one-in*” principle
- TCP effectively deals with uncertainty by (proactively) suppressing demand!
- TCP is moving traffic as fast as the path’s slowest link
- End-points have to speculate on the resources available along the e2e path



(i) e2e Resource Management

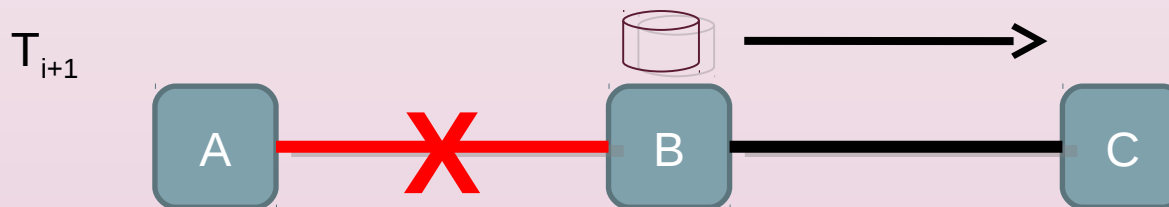
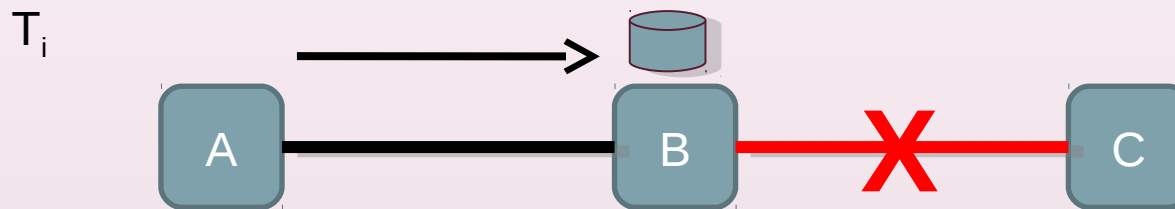
# Vision

1. Push traffic *as far in the path and as fast* as possible
2. Once in front of the bottleneck, *store traffic temporarily* in custodian nodes/routers and deal with congestion locally
3. Exploit all available (sub-)paths making decisions on a *hop-by-hop manner*.



# Caches and resource pooling

- The presence of ubiquitous packet caches enables more efficient usage of resources by enabling pooling of sub-paths.





# Eliminating Uncertainty

## Information-Centric Networking

- Request and Data paths are symmetric
- Instead of the “*data-ACK*” model of TCP, in ICN we have a “*request-data*” model

Uncertainty #1 is minimised!

- Receivers (instead of senders) regulate the traffic that is pushed in the network
- Based on requests forwarded, each forwarding entity knows how much traffic to expect within one RTT.

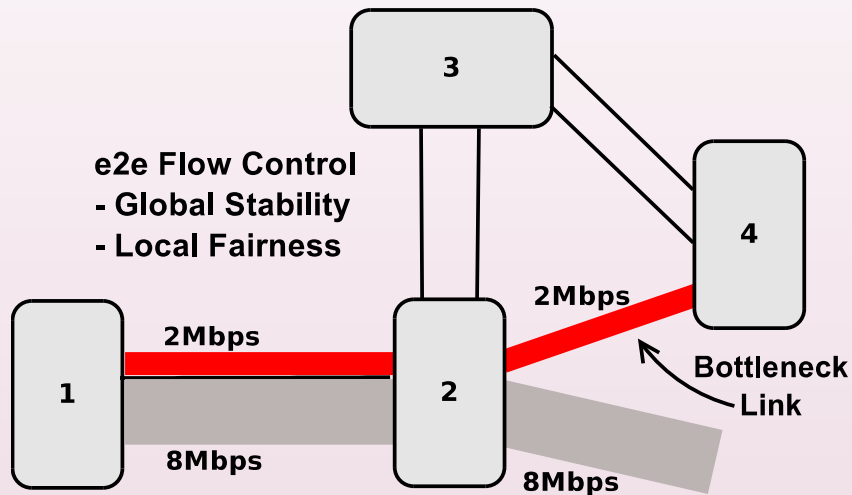
# Eliminating Uncertainty

## In-Network Caching

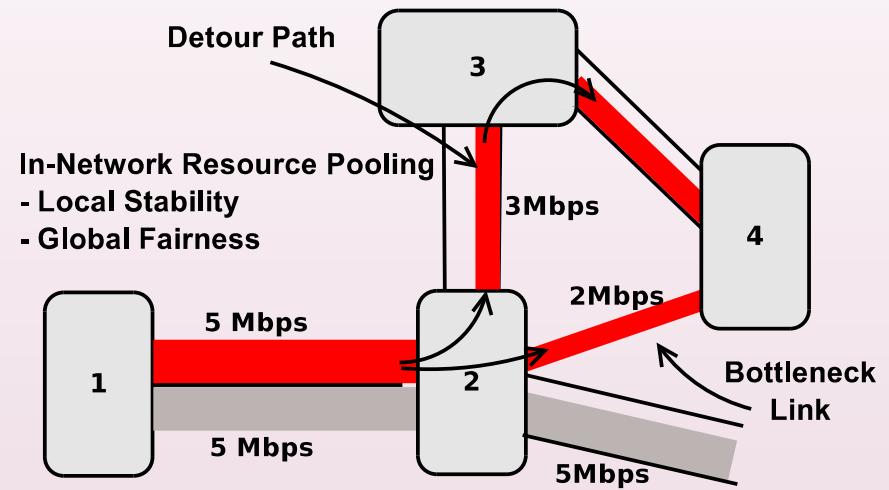
- Caching has been used for *resource optimisation*
  - Reduce delay, save on bandwidth etc.
- Overlay Caching:
  - Put caches in “strategic” places and redirect (HTTP) requests to those caches
- In-Network Caching:
  - Individually named and self-identifiable packets/chunks allow for in-network storage!
  - Put caches in every router and serve network-layer requests for named chunks from caches on the path
- We use in-network caching for **temporary storage**

Uncertainty #2  
(temporarily)  
accommodated

# Stability & Fairness



Global Stability  
Local Fairness



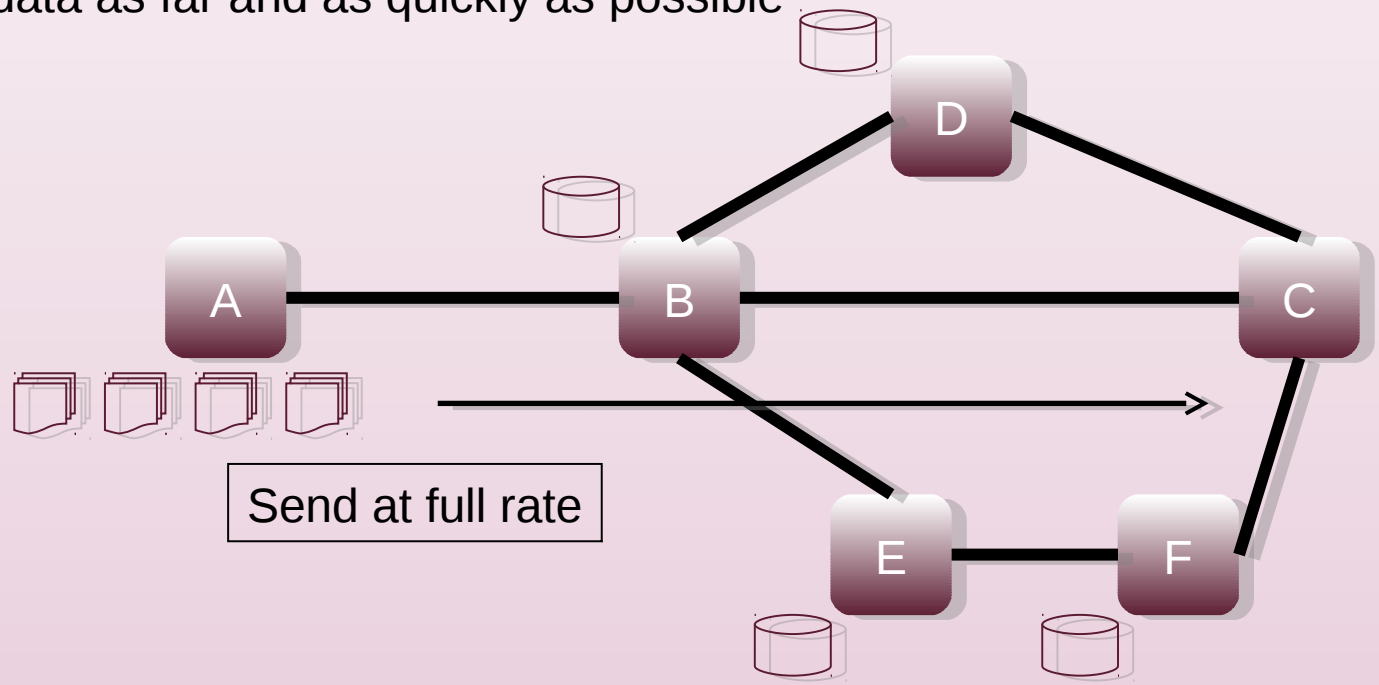
Local Stability  
Global Fairness

## 3-Phase Operation

- **Push-data phase** – Open-Loop System
  - Processor-sharing, RCP-like transmission
  - Open loop system – senders send even more than what they have received requests for
    - Push data as far and as quickly as possible
- **Cache & Detour phase**
  - Every router monitors incoming *Requests*
  - When demand is expected to exceed supply, the local router tries to find alternative paths to detour
  - In the meantime traffic in excess (if any) is cached locally
- **Backpressure phase** – Closed-Loop System
  - If alternative paths do not exist or are equally congested:
    - Pace Requests
    - Send notification upstream to slow down and enter closed-loop transmission

# 3-Phase Operation

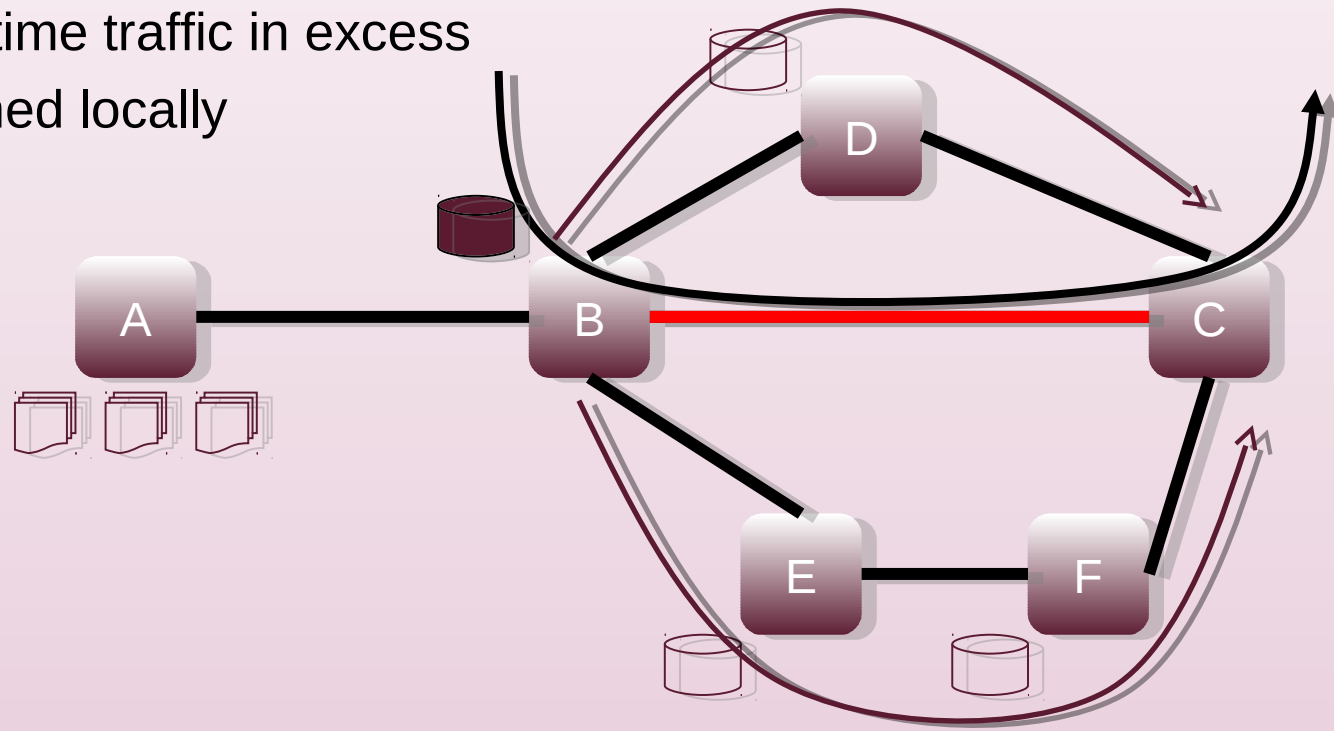
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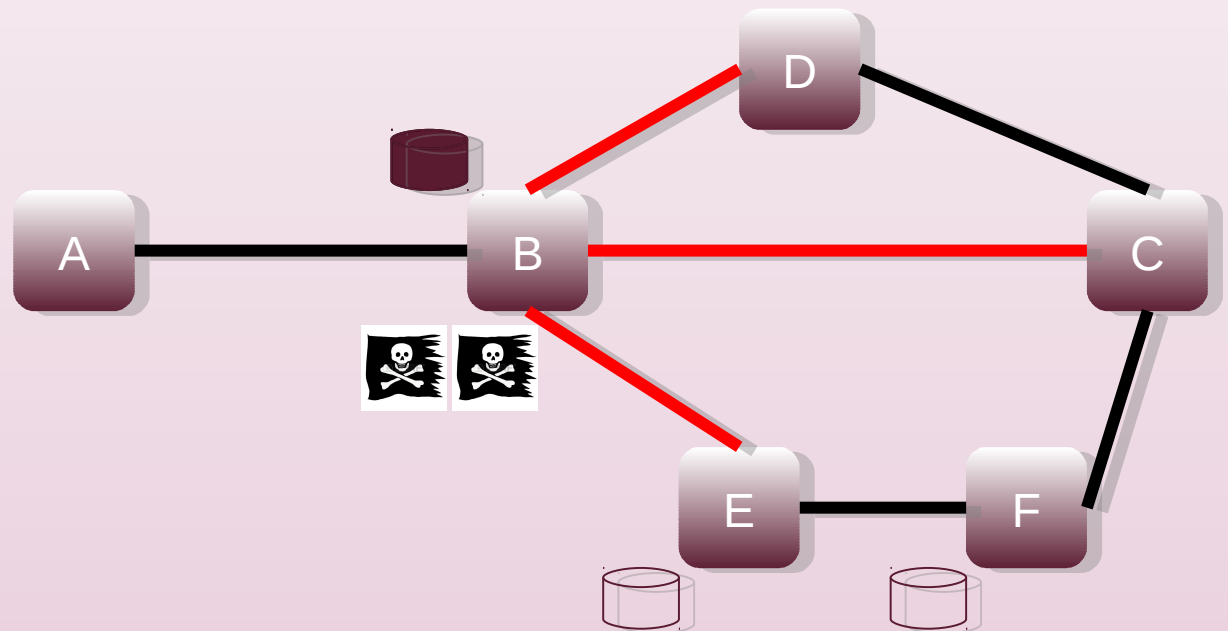
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## 3-Phase Operation

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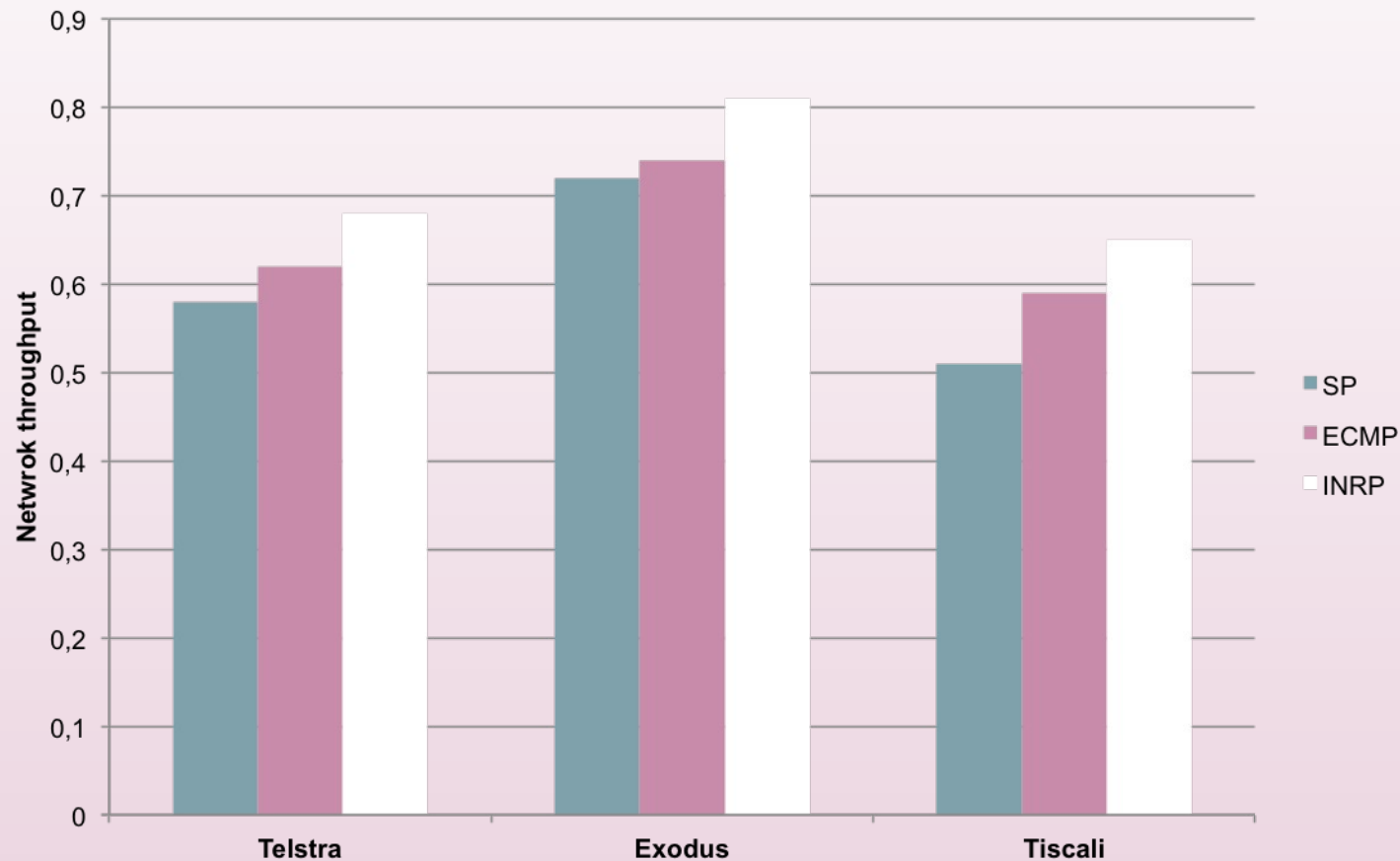


## Data on detour availability

ISP	1 hop	2 hops	3+ hops	N/A
Exodus (US)	49.77%	35.48%	6.68%	8.06%
VSNL (IN)	25.00%	33.33%	0.00%	41.67%
Level 3	92.22%	6.55%	0.68%	0.55%
Sprint (US)	56.66%	37.08%	1.81%	4.45%
AT&T (US)	34.84%	61.69%	0.72%	2.74%
EBONE (EU)	50.66%	36.22%	6.30%	6.82%
Telstra (AUS)	70.05%	10.42%	1.06%	18.47%
Tiscali (EU)	24.50%	39.85%	10.15%	25.50%
Verio (US)	71.50%	17.09%	1.74%	9.68%
<b>Average</b>	52.80%	30.86%	3.24%	13.10%



# Some (very initial) Results



# Summary, Open Issues and Things We Don't (Yet) Know

- Information-Centric Networks:
  - Requires investment and effort
  - Worth doing, but need to get the full set of advantages
- There is an opportunity to deal with congestion control **at the network layer**
- Open Issues:
  - How do you know detour paths are not congested
  - How will this co-exist with traditional TCP flows?
  - Out of order delivery
  - Flows swapping between original and detour paths

# Questions?

## Thanks!

Ioannis Psaras

[i.psaras@ucl.ac.uk](mailto:i.psaras@ucl.ac.uk)

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