A Match Made in Heaven: Marrying Information & Computation

OR: Why are we really doing Information-centric Networking?

Dirk Trossen, Computer Laboratory

We All Know About Video: Staggering Numbers

- 2 billion videos watched on YouTube every day

  - 35 hrs uploaded on YouTube every minute

- 20 mio videos uploaded to FB every month

- 68 mins average iPlayer usage per week

  - 3.1 mio daily iPlayer viewers in Sep 2010

- …in all this, mobile usage just started to take off!

  - Mobile video traffic will exceed 50 percent of total mobile data for the first time in 2011

But There is More Than Video

- Open Government Initiatives

  - UK Open Data Initiative (http://data.gov.uk/about)

    - UK government departments opening data to public from areas like NHS, crime, transport

  - OPEN Government act in the US

    - Extension to Freedom of Information Act from 1966

- And other application areas

  - Sensing, NFC, health data, smart homes, personal life logs, …

…With Staggering Forecasts (Cisco)

- Annual global IP traffic will reach the zettabyte threshold by 2015

- The average smartphone will generate 1.3 GB of traffic per month in 2015 (26x)

- In 2015, there will be 6 million Internet households worldwide generating over a terabyte per month in traffic

- By 2012 Internet video will account for over 50 percent of consumer Internet traffic
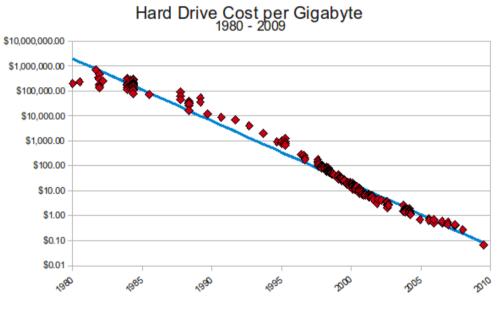
But What About Other Resources?

Is It Only About Information?

The Return of the Big Iron (Centre)

- Google data centres

  - Geographically dispersed centres supplying Google services

  - Estimated $>10^6$ servers

  - Utilizes standard hardware basis optimized for server operation

- Facebook (and others)

  - Serving 690 billion page views per month

  - Now moving from 'leased' centre to own data centres

- Efficient data centre networking crucial!

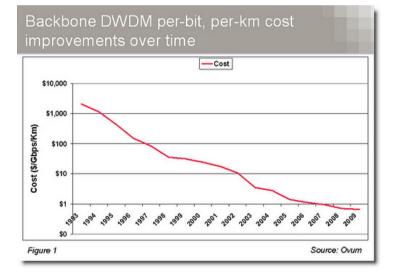- Cloud computing pushing into this direction

Storage & Bandwidth for (Increasingly) Nothing

Hard Drive Cost per Gigabyte
1980 - 2009

Source: http://www.mkomo.com/cost-per-gigabyte

Backbone DWDM per-bit, per-km cost improvements over time

Figure 1   Source: Ovum

But note that storage prices are declining faster and availability is larger (per capita)!

Energy Consumption: We Start Caring About It

Figure 1 – Global ICT spend in 2007, by category

- Increasingly recognized

  - "IT has the equivalent carbon emission output as the airline industry in the UK" (Gartner)

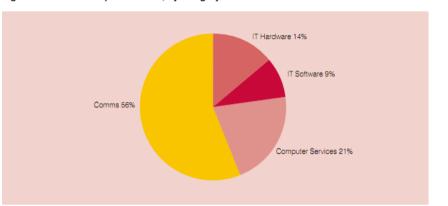 - In the UK between 2000-2006, ICT power-consumption increased by more than 70% (predicted to rise by another 40% by 2020)

  - More than a third of employees in the UK never turn off their computers before leaving the office for the day, which costs the UK £123m a year

- Green computing and ICT identified as key opportunities in funding agencies and corporate investment alike

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So What? The Internet Has Always Been About Information – And It Copes Well With It!

That is correct… (to a point to be discussed)

BUT: Economics have changed the possible starting points for a design

- Computing and storage resources are NOT scarce anymore

  - This led to an almost ubiquitous availability of processing and memory

- Information availability has changed attitude of users

  - WHAT is primary, WHO and WHERE mostly secondary!

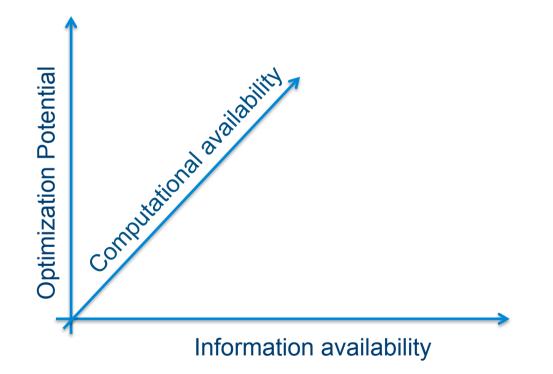 - Information is often not locked anymore behind portals
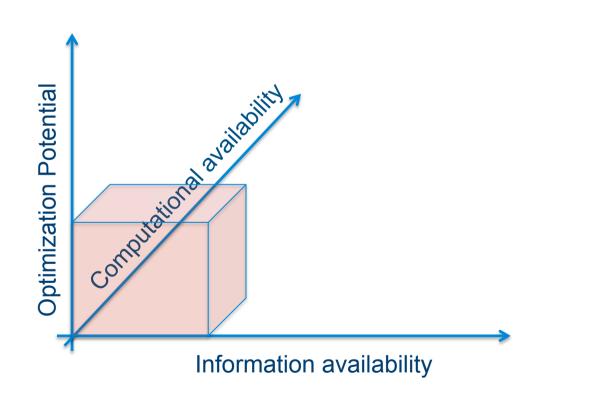
=> Location looses its meaning!

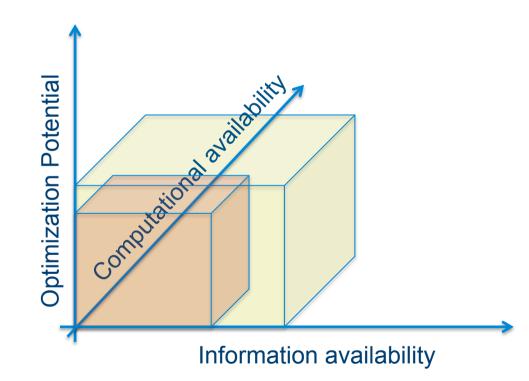# A Match Made in Heaven?

From Plumbing to Systems

Distributed Systems: A Multi-Dimensional Optimization Space

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IP has held us captive in the corner!

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Cloud Computing tries to break out (but costly to loose the IP restriction)

Distributed Systems: A Multi-Dimensional Optimization Space

Optimization Potential

Computational availability

Information availability
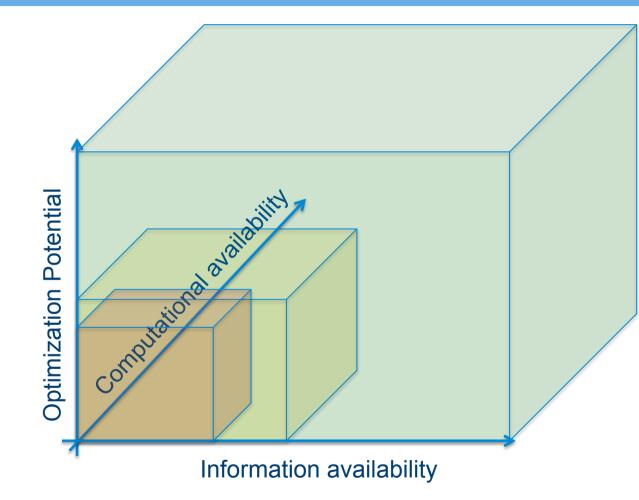
IP has held us captive in the corner!

Cloud Computing tries to break out (but costly to loose the IP restriction)

This is where we want to get to – total freedom to optimize!

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A Marriage Proposal

Hypothesis:

A systems approach that operates on graphs of information with a late (as late as possible) binding to a location at which the computation over this graph is going to happen, enables the full potential for optimization!

This systems approach requires to marry information and computation (and with it storage) into a single design approach for any resulting distributed system

What Are The Promises of this?

- More Resilient and robust

- More Flexible

- More Efficient

- Greener

- Better aligning interests (e.g., economic, security, social)

  - What about more private (if wanted)?

BEWARE: We have NO conclusive evidence on any of this…but early indications!

Our Marriage License: A Functional Model Approach to Designing Distributed/Networked Systems
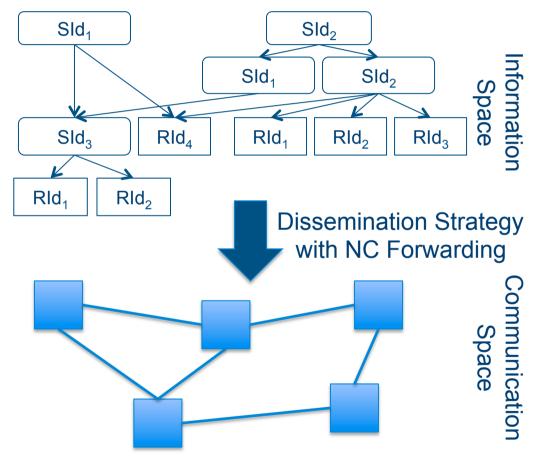
- A single approach to solving (distributed) problems in an information-centric way

    - Ranging from the application space as far into the infrastructure as possible

- A set of architectural design choices as well as technology solutions that follow this approach as strictly as possible

- A prototype for an artifact that allows for playing around with it

Where Does Network Coding Fits In? Diffusing Knowledge

Properties

- Performance ⬆
- Overhead ⬆
- Utilization ⬆
- Security ⬆
- Privacy ⬆
- Accountability ⬆
- Reliability ⬆

Dissemination Strategy with NC Forwarding

And All of This on the Fast-Path Forwarding Plane!

What is the Take-Away Here?

- Information-centric networking is **NOT** about disseminating information *because the Internet is no good at it!*

- Information-centric networking is about utilizing the entire design space provided by information (& storage) as well as computation

  - Aided by technological developments that made computation (and storage) ubiquitously available

- To get there, we need to re-think how we design/build systems

  - We have first results, working prototypes, and a growing test bed

- **More Info:** http://www.fp7-pursuit.eu