



# Trilogy

# Re-Architecting the Internet

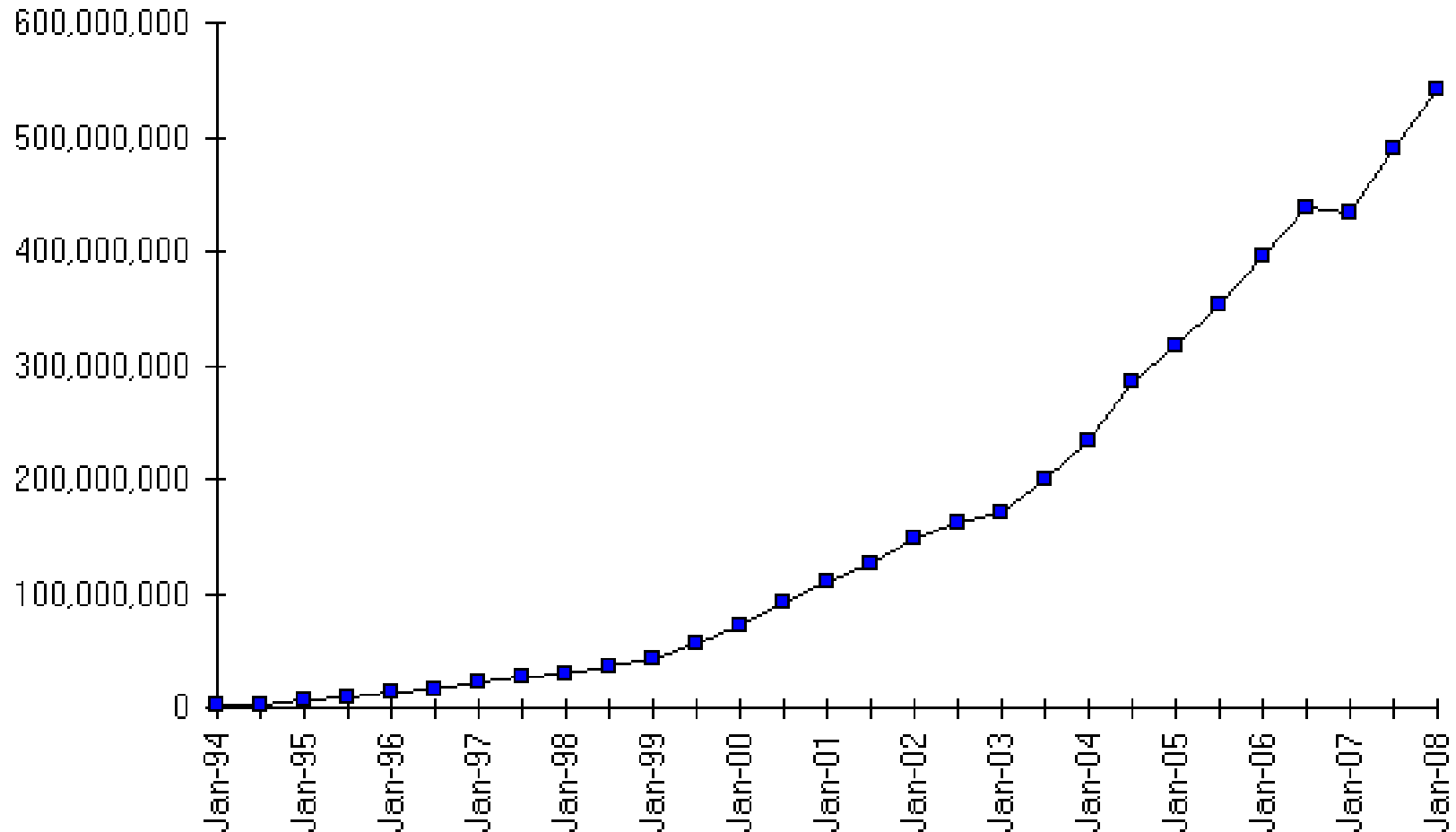
***Project Overview for EU-Japan Symposium,  
June 9<sup>th</sup> – 10<sup>th</sup> 2008***

*matthew.ford@bt.com (Project co-ordinator)*



# The Internet is a success!

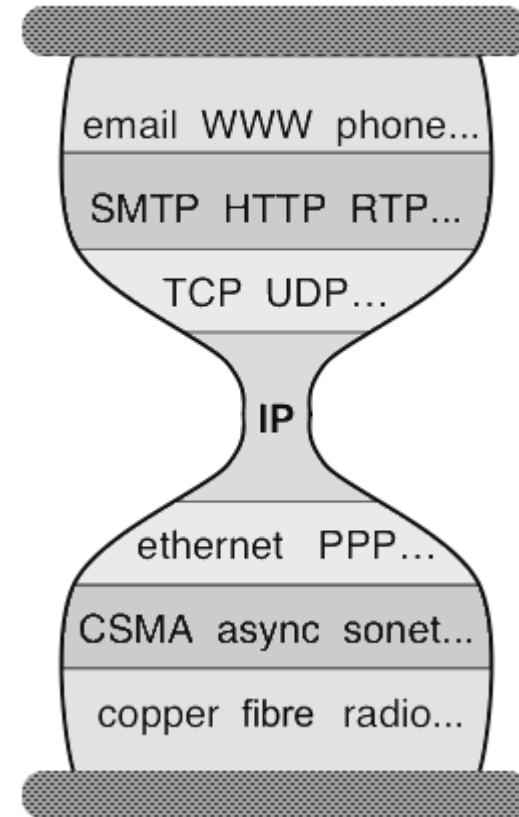
Internet Domain Survey Host Count



Source: Internet Systems Consortium ([www.isc.org](http://www.isc.org))

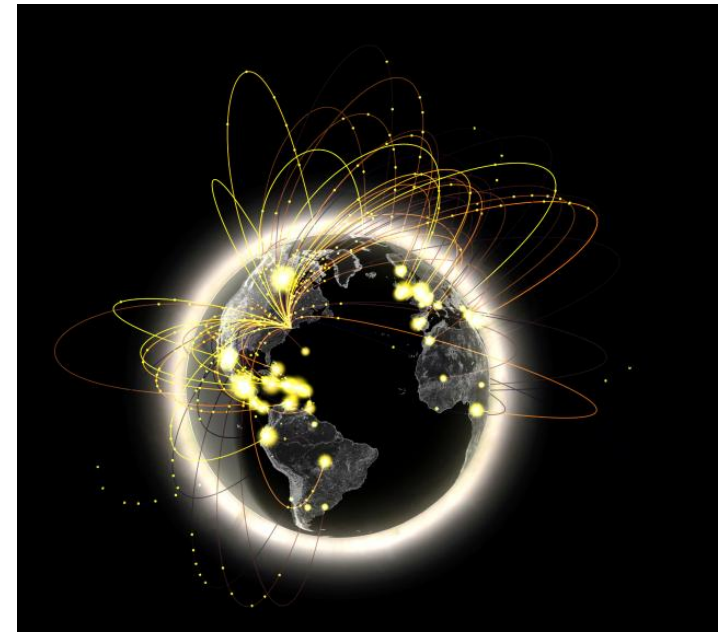
# The Internet hourglass for success

- Narrow IP waist:
  - “IP over everything and everything over IP”
  - Simplicity & transparency
- Properties of ubiquity & robustness
- Maximise interoperability
- Global addressing & reach
- Minimise number of service interfaces
- Isolate end-to-end from network details & changes
- Simplicity – maximises number of usable networks



# The Internet only just works

- Internet out-growing its original design
- All stakeholders affected
  - End-users
    - Spam, security concerns
  - Operators
    - Address space depletion
    - Inter-domain routing limitations
  - Enterprises
    - Multi-homing
    - DDoS
  - Developers
    - Middleboxes



# Design Philosophy of Internet

- Fundamental goal
  - Multiplexed utilisation of existing networks

# Design Philosophy of Internet

## ■ Second-level goals

- Communication must continue despite loss of networks or gateways
- Internet must support multiple types of communications service
- Internet architecture must accommodate a variety of networks
- Internet architecture must permit distributed management of resources
- Internet architecture must be cost effective
- Internet architecture must permit host attachment with a low level of effort
- Resources used in the Internet architecture must be accountable

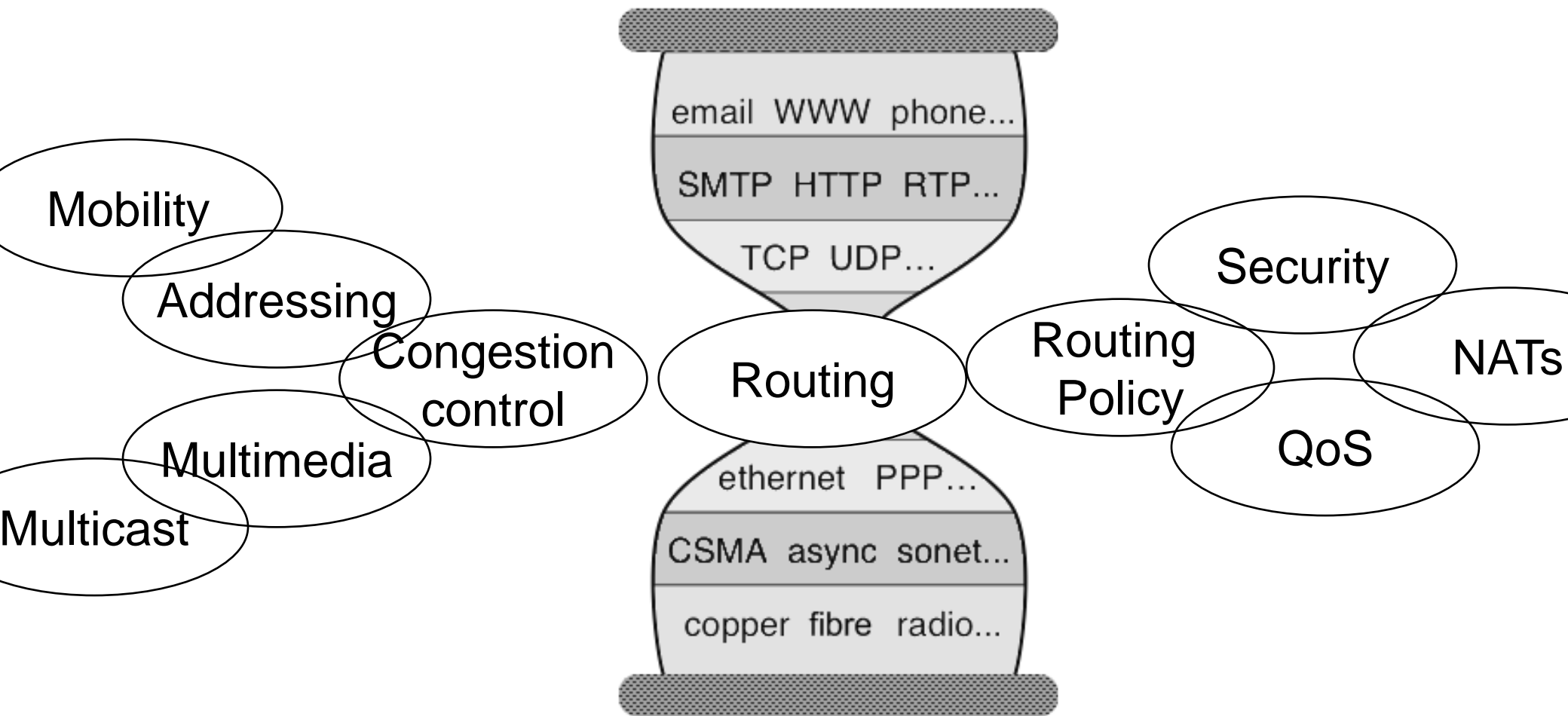
In order of importance

**“An architecture primarily for commercial deployment would clearly place these goals at the opposite end of the list.”**

Dave Clark, 'The Design Philosophy of the DARPA Internet Protocols', Proc. SIGCOMM '88, Computer Communications Review, Vol. 18, No. 4, August 1988



# The Waist of the Internet (for control) is now fat!



Credits: Similar pictures: Steve Deering, Jim Kurose, Rui Aguiar

# Trilogy goal

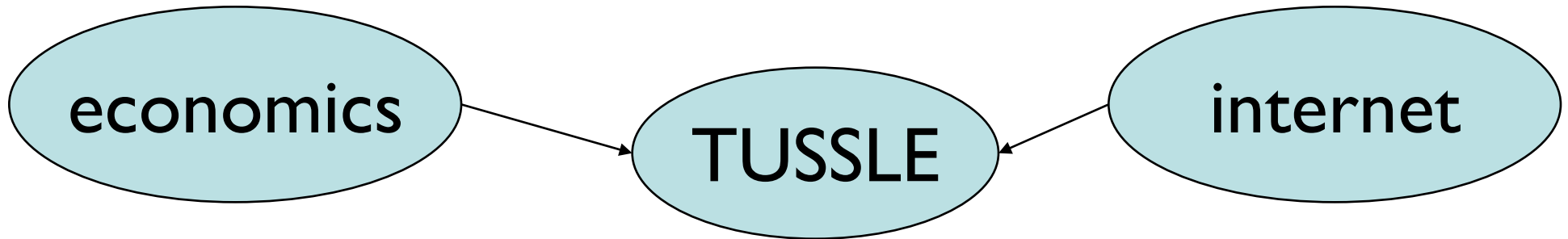
- Our ambition is to narrow the waist again
- By developing a **unified control architecture for the Future Internet**
- Thereby restoring the beneficial properties of the Internet hourglass

# Design for Tussle

- Important reality that surrounds the Internet today: different stakeholders that are part of the Internet milieu have interests that may be adverse to each other, and these parties each vie to favor their particular interests. We call this process “the tussle.”
- Our position is that accommodating this tussle is crucial to the evolution of the network’s technical architecture.

“Tussle in Cyberspace: Defining Tomorrow’s Internet”, Clark, Wroclawski, Sollins, Braden, IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 13, NO. 3, JUNE 2005

# Economics & Tussle

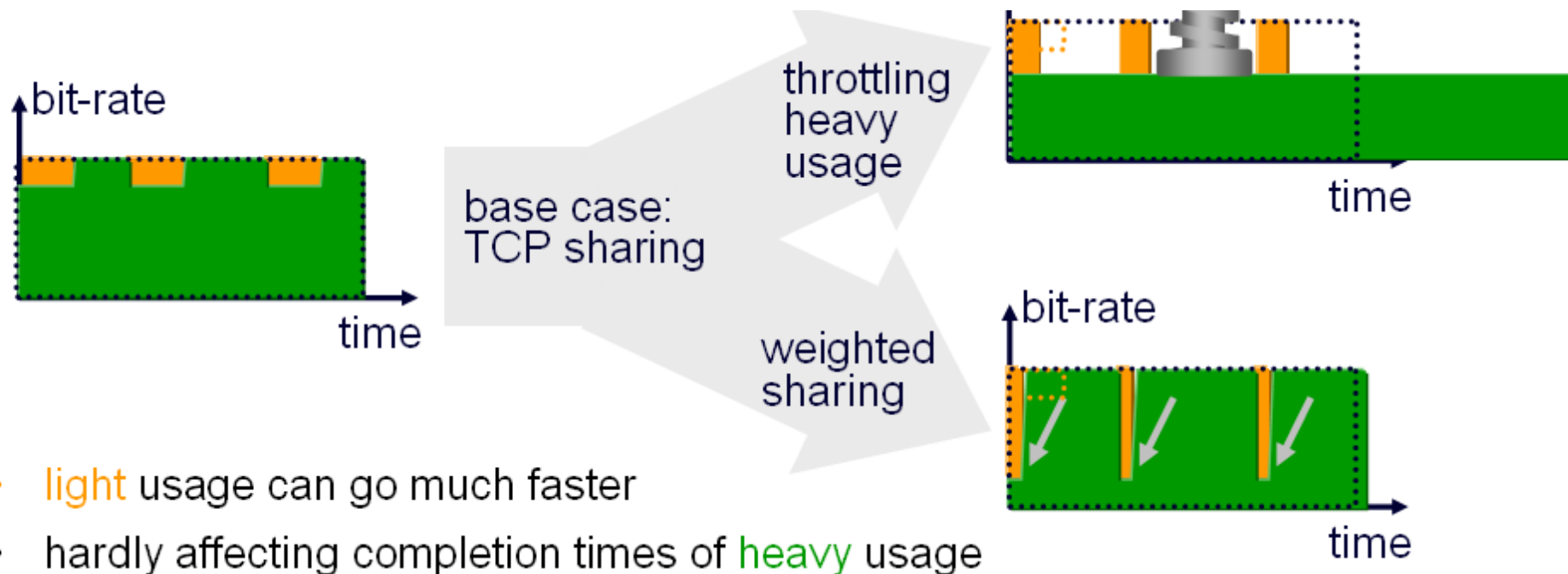


- Internet is no longer a single happy family dedicated to universal packet delivery
- Internet is about economics not just distributed computing systems
- Tussle: different stakeholders that are part of the Internet milieu have interests that may be adverse to each other, and these parties each vie to favour their particular interests.
- On-going contention (tussle) amongst parties over economic & social reward, power, new business models etc
- Example: ISP capacity – peer-to-peer and iPlayer



Credit: "Tussle in Cyberspace: Defining Tomorrow's Internet", Clark et al

# Tackling the p2p, iPlayer problem



- Fighting is not the best outcome!
- Can Designing for Tussle can do better?
- And can the solution must be as simple to deploy as a DPI box?

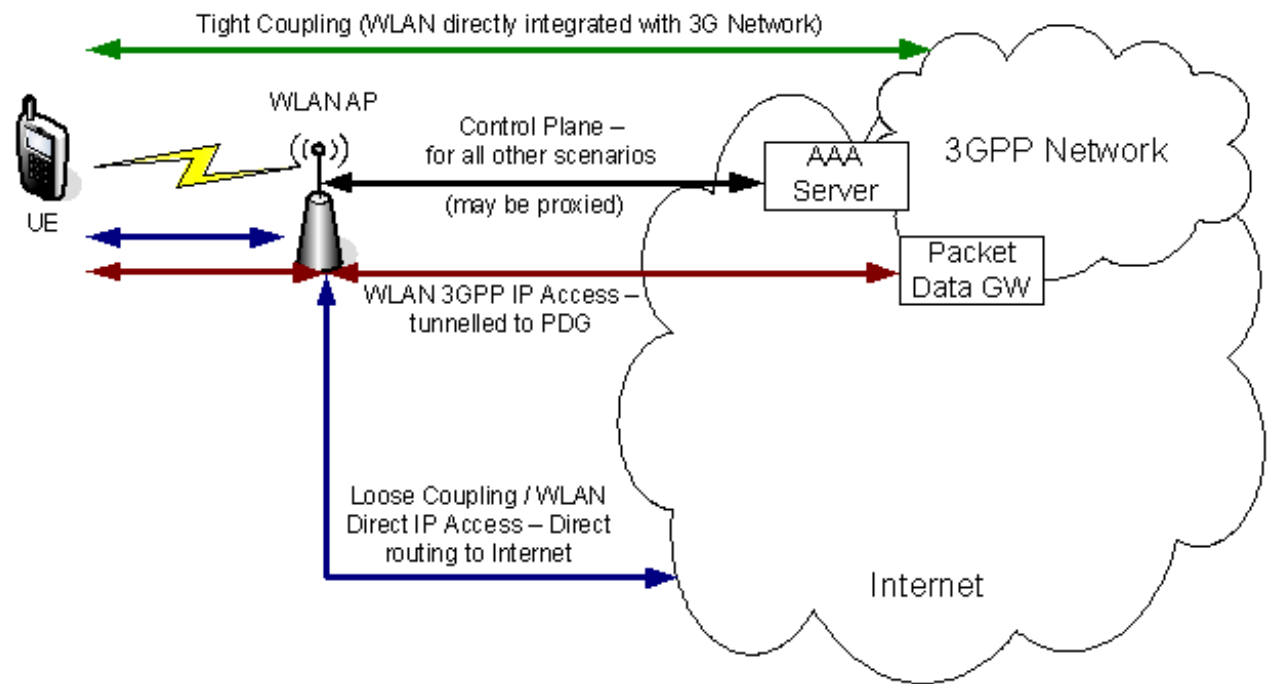
Credit: Bob Briscoe

# Internet – tussle at *run time*

- Normal world
  - Tussle at design time
  - Internet world - things change faster
  - Fast changing technology (software is plastic) (processing, BW, access)
  - Openness & transparency
  - New applications – rapid turnover
- Business models (value chain, actor-network) fluid (how long for??)
- So engineering design should reflect this: “design the playing field not the outcome”, “tussle at run time” (ie whilst the system is in use)

# Tussle example: 3G/WLAN interworking

- Potential conflicts over:
  - Data path control
  - Branding, caching, content insertion
  - Business models
- Tussles over:
  - Economics
  - Trust
  - Openness



# Our design philosophy

- Issues with the two extreme approaches:
  - **All “clean-slate”**
    - Significant technical hurdles for early adopters, with uncertain and distant economic rewards
  - **All “incremental”**
    - Cannot address the set of Internet architectural challenges with a set of incremental patches
      - each isolated fix ossifies some of the architecture – feature interaction hell
  - Neither extreme works in practice
- Our architectural design activities focus on a **clean-slate approach** to develop a Future Internet for the **next 20+ years**
- This design is **tempered and refined** by considering the need for **incremental deployment**



# Summary – An Architecture for Change

## Main Objectives

### ■ WP1: Reachability

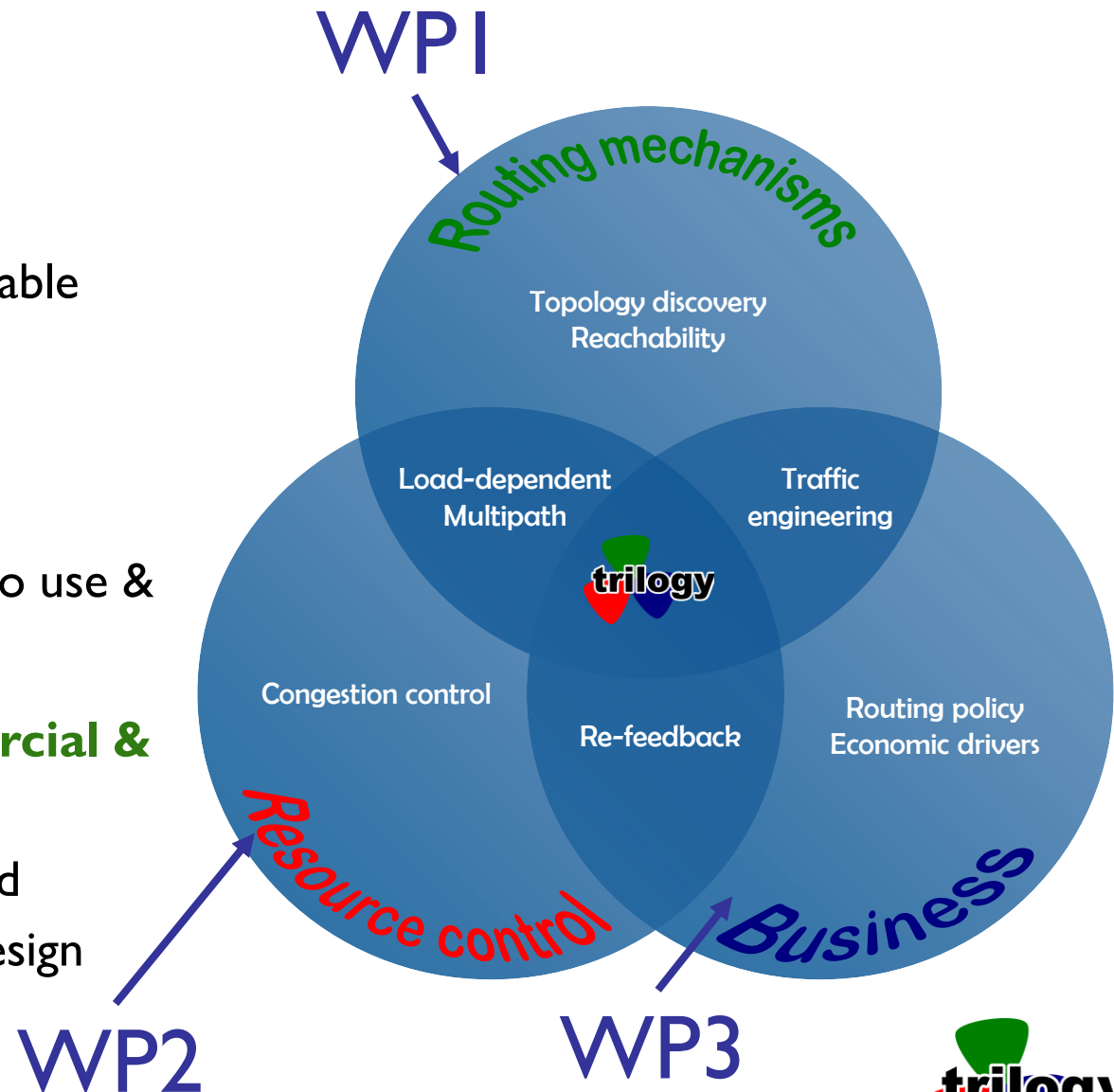
- Enabling two end nodes to communicate across a controllable (scalable, dynamic, resilient) internetwork

### ■ WP2: Resource control

- Allow a diverse set of parties to use & share this internetwork

### ■ WP3: Socio-economic, commercial & strategic factors

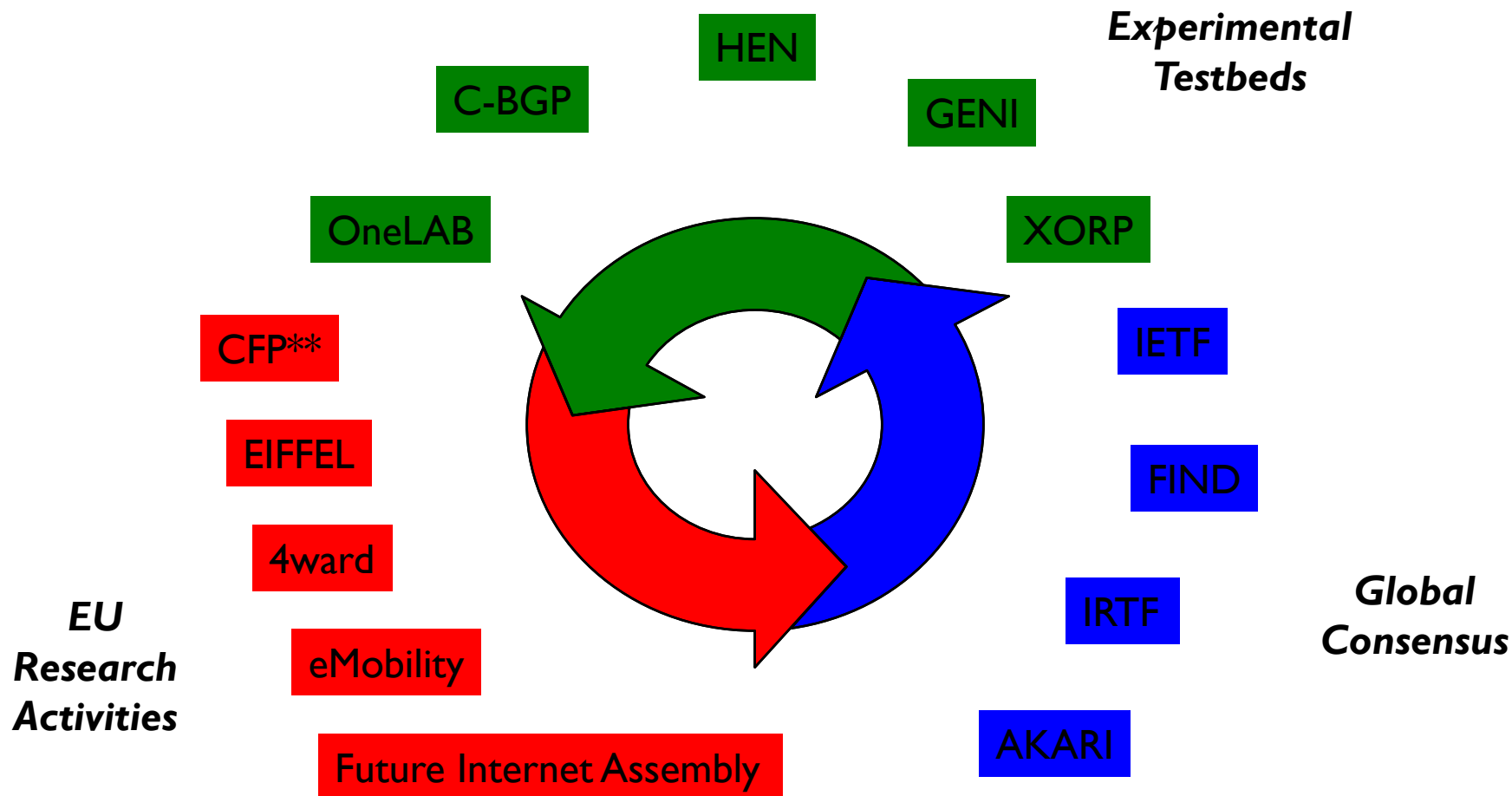
- Assess whether we have indeed achieved a 'design for tussle' design



# Project key issues

- Establish & control transparent reachability in a scalable, dynamic & resilient manner
  - Topics include: routing, multi-homing, remote traffic filtering
- Develop & evaluate a unified approach to resource control that is efficient, fair and incentive-compatible
  - What is a resource?
    - Congestion
    - Storage, battery life, spectrum...
- Allow a diverse set of parties to use & share the internet network
- Understand what architectural features allow controlled behavioural flexibility for different technical, social and economic outcomes
- Interact with business stakeholders from beyond project to get commercial/strategic steer

# Trilogy interactions



\*\*Communications Futures Programme

# ReArch workshop



*ReArch '08 is organised  
in collaboration with  
Trilogy*

## ReArch '08

*“Exploring what is broken with the Internet  
architecture and how to fix it.”*

**IMDEA Networks & University Carlos III of Madrid,  
Spain**

**9<sup>th</sup> December 2008**

**<http://www.sigcomm.org/co-next2008/rearch.html>**



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**Collocated with ACM CoNEXT 2008 Conference sponsored by ACM Sigcomm**

- <http://www.sigcomm.org/co-next2008/rearch.html>
- Submissions are open to all and very welcome
- Submission deadline: 15 August 2008
- “Exploring what is broken with the Internet architecture and how to fix it.”
- Papers that present interesting, fresh ideas at an early stage are more suitable for this workshop than highly polished results or incremental refinements of previous work.
- Position papers also welcome



# Trilogy Participants

## Partners

- **Operators**
  - BT (Coordinator)
  - Deutsche Telekom (WP3 leader)
- **Vendors**
  - NEC Europe (WPI leader)
  - Nokia (WP2 leader)
  - Roke Manor Research
- **Academia**
  - Athens Univ. of Economics and Business
  - Universidad Carlos III de Madrid
  - University College London
  - Université Catholique de Louvain
  - Stanford Law School
- **Project Administration**
  - Eurescom

## Key People

- **Operators**
  - Bob Briscoe, Philip Eardley
  - Anja Feldmann, Roger Karrer
- **Vendors**
  - Rolf Winter, Marcus Brunner
  - Lars Eggert, Pasi Sarolahti
  - Robert Hancock
- **Academia**
  - Costas Courcoubetis
  - Marcelo Bagnulo, Iljitsch van Beijnum
  - Mark Handley, Damon Wischik
  - Olivier Bonaventure
  - Barbara van Schewick
- **Project Administration**
  - Adam Kapovits

# Contacts

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## WP2 – Resource Control

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## WP3 – Social & Commercial Control

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