Towards a new (?) Internet architecture

Dr. Bengt Ahlgren
Bengt.Ahlgren@sics.se

SICS - Swedish Institute of Computer Science
Overview

- The end-to-end arguments as a design principle
- New requirements that are emerging
- Technical responses
- Larger context (non-technical)
- Tussle in Cyberspace
References

• Marjory S. Blumenthal and David D. Clark.  
  Rethinking the design of the Internet: The end to end arguments vs. the brave new world.  
  ACM Transactions on Internet Technology, Vol 1, No 1, August 2001.

• David D. Clark, John Wroclawski, Karen R. Sollins and Robert Braden.  
  Tussle in Cyberspace: Defining Tomorrow’s Internet. 
End-to-end arguments

- Design principles which characterise how the Internet was designed.

- Formulated by Saltzer, Reed and Clark in the beginning of the 80-ies. (A classic!)

- States how application requirements should be provided for in a system.

The end-to-end arguments

“The end-to-end arguments suggest that specific application-level functions usually cannot, and preferably should not, be built into the lower levels of the system – the core of the network.”
The e2e-arguments as a design principle

Benefits:

• The complexity of the core network is reduced, which reduces costs and facilitates future upgrades to the network.

• Generality in the network increases the chances that a new application can be added without having to change the core of the network.

• Applications do not have to depend on the successful implementation and operation of application-specific services in the network, which may increase their reliability.
Result: The core network provides a very general data transfer service which is used by all applications.
The e2e-arguments as a design principle

Some reflections:

- *Basis for innovation!*

- Anyone can launch new applications and services directly to customers without asking anyone for permission.

- You do not need to convince a network operator that they should ‘provide a service’.

- A strong reason and prerequisite for Internet’s success and growth!
The key element: Vertical separation

The basic architectural difference between IP based networks and traditional telecommunication:

- **Data transport is separated from application services**

(A consequence of the end-to-end design principle)

⇒ The Internet architecture maximises innovation in applications and application services!

⇒ Affects business models!

⇒ Cannot only charge for application services – need to charge for the bits!
Vertical separation introduces new business roles. Network operators peer at packet connectivity level – not application level.
Moving away from end-to-end

- A number of new requirements have emerged.
- To certain stakeholders, these requirements may best be met by adding functionality to the network core.
- This has raised concern among those who wish to preserve the benefits of the original Internet design.
Emerging new requirements (1)

- **Operation in an untrustworthy world**
  There are less and less reason to believe that we can trust other end-points to behave as desired.

- **More demanding applications**
  Such as real time requirements from audio and video applications.
Emerging new requirements (2)

• ISP service differentiation

If enhanced services are not provided end-to-end, then it is not possible to design applications needing these services using an end-point implementation.

The concern here, however, is that investment in closed islands of enhanced service, combined with investment in content servers within each island, decreases the motivation for investment in the alternative of open end-to-end services.
Emerging new requirements (3)

- **The rise of third-party involvement**
  An increasingly visible issue is the demand by third parties to interpose themselves between communicating end-points, irrespective of the desires of the ends.

- **Less sophisticated users**
  By implying that substantial software is present at the end-node, the end-to-end arguments are a source of complexity to the user, in that software must be installed, configured, upgraded, and maintained.
Emerging new requirements (4)

- None of these alone are powerful enough to transform the Internet, but taken together they can motivate the move towards a centralised network.

- “At issue is the conventional understanding of the ‘Internet philosophy’: freedom of action, user empowerment, end-user responsibility for actions undertaken, and lack of controls ‘in’ the Net that limit or regulate what users can do. The end-to-end arguments foster that philosophy because they enabled the freedom to innovate, install new software at will, and run applications of the user’s choice.”
Tension between interests

- Controlling dissidents – controlling terrorists
- ISP’s responsible management of services – ISP’s manipulative control (e.g., content pricing)
- Perhaps most contentions: issues surrounding the increasing third-party involvement in communication between cooperating users.
Ex. of reqs in today’s communication

- Users communicate but don’t totally trust each other – negotiate binding contract, external confirmation of identity

- **Users communicate but desire anonymity** – anonymous political speech, ‘whistle blowers’

- End parties do not trust their own software and hardware – growing perception that consumer software and hardware behave as double agent

- **The ends vs. the middle: third parties assert their right to be included in certain sorts of transactions** – gov wiretap, gov spying, gov censoring, gov taxation, ISP traffic regulation, access control to private intranets, private party intervention to protect, e.g., copyright
Ex. of reqs in today’s communication (2)

• **One party tries to force interaction on another** – spam, DoS, intrusion with malicious intent
  “The classic end-to-end arguments would say that each end-node is responsible for protecting itself from attacks by others (hence the popularity of antivirus software), but this may not be viewed as sufficient control in today’s complex network.”

• **Multiway communication**
  “Does this mean that we have to abandon the end-to-end arguments? No, it does not. What is needed is a set of principles that interoperate with each other – some built on the end-to-end model, and some on a new model of network-centered function.”
Technical responses

- **The different forms of the end to end arguments** – one version applies to the core of the network; the other to application design (can the end destination be reached directly?)

- **Modify the end node** – for, e.g., taxation or wiretap; seems fruitless... (c.f., debate on government-accessible encryption keys)

- **Adding functions to the core of the network** – firewalls, traffic filters which prevent certain applications, NAT boxes
The larger context (non-technical)

- Law in cyberspace – solution can also be non-technical

- Competition and the lack of competition
  
  “Any action that an ISP undertakes to enhance its role beyond basic packet forwarding is not likely to be compatible with end-to-end thinking, since the ISP does not control the end-points..."

  For example, some residential users find themselves blocked from running a Web or game server in their home..."

  The concern is not just about choice in ISPs, but that if access to alternative ISPs is constrained or blocked, then users would be able to access some content only with difficulty, if at all.”
Tussle in Cyberspace

The future of the Internet is defined by the tussle between parties with different interests:

- users
- commercial ISPs
- governments
- intellectual property rights holders
- providers of content and higher level services (for profit or for free)
Main design principle

Main principle: “Design for variation in outcome, so that the outcome can be different in different places, and the tussle takes place within the design, not by distorting or violating it. Do not design as to dictate the outcome. Rigid designs will be broken; designs that permit variation will flex under pressure and survive.”
More design principles

- **Modularize along tussle boundaries** – try to isolate different tussles in order to minimise distortion between different functions.

- **Design for choice** – protocols should be designed so that the different parties have a choice with whom to interact with.
Some implications

- Choice often requires open interfaces
- Tussles often happen across interfaces
- It matters if the consequence of choice is visible
- There is no such thing as value-neutral design
- Don’t assume that you design the answer – you design the playing field
One tussle space: Economics

- Economics – an important driving force that changes the Internet

- Competition is necessary in any marketplace – customer must be able to choose ("design for choice" rule)
Revisiting end-to-end

Most important:

- Keeping the network open and transparent for new applications is the most important goal!
Summary

- New requirements are emerging as a result of the success of the Internet – requirements that are difficult to accommodate
- Not only technical solutions are needed: also law and economics
- Increasing tension between interests
- Need to accommodate the tussle between these interests within the network architecture
- Design for choice – customer must be able to choose in order for competition to work
- Keeping the network open and transparent for new applications is the most important goal!