

# One view of the Internet architecture

AfriSIG

November 2017  
Sharm el Sheikh

Avri Doria



# [ ] Some initial questions

- What does this have to do with Internet governance?
  - do those creating the protocols, standards and codes think they are doing Internet governance?
  - or care?
- Are principles involved in protocols & architecture?
  - Internet principles? What sort of principles?
    - What about each “in their respective roles”, is that relevant to protocol principles?
  - does it have an effect on what is produced?

# GOVERNANCE



# Back to the internet governance working definition

A working definition of Internet governance is the development and application *by governments, the private sector and civil society, in their respective roles, of shared principles, norms, rules, decision-making procedures, and programmes that shape the evolution and use of the Internet.* (WGIG and Tunis Agenda § 34)

- *Creative ambiguity*
  - *at its best or at its worse?*
- *What do all these words mean?*
  - *especially when juxtaposed in this way?*
  - *How many ways can they be used?*

# An example of creative ambiguity

- A political scientist's understanding of *Principles, norms, rules and decision-making procedures and programs* may be based international regime theory - “(free-standing injunctions or coherent international regimes)”

Or

- *Principles, norms, rules and decision-making procedures and programs* – includes the code, protocols and standards used to allow an emergent internet to function properly. And this notion includes the most critical Internet policies
  - *those embedded in code.*

# Assertions and counter-assertions

- *Code, Standards, and Protocols are a major means by which these norms, rules decision making procedures and programmes are instantiated in the network*
- ✧ *Historically, for the most part, the people doing the work, don't know or believe that. They are just doing technical work and don't care about policy, hate politics and shun those who talk about governance.*
- ✧ *Historically, for the most part, the policy makers don't think the techies matter and believe that the technology is largely irrelevant, policy is policy and implementation is implementation, and never the twain shall meet.*
- *Is this is changing?*
  - *Slowly perhaps through research work*

# some more very basic definitions

## In English

a protocol is a code of correct conduct, forms of ceremony and etiquette observed by diplomats and heads of state, sometimes a basis for comparison;

a standard is any distinctive flag, a reference point against which other things can be evaluated

a code is a set of rules or principles or laws (especially written ones), a coding system used for transmitting messages requiring brevity or secrecy

## In network engineering

a protocol is the set of rules determining the format and transmission of data

a standard is a formalization of a protocol or a practice

code is the symbolic arrangement of data or instructions in a computer program or the set of such instructions, the implementation of that protocol, what makes the Internet a unique thing in itself

# Two views on Internet Governance

- the Internet can be understood by reference to other institutions in society, e.g.
  - telecommunications,
  - media
  - trade
- and thus is subject to the same rules
- and warrants the same form of analysis

it is  
a new sort of thing  
that requires new rules  
and new analysis



# Is it a thing in itself?

- Is the Internet sui generis?
- While at a high enough level of abstraction we can use pre-existing knowledge structures to try and understand it by analogy, those explanations will always fall short, though they may provide a clue.
- Why makes it is a unique thing in itself?
  - The Internet is a self healing system composed of a boundless complexity of code created in a novel political environment, a thing that continually captures and recombines human intent and know how, and a system that can behave dynamically to produce an unlimited number of unexpected new possibilities.

# What does this mean for academic study?

- While the Internet is unique it does not exist in a vacuum, knowledge from other fields can be used to begin understanding. But important to remember
  - it is only analogy not actual
  - the process is one of adaptation through assimilation and accommodation
    - in the first instance we use the structures that the academy (political theory, economic theory, psychology, social theories of all sorts and varieties) has already created to assimilate the Internet into our understanding
    - then we need to adapt our knowledge structures to accommodate the uniqueness of the Internet.



# What does this mean for Internet Governance

- The uniqueness of the Internet means that extreme care must be taken in trying to apply existing governance regimes, e.g. regulatory policy or oversight mechanisms, to the Internet.
  - they are not likely to work as expected
  - the law of unintended consequences functions in overtime.
  - they are just as likely to cause public harm as they are to contribute to the public good
- That is, you can't treat the Internet as if it were telecommunications or Information and Communication Technology (ICT) or media

# PRINCIPLES



# What are Internet principles?

- Engineering constructs
  - guide system designers
  - give a basis for making choices between equally acceptable engineering solutions.  
i.e. to balance between
    - Cost
    - ease of deployment
    - Human rights
      - Of Expression, Association, Privacy, Access to Culture and Knowledge
      - Property rights, et al.
  - enable distributed community of designers and architects to build a single consistent system
  - Two types
    - Design
    - Operational



# Some Internet principles

- Design Principles
  - Packet based nature of the network
  - The End to End Principle
  - Postel Robustness Principle
  - Layered architecture
  - Hourglass Model
  - Shared Fate
  - Creative Anarchy
  - Variation in outcome
- Operational Principles
  - Naming – “there only can be one”
  - Routing & Addressing
    - Routing on addresses not names
    - Overloading/Separation of Location ID and Endpoint ID
    - Scope of address/name
    - Early vs. Late Binding
    - Types of routing protocol
      - Metric Vector
      - Shortest Path

# Packet based network

- First discussed by Leonard Klienrock and Paul Baram and Donald Davies in 1960.
- Moved away from the centralized switching network paradigm of the telecommunications era
  - create connections, control and manage connections, billing
- Allows for a confederated network of networks where each network handles the datagram (aka packet) using the best paths that exist at that point in time according to its own policies. (hop by hop)
- Allows for development of a network with emerging properties.

## end to end principle

*The function in question can completely and correctly be implemented only with the knowledge and help of the application standing at the end points of the communication system.*

*Corollary:* the only elements that belong in the lowest layers of the network are those elements that are useful to all of the other parts of the network

*Difficulty: identifying the ends*



## e2e too

- First defined in 1980 (Saltzer et al.)
- Often used in political discourse
  - occasionally abused, often misunderstood
- Principle focuses on putting the information at the appropriate place in the network.
  - so for applications, yes, it is at the user interface
  - but, e.g., for routing it might be at the edge of a network
- Does not speak to putting all intelligence at the edges
- Does not speak of a dumb network
  - whatever that means.

# Postel robustness principle

“Be conservative in what you send and liberal in what you accept”

- Documented in RFC 793 - Transmission Control Protocol (i.e TCP)
- Important in building networks
  - Being strict means following the protocols specifications as carefully as possible to avoid ambiguity
  - But if there is enough information to support a request then don't throw it out because of a difference in coding or interpretation (sometimes called an error, but it might not be)

# Layered architecture

- A layered architecture is one where data moves from one layer to another and is subject to a different form of processing at each layer
- A layered architecture encapsulates or transforms the data packet received from the next higher layer, or
- A layered architecture de-encapsulates or transforms the data packet received from the next lower layer
- e.g.

```
{link layer {ip layer {transport layer {application layer { data} } } } }
```

# IP suite layers

## sort of 4 layers

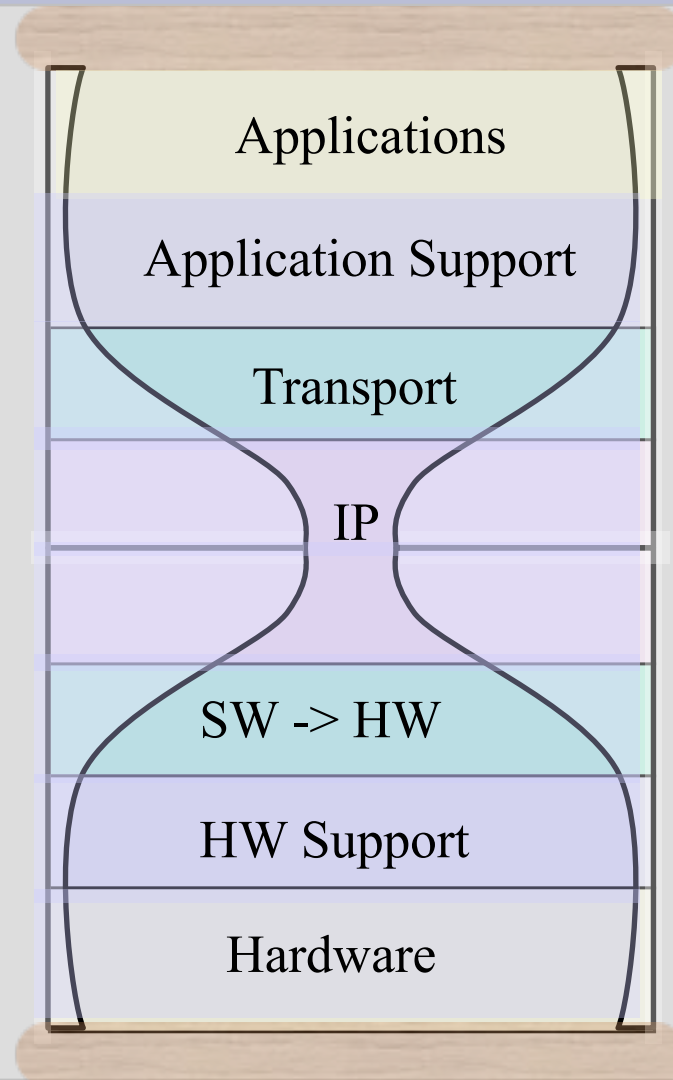
- *Application Support Layer* : DNS, FTP/TFTP, TLS/SSL, SSH, HTTP, HTTPS, IMAP, POP3, IRC, NNTP, RTP/RTCP, SIP, SMTP, SNMP, SSH, BitTorrent
  - Additionally, routing protocols like BGP which run over transport layer
- *Transport Layer*: TCP, UDP, DCCP, SCTP, DTN bundle layer, ...
- *Internet Layer* (has multiple sub-layers – sort of):
  - ICMP, IGMP, and routing protocols like OSPF that run over IP
  - IPv4, IPv6
  - ARP
- *Network Layer*: Ethernet, Wi-Fi, Wi-Max, PPP, Frame Relay, Raw WDM
- *Exceptions*:
  - MPLS which leads to layer stacking and layer inversions
  - And address translation between Transport and Internet layers
  - And VPNs ...

# hourglass model

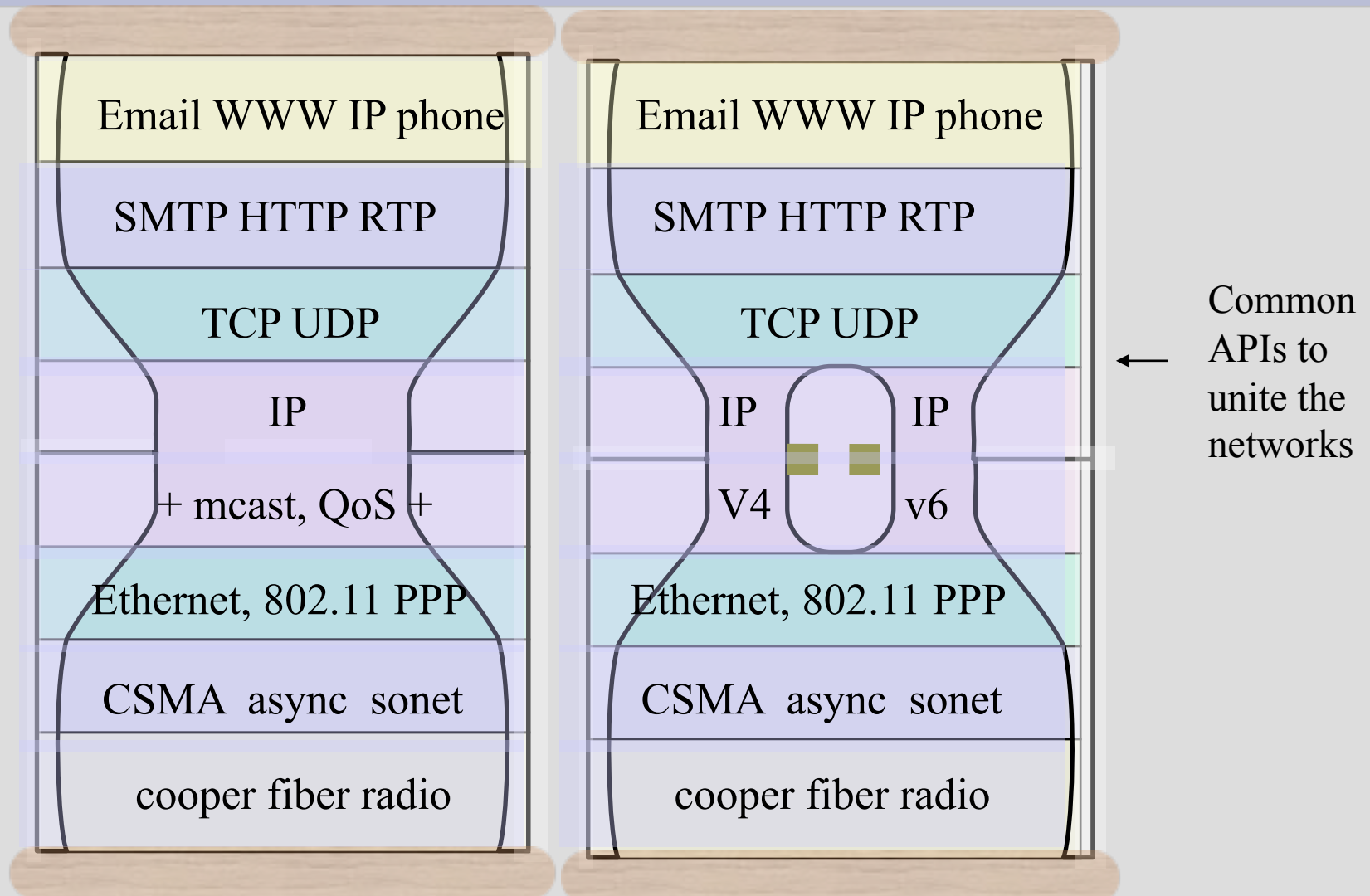
All upper layers converge on IP at the network layer  
All lower layers converge on IP at the network layer  
IP is the waist of the hourglass

- A de facto principle.
- A common point in the architecture that allows for multiple applications to sit over multiple forms of link technology
- A key factor in allowing for innovation.
  - An application layer developer does not need to worry about the infrastructure details
  - Infrastructure developers don't need to worry about applications.

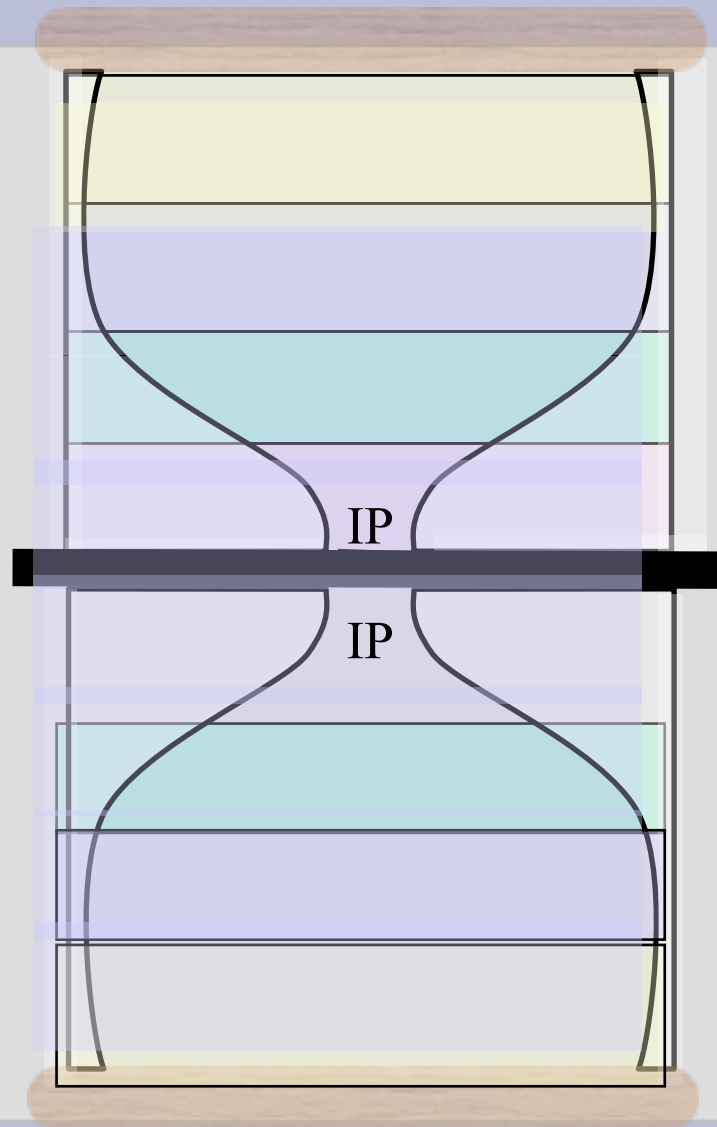
# The proverbial IP hourglass



# Fattening and Splitting



# Middleboxes

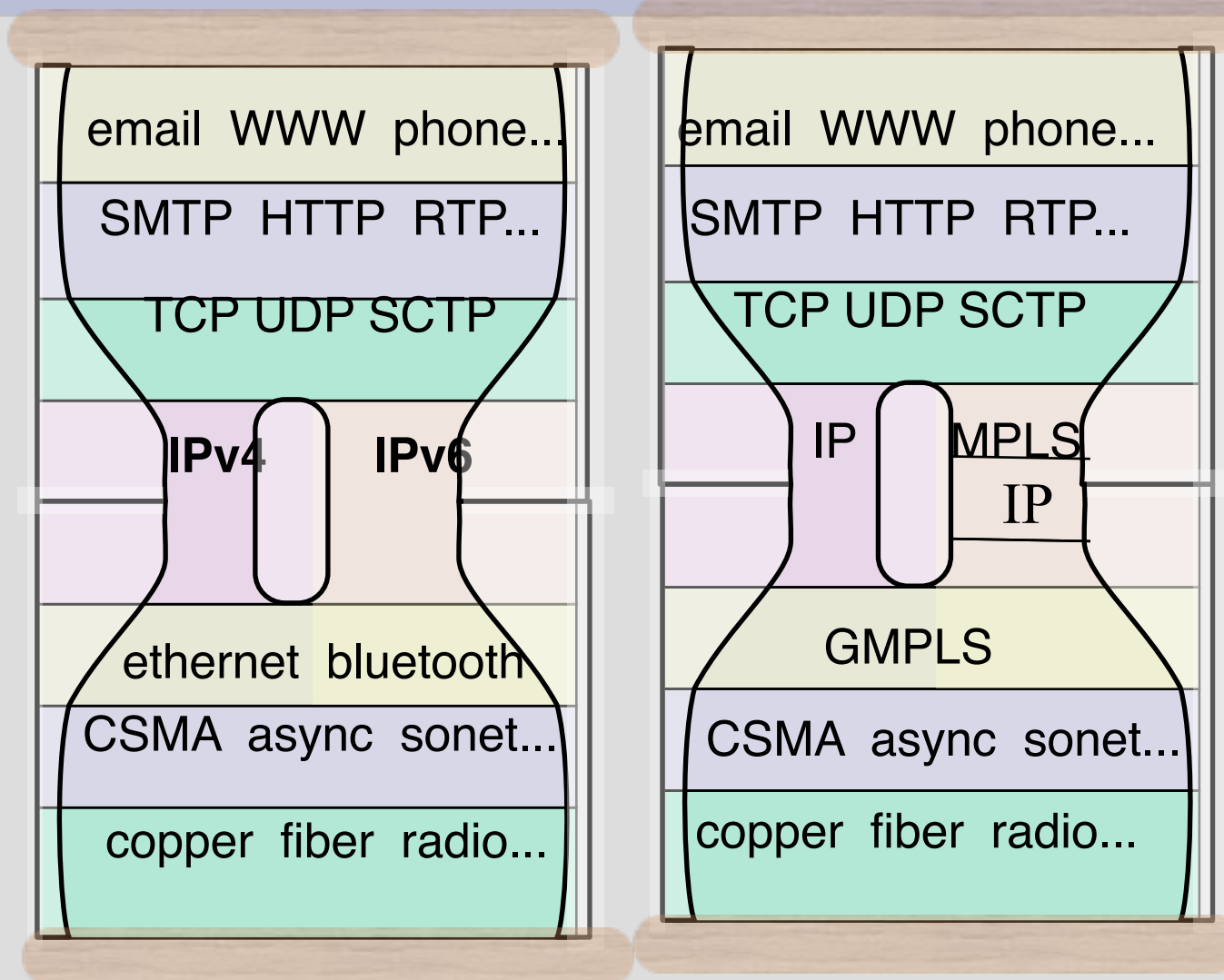


e.g. NAT,  
firewall,  
VoIP server,  
VoD server,  
3G service box  
DSLAM, .....

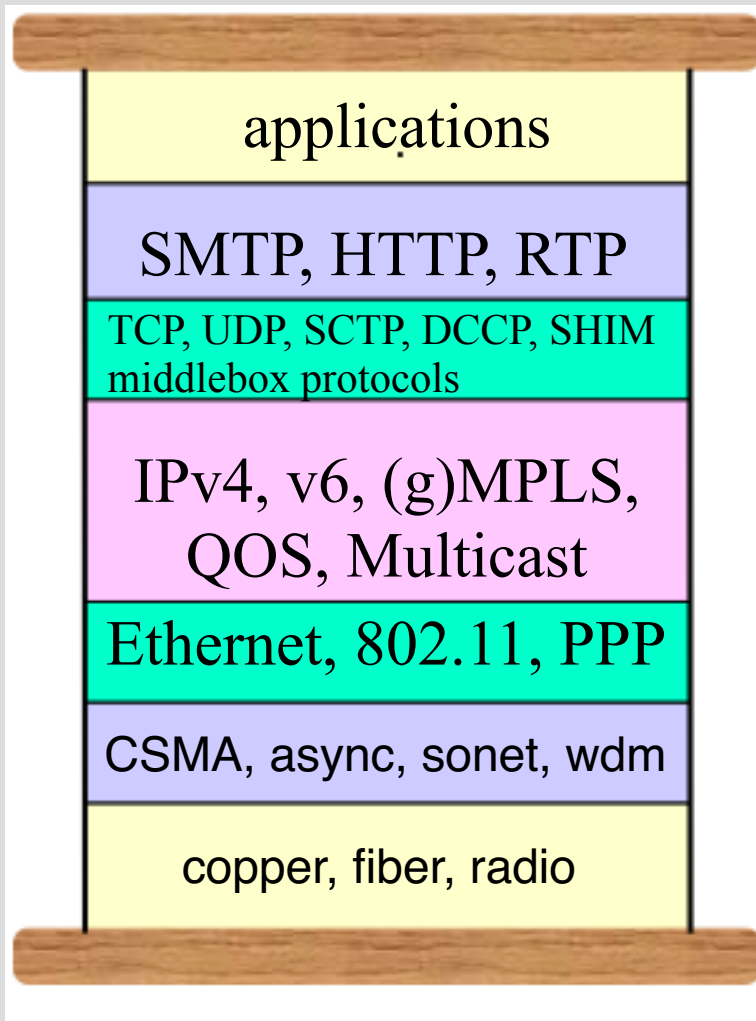




# Replacement and Inversion

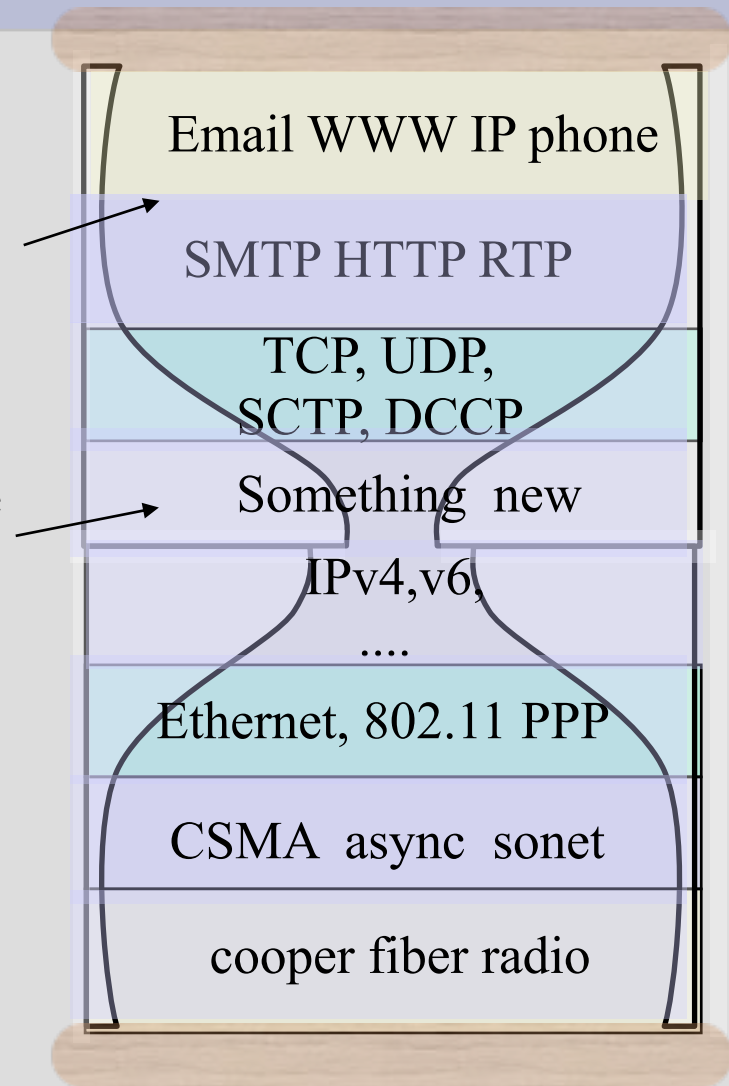


# Ultimately



Port 80  
the new  
waist?

or maybe  
someday



Under construction

# Shared fate

- Means that control information travels the network along the same transport as the data.
- Fundamental to the management of the network
- Without an assumption of shared fate, there needs to be an entire separate network management structure
- Fundamental in Routing design
- ‘Broken’ by Multipath Label Swapping (MPLS) and tunnel based routing techniques
  - Reason for difficulty in managing MPLS and Tunneling

# Creative Anarchy

- Also known as Generative nature
- No top down design
- Principles and creativity instead of a design committee
- Anyone, anywhere, can still contribute the next innovation.
  - Just need to be creative and know how to code.
- Credited for invention of new application models such as wikis and social networks
- Seems as a fundamental problem by some e.g. Jonathan Zittrain, ITU...
  - Responsible for spam and viruses?

# Variation in Outcome

- Just because something is built for one purpose, does not mean it will be used for that purpose.

“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 so as to dictate the outcome. Rigid designs will be broken; designs that permit variation will flex under pressure and survive.”

Clark et al.

# PROTOCOLS & STANDARDS



## [II] Protocols in the software sense

- In order for two network entities to talk to each other, they need messages that:
  - are part of an ordered set
    - (does not need to be strict ordering)
  - include response mechanisms
  - strictly defined syntax
  - strictly defined semantics



# What is the relationship between protocols, code and standards?

What came first  
the standard or the protocol?  
or was it the code?

- sometimes there is dialectical movement in this process
  - e.g. ...protocol -> standard -> code -> protocol+1

But only sometimes  
this depends on which  
Standards Development Organization (SDO)  
controls the process



# But where do protocols/standards come from?

- Some are produced independently and become de facto standards
- Some are produced by Standards Development Organizations (SDO's) through a variety of paths



# Some possible definitions of SDO

- An intergovernmental institution authorized by treaty, or otherwise, to create standards that may be either mandatory or voluntary
- An industry body that creates standards that are used by its members in Request for Product (RFP)
- An ad hoc grouping that creates standards track proposals that becomes standards when adopted by the market
- A private entity that uses contractual conditions to impose its policy standards

Standards are the link between protocols and Internet governance, and the SDO is where it happens.

# Code in the technical sense

- Bit and byte centric,
  - i.e., each bit or byte has meaning based on its position in the datagram and context
- The prototype for many protocols
- The implementation of many protocols
- No matter what the standard says, the code of the dominant player becomes the de facto standard
- Affected by Postel's robustness principle: be conservative in what you send and liberal in what you accept

Code instantiates protocols and becomes the de facto standard.

# Standards in the social sense

- “The wonderful thing about standards is that we have so many of them to choose from” (*Grace Hooper, or Ken Olson, or Patricia Seybold*)
- Standards equalize the playing field
  - Businesses often abhor an even playing field
  - Users need standards
  - Competition requires standards
- Could we have an internet without standards?
  - Standards can limit innovation
  - Standards can enable innovation
  - Depends on what kind of standards
- So who makes the standards?
- Whose **role** is it anyway?



# MULTISTAKEHOLDER MODELS



# Questions about Stakeholders and respective roles

- Arguments for legitimacy
  - Is it the task of governments to make rules even where they are not required or even useful?
  - Does running code define legitimacy? if not, what does?
  - The Roles & Responsivities conundrum
    - With WSIS governments defined a role for themselves
    - Does this denigrate the roles and responsibilities of those who built the network?
  - Are business and intellectual property forces attempting to control what protocols can be used on the Internet?
- Is the Internet the most recent battle field for freedom from authoritative hierarchical control by governments and appropriation of the commons by industry?
- Are there truce lines in this battle? Where are they?

# Forms of

## MultiStakeholder Governance model

- IETF individual participant model in some ways the original multistakeholder organization in Internet Governance – individuals can participate freely
- Other organizations include institutional membership or other participation criteria
- In most of these one stakeholder dominates
  - government led: e.g. ITU – State controlled
  - Business/IP led: e.g. ICANN - multistakeholdergroupism
  - Community led: e.g. IETF, RIRs – individual stakeholders
- For some the hope for the future is multistakeholderism with equal footing:
  - the IGF attempts to approach this goal
  - There are other approaches

# Generalizations

- Real issues are often at confluence of policy and technology
- Each can affect the other
- Internet governance is not just a process, it is a a tussle of conflicting principles and priorities
- Code governs what is possible
- Policy covers what is allowed
- Sometimes code comes first and drives policy
- Sometimes policy comes first and directs code
- Code is often hardened policy
- others?



# The Case of .home RFC6761, RFC 7788 and

## CASE STUDY



# Background

- RFC7788 told implementers to use .home for the homenets
- Everyone, me included, missed it
- .home is a name applied for in ICANN and put on hold
- Once noticed an Errata was issued. Errata breaks the protocol
- A replacement RFC was defined. Now use home.arpa
  
- RFC 6761 allowed for special use names
- RFC7788 did not follow that process

# The problems with RFC6761

The 6761 problem statement draft.

- Problem Statement for the Reservation of Top-Level Domains in the Special-Use Domain Names Registry

<https://www.ietf.org/id/draft-adpkja-dnsop-special-names-problem-04.txt>

- Special-Use Names Problem Statement

<https://datatracker.ietf.org/doc/draft-tldr-sutld-ps>

- The ALT Special Use Top Level Domain

<https://datatracker.ietf.org/doc/draft-ietf-dnsop-alt-tld/>

# Open Question

- How to deal with conflicts between IETF special use and ICANN responsibility for allocating domain names
- If a name is not used by the DNS, is it a domain name?
- How do the IETF and ICANN coordinate a shared responsibility for names

questions?

thanks

[avri@doria.org](mailto:avri@doria.org)



# Extra slides - SDO



# Getting back to examples of SDOs

- IETF  
*Stakeholder:* individuals from any stakeholder group  
*Process:* maybe requirements -> protocol -> code -> protocol+ -> standard -> better code
- ITU-T study group  
*Stakeholder:* governments with some industry  
*Process:* “political” requirement -> architecture -> protocol -> standard -> publication -> code (maybe)
- WGEC  
*Stakeholder:* 1/2 government, 1/2 civil society, private sector + technical community  
*Process:* discussion from principle, recommendations to CSTD (UN)

# some references

- Primary sources:
  - WGIG report: <http://www.wgig.org/docs/WGIGREPORT.doc>
  - The Tunis Agenda: <http://www.itu.int/wsis/docs2/tunis/off/6rev1.pdf>
  - The original article on the end to end design principle:  
<http://web.mit.edu/Saltzer/www/publications/endtoend/endtoend.txt>
  - Tussle Article: <http://www.sigcomm.org/sigcomm2002/papers/tussle.pdf>
- Also:
  - WGIG Background report: <http://www.wgig.org/docs/BackgroundReport.doc>
  - A book on the issues by the WGIG (UN working group on Internet Governance) members [http://www.wgig.org/docs/book/WGIG\\_book.pdf](http://www.wgig.org/docs/book/WGIG_book.pdf)
  - A book analysing some of the current themes in Internet Governance <http://medienservice.land-der-ideen.de/MEDIA/65534,0.pdf>
  - Internet Technology and Networks (charter18) [http://www.apc.org/en/system/files/APCHandbookWeb\\_EN.pdf](http://www.apc.org/en/system/files/APCHandbookWeb_EN.pdf)