Information Technology
Inside and Outside
- David Cyganski & John A. Orr

VII. Networks and the Internet

20. Organization of the Internet

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20. Organization of the Internet

- Objectives:
  - what the Internet is and is not;
  - the systems design process that led to the Internet standards which have proven so broadly useful;
  - specific Internet addressing schemes: OUI and IP addresses, and DNS host names;
  - the central role of routing in the Internet;
  - the makeup of the Internet backbone; and
  - the role played by Internet Service Providers (ISPs).

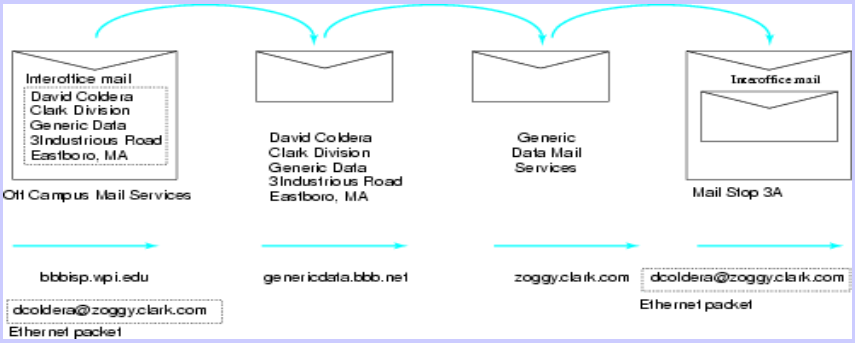
20.1 Introduction

- The Internet is **not a single entity** or even a uniform collection of entities.
  - The Internet describes **a system with the complexity and dynamics of the ``Government.''**
  - The Internet began as an experiment based on the freedom to **interconnect any device based on rules of protocol** and not on the particular wires and signals used to carry that information
  - coordinated collection of **backbone**, **national**, **regional**, and **local access providers**.
  - The **routing of information** on the Internet may **vary from minute to minute** and may involve transmission over many different subsystems chosen on the **basis of available bandwidth and rate structures**.

20.2 How Would You Organize Universal Mail Delivery?

- The **delivery of an e-mail message** via the Internet

Figure 20.1: As explained in the text, there are deep parallels between the routing of mail between organizations and the routing of e -mail between individuals on the Internet.



20.2 How Would You Organize Universal Mail Delivery?(2)

- The **delivery of an e-mail message** via the Internet(2)
  1. Send a piece of **e-mail to our friend David Coldera's PC** at his place of employment. We will **address the e-mail** via a well known protocol. The address describes the broad category of recipients (.com) in the last segment of to specify, and narrower and narrower destination descriptions as we work our way toward the beginning of the line with our friend's computer name and account name last in this right-to-left reading of the address parts.
  2. Our computer **checks the tail end of this address** and determines that it is destined for an off campus location. So, our computer **sends it to a *router* (bbbisp.wpi.edu),** which handles all data packets going off campus. A router is an electronic device that will handle data that arrives and departs from the Internet Service Provider's (ISP's) network. Our computer sends the data there by wrapping it in an electronic sack with the router's LAN address. The sack is an Ethernet packet and the OUI for the router is the label on the sack. This first movement of the e-mail has nothing to do with the detailed address of the destination, and is simply based on the fact that the destination is off campus.

20.2 How Would You Organize Universal Mail Delivery?(3)

- The **delivery of an e-mail message** via the Internet(3)
  3. Once it arrives **at the router**, the e-mail is removed from the original Ethernet packet and **routed onto one of several high-speed digital telephone T1 cables**. In this case it is routed to one that connects this **router with our ISP's network**. The decision is again simply based on the fact that we have no direct connection to the final destination.
  4. Within the ISP's network, our friend's account name and computer name are altogether ignored. The ISP's routers forward the letter to other routers based upon the broadest parts of the address information. A complication is actually being breezed over in this description:a router actually uses a directory scheme known as the **Domain Name System to look up the *host name* in the address (**in this case **zoggy.clark.com),** which provides a more detailed geographic code known as an IP address (think of it as a zip code) for the routing of the data.

20.2 How Would You Organize Universal Mail Delivery?(4)

- The **delivery of an e-mail message** via the Internet(4)
  5. Once it arrives at the **company's router (genericdata.bbb.net)**, the data is placed in **another Ethernet packet destined for the particular PC that appeared in the address (zoggy)**. That Ethernet address is obtained by looking up the computer's name in a local directory (it is called an Address Resolution Protocol, or ARP, table).
  6. Finally, having reached **the computer, zoggy**, the e-mail is removed from the Ethernet packet and placed into our **friend's e-mail arrival box.**

20.2 How Would You Organize Universal Mail Delivery?(5)

20.2.1 The Internet: Three Addressing Schemes

1. **OUI Addresses:** These **48-bit addresses uniquely identify every Ethernet** (and Token-Ring LAN card) ever made. These are permanently attached to each card at the time of manufacture.

2. **IP Addresses:** These 32-bit addresses identify every attachment of a machine to the Internet (this has been carefully worded to be exactly correct as a single computer may be attached in more than one way to the Internet). Groups of these addresses, called sub nets, are *geographically co-located*.

20.2 How Would You Organize Universal Mail Delivery?(6)

20.2.1 The Internet: Three Addressing Schemes(2)

3. **DNS Host names:** These alphanumeric addresses parallel the IP Addresses in identifying individual network connections and sub nets, but are further distinguished by a domain hierarchy based on some or all of the following: country code, service code, network name, and/or organization name. Let's examine a concrete example. There is a computer on our campus that is known as *ece.wpi.edu*. This name is actually the DNS host name for the computer. It is easy for people to remember this name because it breaks down into natural units:
   - **ece:** This is the primary computer in the Electrical and Computer engineering (ECE) Department.
   - **wpi:** The ECE department of which we are speaking is in an institution known as WPI.
   - **edu:** WPI is an educational institution.

20.2 How Would You Organize Universal Mail Delivery?(7)

20.2.2 Tracing a Route

Table 20.1: The round trip times reported for Internet communications to a series of routers. All time intervals are reported in milliseconds.

```
 1  bbnplanet.WPI.EDU (130.215.24.9)  9.215 ms  15.666 ms  16.532 ms
 2  worcester-cr1.bbnplanet.net (131.192.56.25)  36.596 ms  42.497 ms  63.827 ms
 3  cambridge1-mr3.bbnplanet.net (206.34.110.9)  60.083 ms  76.261 ms  56.262 ms
 4  cambridge1-br2.bbnplanet.net (206.34.78.21)  98.313 ms  74.044 ms  27.291 ms
 5  cambridge2-br2.bbnplanet.net (4.0.2.26)  139.187 ms  446.458 ms  482.561 ms
 6  cambridge2-br1.bbnplanet.net (192.233.33.5)  104.088 ms  76.225 ms  61.284 ms
 7  borderx2-hssi3-0.Boston.mci.net (204.70.179.121)  50.918 ms  167.298 ms  51.31
 8  core2-fddi1-0.Boston.mci.net (204.70.179.65)  240.09 ms  29.653 ms  57.768 ms
 9  core3-hssi-1.WestOrange.mci.net (204.70.1.9)  86.49 ms  79.266 ms  105.992 ms
10  ohio-state-university.Washington.mci.net (166.48.43.250)  64.843 ms  78.222 ms
11  ohio-state-university.Washington.mci.net (166.48.43.250)  104.159 ms  125.177
12  sot5-atm4-0.columbus.oar.net (199.18.202.25)  160.183 ms  189.177 ms  301.07 m
13  oeb8-atm0-0.columbus.oar.net (199.18.202.18)  82.77 ms  70.595 ms  144.468 ms
14  alp-oeb-2.oar.net (199.18.105.182)  157.439 ms  123.238 ms  100.807 ms
15  199.18.101.146 (199.18.101.146)  77.474 ms  146.6 ms  91.233 ms
16  rover.acorn.net (199.218.0.2)  78.937 ms  70.749 ms  92.026 ms
```

20.2 How Would You Organize Universal Mail Delivery?(8)

20.2.2 Tracing a Route(2)

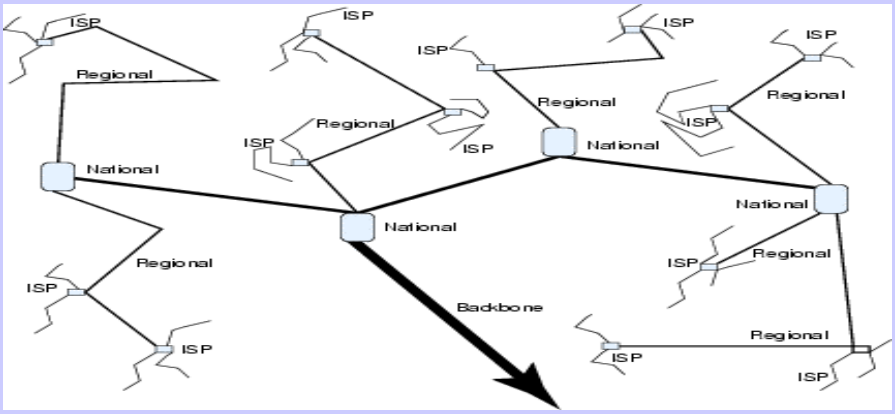
- **Previous Examples**
  - **the number of routers (16)** that need to be traversed on this path. This provides a good picture of the complexity that underlies that Internet despite the impression one obtains of the Internet being a single entity.
  - The **three** numbers report the **round-trip time** (in thousandth of a second) from our machine initiating the probe until the response returned. For example, the three probes of **router number 12** yielded round-trip times of **160.183, 189.177, and 301.07 milliseconds**.

20.3 What Makes up the Backbone of the Internet?

- The various ISPs are like the letter carriers who pick up and deliver the mail to your door. The ISPs will handle movement of data directly that passes from one customer to another of the same ISP. However, data destined for another ISP in the same region is passed between the ISPs through the services provided by a regional Internet access provider. Data headed outside the region will be passed by the regional provider to a national provider, which in turn may purchase access to a backbone cable from a backbone provider to send large collections of data from coast to coast (or similarly large distances)

20.3 What Makes up the Backbone of the Internet?(2)

Figure 20.2: The Internet comprises a system of hierarchical access providers that move data over short and long distances by using the same scheme that has been used by post offices for centuries.



20.3 What Makes up the Backbone of the Internet?(3)

Figure 20.3: The Internet is constructed from a wide variety of telecommunication technologies. The use of a common protocol allows us to enjoy the illusion of a single and uniform abstract entity.