The Future of the Nets
or will it be The Net?

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Nets?

◆ multiple 'nets
◆ coming together
  even if it may not seem to make sense
◆ some nets
  phone net
  Internet
  enterprise net
  virtual net
◆ soon one?
  the Internet

Schedule

◆ a little history

◆ a little architecture

◆ the current Internet

◆ some of what's coming

◆ some opinions/worries

◆ a bit over stated in some places to show differences

Background and History

◆ historical competition between circuit- and packet-based network designs

   circuit: phone net, SNA, ATM, frame relay, MPLS, switched optical ...

   packet: XNS, IPX, AppleTalk, IP

◆ historical competition between smart and stupid networks

   smart: phone net

   stupid: Internet

◆ layers get confusing

   layers 1, 2, 3 & 8 interact

Packets!

◆ basic Internet decision: use packets not circuits

Kleinrock's work showed packet switching to be a more efficient switching method

◆ packet (a.k.a. datagram)

| Dest Addr	Src Addr	payload

self contained

handled independently of preceding or following packets

contains destination and source **internetwork** address

may contain processing hints (e.g. QoS tag)

no delivery guarantees

net may drop, duplicate, or deliver out of order

reliability (where needed) is done at higher levels

End-to-End Argument

◆ 1981 paper by Saltzer, Reed & Clark

◆ "smart networks" do not help

adding functions into network can be redundant since actual function is end-to-end

e.g. encryption, data reliability

also harder to change with new technology

also see Lampson *Hints for Computer System Design*

◆ e2e argument projected to mean

no per-session knowledge or state in the network

but some "soft-state" (auto refreshed) may be OK

network should be transparent to end-to-end applications

Traditional Phone Network

- circuits
- connection-oriented
- hard state in network devices
- central resource control
- socialist? "for the good of all"
- applications in network
    - e.g., phone switch
    - end-to-end touch-tone signaling was a mistake
- predictable development path
    - extended development cycle
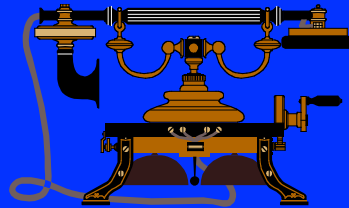
Internet

- datagrams
- soft state in network devices
- competitive resource control
- capitalist? "individual initiative"
    - but too much selfishness hurts all
    - must play by the same rules - but no enforcement
        - **the tragedy of the commons**
- applications in hosts at edges (end-to-end)
- hard to predict developments
    - chaos at "Internet time"

Smart vs. Stupid Networks

◆ phone network technology: self-named "Intelligent Network" (IN)

  many network-based services

    admission control, number translation, accounting, ...

◆ Isenberg's *Rise of the Stupid Network* compared IN to Internet

  Isenberg's basic messages:

    network (i.e. carrier) -based services slow to change

    voice is not all there is

    carrier gets in the way

    just "deliver the bits" works

But!!

◆ a "stupid network" is a commodity service

  the price of a commodity service is driven by the stupidest vendor

◆ hard to make money delivering commodity services

◆ new network infrastructure is very expensive

  fiber optic cables (with installation) & hardware

◆ access rights can also be very expensive

  e.g. wireless spectrum licenses

◆ carriers need something else to make money

  common dream is that content will save the day

    may be a false dream

But!! (2)

◆ packets w/o circuits cause problems
  can not do guaranteed QoS
    can not control path packets take
    can not reserve capacity for application
  security control harder
    do not have logical "wire" back to source
  management harder
    can not see data patterns on the network
    finding non-catastrophic failures harder
  service provider interconnections harder
    no clean interface

!QoS

Conceptualization Problem

◆ fundamental disconnect between "Internet" and "phone" people "bell-heads vs. net-heads"

◆ by their definition the Internet can not work
  and must be fixed - they will rescue us

"*You can not build corporate network out of TCP/IP.*"
IBM circa 1992
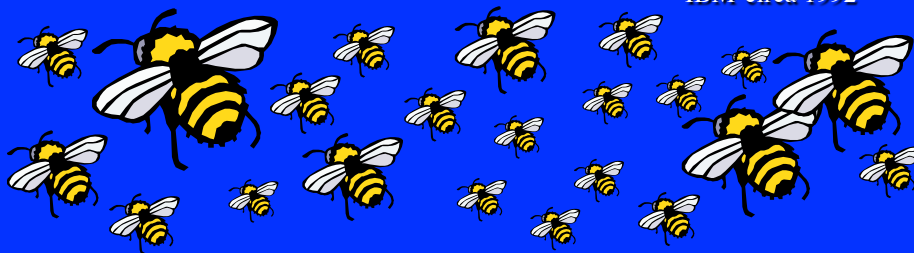
More Conceptualization Problems

◆ service provided by 3rd parties - not only by carriers

 different from phone world

◆ a quote from Sunday, 16 Apr 2000 11:10:57

```
Hi Roy,
  I still don't understand why it is a "users"
  choice where the "services" are executed - I
  would have thought that this would be
  networks choice - and the means for doing
  that is what we are now discussing.  Can you
  please clarify why a user "MAY" which to
  decieded this.
```

Summary of Architectural Points

◆ datagram-based network
 not circuit switched
◆ network of networks
 different parts under different management
◆ minimize per-session state in network
 some auto-refreshed state is OK
◆ end-to-end model maximizes flexibility
 network does not need to know what you are doing
◆ "smart wires" can get in the way
 e.g., nested control loops
◆ reliable delivery is an option
 not a requirement - normal service is "best effort"

Current Internet Architecture

✖ you are here
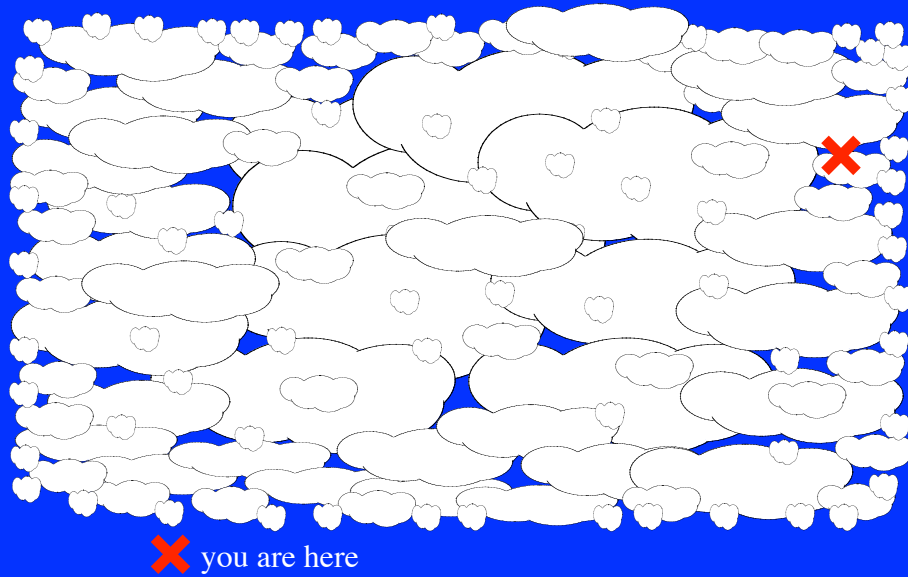
Important Developments

◆ many areas

◆ a few sample areas:

wires

sub-network

network

telephony

◆ a few snap shots

far too much going on to do a comprehensive review

Wires

◆ Ethernet

◆ wireless:

   WLAN

   WPAN

   3G

◆ cable modem

Ethernet

◆ 1 Gb done

◆ 10 Gb underway

   open issues

      e.g. framing: Ethernet or SONET

      push to support jumbo frames (> 1500 byte)

         but backwards compatibility issues

◆ moving into the carrier space

   metro Ethernet & long haul Ethernet

   a big challenge to traditional carriers

Wireless: LANs

- IEEE 802.11
  - 11 Mbps LAN
  - widespread use
- some competing technologies
  - 802.11 seems to have the market
- IEEE standard

- 802.11 based ISPs (some free nets) starting up
  - e.g. down town Palo Alto CA
- also used for home networks

Wireless: PAN

- IEEE 802.15, a.k.a. Bluetooth
  - grouper.ieee.org/groups/802/15/index.html
  - also www.bluetooth.com
- **W**ireless **P**ersonal **A**rea **N**etwork
  - 10 m radius wireless
  - low power
- IETF IP over Bluetooth BOF

- worry about interference and small # of nodes

Wireless: 3G

◆ 3G - third generation cell phones
   2Mbps data ("Internet") a major push

◆ multiple groups: 3GPP, 3GPP2
   3GPP: ETSI, T1P1, ARIB/TTC, TTA, CWTS
      aim is "all-IP" based mobile networks
   3GPP2: ANSI-driven (3GPP restricted to GSM)

◆ collaboration between 3GPP and IETF
   3GPP to use IETF protocols

◆ BIG money paid for licenses
   hard to see payback model
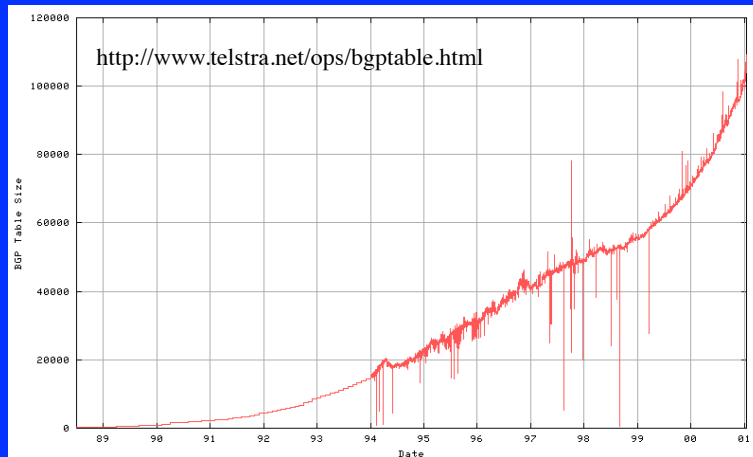
Cable Modem

◆ PacketCable
   support for voice over cable
   includes QoS
   developed by Cable Labs
   accepted by ITU-T

◆ provides alternative to local telco
   but assumes telco model

◆ some rollout
   rate arbitrage but can it last?

Internet Routing

◆ little new work in the routing area

◆ but it is needed

http://www.telstra.net/ops/bgptable.html

Quality of Service (QoS)

◆ QoS controls seen as critical (by some) for future converged Internet

  a big net-head vs. Bell-head difference

  over-provision vs. complex controls

  should there be busy signals on the Internet?

◆ QoS requirements coming from many places

  ITU-T, TIA, QoS Forum, ETSI, IEPS, . . .

QoS Technology: per-flow

◆ IETF Integrated Services (intserv) WG

Resource Reservation Protocol (RSVP) signaling

intserv services: Guaranteed & Controlled Load Service

renamed by the ITU-T Y.iptc to:

"delay sensitive statistical bandwidth capability"

"delay insensitive statistical bandwidth capability"

intserv offers link-level per-flow QoS control

RSVP offers signaling for intserv

also used as a general signaling protocol - e.g. MPLS

QoS Technology: class-based

◆ IETF Differentiated Services (diffserv) WG

class-based QoS

packets marked at network "edge"

routers use markings to decide how to handle packets

four services

best effort - normal Internet traffic

7 precedence levels - prioritized classes of traffic

Expedited Forwarding (EF) - leased line like service

Assured Forwarding (AF) - 4 queues with 3 drop classes

requires edge policing - technology not yet defined

QoS Technology: Other Ideas

◆ a number of similar ideas from traditional telcom
◆ map flow-based QoS into a circuit of some type

    MPLS Label Switched Paths

    ATM VCs

    optical lambdas

◆ the old circuits vs. packets fight
◆ could make sense for trunks

Can QoS Work?

◆ traditional Internet is "best effort"

    equal degradation under load

◆ QoS is unequal treatment under stress

    Bill pays to get Fred's traffic dumped

◆ a number of QoS technologies have been developed
◆ but value proposition is also needed

    who will pay more to get better service?

    will there be enough customers to pay for the service?

◆ many US ISPs are not interested

IEPS

- **IEPS** = Internet-based International Emergency Preparedness Scheme

  draft-folts-ohno-ieps-considerations-00.txt

- since the Internet is

  1/ taking over the phone system

  2/ has other information needed in an emergency

- emergency personnel need to have priority in their use of the Internet (during an emergency)
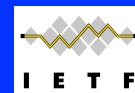
  currently have for-fee priority on some phone networks

IPv6

- IETF ipngwg working group
- technology standards done - many implementations
- waiting on uncle Bill
- cell phones and China may show the way

  but routing is not any better

Telephony

◆ telephony cntrl: MGCP, megaco/H.248. H.323, SIP

◆ phone number resolution: enum

◆ wireless: wap, SeaMoby, 3G, rohc

◆ settlements: ITU-T

◆ PSTN/IN control: pint, spirits

◆ finding PSTN gateways: trip

◆ lawful interception: raven, ETSI, T1

Telephony Control: Phone Model

◆ two protocols

  MGCP - Media Gateway Control Protocol - RFC 2705

    informational RFC: **not an IETF standard**

    well supported in industry - including cable modems

  megaco/H.248 - joint IETF/ITU-T effort

    in RFC Editor's queue (Aug '00), also ITU-T publication

    MGCP was an input to the effort

◆ break up phone switch into controller and gateways

  "looks" like phone switch

  a.k.a. softswitch (but softswitches can often do much more)

  MGC is in control
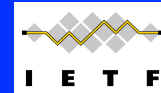
Telephony Cntrl: Internet Model

◆ two protocols

   H.323 - ITU standard

      e.g. net meeting

   SIP - **S**ession **I**nitiation **P**rotocol - IETF Proposed Standard

      RFC 2543

◆ interworking effort underway

◆ Internet model of smart edges

   light-weight servers in network (proxy, forwarding)

   do not have to be run by connectivity provider

The Importance of Phones

◆ big issue in IETF development of telephony technology for IP networks

◆ phone people assumed that phone traffic would have precedence over all other use

   IETF did not agree   I'm more important!

◆ particular issue in responding to congestion

   everyone thinks the other guy should back off

I'm more important!   I'm more important!

   I'm more important!

Finding Things Using Phone Numbers

◆ **T**elephone **Num**ber Mapping (enum) - IETF WG

◆ IETF working group - doc in RFC Editor's queue

　　input: an e.164 style phone number

　　output: one or more URLs

◆ uses domain name (DNS) system

　　for phone number of **+ 46 8 9761234**

　　look up **4.3.2.1.6.7.9.8.6.4.e164.arpa**

◆ significant political issues

　　who controls per-country mappings?

　　who controls or runs the mappings for a user

Wireless: Mobile Phone

◆ **W**ireless **A**pplication **P**rotocol (WAP)

　　"walled garden" wireless support

　　own version of **HTTP** etc

　　requires **gateway** to Internet

◆ 3G - third generation wireless

　　conflicting views - **WAP** vs. direct Internet

◆ Q- "why IP to mobile phone?"

　　A - to enable application development

Wireless: Mobile Support
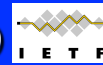
◆ **Sea**mless **Mob**ility (SeaMoby)

    fast mobility within an access network

    between locations, between media

        e.g. plug Palm VII™ into base station

    new IETF Working Group

◆ **Ro**bust **H**eader **C**ompression (rohc)
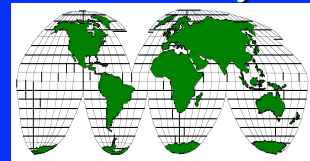
    compress IP/UDP/RTP/TCP headers over links with high
        error rates and long roundtrip times

    i.e. make it possible to support good

        VoIP for web enabled cell phones

Settlements

◆ no current equivalent of telephone settlement system
for Internet

    major pain for non-US ISPs

    they have to pay to connect to U.S.

◆ ITU-T SG 3 proposal to extend telco settlements
system to Internet

    owner of international link can demand payment from
        every ISP that "generates" traffic on the link

    would have force of law in some places

    but may result in isolation

    would your ISP pay to send traffic to Australia?

PSTN / IN Control - IETF WGs

◆ **P**STN and **I**nternet **I**nternetworking (pint)
  - Internet control of PSTN services
  - e.g. click-to-call

Call Scott

◆ **S**ervice in the **PSTN / IN R**equesting **I**nternet **S**ervice (spirits)
  - notification of PSTN events to Internet servers
  - e.g. Internet call-waiting

I E T F

◆ call processing language: CPL
  - tell phone switch what to do

Scott is calling
- hang up on him
- take message
- voice mail
- forward to joe
- accept call

◆ interesting security
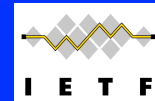 and accounting issues

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Finding PSTN Gateways

◆ **T**elephony **R**outing over **IP** (TRIP) - IETF WG

◆ Internet routing protocol to find PSTN gateways
  - combination of **BGP**, **IS-IS** and **OSPF**

◆ **TRIP** is used by location servers (LSs) to exchange phone reachability information
  - LS advertises phone numbers it can reach
  - e.g. country, local area, or organization
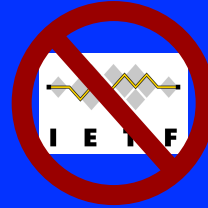
I E T F

◆ telephony signaling protocol independent
  - i.e. supports **SIP** & **H.323**

Lawful Interception

◆ IETF www.ietf.org/mailman/listinfo/raven

"raven" discussion in IETF resulted in a

decision to not mandate intercept features

technical and logical reasons

e.g. no consistent international definition

◆ ETSI www.etsi.org/technicalactiv/li.htm

define requirements, security, handover, etc

◆ TIA www.tiaonline.org/standards/newdocs.cfm proj # 4846

define interfaces

"safe harbor"

Directions in Internet Services and Applications

◆ thoughts on a few topics

ISPs

users

content

regulations

ISPs

◆ what is an ISP?

traditional ISPs have IP history

telco-based have circuit history

◆ what will it be?

telcos have the $ but generally not the Internet experience

try to remake the Internet into telco model

but assume that content will rule

◆ what is the business models

is there something other than commodity?

Who Owns the User?

◆ traditional ISPs (traditional Internet)

a service provider owns the customer for that specific service

◆ telco-based ISPs

the connectivity provider owns the customer for all services

e.g. WAP

inhibits innovation & restricts competition

Will Content ever Succeed?

- ◆ has not to date
  - all video-on-demand trial have failed
- ◆ long term carrier assumption of revenue future
- ◆ if you are asking "what is the application"
  - you have already lost
- ◆ many looking for "the killer app"
  - what was killer app for telephone
  - what was killer app for auto?
- ◆ if you must have one: connectivity
- ◆ content will be a service but not the only service

Social Pressures

- ◆ the Internet is aggressively non-national
  - the 1st amendment is a local ordinance
- ◆ threat to "order"
  - as information sometimes is
- ◆ governments feel they must "protect" citizens
  - e.g. China
- ◆ Internet routes around censorship - sort of
- ◆ what authority does the FCC have?

Regulations

◆ regulators are in trouble

◆ current regulations are based on service

    if you offer telephone service you get telephone regulations

    if you offer video service then you get cable TV regulations

◆ what do they do with a converged network?

◆ regulations push social and revenue goals

    universal service fee, content controls

◆ they will figure out a way

    they have motivations (tax revenue, content control)

Been There, Do We Need to Be There?

◆ are there regulations needed to define IP telephony?

◆ are there standards needed to define IP telephony?

◆ some people seem to think so

    e.g. requiring the use of e.164 numbers to identify callers

    (fyi - I will be using a domain name for my phone)

◆ but do we have any idea what it will be?

    if "yes"

        what's the point of adding IP

    if "no"

        then we do not know the definition

Projections

- Internet model clouds the economic model
    - other than selling shovels to the gold miners
- end to end can leave out the middleman

"but who is going to make money on that?"

John Mcquillan