Analog Communication

Phone
Econo Finan
Educ
Transportation
Agri-culture
TV Radio

Phone Infra

BCAST Infra
Internet: as of Yesterday

Phone Infra

Internet

Phone
Econo Finan
Educ
Transportation
Agriculture

TV Radio

BCAST Infra
Internet: as of Today

Phone Infra

Econo Financ

Educ

Transportation

Agri-culture

TV Radio

Internet

Internet Infra
(fiber, cable & wireless)

BCAST Infra
Internet: as of Tomorrow

Internet Infrastructure
(fiber, cable, and wireless)
Internet Infrastructure for digital communication society

Phone  Econom.  Educ  Transportation  Agriculture  TV  Radio

Internet

(Integrated) Internet Infrastructure

A testbed is VERY important!
IPv4: Not enough IP addresses and growing requirements

IPv4

Cable
Optical Fiber
Wireless
Satellite

Transportation
Econo Finance
TV Radio
Phone
Educ
Agriculture
IPv6: The Internet Infrastructure

Transportation
Econo Finance
TV Radio
Phone
Educ

IPv6

Cable
Optical Fiber
Wireless
Satellite

Agri-culture
Industry Standards Drive Ubiquity

Percentage of Ownership vs. Years Since Introduction

- Televisi
  - (1926)
- Electricit
  - (1873)
- Telephon
  - (1876)
- Automobile
  - (1886)
- Microwave
  - (1953)
- VCR
  - (1952)
- PC
  - (1975)
- Internet
  - (1975)
<table>
<thead>
<tr>
<th>Internet Generation</th>
<th>Government Internet</th>
<th>Email, Ftp</th>
<th>Professionals</th>
<th>1G</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9.6 k</td>
<td>10 * 4</td>
<td>10 * 10</td>
<td>1G</td>
</tr>
</tbody>
</table>

Email: Email, Ftp

Professionals: 10 * 4

1G: 1Gbps

Government Internet

Public Internet

Global Internet
<table>
<thead>
<tr>
<th>1 G</th>
<th>2 G</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10 * 4</td>
<td>10 * 8</td>
<td></td>
</tr>
<tr>
<td>Professionals</td>
<td>Innovators</td>
<td></td>
</tr>
<tr>
<td>Email, Ftp</td>
<td>WWW</td>
<td></td>
</tr>
<tr>
<td>9.6 k</td>
<td>56 k</td>
<td></td>
</tr>
<tr>
<td>Government Internet</td>
<td>Public Internet</td>
<td></td>
</tr>
<tr>
<td>Generation</td>
<td>1 G</td>
<td>2 G</td>
</tr>
<tr>
<td>------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>10 * 4</td>
<td>10 * 9</td>
</tr>
<tr>
<td>Users</td>
<td>Professionals</td>
<td>Innovators</td>
</tr>
<tr>
<td>Services</td>
<td>Email, Ftp</td>
<td>WWW</td>
</tr>
<tr>
<td>Internet</td>
<td>Government Internet</td>
<td>Public Internet</td>
</tr>
</tbody>
</table>
Industry Integration / Convergence

Telecom Industry
- Wireline
- PSTN
- ISDN
- PTN

Computer Industry
- main frames
- PC-LAN
- PC/Server
- desk top computing

Media Industry
- electronic publishing and entertainment

Internet
- PC-LAN
- PC/Server
- mobility mobile/mobile
- WAP
- WWW
- 3G/mobile Internet

The Converged Industry

New Telecoms Industry
Carrier class

Next battle ground
IP sensor Prototype
(Thermo Sensor Node)

Inside view

Outside view
Network Appliances (on sale)

Cellular Phone with Internet Connectivity

Digital Camera with Network Connectivity

Digital Video Camera With A/V Network Connection

Microwave with Network Connectivity

© Cannon

© NTT DoCoMo

© Sony

© Sharp

© Canon

© Sharp
Refrigerator Node

- Control Panel
- Voice Output (Speaker)
- LCD Panel
- Voice Input (Mic)
Joint Graduate Level Course on “Network Security” among 3 Universities, Dec 12, 2000 from San Diego U.S.A.

NAIST

KEIO SFC

U-Tokyo

Students @ 3 universities in Japan

3 professors @ San Diego Super Computer Center
Vision: World at your fingertips

ADSL, Cable TV,

Service Gateway

IP TASK V6 FORCE
What is the Key Enabler for Mass Deployment of Mobile IP-Services??

It must be

!! Cheap Cheap Cheap Cheap Cheap Cheap Cheap Cheap Cheap Cheap!!

2000 2001 2002 2003 2004 2005 (1 Billion Users Forecast)
100% IPv6 readiness by 2005

- Prime Mister of Japan Yoshiro Mori
- Korean MIC followed Japan Feb 23rdm 2001
Why IPv6?

(Network Layer)

of the Internet

The Transparency
Internet Scaling challenges

QoS
Great IP Address Crunch
Security
Authentication and usage tracking
Maintain IS technical advantage
Accurate system information
IPv4 is in the same state as DOS/Windows 3.1!
**IPv4 Address Usage Estimate**

- Approximately **70** units are left = **27 %**
  - Here one unit means 1/256 of the total IPv4 address space size, i.e. /8 (=equivalent size of Class A)

- **Address Usage Rate (units per a year)**

<table>
<thead>
<tr>
<th></th>
<th>RIPE/NCC (Europe)</th>
<th>APNIC (AsiaPacific)</th>
<th>ARIN (America)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>0.8</td>
<td>0.58</td>
<td>1.29</td>
<td>2.67</td>
</tr>
<tr>
<td>2000</td>
<td>1.2</td>
<td>1.16</td>
<td>2.08</td>
<td>4.44</td>
</tr>
<tr>
<td>2001</td>
<td></td>
<td></td>
<td></td>
<td>??</td>
</tr>
</tbody>
</table>
Internet IP Address Need forecasts

IPv4 = 1 inch
IPv6 = Diameter of our Galaxy

Source: Internet Software Consortium (http://www.isc.org)
Comparison of IPv4 - v6 Resources

ARIN: 74%
APNIC: 9%
RIPE NCC: 17%
ARIN: 19%
APNIC: 38%
RIPE NCC: 43%
## Wireless Mobility Needed for Always-On IP Address Resource

<table>
<thead>
<tr>
<th>Million</th>
<th>Year 2005</th>
<th>Year 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Phones</td>
<td>1500</td>
<td>3000</td>
</tr>
<tr>
<td>Mobile IP Phones</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>1% Roaming</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>400 Wireless Networks</td>
<td>2000</td>
<td>4000</td>
</tr>
</tbody>
</table>
**GRACEFULL TRANSITIONS**

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Legacy IPv4 Internet</th>
<th>Legacy IPv6</th>
<th>IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Large IPv4 Ocean, Small IPv6 islands</td>
<td>A large IPv4 net, a large IPv6 net</td>
<td>IPv6 Ocean IPv4 Islands, legacy v4 apps</td>
</tr>
<tr>
<td>2</td>
<td>TB 6to4 6over4 NAT-PT BIS SOCKS</td>
<td>NAT-PT BIS SOCKS</td>
<td>DSTM NAT-PT BIS SOCKS &quot;4to6 ?&quot;</td>
</tr>
<tr>
<td>3</td>
<td>IPv4</td>
<td>IPv6</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*IPv6 - a small step for IP but a giant leap for Telcos*
<table>
<thead>
<tr>
<th>Critical Success Factor</th>
<th>Today with IPv4</th>
<th>IPv6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Effectiveness</td>
<td>Costly workarounds</td>
<td>&gt;1 billion addresses / person</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Frequent renumbering as site grows</td>
<td>Simplified network planning and management</td>
</tr>
<tr>
<td>Reliability</td>
<td>Operational complexity</td>
<td>Return to simple and scalable architecture</td>
</tr>
<tr>
<td>Availability</td>
<td>Single points of failure</td>
<td>24x7 operation</td>
</tr>
<tr>
<td>Scalability</td>
<td>Client/server</td>
<td>Peer-to-peer</td>
</tr>
<tr>
<td>Accessibility</td>
<td>Obstacles to deploying next generation</td>
<td>Pervasive enabler</td>
</tr>
<tr>
<td></td>
<td>applications (e.g., VoIP)</td>
<td>Simplified application development</td>
</tr>
<tr>
<td>Security</td>
<td>Interferes with some applications</td>
<td>Enabler for end-to-end security</td>
</tr>
</tbody>
</table>
Early conclusion

Internet 2001 is a baby!

Internet Growth
100 IP Adds/person!

Always-On
Info Soft
Appliances

IPV6

The Internet Tidal Wave
Finally

The longer the upgrade is postponed, the costlier it will be and the more complex the transition will be!

(compared to IPv4)
The BIG Questions!

- Why √
- When?
- Where?
- What is the cost?
"IPv6 is here and now
So take the internet where no other network
has gone before!"

Vint CERF
Honorary Chairman