- Ancient Egyptians believed the heart was the center of intelligence and emotion.
- They also thought so little of the brain that during mummification, they removed the brain.
Historical Transitions!

Gregorian Calendar

Pope Gregory XIII

Adopted Oct 4, 1582

Protestants - GB: 2 Centuries

Protestants - Russia: 3.5 Centuries later

Muslim nations: Hegir - dual

China: Its own calendar
Vision & Way Forward

Historical Flag Days Transitions!

US Area Codes

Y2K - Jan 1, 2000

Euro – Feb 2002
From Internet to InternAT

From Network of Networks to NATwork of NATworks
The IPv4 Address Exhausting Debate 😊

2010

Geoff Huston

2011

Tony Hain

IPv4 Exhausition Counter

Reserver blocks (IANA)

7%

Until X-day (estimation)

20/256

IPv6 FORUM
IPv4 Address Fractal Map – April 2010

Only 2 Address Blocks Are Clean, the rest is called dirty !!!

| 000 | 001 | 002 | 003 | 004 | 005 | 006 | 007 | 008 | 009 | 010 | 011 | 012 | 013 | 014 | 015 | 016 | 017 | 018 | 019 | 020 | 021 | 022 | 023 | 024 | 025 | 026 | 027 | 028 | 029 | 030 | 031 | 032 | 033 | 034 | 035 | 036 | 037 | 038 | 039 | 040 | 041 | 042 | 043 | 044 | 045 | 046 | 047 | 048 | 049 | 050 | 051 | 052 | 053 | 054 | 055 | 056 | 057 | 058 | 059 | 060 | 061 | 062 | 063 | 064 | 065 | 066 | 067 | 068 | 069 | 070 | 071 | 072 | 073 | 074 | 075 | 076 | 077 | 078 | 079 | 080 | 081 | 082 | 083 | 084 | 085 | 086 | 087 | 088 | 089 | 090 | 091 | 092 | 093 | 094 | 095 | 096 | 097 | 098 | 099 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 | 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 196 | 197 |
All ISPs will have to take off like this!”

Anonymous 2010
The Internet Losers will meet their Enemy!

July 1, 2010

[Image of a horse pulling a cart with packages]
A Fitness Goal

• perhaps we can trim down from an hourglass to a wineglass

• promising signs: IP-over-SONET, IP-over-WDM

• IPv6 to restore simplicity and functionality
World-wide IPv6 BGP Weather Map

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>United States</td>
<td>797</td>
</tr>
<tr>
<td>2</td>
<td>Germany</td>
<td>216</td>
</tr>
<tr>
<td>3</td>
<td>United Kingdom</td>
<td>153</td>
</tr>
<tr>
<td>4</td>
<td>Indonesia</td>
<td>144</td>
</tr>
<tr>
<td>5</td>
<td>Australia</td>
<td>137</td>
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<tr>
<td>6</td>
<td>Netherlands</td>
<td>126</td>
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<tr>
<td>7</td>
<td>Canada</td>
<td>126</td>
</tr>
<tr>
<td>8</td>
<td>Japan</td>
<td>113</td>
</tr>
<tr>
<td>9</td>
<td>Russian Federation</td>
<td>90</td>
</tr>
<tr>
<td>10</td>
<td>Italy</td>
<td>84</td>
</tr>
<tr>
<td>11</td>
<td>France</td>
<td>79</td>
</tr>
<tr>
<td>12</td>
<td>EU</td>
<td>74</td>
</tr>
<tr>
<td>13</td>
<td>Korea, Republic of</td>
<td>66</td>
</tr>
<tr>
<td>14</td>
<td>Switzerland</td>
<td>62</td>
</tr>
<tr>
<td>15</td>
<td>Sweden</td>
<td>61</td>
</tr>
<tr>
<td>16</td>
<td>Poland</td>
<td>55</td>
</tr>
<tr>
<td>17</td>
<td>New Zealand</td>
<td>54</td>
</tr>
<tr>
<td>18</td>
<td>China</td>
<td>54</td>
</tr>
<tr>
<td>19</td>
<td>Austria</td>
<td>51</td>
</tr>
<tr>
<td>20</td>
<td>Czech Republic</td>
<td>48</td>
</tr>
<tr>
<td>21</td>
<td>Brazil</td>
<td>43</td>
</tr>
<tr>
<td>22</td>
<td>Hong Kong</td>
<td>43</td>
</tr>
<tr>
<td>23</td>
<td>Finland</td>
<td>35</td>
</tr>
<tr>
<td>24</td>
<td>Taiwan, Province of China</td>
<td>32</td>
</tr>
</tbody>
</table>
"The Myth of the IPv6 Killer App"
Vint Cerf 2008
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>3,655,206,348</td>
<td>4,514,400</td>
<td>51,065,630</td>
<td>5.3 %</td>
<td>3.5 %</td>
<td>1,031.2 %</td>
</tr>
<tr>
<td>Asia</td>
<td>3,776,181,949</td>
<td>109,003,993</td>
<td>578,538,257</td>
<td>15.3 %</td>
<td>39.5 %</td>
<td>406.1 %</td>
</tr>
<tr>
<td>Europe</td>
<td>780,401,065</td>
<td>105,096,093</td>
<td>384,633,765</td>
<td>48.1 %</td>
<td>26.3 %</td>
<td>266.0 %</td>
</tr>
<tr>
<td>Middle East</td>
<td>197,090,443</td>
<td>3,284,800</td>
<td>41,939,200</td>
<td>21.3 %</td>
<td>2.9 %</td>
<td>1,176.8 %</td>
</tr>
<tr>
<td>North America</td>
<td>337,167,248</td>
<td>108,096,800</td>
<td>248,241,969</td>
<td>73.6 %</td>
<td>17.0 %</td>
<td>129.6 %</td>
</tr>
<tr>
<td>Latin America/Caribbean</td>
<td>578,091,673</td>
<td>18,068,919</td>
<td>139,009,209</td>
<td>24.1 %</td>
<td>9.5 %</td>
<td>669.3 %</td>
</tr>
<tr>
<td>Oceania / Australia</td>
<td>33,981,562</td>
<td>7,620,480</td>
<td>20,204,331</td>
<td>59.5 %</td>
<td>1.4 %</td>
<td>165.1 %</td>
</tr>
<tr>
<td>WORLD TOTAL</td>
<td>6,676,120,288</td>
<td>360,985,492</td>
<td>1,963,632,361</td>
<td>25.9 %</td>
<td>100.0 %</td>
<td>305.5 %</td>
</tr>
</tbody>
</table>

IPv4 Achieved the Critical 20%
IPv6 Can Drive Growth & Continuity!
The Next Big Internet

Billions of Smart Devices
- Vehicles
- Buildings

Trillions of
- RFIDs
- Sensors

5 Billions
- Mobile Phones
- PDAs

650 M Nodes
## Enterprise vs. Cloud

<table>
<thead>
<tr>
<th>Enterprise Class</th>
<th>Global class</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-premise</td>
<td>Hybrid/off-premise</td>
</tr>
<tr>
<td>100s -1000s of nodes</td>
<td>10,000+ nodes</td>
</tr>
<tr>
<td>Proprietary</td>
<td>Commodity</td>
</tr>
<tr>
<td>HW resiliency</td>
<td>SW resiliency</td>
</tr>
<tr>
<td>Max performance</td>
<td>Max efficiency</td>
</tr>
<tr>
<td>Silo’ed Resources</td>
<td>Shared Resources</td>
</tr>
<tr>
<td>Clusters</td>
<td>Grids/Cloud</td>
</tr>
<tr>
<td>Static</td>
<td>Elastic</td>
</tr>
<tr>
<td>Shared storage</td>
<td>Replicated storage</td>
</tr>
<tr>
<td>Facility costs</td>
<td>Power Usage Efficiency</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost-Center</th>
<th>Value/Revenue-Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td></td>
</tr>
<tr>
<td>Shared storage</td>
<td></td>
</tr>
<tr>
<td>Facility costs</td>
<td></td>
</tr>
</tbody>
</table>

**Courtesy:** John Rhoton  
Distinguished Technologist  
HP EDS CTO Office  

**Vision & Way Forward**
Market context
A service-centric perspective sheds light on all value chain constituents

Hosted / outsourced service provider
- Enterprise-class software
- Dedicated and shared infrastructure

Cloud service provider
- Global-class software
- Massive scale-out infrastructure

IT organization
Internal service provider
- External services
- In-house services
- Cloud services

Business users
- S
- S
- S

Business outcome

Vision & Way Forward
Cloud Model

- Application
  - CRM
  - Email
  - UC
  - ......
  - ......

- Platform
  - Programming Language
  - APIs
  - Development Environment

- Virtualisation
  - Provisioning
  - Virtualisation
  - Billing

- Hardware
  - Memory
  - Computation
  - Storage

- Co-location
  - Real Estate
  - Power
  - Cooling
  - Bandwidth

Integration
Operation
Governance
First Cloud of Cloud Computing
Cloud Landscape

Vision & Way Forward

Governance

Operation

Integration

Application

Platform

Infrastructure
Major Problem of CC is NAT

- Overhead of unnecessary translation

- Protocol incompatibilities
  - IPsec,...

- Breaks peer-to-peer applications
  - Instant messaging
  - Interactive games
  - VoIP
  - Real-time collaboration and sharing
    - Netmeeting, BitTorrent, Groove

- Limits implementation of application servers
  - How far can you distribute your web-services?
  - Grid computing

Building work-arounds for everything NAT breaks is an unnecessary and inefficient effort!
**Why Cloud Computing?**

**Cost Reduction**
- Benefit from economies of scale and experience curve
- Predictability of spend
- Avoids cost of over-provisioning
- Reduction in up-front investment

**Risk Reduction**
- Offload risk of running the data-centre, data protection, and disaster recovery
- Reduces risk of under-provisioning

**Focus on core competency**
- Reduce effort and administration related to IT
- Automatic service evolution

**Flexibility**
- Roll-out new services, retire old
- Scale up and down as needed; quickly
- Faster time to market: Lower barriers to innovation
- Access from any place, any device, any time

Vision & Way Forward
**Synergies between CC & IPv6**

**Scalability**

- Massive scalability
  - Hierarchical internal address space of provider
  - Avoid connection brokers (ALG/NAT)
- No “need” for NAT
- Always connected user experience
  - Mobile IPv6
- Customer connectivity
- “Easier” implementation
- Unified Communications
- Large number of virtual interfaces
- Beyond capacity of CGN
- Direct connectivity required
  - Impossible to distinguish between internal and external systems
    - Intra-cloud
    - Inter-cloud
    - User-access
- P2P potential

**Always-on & Seamless**

**Mobility**

- Seamless user experience
- Always Connected users
  - Move from one access network to another
- Cloud Abstraction
- Workload rebalancing
  - Virtual Machine relocation

**Automatic Deployment**

- Ease of provisioning
  - Stateless auto configuration
  - Dynamic renumbering
- Dynamic allocation of capacity
  - Auto configuring virtual machines based on demand fluctuation
- Mandated encryption and authentication helps a lot in IPv6
Internet of Things
Technological Revolutions

Industrial Revolution (machines, factories, channels)
Steam Age (coal, Iron, Railways)
Steel Age (electricity, chemistry)
Automobile Age (petrol, petrochemistry)
Age of Telecommunications and IT
Age of Smart Infrastructures

Each Revolution transforms the economy and leads to growth, development and new innovation forms.

Each Revolution reshapes the opportunity space, and our ways of working and living.

Courtesy Joao da silva
At the beginning of a new Age

- Mature industries are close to technology exhaustion, their innovation drive is weak
- Old economies stagnate, new technologies are incipient
- Need to select the new engines of growth
- Moving from laissez faire to the active comeback of the state
- Shifting from supply-push to demand-pull in investment and innovation
- Moving from individual focus to collective interests
- Old industries and markets are rejuvenated
- Making the best out of our technological potential
Today’s Drivers and Opportunities

- Rising costs of energy, transport, health
- Huge inefficiencies in energy and transport and health related processes
- Growing environmental threats
- Growing security threats
- Untapped potential of ICT as smart infrastructure enablers

- Energy distribution and management
- Transport, mobility, architecture, urban planning
- Production, waste disposal, recycling
- Health, well being, third age
- Sports, leisure, culture
The Age of Networking

Smart Energy Networks

Smart Transport Networks

Game Machine Telephone PC DVD Audio TV STB DVC

Smart Living

Smart Health Networks

SmartSpace
"The Internet of Things has the potential to change the world, just as the Internet did. Maybe even more so."

Kevin Ashton, 2009
What Are “Things”? Not Only RFID?

- Static information appliances: computers – fixed, portable, mobile; servers, etc.
- Mobile information appliances: cell phones, digital cameras, PDAs, scanners, Web Tablets, pocket PCs, games, iPods, talking books, DVD players, mobile devices that use services such as GPS, digital maps and IVR, etc.
- Mobile networks: vehicle cargo containers, tankers, supply chain assets (stock-keeping-units – SKUs), etc.
- Static devices: medical devices, HVAC (heating, ventilation, airconditioning systems for climate control in buildings), industrial machinery, distributed generation, etc.
- Controllers: industrial controllers, appliance controllers, etc.
- Smart sensors: accelerometers, pressure gauges, flow/position/speed/temperature biosensors, etc.;
- Microprocessors and microcontrollers: 8-, 16-, 32-, 64-bit chips, etc.
- Internet of Devices (M2M)
- Internet of Things
  - 6,000-7,000 objects surrounding each of us in our daily life!
Technological vision and ITU 2005 report on “Internet of Things”

- Sensor networks
- WSN
- Sensors and actuators
- 2D Codes
- IPv6
- RFID
- Context awareness
- Smart materials
- Edge intelligence
- Cognitive robotics
- Nanotechnology
- The disappearing processor
- Nanomaterials

ITU: again wrong on IPv6
Application Potential

Smart+Connected Communities

- Disaster prevention & management
  - Fires
  - Floods
  - Avalanches
  - Chemical leakages

- Telematics
  - Road Conditions
  - Law enforcement
  - Traffic management

- Water salinity
  - Quality Control
  - Underwater monitoring

- Vehicle Status
  - Localization

- Localization
  - Health Care
  - Security

Global Sensor
Network

Government agencies, Local Authorities,
Military, City Management, End User

User

Smart Home
- Appliance Control
- Enforced Security
- Accident Prevention
Protocols for Things of Internet

- **Application Protocols**
- **UDP/ICMP**
- **IPv6 (6LoWPAN, ROLL)**
- **IEEE 802.15.4**

**Standards Development Organization**
- ZigBee
- IETF

Vision & Way Forward
Connecting the Embedded Devices to the Internet

IPv6 Lowpan

RESTful API
Web Server

Web Cloud

Search Compose Visualize Physical Mashups

RESTful API
Web Server

Search Compose Visualize Physical Mashups

Web Cloud

RESTful API
Web Server
Smart Gateway

API1 BT
API2 Zigbee

Non-IP devices
6LoWPAN – An Open IETF Standard

- **6LoWPAN - IPv6 over Low power WPAN**
  - Massively scalable networking as an end-to-end part of the Internet

- **6LoWPAN applicable to any low-power, low-rate wireless radio**
  - IP protocols tie together heterogeneous networks.

- **IPv6 addresses the Smart grid requirements**
  - End-to-end Addressing, Security, Mobility, Traffic Multiplexing
  - Reusability and Maintainability,
  - Web-services

Internet: the most successful, innovative, massive network ever created

6LoWPAN = IPv6 = Internet
EU: - Communication in 2007 on IoT – RFID (IPv6)

USG: NIC: 6 Disruptive Civil Technologies – IoT in 2008 -v6?

China: Premier Wen in August 7, 2009: “Internet + IoT = Wisdom of Earth”

Dec 9, 2009, Zhou Hongren, Exe. Vice Chair ACSI - “Advised Guangdong Province to deploy IPv6” (watch this space!)
Autonomous Smart Object Networks

The "True" Internet of things

The Extended Internet
Application Layer Overlays

Data Centers

Secured Access via a Server

Secured Direct Access to a Smart Object

Firewall

Proxy Engine: Server or Router+Server

Partially or Fully meshed application Overlay network
IPv6 Sensors

Cisco uIPv6

- Code base: Contiki OS/UIP stack + KAME stack
- All IPv6 features (except MLD) are implemented
  
  Code size ≈ 11.5 KByte
  RAM usage ≈ 0.2+1.6
  =1.8KByte
- Obtained IPv6 ready phase 1 logo
- Open source release October 14th, 2008
  
  http://www.sics.se/contiki

- Other implementations: Archrock, Sensinode, PicosNet, Dust Networks, Gainspan, ZeroG, etc…

AREO in the Data Center

Vision & Way Forward
Main Policy Challenges

- Security and confidentiality
- Privacy and data protection
- Management of critical global resources
- Naming and meaning on digital networks
- Standards-setting and interoperability
  - Harmonisation is needed to ensure smooth development and widespread adoption
  - Spectrum, communication protocols and tag formats
- Social and human impacts
  - Better personal safety, more efficient care of human health
  - Better environmental protection
  - Internet of Things should support individuality and self-expression, not create a (perceived) societal/individual surveillance
  - Impact of technology on human relationships and intimacy
Relationship: Standard Bodies
(Activities mainly in North America)

IEE SCC21 (Standards Coordinating Committee 21)
IEE PSRC (Power System Relaying Committee)

I EC Strategic Group on Smart Grid (SG3)
IEC TC8, SB1

Contextual Framework
Business Requirements / Use Cases

IEC other TCs
TC 13, 34, 56, 65, 82, 88, 95, 105 etc.

IEC 61968 (CIM)-Based Information Exchange

IEEE NEMA
http://www.nema.org/

UCA
http://ucaig.org/

CIM
http://cimag.uciaug.org/

Open Smart Grid (OpenSG) Subcommittee
http://osug.uciaug.org/

OpenSG users group
http://osug.uciaug.org/

EPRI ELECTRIC POWER RESEARCH INSTITUTE
http://www.epri.com/

http://www.nist.gov/
Covers ALL
Outsource

IEEE TC57
WG10, WG13, WG15, WG17, WG19

http://tc57.iec.ch/

Enterprise Semantics
Data Warehouse
EMS
Distribution Management
Distribution Automation
Customer Information

ZigBee Alliance
HomePlug

FORUM
Smart Grid Framework
Smart Grid Standards

Figure 4: Domain Decomposition
Vision & Way Forward

Network Architecture in the Smart Grid

Architectural Requirements in the NIST Framework and how to meet them
# Architectural designs

## Internet Architecture

<table>
<thead>
<tr>
<th>Application</th>
<th>Application Protocol, encoding, AAA, identity, encryption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>End to end reliability</td>
</tr>
<tr>
<td>Internet</td>
<td>End to end routing, VPN, Network AAA, identity, encryption</td>
</tr>
<tr>
<td>Data Link</td>
<td>Link encoding on the physical layer</td>
</tr>
<tr>
<td>Physical</td>
<td>Physical Interconnect</td>
</tr>
</tbody>
</table>

## “1-2-7” Architecture

<table>
<thead>
<tr>
<th>Application</th>
<th>Application Protocol, encoding, AAA, identity, encryption, End to end reliability, end to end routing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Link</td>
<td>Link encoding on the physical layer</td>
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<tr>
<td>Physical</td>
<td>Physical Interconnect</td>
</tr>
</tbody>
</table>
## Examples

### Internet Architecture
- The Internet
  - IPv4 or IPv6
- The ISO OSI Reference Model
  - breaking the application into several layers
- Novell Netware
- AppleTalk
- DECNet
- XNS Internet Transport etc

### “1-2-7” Architectures
- IEC 14908
  - Implements 7 layers, but in the application protocol
- Zigbee 1.0
- Many others in the Grid

Vision & Way Forward
IPv6?

• The Chairman/CEO of ARIN has advised NIST:
  – There are not enough IPv4 addresses left to address a major new application
• The Chair of the IETF has advised NIST:
  – Re-use of the IPv4 address space in air-gap networks is regularly tried and regularly causes problems in networks
  – The IETF strongly recommends IPv6 deployment
NIST asked the IETF
Draft-baker-ietf-core

• The reader is warned:
  – IPv4 is running out of address space, and
  – IPv6 has positive reasons that one might choose it
    apart from the IPv6 space, such as the address
    autoconfiguration facility and its ability to support an
    arbitrarily large number of hosts in a subnet.

• As such, the IETF recommends that one always
  choose IPv6 support, and additionally choose
  IPv4 support in the near term.
IPv6 based Architecture for the Smart Grid

Sensors/Switches/Things

Relays/Aggregators

Transport Network

Applications

Enterprise

Household

3rd Party

Utilities

IPv6/WiMAX, LTE, xDSL, LAN
Optical Fiber, Satellite

IPv6/IPSec

Web, Email, ZigBee,
Mobile Applications,
Microsoft Hohm,
Google PowerMeter

Vision & Way Forward
"Peace of cake!"

Anonymous 2008
Only Time Will Tell…

Finally an email that walks!