Rocky Mountain IPv6 Task Force

RMv6TF

IPv6 FORUM

# Cloud Computing

# Internet of Things

# Smart GRID

Vision & Way Forward

IPv6 FORUM

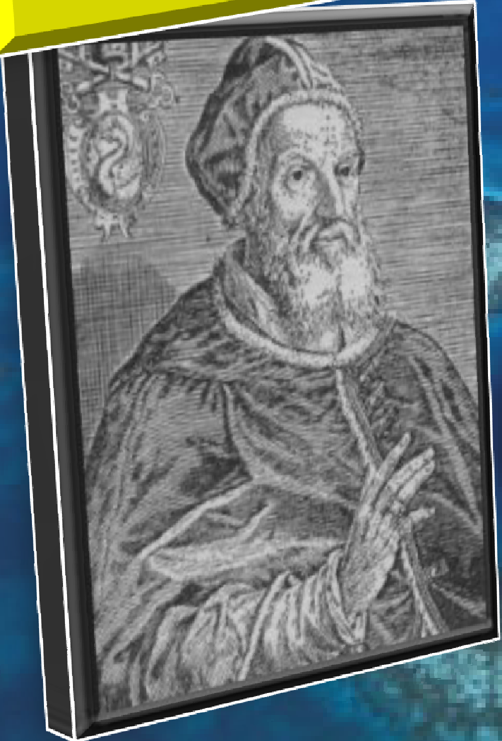
# The Heart Won First
# The Brain Still Second

- 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 Calender

Pope Gregory XIII



Adopted Oct 4, 1582

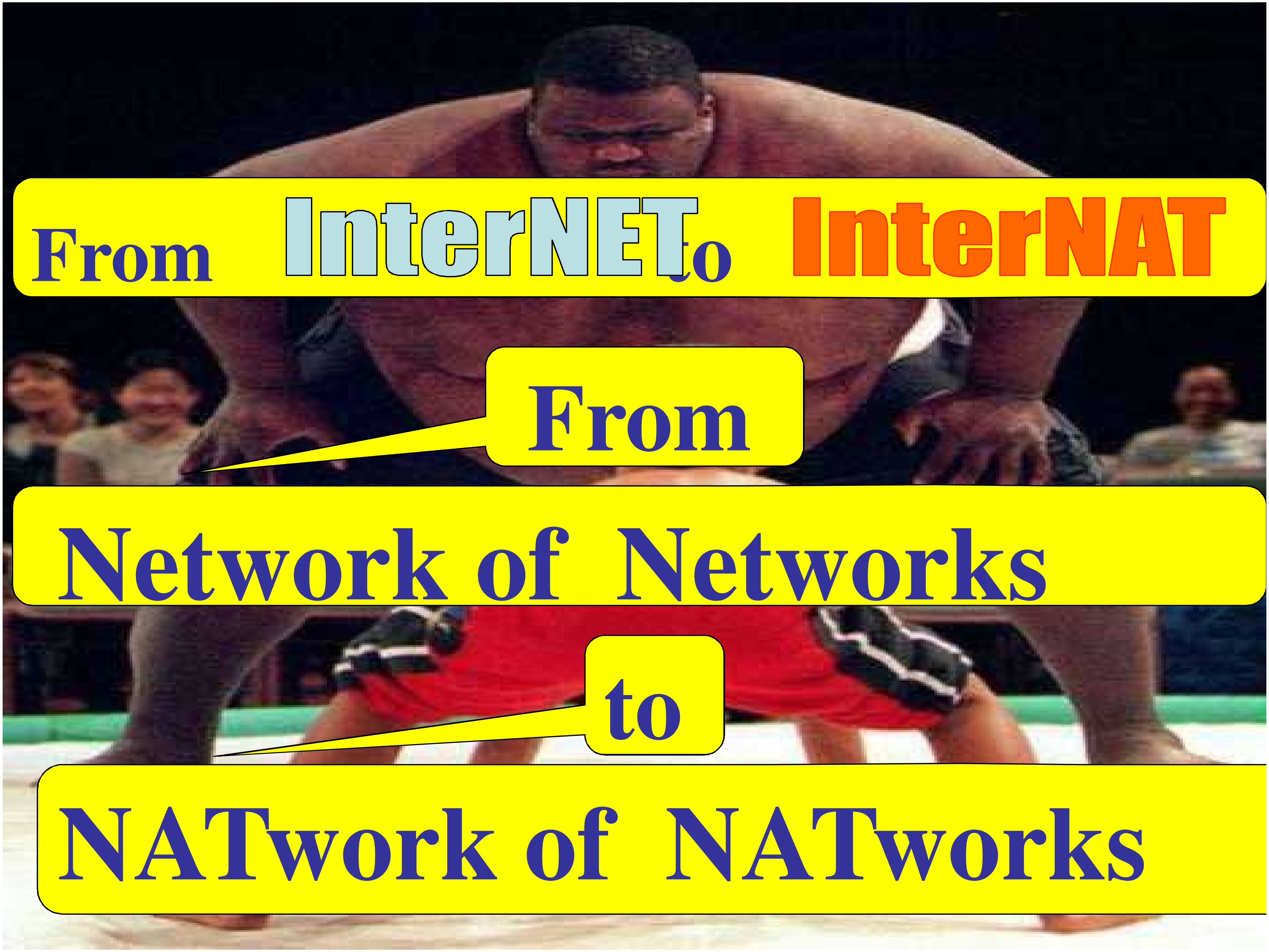
Protestants - GB: 2 Centuries

Protestants - Russia:
3.5 Centuries later

Muslim nations: Hegir - dual
China: Its own calendar

# 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 ☺

Geoff Huston

Tony Hain

2030

2010


# IPv4 Address Fractal Map – April 2010

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

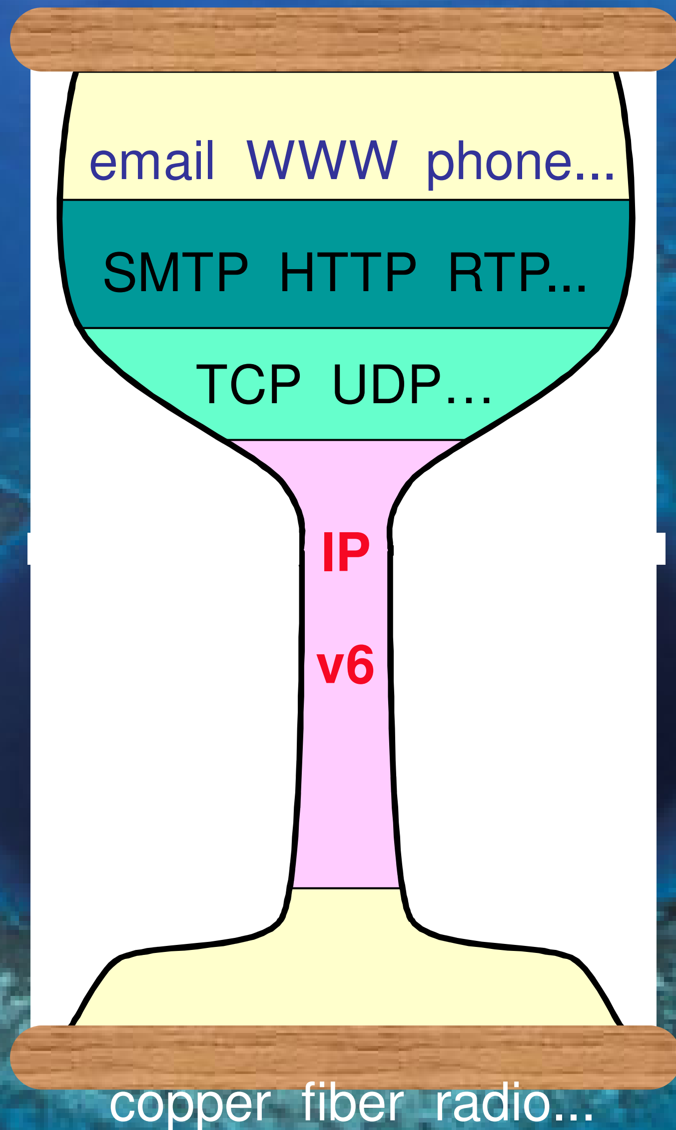
| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 000 Local | 001 Reserved | 014 [illegible] | 015 HP | 016 DEC | 019 Ford | 020 CSC | 021 U.S. DoD | 234 Multicast | 235 Multicast | 236 Multicast | 239 Multicast | 240 ClassE | 241 ClassE | 254 ClassE | 255 ClassE |
| 003 GE | 002 Reserved | 013 Xerox | 012 AT&T | 017 Apple | 018 MIT | 023 Reserved | 022 U.S. DoD | 233 Multicast | 232 Multicast | 236 Multicast | 238 Multicast | 243 ClassE | 242 ClassE | 253 ClassE | 252 ClassE |
| 004 L3 | Reserved | 008 L3 | 011 U.S. DoD | 030 U.S. DoD | 029 U.S. DoD | 024 Cable | 025 UK Defense | 230 Multicast | 231 Multicast | 226 Multicast | 225 Multicast | 244 ClassE | 247 ClassE | 248 ClassE | 251 ClassE |
| 005 Reserved | 006 U.S. DoD | 009 IBM | 010 Private | 031 Reserved | 028 U.S. DoD | 027 Reserved | 026 U.S. DoD | 229 Multicast | 228 Multicast | 227 Multicast | 224 Multicast | 245 ClassE | 246 ClassE | 249 ClassE | 250 ClassE |
| 058 APnic | 057 SITA | 054 Merck | 053 Cap Debis | 032 AT&T | 035 MERIT | 036 Reserved | 037 Reserved | 218 APnic | 219 APnic | 220 APnic | 223 Reserved | 202 APnic | 201 LACnic | 198 Various | 197 Reserved |
| 059 APnic | 056 U.S. Postal | 055 U.S. DoD | 052 El duPont | 033 U.S. DoD | 034 Halliburton | 039 Reserved | 038 PSI | 217 RIPE | 216 ARIN | 221 APnic | 222 APnic | 203 APnic | 200 LACnic | 199 ARIN | 196 AfriNIC |
| 060 APnic | 061 APnic | 050 Reserved | 051 UK DSS | 046 Reserved | 045 Interop | 040 Eli Lily | 041 AfriNIC | 214 U.S. DoD | 215 U.S. DoD | 210 APnic | 209 ARIN | 204 ARIN | 205 ARIN | 194 RIPE | 195 RIPE |
| 063 ARIN | 062 RIPE | 049 Reserved | 048 Prudential | 047 Bell-Northern | 044 Radio | 043 Inet | 042 Reserved | 213 RIPE | 212 RIPE | 211 APnic | 208 ARIN | 207 ARIN | 206 ARIN | 193 RIPE | 192 Various |
| 064 ARIN | 067 ARIN | 068 ARIN | 069 ARIN | 122 APnic | 123 APnic | 124 APnic | 127 Loopback | 128 Various | 131 Various | 132 Various | 133 Various | 186 Next | 187 Next | 188 Various | 191 Various |
| 065 ARIN | 066 ARIN | 071 ARIN | 070 ARIN | 121 APnic | 120 APnic | 125 APnic | 126 APnic | 129 Various | 130 Various | 135 Various | 134 Various | 185 Next | 184 Next | 189 LACnic | 190 LACnic |
| 078 RIPE | 077 RIPE | 072 ARIN | 073 ARIN | 118 APnic | 119 APnic | 114 Next | 113 Next | 142 Various | 141 Various | 136 Various | 137 Various | 182 Next | 183 Next | 178 Next | 177 Next |
| 079 RIPE | 076 ARIN | 075 ARIN | 074 ARIN | 117 APnic | 116 APnic | 115 Next | 112 Next | 143 Various | 140 Various | 139 Various | 138 Various | 181 Next | 180 Next | 179 Next | 176 Next |
| 080 RIPE | 081 RIPE | 094 RIPE | 095 RIPE | 096 ARIN | 097 ARIN | 110 Next | 111 Next | 144 Various | 145 Various | 158 Various | 159 Various | 160 Various | 161 Various | 174 Next | 175 Next |
| 083 RIPE | 082 RIPE | 093 RIPE | 092 RIPE | [illegible] ARIN | 098 ARIN | 109 Reserved | 108 Reserved | 147 Various | 146 Various | 157 Various | 156 Various | 163 Various | 162 Various | 173 Next | 172 Various |
| 084 RIPE | 087 RIPE | 088 RIPE | 091 RIPE | 100 Next | 103 Reserved | 104 Reserved | 107 Reserved | 148 Various | 151 Various | 152 Various | 155 Various | 164 Various | 167 Various | 168 Various | 171 Various |
| 085 RIPE | 086 RIPE | 089 RIPE | 090 RIPE | [illegible] Next | 102 Reserved | 105 Reserved | 106 Reserved | 149 Various | 150 Various | 153 Various | 154 Various | 165 Various | 166 Various | 169 Various | 170 Various |

# All ISPs will have to take off like this!”

**Anonymous 2010**

# The Internet Losers will meet their Enemy!

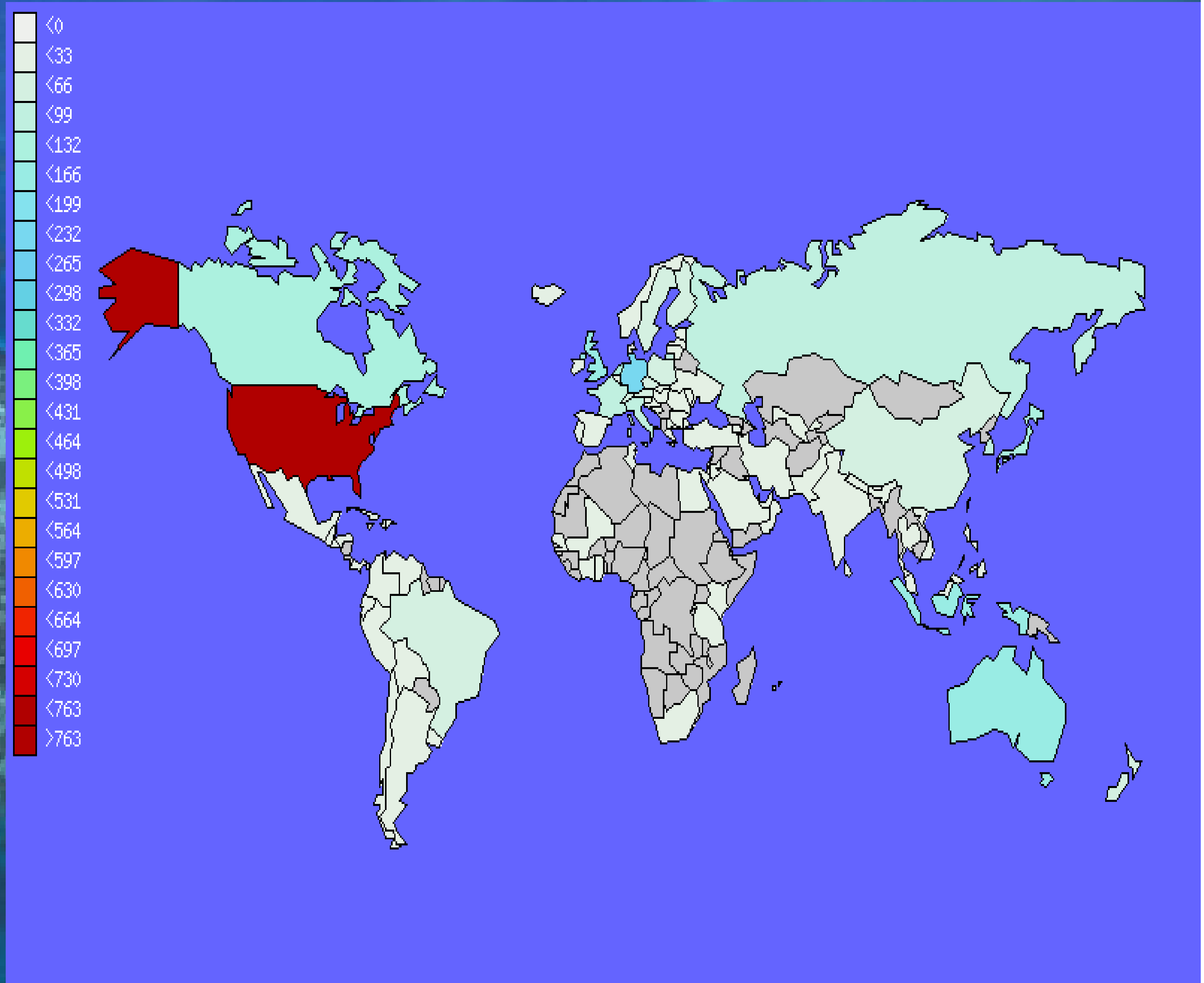
# A Fitness Goal




- 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

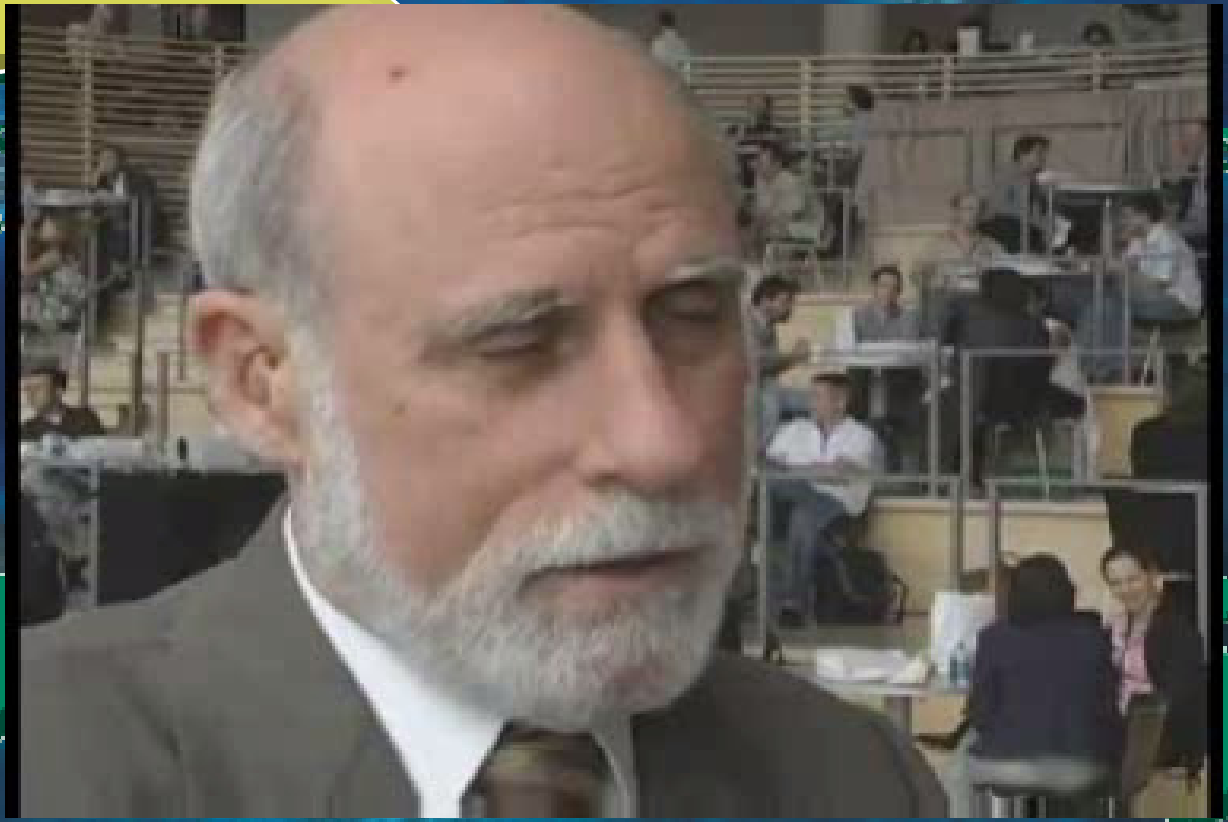
| | | |
|---|---|---|
| 1 | United States | 797 |
| 2 | Germany | 216 |
| 3 | United Kingdom | 153 |
| 4 | Indonesia | 144 |
| 5 | Australia | 137 |
| 6 | Netherlands | 126 |
| 7 | Canada | 126 |
| 8 | Japan | 113 |
| 9 | Russian Federation | 90 |
| 10 | Italy | 84 |
| 11 | France | 79 |
| 12 | EU | 74 |
| 13 | Korea, Republic of | 66 |
| 14 | Switzerland | 62 |
| 15 | Sweden | 61 |
| 16 | Poland | 55 |
| 17 | New Zealand | 54 |
| 18 | China | 54 |
| 19 | Austria | 51 |
| 20 | Czech Republic | 48 |
| 21 | Brazil | 43 |
| 22 | Hong Kong | 43 |
| 23 | Finland | 35 |
| 24 | Taiwan, Province of China | 32 |



# Killer Apps

# "The Myth of the IPv6 Killer App"

Vint Cerf 2008



IPv6 FORUM

Yv4

# WORLD INTERNET USAGE & POPULATION STATISTICS

Yv6

| World Regions | Population ([illegible] Est.) | Internet Users Dec/31, 2000 | Internet Usage, Latest Data | % Population ( Penetration ) | Usage % of World | Usage Growth 2000-2008 |
|---|---|---|---|---|---|---|
| Africa | [illegible] | 4,514,400 | [illegible] | 5.3 % | 3.5 % | 1,031.2 % |
| Asia | [illegible] | [illegible] | [illegible] | 15.3 % | 39.5 % | 406.1 % |
| Europe | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 266.0 % |
| Middle East | [illegible] | 3,284,800 | 41,939,200 | [illegible] | [illegible] | [illegible] |
| North America | [illegible] | [illegible] | [illegible] | 73.6 % | [illegible] | 129.6 % |
| Latin America/Caribbean | [illegible] | [illegible] | [illegible] | 24.1 % | 9.5 % | 669.3 % |
| Oceania / Australia | 33,981,562 | 7,620,480 | [illegible] | [illegible] | 1.4 % | 165.1 % |
| WORLD TOTAL | 6,676,120,288 | 360,985,492 | 1,963,632,361 | [illegible] | [illegible] | [illegible] |

**First IPv6 Killer App!**

IPv4 Achieved the Critical 20%

IPv6 Can Drive Growth & Continuity!

# The Next Big Internet

Smart GRID

Internet of Things

Billions of
Smart Devices
- Vehicles
- Buildings

Trillions of

- RFIDs
- Sensors

5 Billions
- Mobile Phones
- PDAs

650 M
Nodes

Cloud Computing

# CLOUD COMPUTING

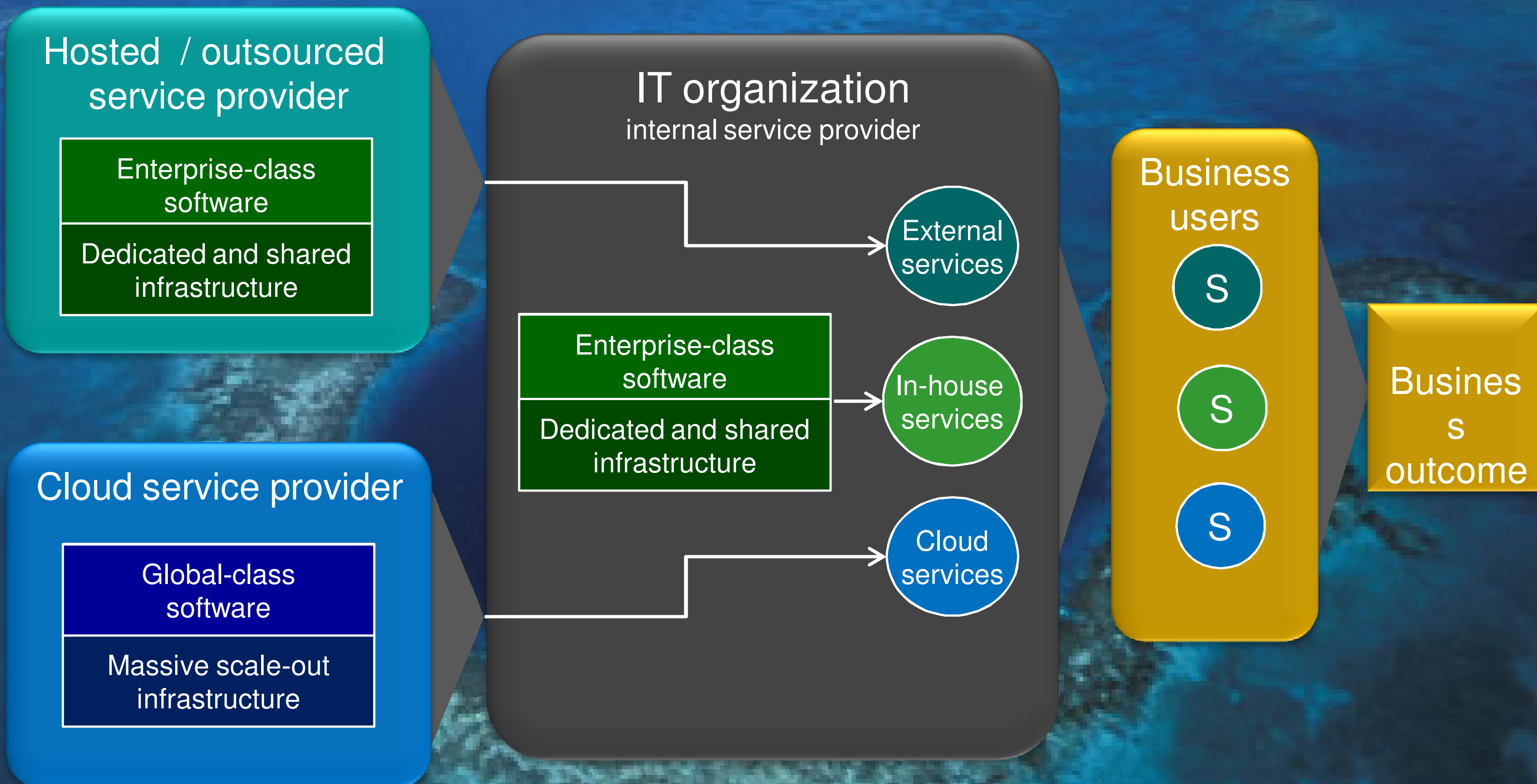
## Enterprise vs. Cloud

| Enterprise Class | Global class |
|---|---|
| On-premise | Hybrid/off-premise |
| 100s -1000s of nodes | 10,000+ nodes |
| Proprietary | Commodity |
| HW resiliency | SW resiliency |
| Max performance | Max efficiency |
| Silo'ed Resources | Shared Resources |
| Clusters | Grids/Cloud |
| Static | Elastic |
| Shared storage | Replicated storage |
| Facility costs | Power Usage Efficiency |
| Cost-Center | Value/ Revenue-Center |

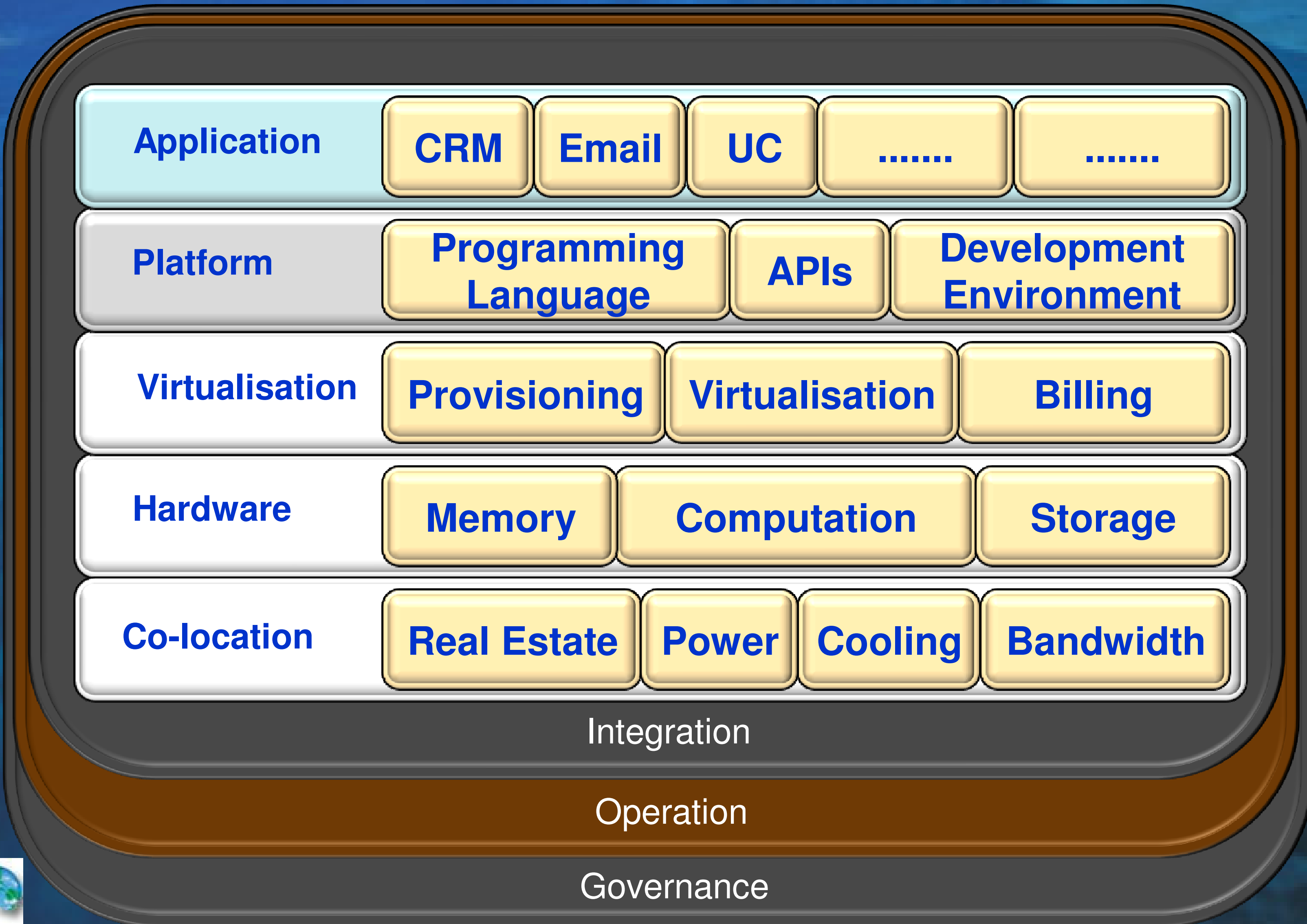
Courtesy: John Rhoton
Distinguished Technologist
HP EDS CTO Office

# Market context

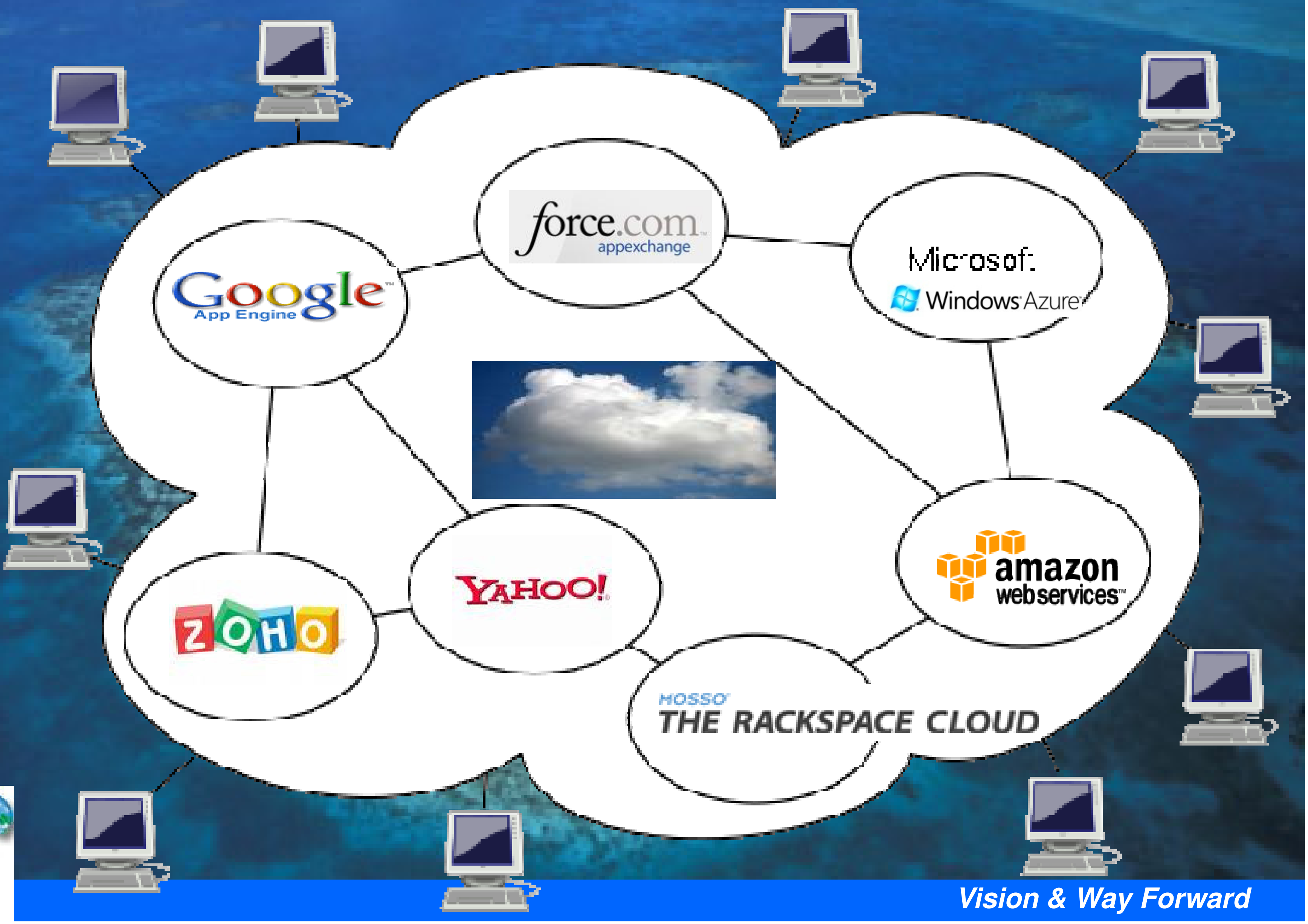
## A service-centric perspective sheds light on all value chain constituents



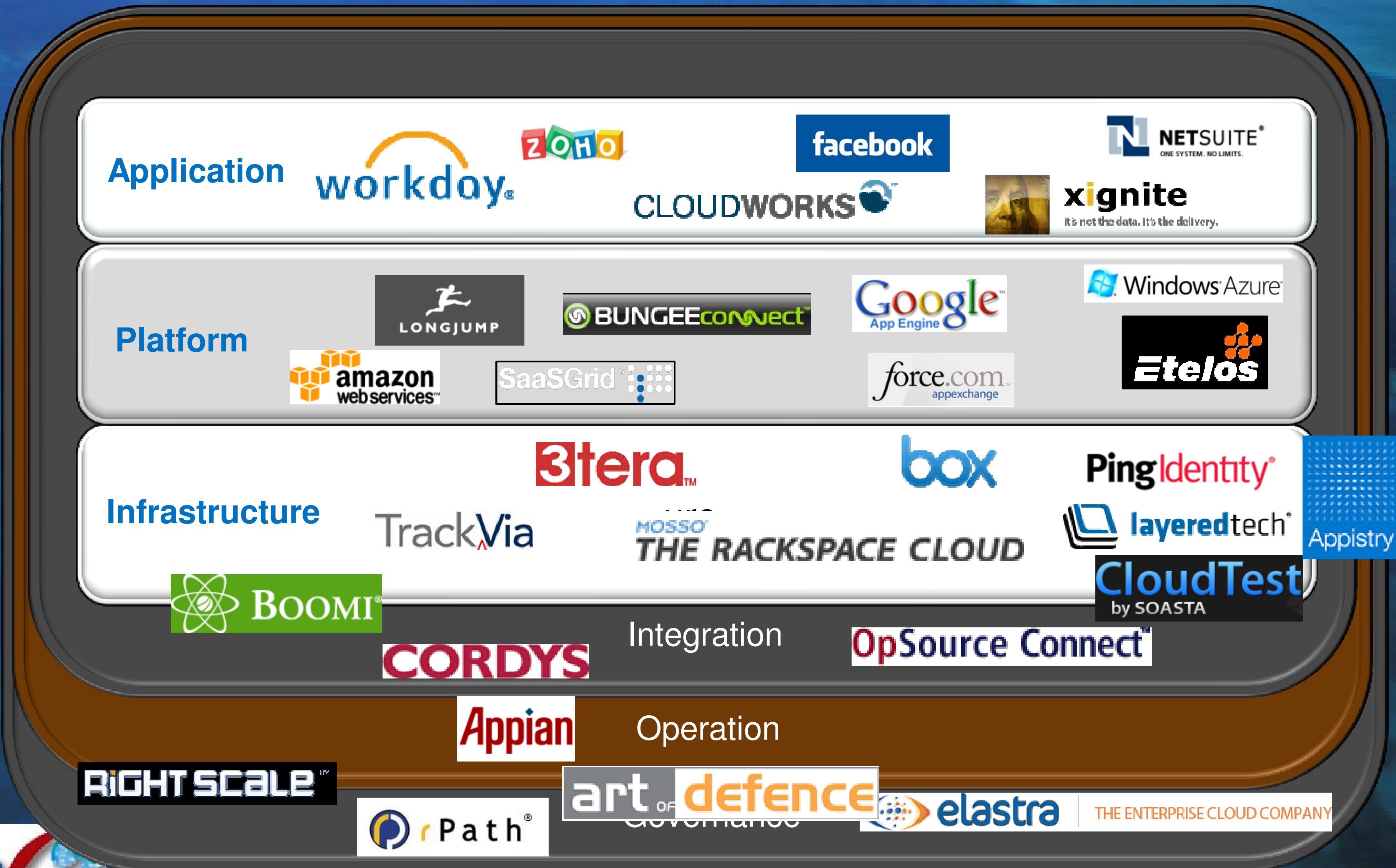
# Cloud Model


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

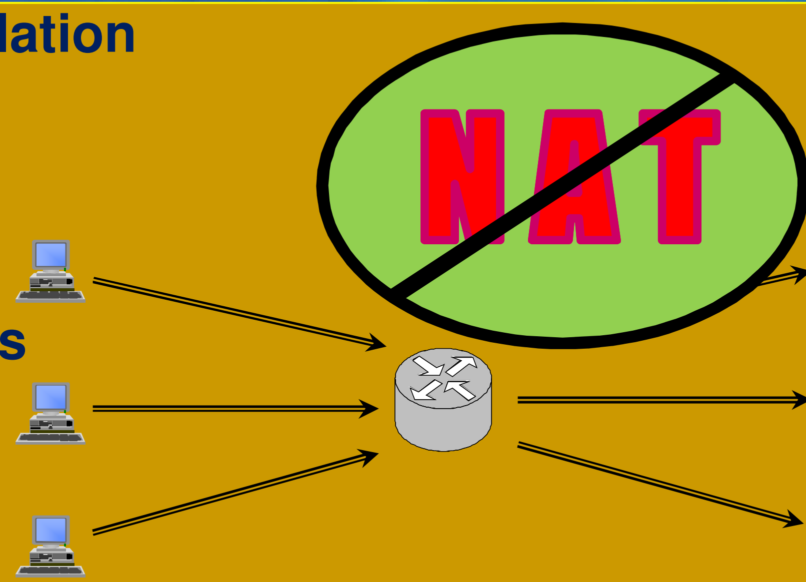


# Cloud Landscape



# 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

# Synergies between CC & IPv6

## Scalability

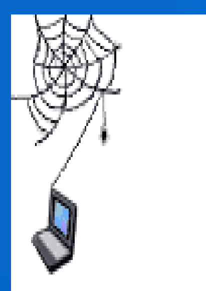
- ✓ Massive scalability
  - ➢ Hierarchical internal address space of provider
  - ➢ Avoid connection brokers (ALG/NAT)
- ✓ No "need" for NAT
- ✓ Always connected user experience Mobile IPv6
- ✓ Customer connectivity
- ✓ "Easier" implementation
- ✓ Unified Communications

- ✓ 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

<u>**Mobility**</u>

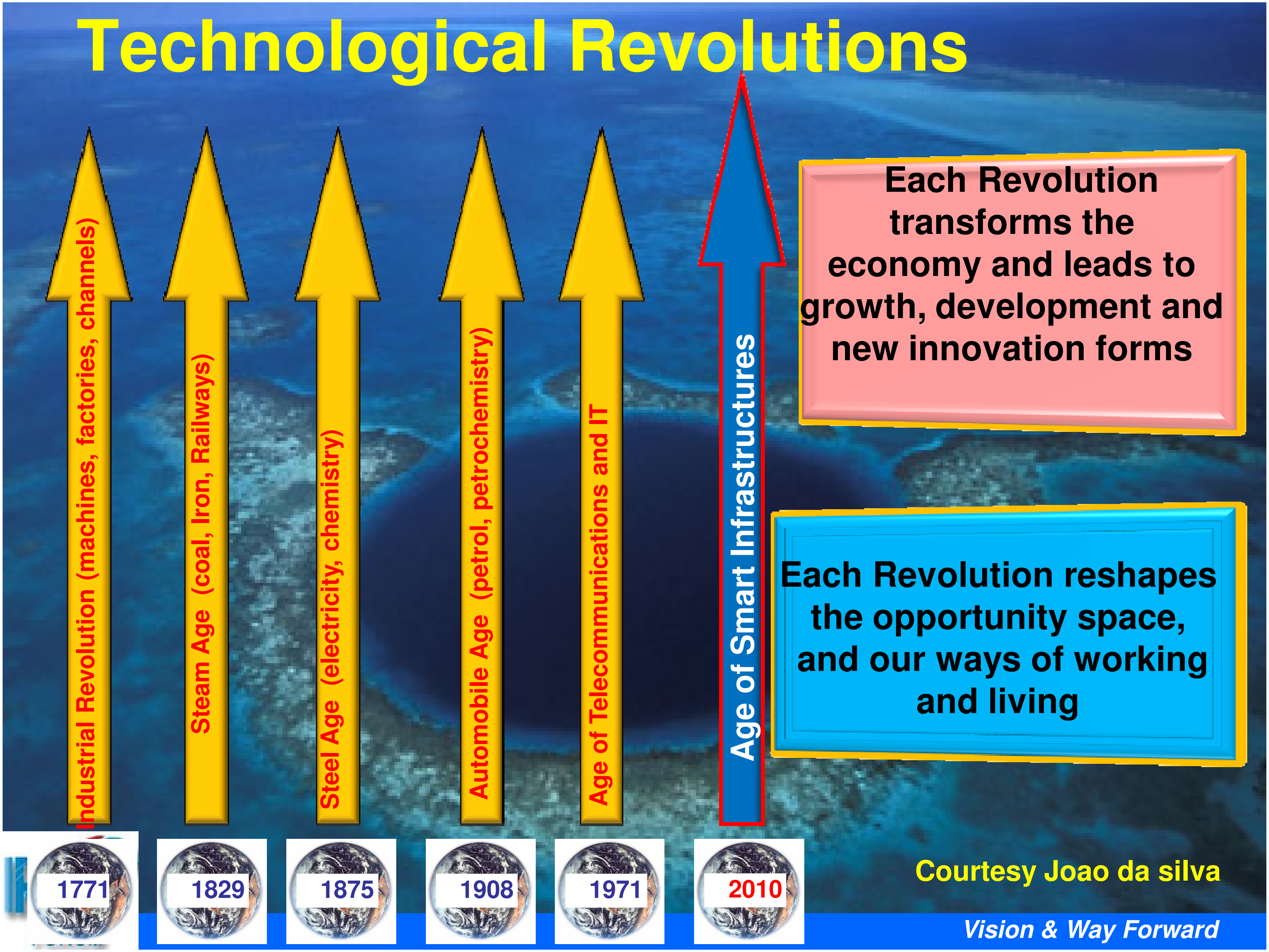
- ✓ Seamless user experience
- ✓ Always Connected users
  - • Move from one access network to another
- ✓ Cloud Abstraction
- ✓ Workload rebalancing
  - Virtual Machine relocation



***<u>Automatic Deployment</u>***

- ✓ 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
Vision & Way Forward


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
1771
1829
1875
1908
1971
2010
Courtesy Joao da silva
Vision & Way Forward

# 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

# Internet of Things

Courtesy Gerald Santucci

***How It All Got Started***

- **Kevin Ashton, Auto-ID @ MIT, 1998**
- **EPCglobal , 2003**
- **ITU Report, 2005**
- **EC Communication on RFID, 2007**
- **EU Presidency Conferences**
  - **Berlin (DE) and Lisbon (PT), 2007**
  - **Nice (FR), 2008**
- **Telecom Council Conclusions on Future Networks and the Internet, 2008**

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

**Kevin Ashton, 2009**

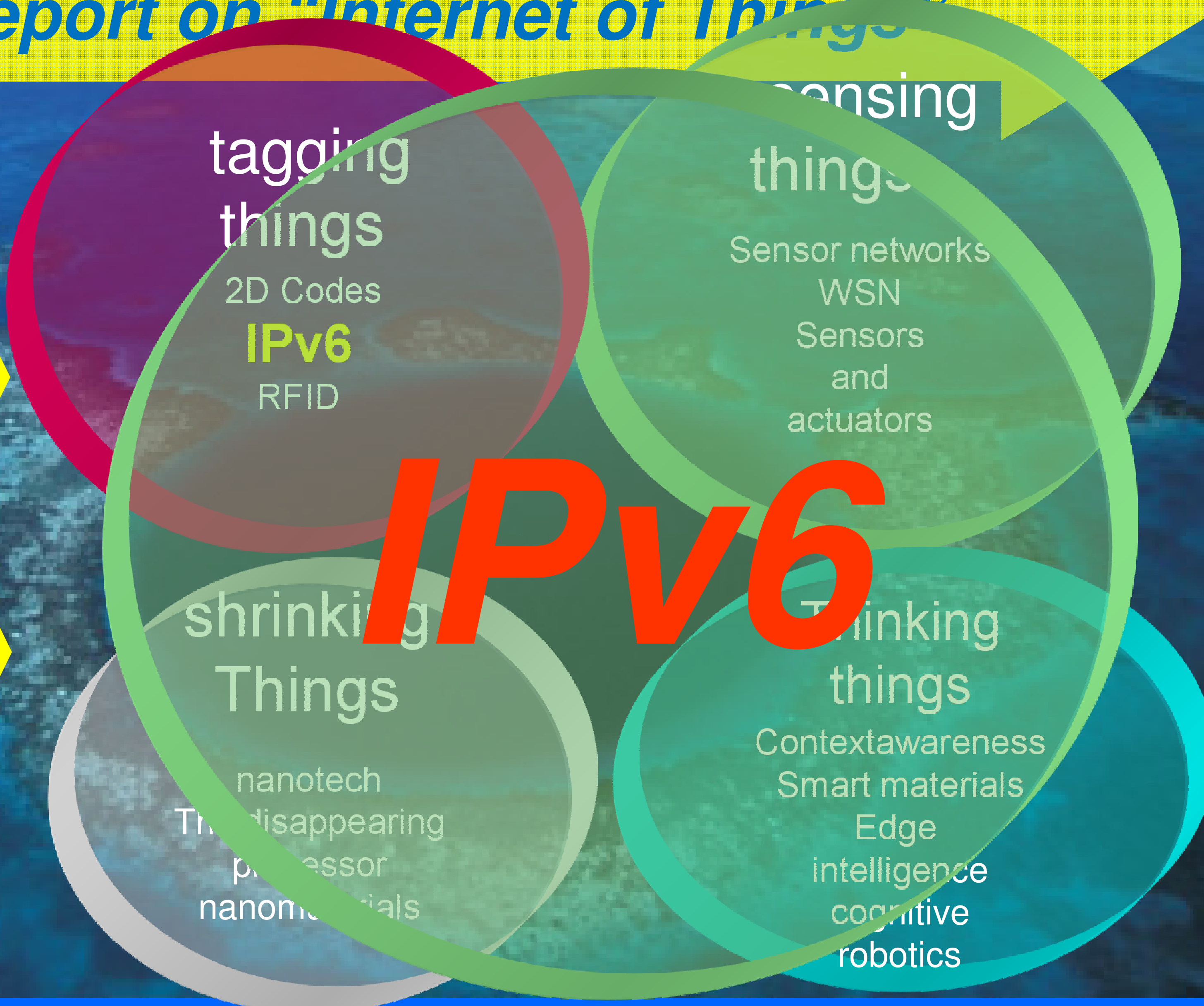
# *What Are "Things"?*

# *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"

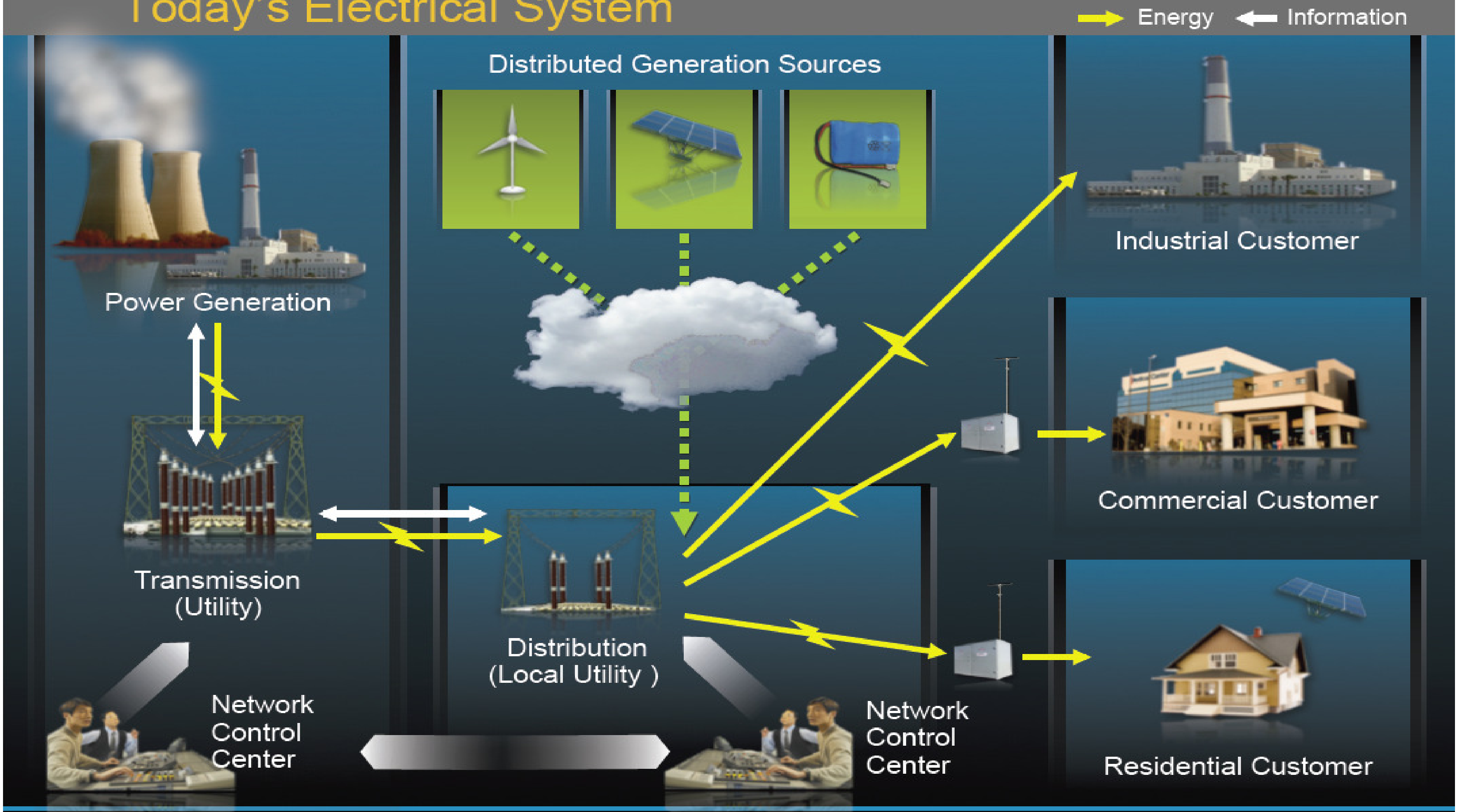
**ITU: again wrong on IPv6**

# Application Potential

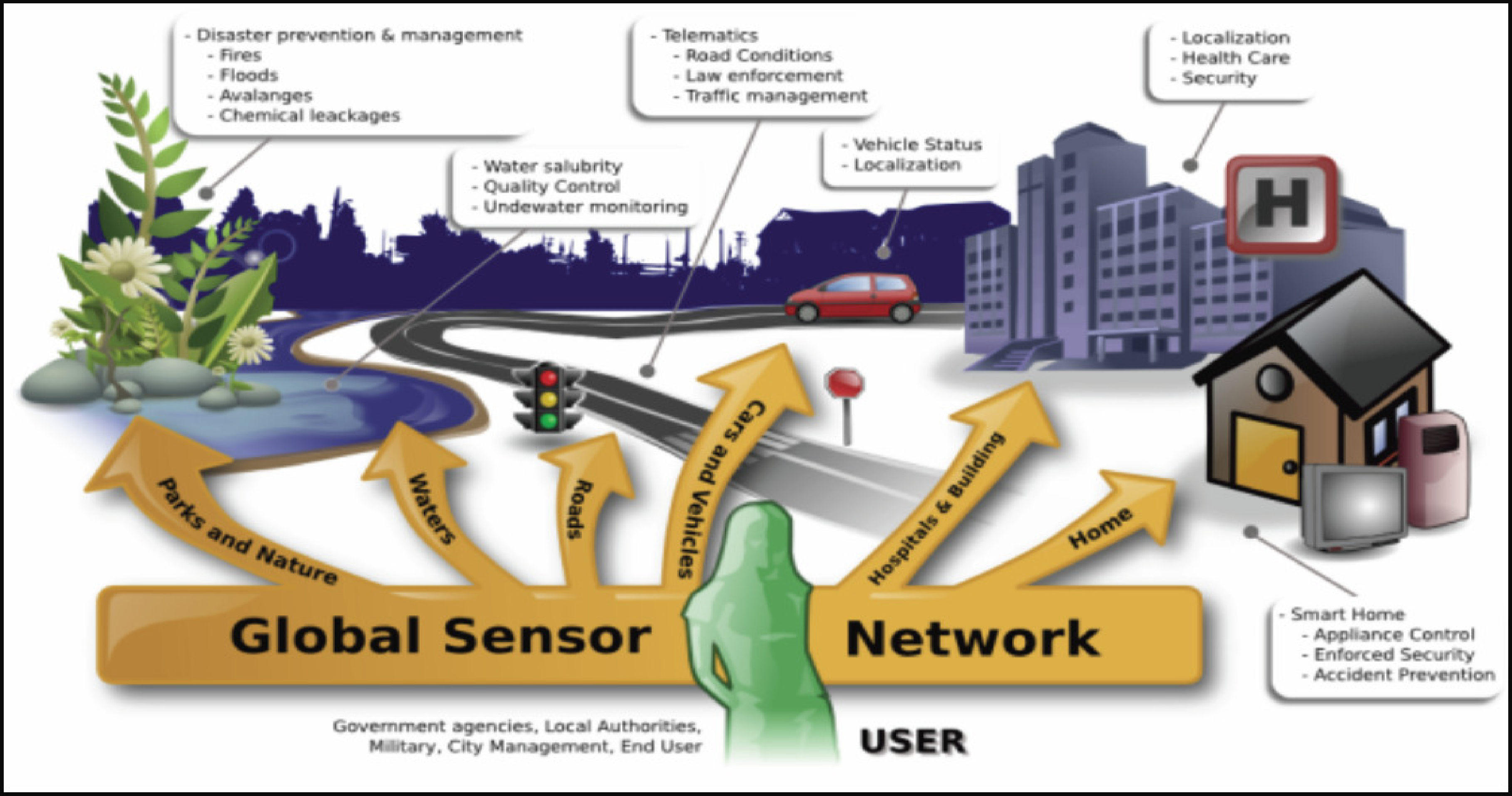
## Power Management

Today's Electrical System



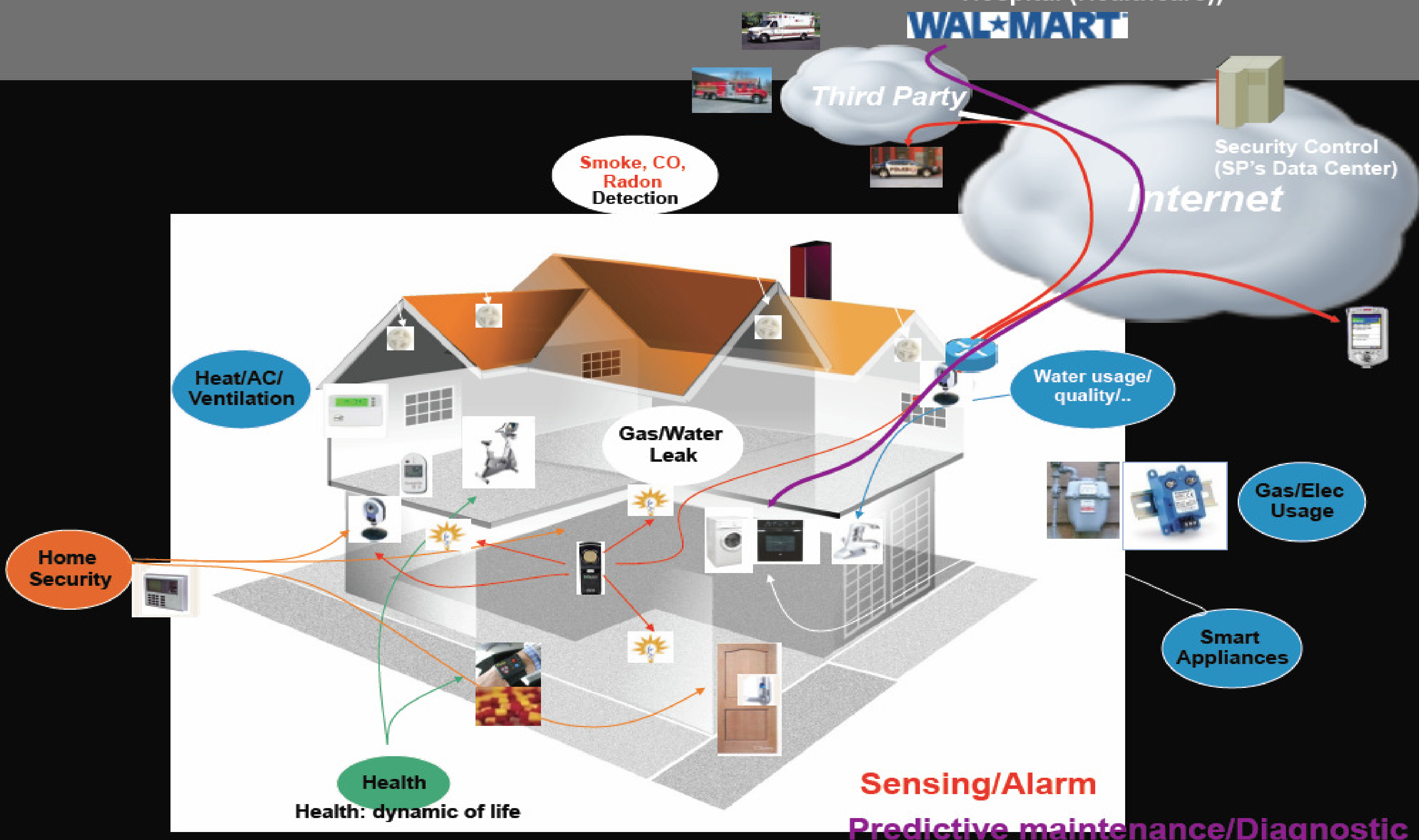
# Application Potential

## Smart+Connected Communities



# Application Potential

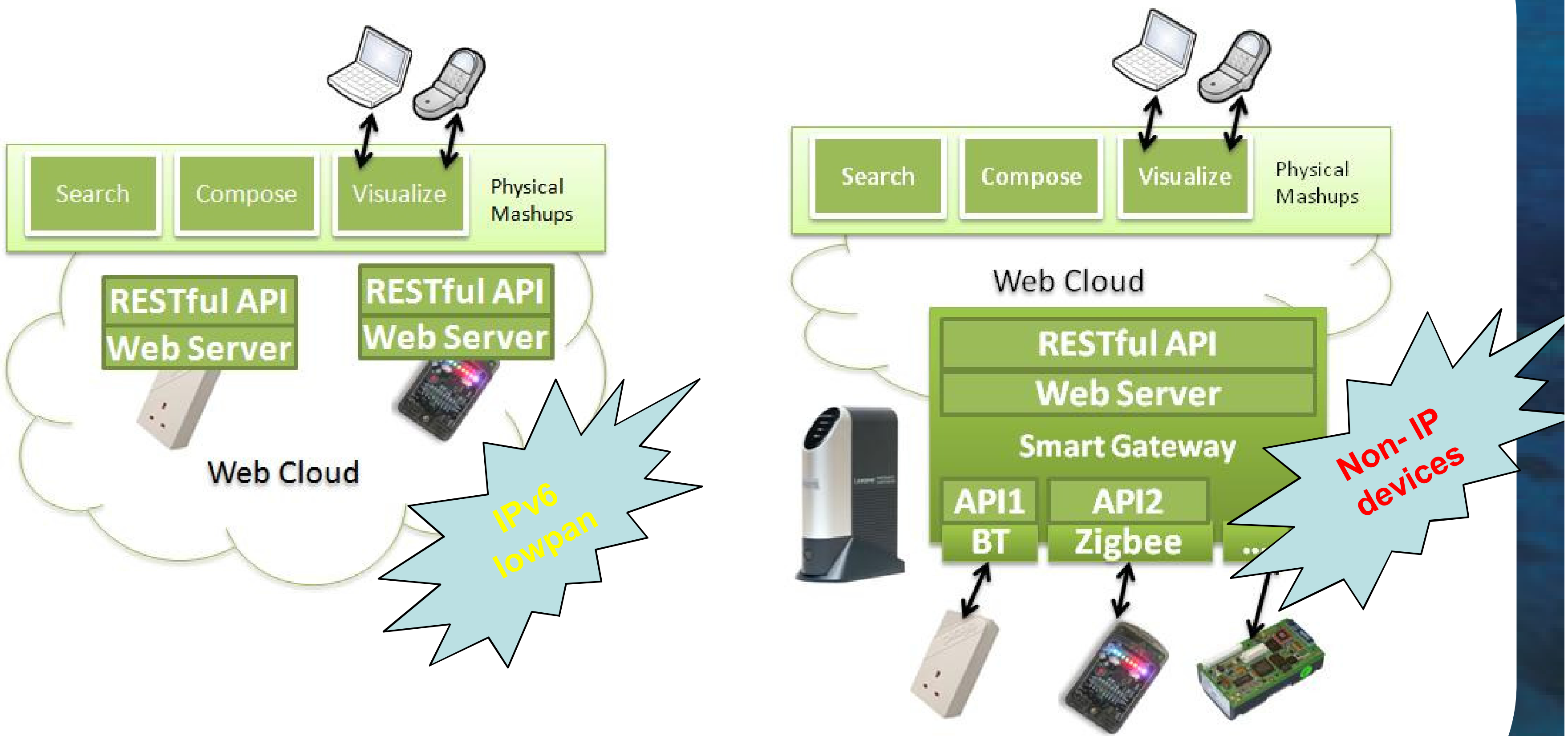
## Connected Home



# Protocols for Things of Internet

| Protocols | Standards Development Organization |
| --- | --- |
| Application Protocols | ZigBee™ |
| UDP/ICMP | IETF |
| IPv6 (6LoWPAN, ROLL) | IETF |
| IEEE 802.15.4 | IEEE |

# Connecting the Embedded Devices to the Internet






36

# 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

# Government Perspective

**EU: - Communication in 2007 on IoT – RFID (IPv6)**

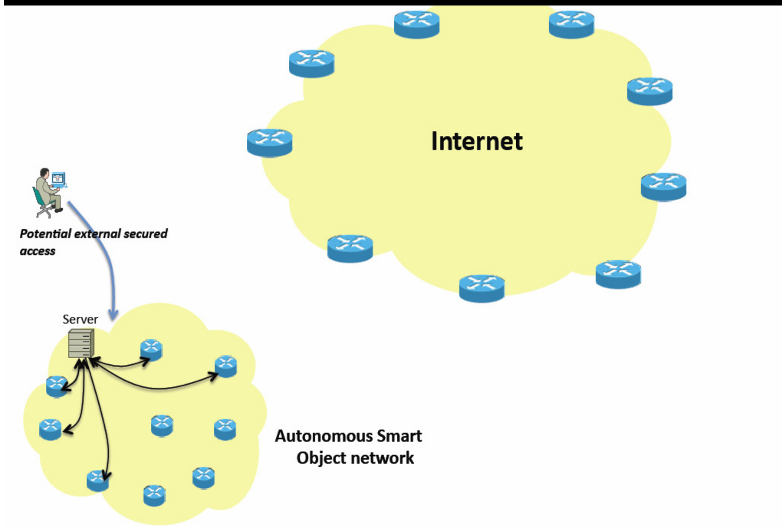
**USG: NIC: 6 Disruptive Civil Technologies – IoT in 2008 -v6?**

**China: Premier Wen in August 7, 2009:**

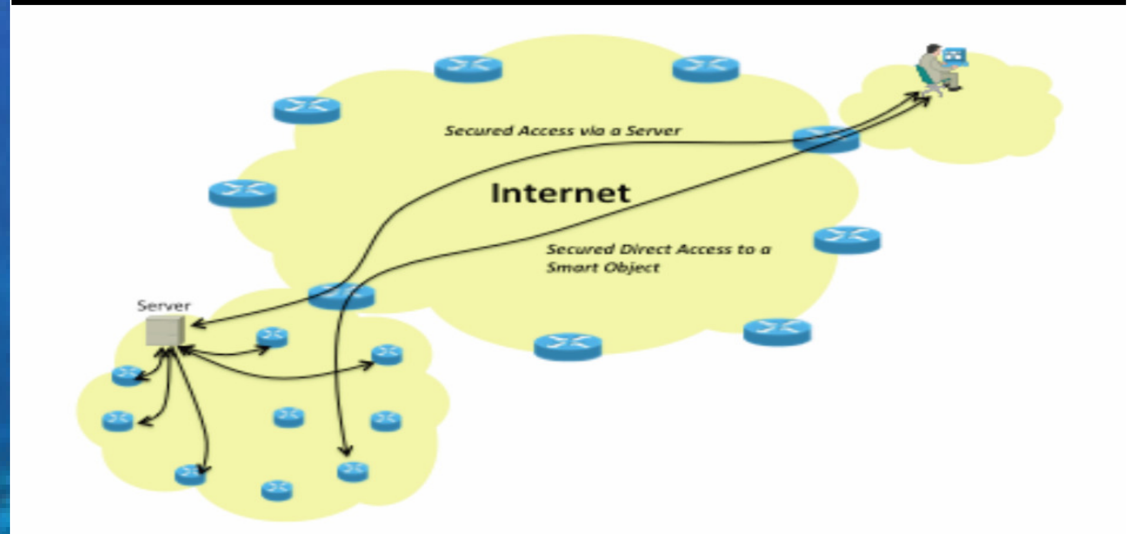
**"Internet + IoT = Wisdom of Earth"**

**Dec 9, 2009, Zhou Hongren, Exe. Vice Chair ACSI - "Advised Guangdong Province to deploy IPv6" (watch this space!)**

# Autonomous Smart Object Networks

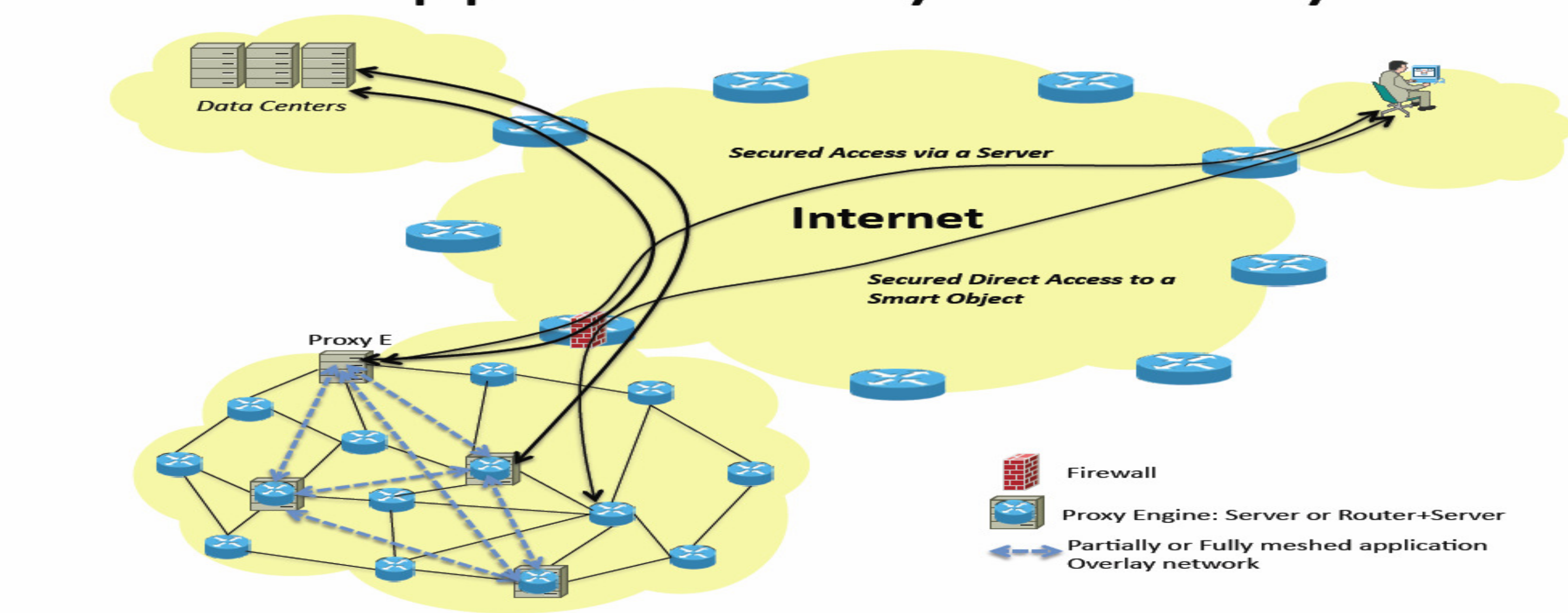



# The “True” Internet of things



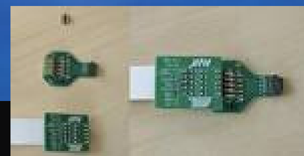

# The Extended Internet

## Application Layer Overlays



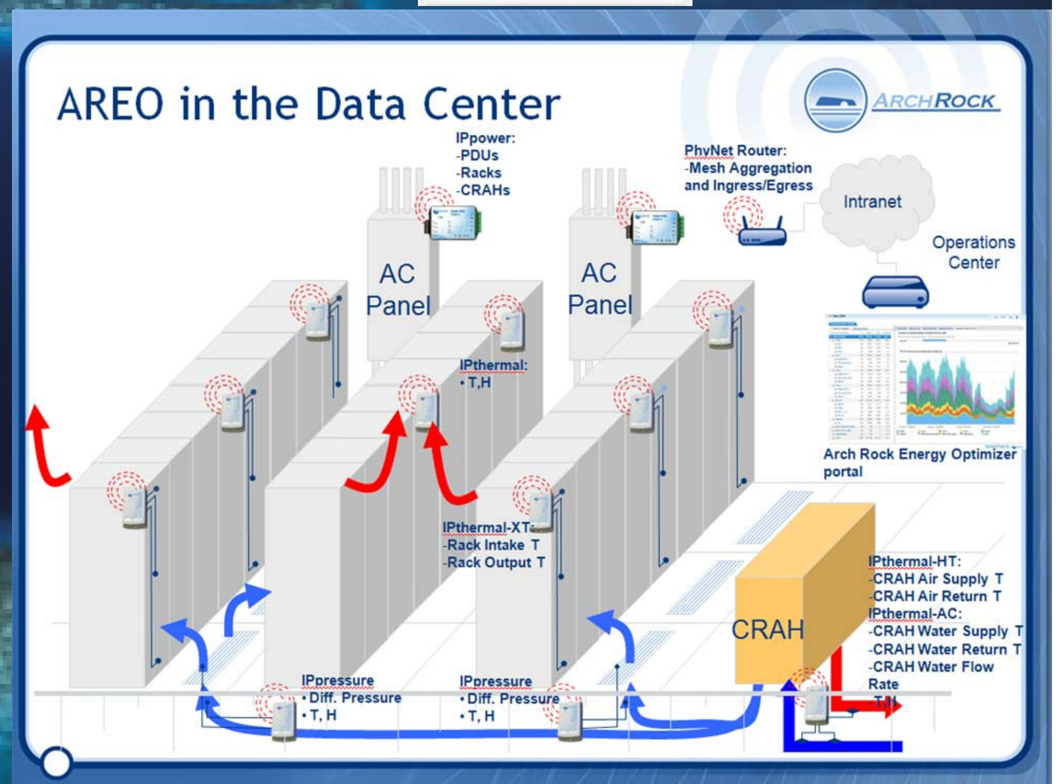
# IPv6 Sensors

## 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…

ARCHROCK

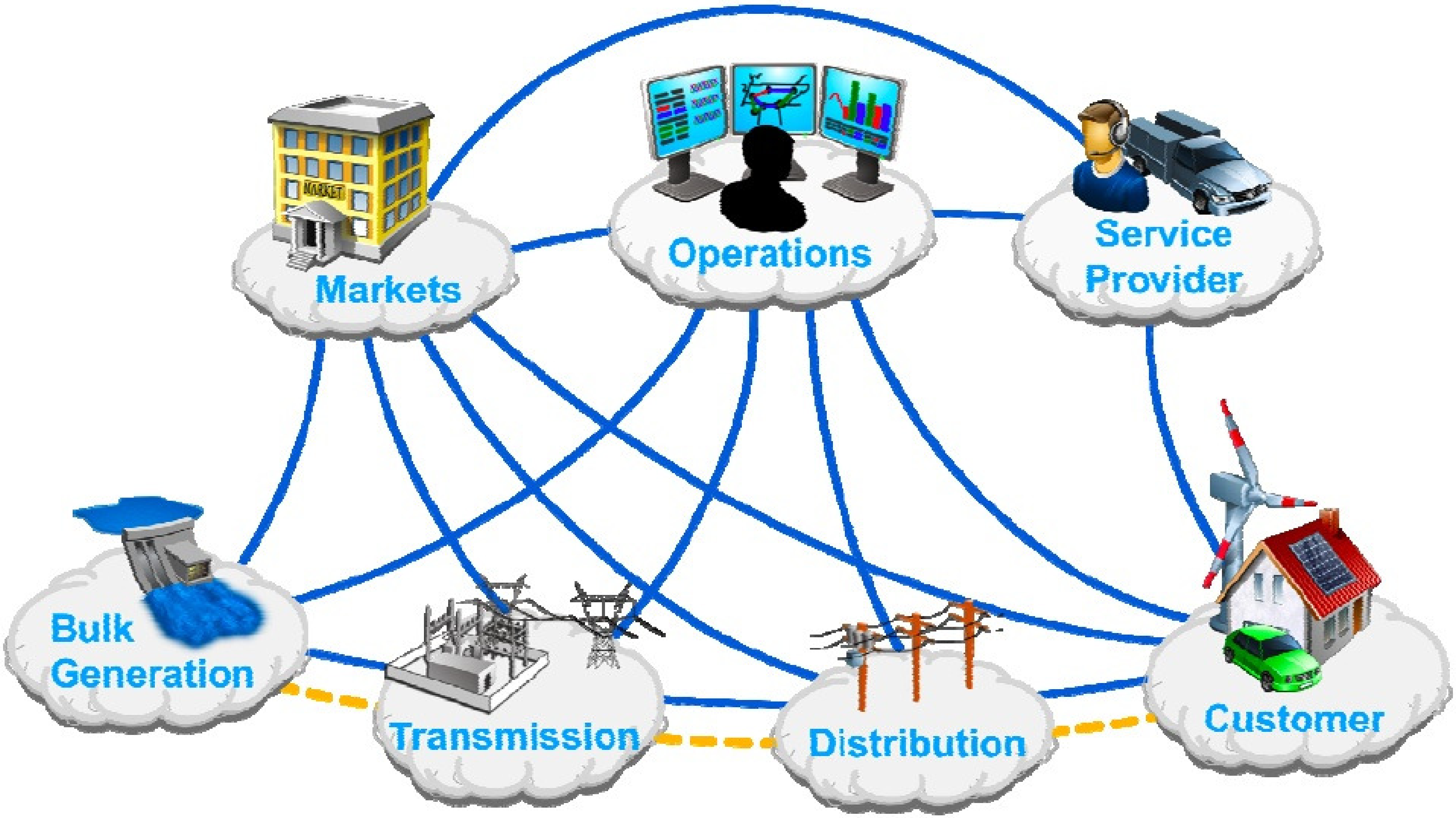


# Main Policy Challenges

- **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


SmartGRID
Vision & Way Forward

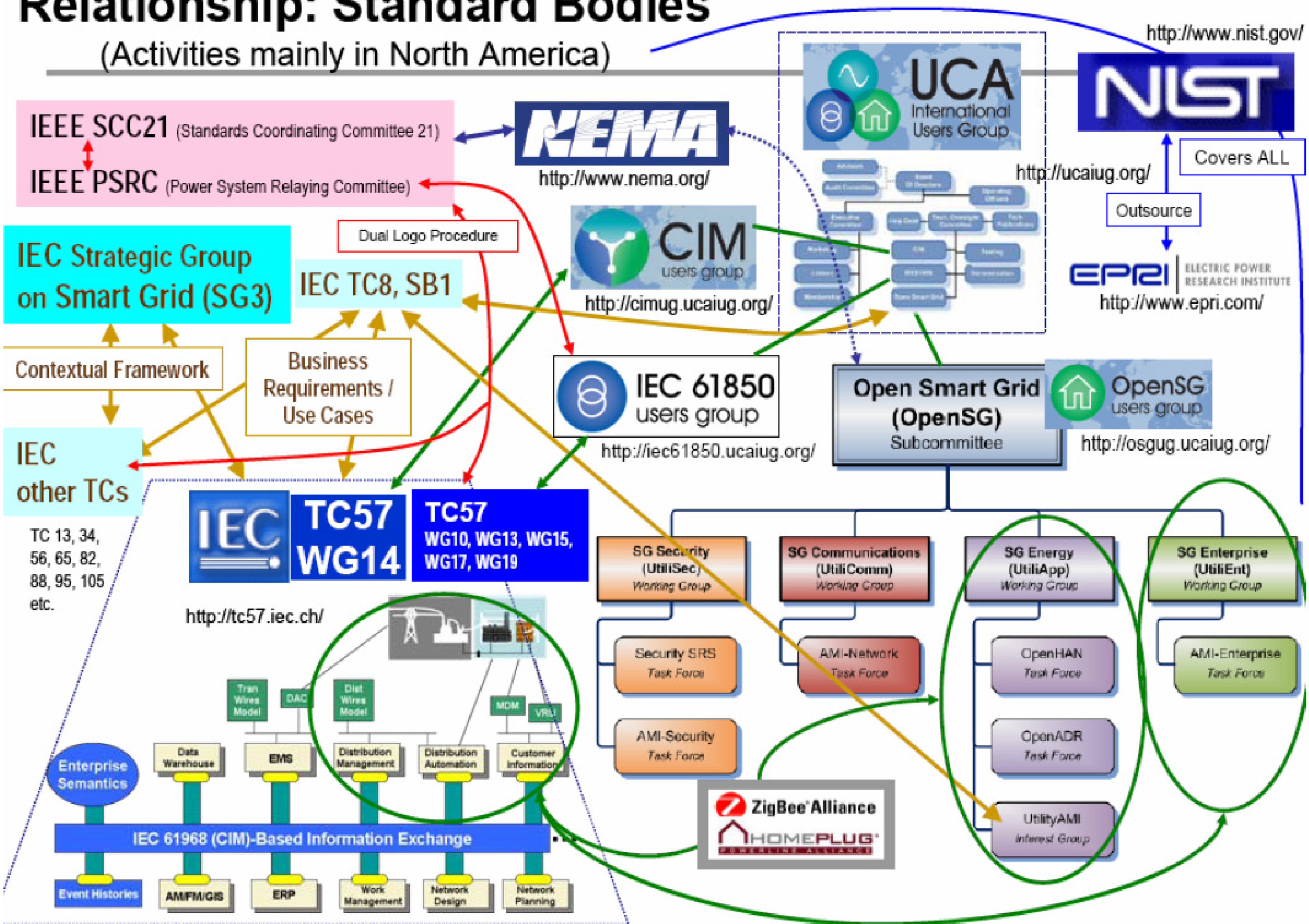
# Smart Grid operational domains



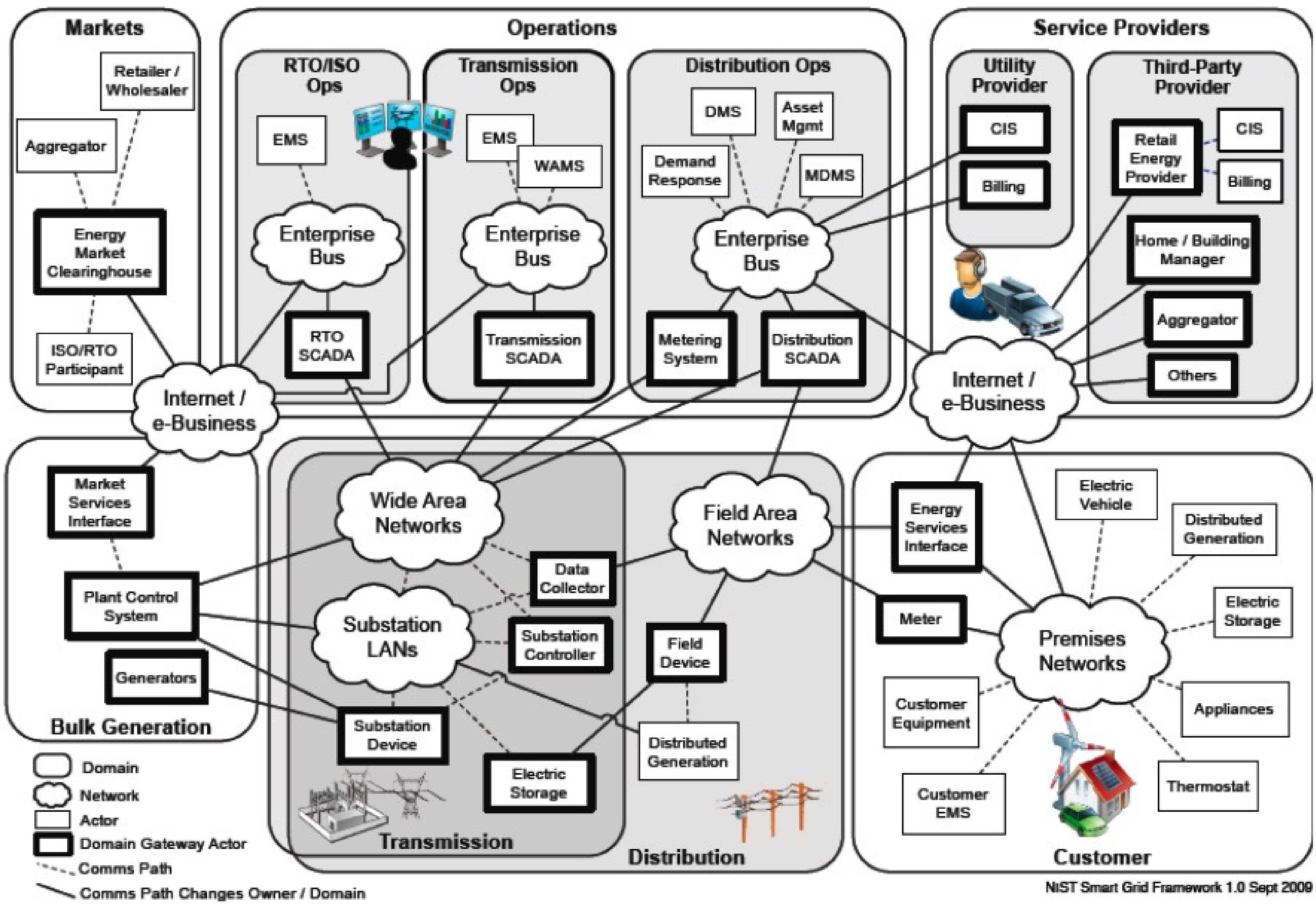

NIST Smart Grid Framework 1.0 Sept 2009

# Relationship: Standard Bodies

(Activities mainly in North America)



# Smart Grid Framework




*NIST Smart Grid Framework 1.0 September 2009*

# Smart Grid Standards


Figure 4: Domain Decomposition

NIST asked the IETF

# Network Architecture in the Smart Grid

**Architectural Requirements in the NIST Framework and how to meet them**

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*Vision & Way Forward*

# Architectural designs

### Internet Architecture

| | |
|---|---|
| **Application** | **Application Protocol, encoding, AAA, identity, encryption** |
| Transport | End to end reliability |
| Internet | End to end routing, VPN, Network AAA, identity, encryption |
| Data Link | Link encoding on physical layer |
| Physical | Physical Interconnect |

### "1-2-7" Architecture

| | |
|---|---|
| **Application** | **Application Protocol, encoding, AAA, identity, encryption, End to end reliability, end to end routing** |
| Data Link | Link encoding on the physical layer |
| Physical | Physical Interconnect |

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# Examples

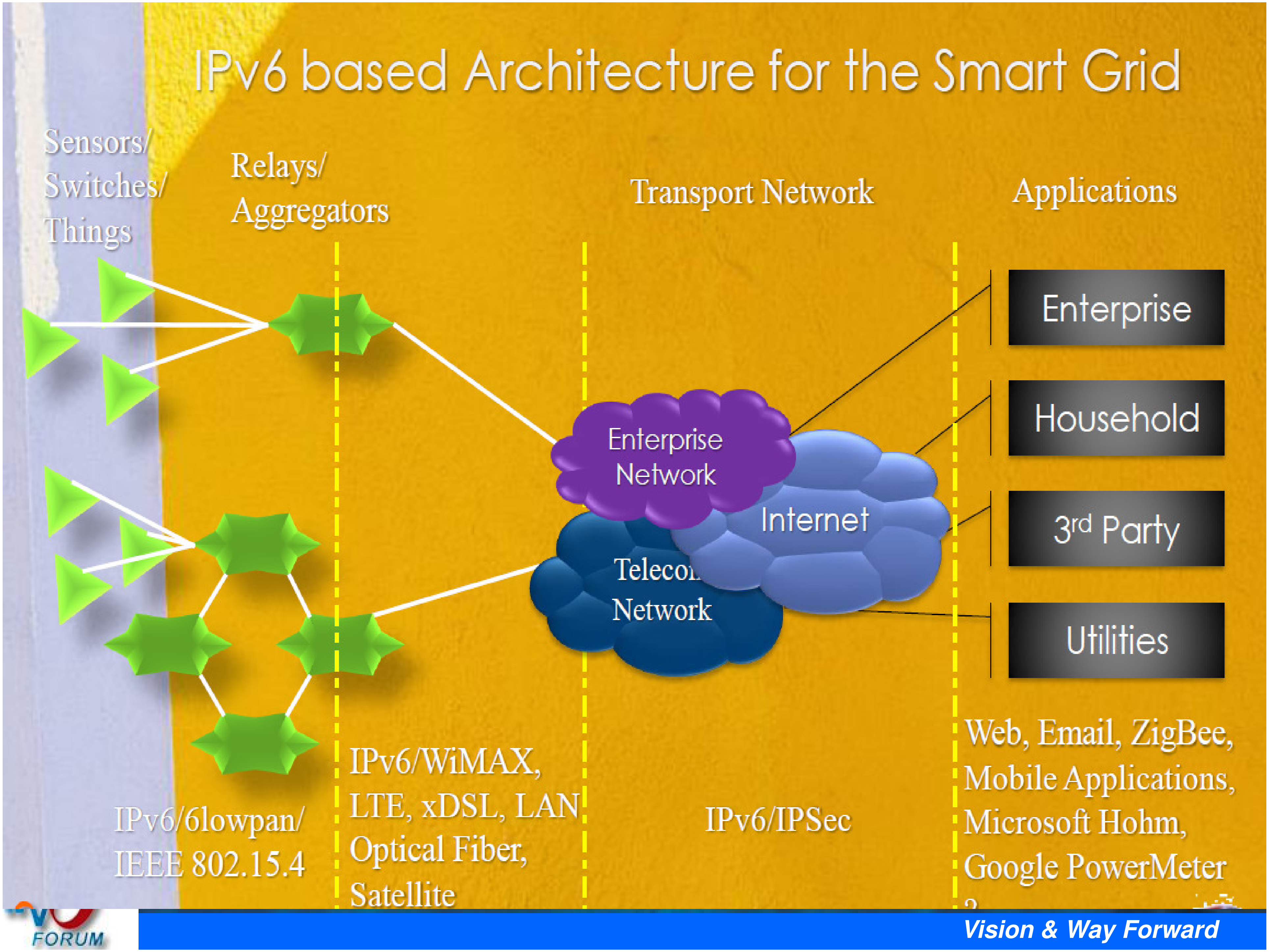
| *Internet Architecture* | *"1-2-7" Architectures* |
|---|---|
| • The Internet<br>– IPv4 or IPv6<br>• The ISO OSI Reference Model<br>– breaking the application into several layers<br>• Novell Netware<br>• AppleTalk<br>• DECNet<br>• XNS Internet Transport<br>• etc<br><br>Designed to work in Enterprise and general networks | • IEC 14908<br>– Implements 7 layers, but in the application protocol<br>• Zigbee 1.0<br>• Many others in the Grid<br><br>Wire replacement, designed to work in local networks |

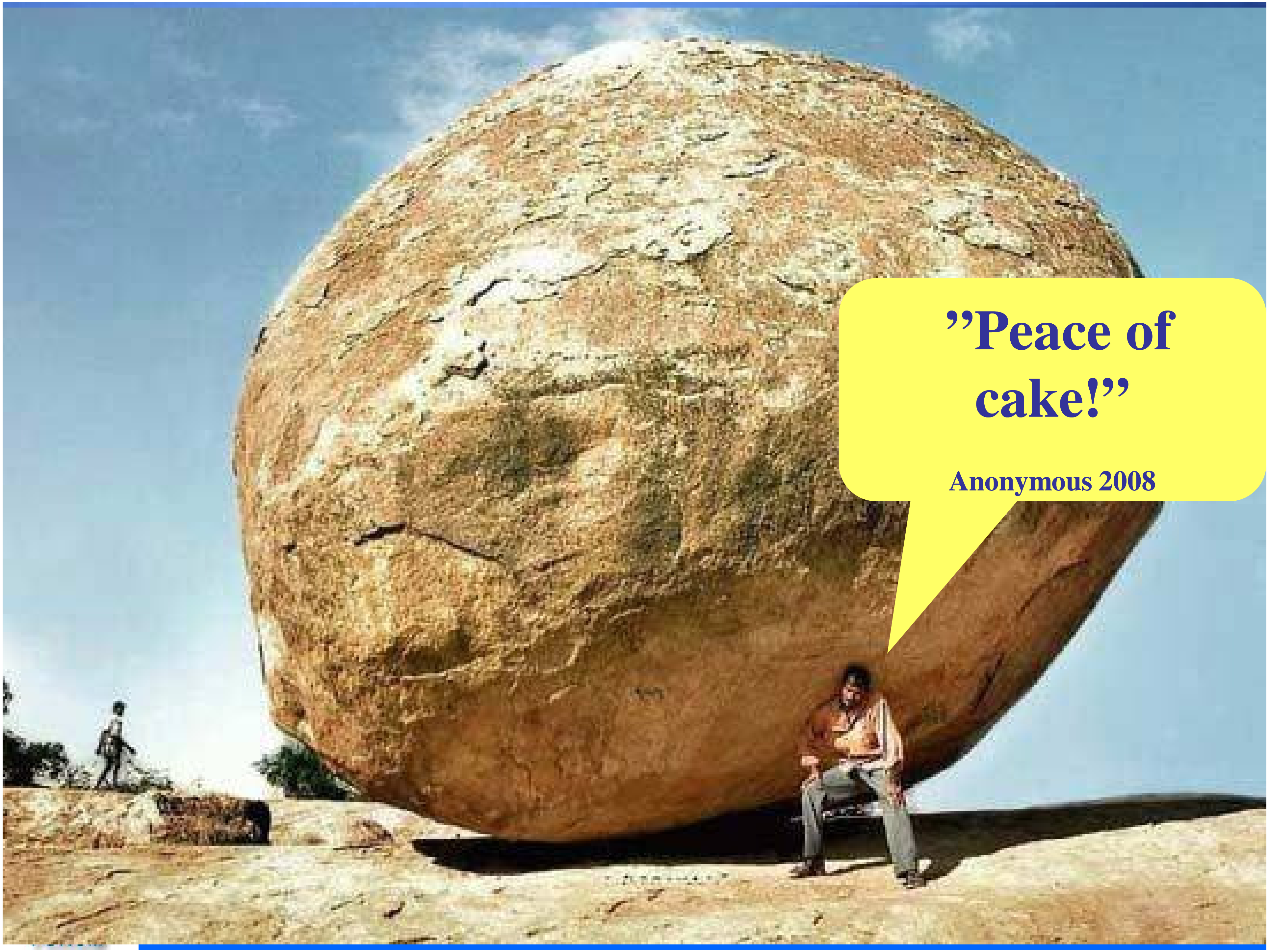
# IPv6?

- 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

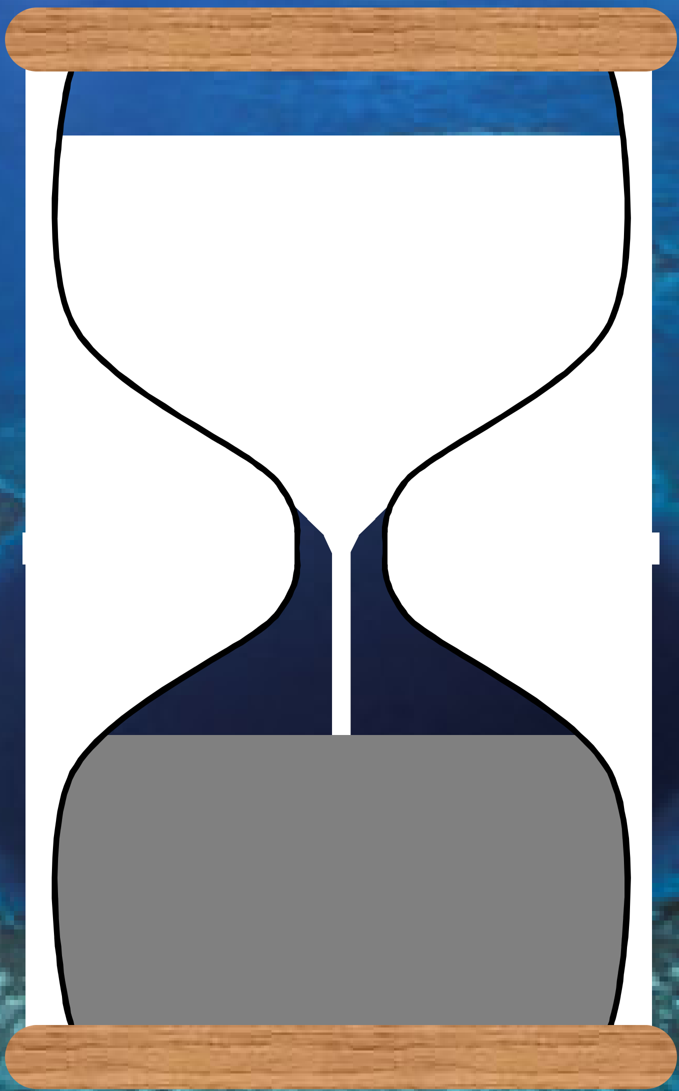
# NIST asked the IETF Draft-baker-ietf-core

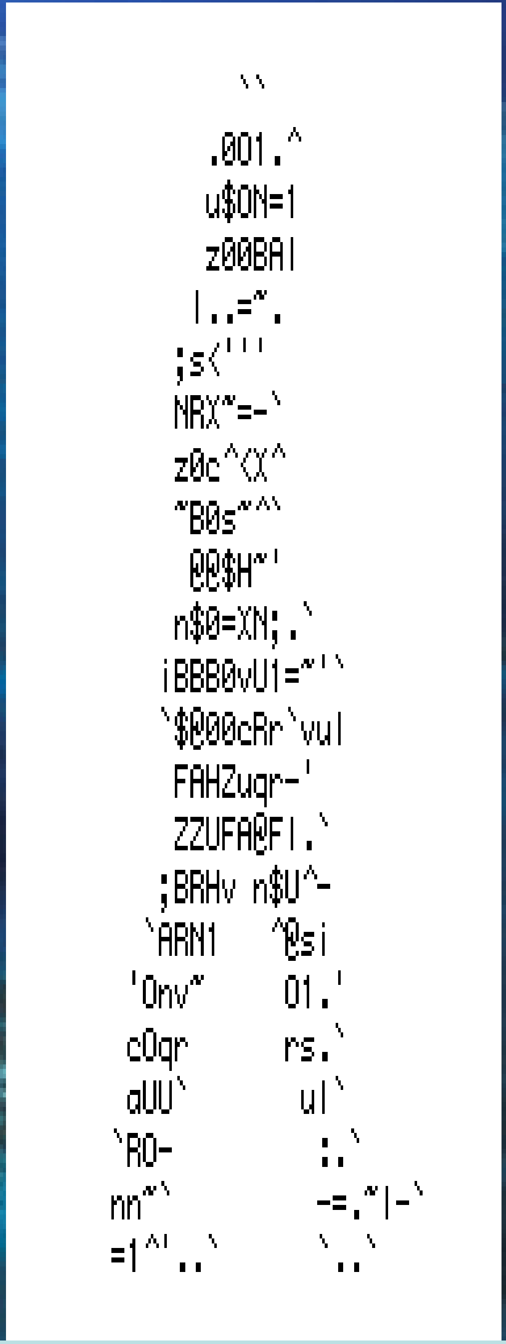
- The reader is warned:
  - IPv4 is running out of address space, and
  - IPv6 has positive reasons that one might choose it apart from the IPv6 space, such as the address autoconfiguration facility and its ability to support an arbitrarily large number of hosts in a subnet.
- As such, the IETF recommends 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 Network
Internet
Telecom Network
Enterprise
Household
3rd Party
Utilities
IPv6/6lowpan/ IEEE 802.15.4
IPv6/WiMAX, LTE, xDSL, LAN Optical Fiber, Satellite
IPv6/IPSec
Web, Email, ZigBee, Mobile Applications, Microsoft Hohm, Google PowerMeter
FORUM
Vision & Way Forward


”Peace of cake!”
Anonymous 2008

# Only Time Will Tell…





Finally an email that walks !